1990 TDRI Year-End Conference on
Industrializing Thailand and Its Impact on the Environment

The Greening of Thai Industry: Producing More and Polluting Less

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Session: Industrializing Thailand and the Impact on Its Environment

Research Report No. 5

The Greening of Thai Industry: Producing More and Polluting Less

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Industrializing Thailand and Its Impact on the Environment

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Abbreviations/Terminology

BMA	Bangkok Metropolitan Area
BMR	Bangkok Metropolitan Region
BOD	Biochemical Oxygen Demand
(O)BOI	(Office of the) Board of Investment
CO_2	Carbon Dioxide
CTF	Central Treatment Facility
DIW	Department of Industial Works
DD	Dissolves Oxygen
DOH	Department of Health
EGAT	Electricity Generating Authority of Thailand
EIA	Environmental Impact Assessment
FAC	The Factories Act of 1969
FTI	Federation of Thai Industries
GDP	Gross Domestic Product
IEAT	Industrial Estate Authority of Thailand
IED	Industrial Environment Division
IFCT	Industrial Finance Corporation of Thailand
IRR	Interest Rate of Return
ISC	Investment Service Center
MOI	Ministry of Industry
MOPH	Ministry of Public Health
MSTE	Ministry of Science, Technology, and Energy
(O)NEB	(Office of the) National Environment Board
NEDP	National Economic Development Plan
NEQA	National Environmental Quality Act
(O)NESDB	(Office of the) National Economic and Social Development Board
NIC	Newly Industrialized Country
NIE	Newly Industrialized Economies
NO_x	Nitrogen Oxide
OECD	Organization for Economic Cooperation and Development

PHA	The Public Health Act of 1941
SO2	Sulfur Dioxide
SPM	Suspended Particulate Matter
TSIC	Thailand Standard Industrial Classification

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บทคัดย่อ

การพัฒนาอุตสาหกรรมและคุณภาพสิ่งแวดล้อมในปัจจุบัน

การพัฒนาอุตสาหกรรมที่ผ่านมา ด้านหนึ่งได้ส่งผลกระทบที่สำคัญต่อการเจริญเติบโตอย่างรวดเร็วทางเศรษฐกิจ และฐานะทางการเงินของประเทศ ตลอดจนได้ยกระดับคุณภาพชีวิตทางวัตถุของประชาชน โดยเปิดโอกาสให้คนไทยสามารถบริโภคสินค้าที่มีคุณภาพทัดเทียมกับนานาประเทศ อีกด้านหนึ่ง การพัฒนาที่ไม่ได้คำนึงถึงผลกระทบต่อคุณภาพสิ่งแวดล้อมโดยขาดการลงทุนในการควบคุมและป้องกันมลพิษจากอุตสาหกรรมในระดับที่เพียงพอได้ส่งผลให้เกิดการแพร่กระจายของสารพิษ ทำให้แม่น้ำลำคลองเน่าเสียและทำให้อากาศเสีย และส่งผลกระทบต่อคุณภาพชีวิตทางสุขภาพอนามัยของคนไทยอันเนื่องมาจากสิ่งแวดล้อมรอบๆตัวกำลังเสื่อมสภาพลง

จากจำนวนโรงงานอุตสาหกรรมที่ขึ้นทะเบียนไว้กับกรมโรงงานอุตสาหกรรม ประมาณ 600 โรงงาน ในปี 2512 ได้เพิ่มเป็น 51,500 โรงงานในปี 2532 ในด้านที่ตั้งของโรงงานอุตสาหกรรมในปี 2532 พบว่าร้อยละ 52 กระจุกตัวอยู่ในเขตกรุงเทพฯและปริมณฑล นอกเหนือจากนี้ยังมี โรงงานที่ตั้งในนิคมอุตสาหกรรม ในปี 2532 จากจำนวนนิคมอุตสาหกรรมทั้งหมด 23 แห่ง 12 แห่งตั้งอยู่ในเขตกรุงเทพฯและปริมณฑล สำหรับภาคกลาง (รวมพื้นที่ชายฝั่งทะเลตะวันออก) มีจำนวนนิคมอุตสาหกรรม ถึง 7 แห่ง ภาพการกระจุกตัวของอุตสาหกรรมในเขตกรุงเทพฯและปริมณฑลจะชัดเจนยิ่งขึ้นเมื่อพิจารณาด้านมูลค่าการผลิตที่สูงถึง ร้อยละ 76 ของมูลค่าเพิ่มของภาคอุตสาหกรรมเกิดขึ้นในพื้นที่นี้ ซึ่งแสดงถึงว่าอุตสาหกรรมขนาดกลางและขนาดใหญ่กระจุกตัวอยู่ในบริเวณดังกล่าว

ของเสียที่เกิดจากอุตสาหกรรมนั้นแตกต่างจากของเสียที่เกิดจากกิจกรรมในครัวเรือน ของเสียจากอุตสาหกรรมที่ควรให้ความสำคัญเป็นพิเศษ เนื่องจากเป็นพิษต่อ ชีวิตมนุษย์ สัตว์หรือ พืช คือกากสารพิษ (Hazardous Waste) เช่น โลหะหนัก สารเคมี น้ำมัน สารละลาย อุตสาหกรรม 5 ประเภทแรกที่ปล่อยสารพิษ ออกมาในปริมาณมาก คือ อุตสาหกรรมโลหะ (Basic Metal) อุตสาหกรรมชุบหรือกลึงโลหะ (Fabricated Product) อุตสาหกรรมซ่อมประกอบทำอุปกรณ์ขนส่ง (Transport Equipment) อุตสาหกรรมอีเลคโทรนิค (Electrical Machinery) และอุตสาหกรรมเคมี (Chemicals) จำนวนโรงงานเหล่านี้อยู่รวม 15,126 โรงทั่วประเทศ ในจำนวนนี้ 10,152 โรงงาน ตั้งอยู่ในเขตกรุงเทพฯและปริมณฑล ซึ่งจ้างคนงานถึงร้อยละ 88 ของคนงานทั่วประเทศที่ทำงานในอุตสาหกรรมทั้ง 5 ประเภทนี้

ในปี 2522 ร้อยละ 71 ของมูลค่าเพิ่มของอุตสาหกรรม มาจากอุตสาหกรรมที่ไม่ผลิตกากสารพิษ และลดลงเหลือร้อยละ 42 ในปี 2532 ส่วนอุตสาหกรรมที่ผลิตกากสารพิษมีสัดส่วนในมูลค่าเพิ่มของภาคอุตสาหกรรมจากร้อยละ 29 เป็นร้อยละ 58 ในช่วงเวลาเดียวกัน ปริมาณของกาก

สารพิษที่เกิดขึ้นในปี 2529 มีประมาณ 1.1 ล้านตัน ในปัจจุบัน ประเทศไทยมีศูนย์กำจัดกากสารพิษเหล่านี้เพียง แห่งเดียวที่ ต.แสมดำ เขตบางขุนเทียน ซึ่งมีความสามารถในการบำบัดโดยประมาณเพียง 40,000 ตันต่อปี หรือน้อยกว่า 10 เปอร์เซ็นของปริมาณสารพิษที่เกิดขึ้น ดังนั้นจะมีกากสารพิษตกค้างอยู่ถึงหนึ่งล้านตันต่อปี กากสารพิษตกค้างปริมาณเหล่านี้ นอกจากจะมีผลโดยตรงต่อคุณภาพสิ่งแวดล้อมและสุขภาพอนามัยของมนุษย์แล้ว ยังสามารถสะสมและเพิ่มพูนความเข้มข้นในห่วงโซ่อาหารได้ ดังรายงานการวิจัยของ (ศิวะบวรและคณะ 2533) ซึ่งพบการปนเปื้อนของสารตะกั่ว แคดเมี่ยมและปรอท ในอาหารทะเล 9 ชนิด จากอ่าวไทย

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สำหรับคุณภาพอากาศนั้นพบว่าก๊าซซัลเฟอร์ไดออกไซด์ (SO_2) ที่ปล่อยจากภาคอุตสาหกรรมมีถึงร้อยละ 30 เมื่อเทียบกับภาคเศรษฐกิจอื่น และ พบว่าร้อยละ 55 ของก๊าซที่เกิดขึ้นจากภาคอุตสาหกรรมอยู่ ในเขตกรุงเทพฯและปริมณฑลซึ่งเมื่อรวมกับปริมาณก๊าซซัลเฟอร์ไดออกไซด์ที่เกิดในภาคกลางแล้วจะสูงถึง ร้อยละ 80 คุณภาพอากาศในเขตจังหวัดสมุทรปราการเป็นตัวอย่างผลกระทบของอุตสาหกรรมต่อคุณภาพอากาศได้เป็นอย่างดีกล่าวคือ หากไม่มีมาตรการใดในการควบคุมมลพิษอากาศเพิ่มเติม ในปี 2535 ปริมาณก๊าซซัลเฟอร์ไดออกไซด์ และไนโตรเจนอ๊อกไซด์ จะเกินมาตรฐานคุณภาพอากาศที่กำหนดไว้โดย สำนักงานคณะกรรมการสิ่งแวดล้อมแห่งชาติ (ไจก้า 2533)

ปัจจัยที่กำหนดสภาวะแวดล้อมปัจจุบัน

พระราชบัญญัติหลักในการควบคุมมลพิษจากอุตสาหกรรม ได้แก่ พระราชบัญญัติควบคุมโรงงาน พระราชบัญญัติสาธารณสุขและพระราชบัญญัติคุณภาพสิ่งแวดล้อม อย่างไรก็ตามหน่วยงานที่ดูแลยังขาดกลไกการควบคุมมลพิษจากอุตสาหกรรมอย่างมีประสิทธิภาพ การขออนุมัติจัดตั้งโรงงานอุตสาหกรรมที่เข้าข่ายในการจัดทำรายงานผลกระทบสิ่งแวดล้อม จะต้องส่งรายงานดังกล่าวให้สำนักงานคณะกรรมการสิ่งแวดล้อมแห่งชาติเป็นผู้พิจารณาก่อนที่กรมโรงงานอุตสาหกรรมจะออกใบอนุญาติประกอบการให้ ในขณะที่สำนักงานกรรมการสิ่งแวดล้อมแห่งชาติมีอำนาจเพียงการเสนอแนะเพื่อเห็นชอบเพื่อปรับปรุงแก้ไขและไม่เห็นชอบเท่านั้น จะไม่มีสิทธิในการระงับหรือทำการตรวจสอบหรือบังคับ ควบคุมตามที่ระบุไว้ในรายงานแต่อย่างไร เป็นที่ยอมรับกันโดยทั่วไปว่าโรงงานจำนวนมากถึงแม้ว่าจะติดตั้งระบบกำจัดมลพิษแล้วก็ตาม แต่ในทางปฏิบัติไม่ควบคุมให้มีการบำบัดอย่างทั่วถึง ส่งผลให้เกิดมลพิษอยู่เนือง ๆ

ในส่วนของการนิคมอุตสาหกรรม นอกเหนือจากการจัดหาที่ตั้งอุตสาหกรรมแล้ว ยังต้องดูแลควบคุมมลพิษและบำบัดของเสียจากอุตสาหกรรมด้วยตัวเอง ในปัจจุบันการนิคมอุตสาหกรรมจะเน้นในเรื่องของการบำบัดน้ำเสียเป็นหลัก ในจำนวนนิคมอุตสาหกรรมที่มีอยู่ในปัจจุบัน ไม่ปรากฏว่ามีโรงบำบัดกากสารพิษกลาง เตาเผากากสารพิษหรือมาตรในการควบคุมอากาศเสียแต่อย่างไร นอกจากนี้กรมโรงงานอุตสาหกรรมก็ไม่มีอำนาจในการเข้าตรวจสอบโรงงานที่อยู่ในเขตความรับผิดชอบของการนิคมอุตสาหกรรม

ในกรณีของกรมโรงงานอุตสาหกรรมเอง กรมโรงงานอุตสาหกรรมประกอบด้วยบุคคลากร 699 คน ต่อโรงงานที่มีอยู่ 50,000 โรงงาน (1:72) และงบประมาณ 1,900 บาทต่อ โรงงานในปี 2532 ซึ่งพิจารณาดูแล้วแทบจะเป็นไปไม่ได้ในการควบคุม ตรวจสอบ และบังคับควบคุม

ในด้านการส่งเสริมการลงทุนของภาคอุตสาหกรรม จากผลวิเคราะห์ข้อมูลการลงทุนด้านอุตสาหกรรมระหว่างปี 2529-2532 ของสำนักงานคณะกรรมการส่งเสริมการลงทุน (BOI) แสดงให้เห็นว่า ได้มีการอนุมัติการลงทุนอุตสาหกรรมที่ผลิตกากสารพิษเพิ่มขึ้นจากปริมาณเงินลงทุนร้อยละ 25 สูงขึ้นเป็นร้อยละ 55 ในขณะที่การควบคุมและกำจัดกากสารพิษมีขีดความสามารถในปริมาณที่ต่ำกว่าปริมาณสารพิษที่เกิดขึ้น

หน่วยงานและกฎระเบียบที่กล่าวข้างต้นนั้น ส่วนใหญ่กำหนดขึ้นให้มีความเหมาะสมกับการพัฒนาอุตสาหกรรมในระยะแรกซึ่งมีโรงงานเพียง 600 โรงงาน (เมื่อสิ้นปี 2512) ใช้วัตถุดิบในการผลิตที่มีกากของเสียที่สลายตัวได้ง่าย หากเปรียบเทียบกับขบวนการผลิตและเทคโนโลยีในปัจจุบันที่มีการใช้สารเคมีและวัสดุที่สลายตัวได้ยากในธรรมชาติ ประกอบกับการขยายตัวของโรงงานอุตสาหกรรมอย่างต่อเนื่องในอัตรากว่า ร้อยละ 10 ต่อปีในรอบทศวรรษที่ผ่านมา จะเห็นได้ว่าสถานะภาพและขีดความสามารถของหน่วยงานและกฎระเบียบเป็นสาเหตุส่วนหนึ่งที่ทำให้การจัดการด้านสิ่งแวดล้อมของรัฐไม่ได้ผล

แนวโน้มในอนาคต

<u>กากสารพิษ</u> – ในปี 2534 กากสารพิษจากอุตสาหกรรมจะมีเป็นจำนวน 1.9 ล้านตัน ต่อปี ร้อยละ 95.5 เกิดจากภาคอุตสาหกรรมการผลิต ส่วนที่เหลือเกิดจากของเสียชุมชน โรงพยาบาล และ การใช้ถ่านหิน และจากปริมาณกากสารพิษทั้งหมดที่เกิดขึ้น ร้อยละ 70 อยู่ในเขตกรุงเทพฯและปริมณฑล ภายในปี 2539 จะมีปริมาณกากสารพิษถึง 3.5 จนถึงปี 2544 จะเพิ่มจำนวนเป็น 6 ล้านตันต่อปี

<u>น้ำเสีย</u> - ได้มีการประมาณการไว้ว่าในปี 2534 มีน้ำเสียจากโรงงานอุตสาหกรรม ในรูปของ BOD 0.5 ล้านตันต่อปี (เทียบเท่าน้ำโสโครกจากประชากร 27.2 ล้านคน) ร้อยละ 33 เกิดจากโรงงานน้ำตาล ร้อยละ 24 เกิดจาก โรงงานสุรา เบียร์และเครื่องดื่ม ร้อยละ 16 เกิดจากโรงงานกระดาษ จากประมาณการของการ เติบโตทางเศรษฐกิจและของภาคอุตสาหกรรม ภายในปี 2539 จะมีน้ำเสีย (BOD) สูงถึง 0.73 ล้านตัน ต่อปี (เทียบเท่าน้ำโสโครกจากประชากร 40.5 ล้านคน)

<u>อากาศเสีย</u> - สารมลพิษอากาศที่เกิดจากภาคอุตสาหกรรมที่สำคัญ คือ ก๊าซซัลเฟอร์ไดออกไซด์ (SO_2) ก๊าซไนโตรเจนออกไซด์ (NO_x) ก๊าซคาร์บอนไดออกไซด์ (CO_2) และฝุ่นละออง (Suspended Particulate Matters: SPM)

- ก๊าซซัลเฟอร์ไดออกไซด์ (SO_2) ในปี 2534 โรงไฟฟ้าเป็นแหล่งปล่อยก๊าซ SO_2 สู่บรรยากาศ มากที่สุด แหล่งปล่อยก๊าซ SO_2 ที่ปล่อยจากอุตสาหกรรมมีปริมาณ 0.21 ล้านตัน คิดเป็นร้อยละ 30 ของ ก๊าซ SO_2 ที่เกิดขึ้นทั้งหมด ปริมาณก๊าซ SO_2 จะเพิ่มขึ้นเป็น 0.28 ล้านตัน ในปี 2539 และ 0.85 ล้านตันในปี 2554

- ก๊าซไนโตรเจนออกไซด์ (NO_x) ในปี 2534 กิจกรรมการคมนาคมขนส่งปล่อยก๊าซ NO_x ถึงร้อยละ 60 ของก๊าซ NO_x ที่เกิดขึ้นทั้งหมด แหล่งรองลงมาคือโรงไฟฟ้า และอุตสาหกรรม ตามลำดับอุตสาหกรรมปล่อยก๊าซ NO_x เป็นปริมาณ 0.07 ล้านตัน (ร้อยละ 13) ในปี 2534 และเพิ่มขึ้น 0.09 ล้านตันในปี 2539 และเป็น 0.2 ล้านตันในปี 2554

- ก๊าซคาร์บอนไดออกไซด์ (CO_2) ในปี 2534 กิจกรรมการคมนาคมขนส่งเป็นแหล่งปล่อย ก๊าซ CO_2 ที่สำคัญที่สุด (ร้อยละ 32) ตามด้วยโรงไฟฟ้า (ร้อยละ 26) และอุตสาหกรรม (ร้อยละ 23) อุตสาหกรรมปล่อยก๊าซ CO_2 ในปริมาณสูงถึง 34 ล้านตัน ในปี 2534 และเพิ่มขึ้นเป็น 70 ล้านตัน ในปี 2554 อย่างไรก็ตามในปี 2554 โรงไฟฟ้าจะเป็นแหล่งปล่อยก๊าซ CO_2 ที่สำคัญที่สุดตามด้วย กิจกรรมการคมนาคมขนส่งและอุตสาหกรรมตามลำดับ

- ฝุ่นละออง (SPM) นับตั้งแต่ปี 2534 อุตสาหกรรมเป็นแหล่งปล่อยฝุ่นละอองสูงที่สุด ตามด้วยกิจกรรมการคมนาคมขนส่งและการใช้เชื้อเพลิงของชุมชน ฝุ่นละอองที่เกิดจากภาคอุตสาหกรรมมีปริมาณ 0.35 ล้านตันในปี 2534 เพิ่มเป็น 0.47 ล้านตันในปี 2539 และเป็น 1.07 ล้านตันในปี 2554

การพิจารณามาตรการทางเศรษฐกิจ

การเจริญเติบโตของภาคอุตสาหกรรมได้ทำให้ อัตราการเพิ่มขึ้นของมลพิษอุตสาหกรรมเพิ่มสูงขึ้น ในขณะที่ กฎระเบียบ และวิธีปฏิบัติที่มีอยู่ในปัจจุบัน ไม่สามารถควบคุมให้อุตสาหกรรมจัดการกับสารมลพิษอย่างมีประสิทธิภาพได้ และ ไม่สามารถดึงดูดใจให้อุตสาหกรรมหันไปใช้ขบวนการผลิตหรือวัตถุดิบที่มีผลกระทบต่อสิ่งแวดล้อมน้อยลง มาตรการทางเศรษฐกิจเป็นกลยุทธหนึ่งในการควบคุมการปล่อยสารมลพิษ ซึ่งใช้กันอย่างแพร่หลาย ในประเทศแถบ ยุโรป อเมริกา ญี่ปุ่น หรือแม้แต่ในประเทศเพื่อนบ้าน เช่น มาเลเซีย มาตรการทางเศรษฐกิจยังเป็นกลยุทธในการระดมทุนเพื่อก่อสร้างระบบบำบัดมลพิษ และ แก้ไขสภาพแวดล้อมที่ถูกปนเปื้อนจากสารมลพิษ ความร่วมมือของอุตสาหกรรมต่อการปฏิบัติตามมาตรการทางเศรษฐกิจ เกิดจากความเข้าใจและความตระหนักถึงผลกระทบของของสภาพแวดล้อมเสื่อมโทรม ซึ่งในระยะยาวแล้ว อาจกลายเป็นข้อจำกัดที่สำคัญในการเจริญเติบโตทางเศรษฐกิจ ดังเช่นที่กำลังเกิดแก่ธุรกิจท่องเที่ยวในปัจจุบัน

หลักการที่สำคัญของมาตรการทางเศรษฐกิจ คือ ผู้ผลิตมลพิษต้องจ่าย (Polluters Pay Principle) กล่าวคือ ค่าใช้จ่ายในการรักษาและชำระล้างสภาพแวดล้อมที่ถูกปนเปื้อนให้สะอาด และค่าใช้จ่ายในการบำบัดมลพิษ ควรเก็บจากผู้ปล่อยมลพิษ ตามปริมาณ ประเภท ตลอดจนระยะทางในการเก็บขนสารมลพิษ อัตราค่าบำบัดมลพิษ (Pollution charge) ในทางหลักการควรครอบคลุมต้นทุนทุกประเภทและทุกขั้นตอน นับตั้งแต่การก่อสร้างและการติดตั้งระบบบำบัด การเก็บขน การขนส่ง การบำบัด และการกำจัดขั้นสุดท้าย หากอัตราค่าบำบัดมลพิษสูงพอ ผู้ประกอบการก็จะมีแรงจูงใจในการปรับปรุงขบวนการผลิต และเปลี่ยนแปลงประเภทวัตถุดิบที่ใช้เพื่อให้เกิดสารมลพิษน้อยที่สุด

การจัดตั้งกองทุนสิ่งแวดล้อมเป็นข้อเสนอที่เป็นรูปธรรมในการบริหารจัดการเงินที่รับมาใช้ กองทุนสิ่งแวดล้อมจะนำเงินที่เก็บจากผู้ประกอบการมาใช้ในการก่อสร้าง และดำเนินการระบบบำบัดมลพิษส่วนกลาง หรือเป็นแหล่งเงินกู้ดอกเบี้ยต่ำ ให้แก่ผู้ประกอบการขนาดเล็กหรือกลางที่มิได้ใช้บริการของระบบบำบัดมลพิษส่วนกลาง ในกรณีกากสารพิษซึ่งเป็นสารมลพิษที่อุตสาหกรรมปล่อยออกมามากที่สุดนั้น ศูนย์บำบัดกากสารพิษ ต.แสมดำ อ.บางขุนเทียน ของกรมโรงงานอุตสาหกรรม เป็นตัวอย่างที่ดีระบบบำบัดกลาง ซึ่งคิดค่าบริการจากโรงงานอุตสาหกรรม อย่างไรก็ตามศูนย์ดังกล่าวมีความสามารถในการรับกากสารพิษเพียง ร้อยละ 2 ของกากสารพิษที่จะเกิดในปี 2534 ศูนย์บำบัดกลางที่บางขุนเทียนได้ให้แนวคิดที่ดีของการระดมทุนจากกลุ่มอุตสาหกรรม จากการคาดคะเนปริมาณกากสารพิษที่จะเกิดในปี 2534 จำนวน 1.9 ล้านตัน พบว่ากากสารพิษจำนวน 595,000 ตัน เท่านั้นที่มีความคุ้มค่าทางเศรษฐกิจในการใช้ระบบบำบัดส่วนกลาง อัตราค่าบำบัดกากสารพิษ (ซึ่งรวมค่าขนส่ง บำบัดและกำจัดขั้นสุดท้าย) ที่ประเมินโดย Engineering Science et.al.(1989) มีค่าเท่ากับ 1,000 บาท

ต่อตัน อย่างไรก็ตาม อัตราค่าบำบัดควรจะรวมถึงค่าใช้จ่ายในการชำระล้างสิ่งแวดล้อมที่อาจถูกปนเปื้อนโดยเจตนา หรือไม่เจตนา ซึ่งคิดเป็นเงินประมาณ 2,000 บาทต่อตัน (อัตราดังกล่าวเป็นค่าเฉลี่ย ในทางปฏิบัติ อัตราการบำบัดจะไม่เท่ากันขึ้นกับประเภทและปริมาณของกากสารพิษ) เมื่อคูณอัตราดังกล่าวกับปริมาณ กากสารพิษ 600,000 ตัน ในปี 2534 คิดเป็นเงินทั้งสิ้น 1,200 ล้านบาท เงินจำนวนดังกล่าวคิดเป็นร้อยละ 0.2 ของมูลค่าเพิ่มของอุตสาหกรรมที่ผลิตกากสารพิษ หรือคิดเป็นร้อยละ 1 ของกำไร โดยสมมุติว่าอุตสาหกรรมเหล่านี้มีอัตรากำไรขั้นต่ำ ร้อยละ 20

ในกรณีน้ำเสียของอุตสาหกรรมนั้น ประเมินอัตราค่าบำบัดจากระบบบ่อบำบัดน้ำเสียเป็น 1,000 บาทต่อตัน(BOD) จะได้เงินเข้ากองทุน 500 ล้านบาท ในปี 2534 หรือคิดเป็น ร้อยละ 1.8 ของมูลค่าเพิ่มของอุตสาหกรรมที่ปล่อยน้ำเสีย จากตัวเลขสัดส่วนของค่าบำบัดมลพิษต่อมูลค่าเพิ่มและต่อกำไรแสดงให้เห็นว่า การจัดตั้งกองทุนสิ่งแวดล้อมเพื่อระดมทุนจากผู้ประกอบการมาใช้ในการบำบัดมลพิษเป็นสิ่งที่เป็นไปได้ ในแง่ของภาคอุตสาหกรรมเองนั้น กองทุนสิ่งแวดล้อมเป็นทางออกทางหนึ่งในการ จัดการปัญหามลพิษอุตสาหกรรมที่เกิดขึ้น ก่อนที่สิ่งแวดล้อมจะเสื่อมโทรมจนถึงจุดที่เป็นข้อจำกัดในการเติบโตของอุตสาหกรรม และ เป็นการสร้างภาพพจน์ที่ดีให้แก่ตนเองในการพัฒนาคุณภาพชีวิตของสังคม

ปัญหาของอากาศเสียจากอุตสาหกรรมที่เกิดจากการใช้เชื้อเพลิงในระบบการผลิต โดยเฉพาะ ถ่านหินลิกไนท์ ซึ่งก่อให้เกิดก๊าซซัลเฟอร์ไดออกไซด์ ไนโตรเจนออกไซด์ คาร์บอนไดออกไซด์ และ ฝุ่นละอองในปริมาณที่สูง แต่มีราคาต่ำกว่าครึ่งในระดับพลังงานที่เท่ากันเมื่อเปรียบเทียบกับก๊าซธรรมชาติ ซึ่งแสดงให้เห็นถึงการกำหนดราคาเชื้อเพลิงที่ไม่ได้รวมต้นทุนภายนอก (Externalities Cost) ดังนั้น การปรับราคาของถ่านหินลิกไนท์ควรเป็นมาตรการทางหนึ่งในการควบคุมมลพิษด้านอากาศ

หลักการและเหตุผลในการกำหนดแนวนโยบาย

ในการกำหนดแนวนโยบายในการควบคุมมลพิษจากภาคอุตสาหกรรม ควรที่จะยึดหลักการห้าประการไว้เป็นแนวทางดังนี้

1. คุณภาพสิ่งแวดล้อมเป็นเป้าหมายสูงสุด (The Ambient Quality Target)

นโยบาย กฎระเบียบหรือมาตรฐาน ที่กำหนดควรมีเป้าหมายสูงสุดที่คุณภาพสิ่งแวดล้อม กล่าวคือ มาตรฐานคุณภาพน้ำในแม่น้ำเป็นเป้าหมาย ส่วนมาตรฐานน้ำทิ้งจากโรงงาน หรือจากชุมชนเป็นวิธีการเพื่อบรรลุเป้าหมาย ดังนั้น มาตรฐานน้ำทิ้งจึงควรยืดหยุ่นและเปลี่ยนแปลงได้ตามความเหมาะสม และตามมาตรฐานคุณภาพน้ำในแม่น้ำแต่ละสาย แต่ละช่วง ในกรณีคุณภาพอากาศ ก็เช่นเดียวกัน มาตรฐานอากาศเสียจากปล่องของโรงงานไม่ควรเป็นค่าเดียวกันทั้งประเทศ ควรแปร

เปลี่ยนได้ตามมาตรฐานคุณภาพอากาศในแต่ละพื้นที่

2. ใช้วิธีการที่มีค่าใช้จ่ายต่ำสุด (The Minimum Cost Principle)

นโยบายและมาตรการที่นำมาใช้ควรจะเป็นสิ่งที่ปฏิบัติได้ และสามารถบรรลุเป้าหมายคุณภาพสิ่งแวดล้อมด้วยค่าใช้จ่ายที่ต่ำที่สุด เช่น การกำหนดมาตรฐานคุณภาพน้ำ หรือ อากาศ ควรคำนึงถึงความเป็นไปได้ของเทคโนโลยีการบำบัดควบคู่กับค่าใช้จ่ายที่เกิดขึ้น หลักการนี้ยังครอบคลุมถึงวิธีการบริหารจัดการมลพิษด้วย เช่น การให้เอกชนเข้ามามีส่วนร่วมในการตรวจสอบติดตาม (Monitoring) อาจจะมีค่าใช้จ่ายที่ต่ำกว่าการปฏิบัติงานโดยรัฐเพียงฝ่ายเดียว เมื่อเทียบกับประสิทธิผลในระดับเดียวกัน

3. ผู้ก่อให้เกิดมลพิษต้องจ่าย (Polluters Pay Principle)

ในสภาพที่ธรรมชาติไม่สามารถทนต่อภาวะมลพิษได้อีกต่อไป การลงทุนเพื่อกำจัดกากสารพิษ น้ำเสีย และอากาศเสีย เป็นสิ่งที่หลีกเลี่ยงไม่ได้ ค่าใช้จ่ายในการลงทุน ดำเนินการและอื่นๆ ต้องเก็บจากผู้ผลิตมลพิษ หลักการนี้เป็นหลักการที่ใช้กันทั่วโลก โดยเฉพาะอย่างยิ่งในภาวะที่อุตสาหกรรมหลักของไทยเป็นอุตสาหกรรมส่งออก รัฐไม่ควรนำภาษีของประชาชนไทยมาเป็นค่าใช้จ่ายในการกำจัดมลพิษ เพื่อให้ผู้บริโภคในต่างประเทศได้บริโภคสินค้าในราคาถูกลง ในความเป็นจริงแล้วผู้ผลิตหรืออุตสาหกรรมจะผลักภาระค่าใช้จ่ายลงไปในราคาสินค้าในระดับที่ผู้บริโภคยังยอมรับได้ ดังนั้นเมื่อกล่าวจนถึงที่สุดแล้ว ค่าใช้จ่ายในการกำจัดมลพิษจึงเป็นภาระของทั้งผู้ผลิตและผู้บริโภค อย่างไรก็ตามถ้าราคาสินค้าสูงเกินกว่าที่ผู้บริโภคจะยอมรับได้ อุตสาหกรรมย่อมถูกกระทบกระเทือน ดังนั้นจึงนำมาสู่หลักการที่สำคัญใน 2 ข้อหลัง

4. การรักษาความสามารถในการแข่งขัน (The Competitiveness Imperative)

นโยบายที่กำหนดควรคำนึงถึงความสามารถในการแข่งขันของอุตสาหกรรมไทย ในระยะยาวแล้วการควบคุมมลพิษที่เข้มงวดขึ้นอาจส่งผลกระทบต่อการเปลี่ยนโครงสร้างอุตสาหกรรมไทยโดยอุตสาหกรรมที่มีกากสารพิษจะน้อยลง แต่ก็มิได้หมายความถึงความถดถอยของอุตสาหกรรมโดยรวม

5. นโยบายต้องมีขั้นตอน (Policy Transition)

การเปลี่ยนแปลงโครงสร้างอุตสาหกรรมที่มีมลพิษมาก ไปสู่โครงสร้างอุตสาหกรรมที่มีมลพิษน้อยลง เป็นวิธีการหนึ่งในการรักษาคุณภาพสิ่งแวดล้อม อย่างไรก็ตามประเทศไทยในปัจจุบันโดยเฉพาะในเขตกรุงเทพและปริมณฑลนั้นได้กลายเป็น "สวรรค์ของมลพิษ" แล้ว ดังนั้น เพื่อให้การเปลี่ยนแปลงเป็นไปอย่างเป็นธรรมและมีประสิทธิภาพ นโยบายที่กำหนดจึงควรเป็นขั้นตอน ให้เวลาและมีเป้าหมายชัดเจน เช่น มาตรฐานคุณภาพสิ่งแวดล้อมอาจจะเริ่มต้นในระดับที่ยอมรับได้และจึงเข้มงวดมากขึ้นๆ ตามระยะเวลาและเป้าหมายที่กำหนด หรือในกรณีการย้ายที่ตั้งของโรงงานอุตสาหกรรม บางประเภทก็เป็นสิ่งที่ต้องใช้เวลาและปัจจัยสนับสนุนด้านอื่นๆ อย่างมีขั้นตอน

แนวนโยบายและมาตรการแก้ไข

การพัฒนาอุตสาหกรรมในระยะ 10 ปีที่ผ่านมานอกเหนือจากการเจริญเติบโตที่สูงถึงร้อยละ 10 ต่อปีแล้ว การเปลี่ยนแปลงโครงสร้างการผลิตของอุตสาหกรรม จากอุตสาหกรรมที่ใช้วัตถุดิบไม่เป็นสารพิษมาเป็นอุตสาหกรรมที่เป็นสารพิษมากขึ้นนั้น ก่อให้เกิดปัญหาที่ซับซ้อนในการจัดการมลพิษเหล่านี้มากยิ่งขึ้น ในขณะเดียวกันการจัดการมลพิษทางน้ำที่ยังไม่สามารถดำเนินการในระดับที่ยอมรับได้ เช่น คุณภาพน้ำที่ต่ำกว่ามาตรฐานที่กำหนดไว้ของสำนักงานสิ่งแวดล้อมแห่งชาติ ของแม่น้ำเจ้าพระยา และแม่น้ำท่าจีน ซึ่งมีแนวโน้มที่จะเสื่อมโทรมมากกว่านี้หากไม่มีการควบคุมอย่างมีประสิทธิภาพ นอกจากนี้ในด้านมลพิษทางอากาศจากภาคอุตสาหกรรมจะมีปริมาณเพิ่มมากขึ้น อันเนื่องมาจากการใช้พลังงานเชื้อเพลิงในขบวนการผลิต ในภาพรวม ปัญหาของการกระจุกตัวของโรงงานอุตสาหกรรมที่มีมากในเขต กทม.และปริมณฑล ได้ก่อให้เกิดมลพิษจากอุตสาหกรรมในอัตราและปริมาณที่สูงเกินกว่าที่สภาพแวดล้อมจะรับได้ จากการพิจารณาปัจจัยกำหนดสภาวะแวดล้อมปัจจุบันและการพิจารณามาตรากการทางเศรษฐกิจ ข้อเสนอแนะแนวนโยบายและมาตรการหลักในการจัดการสิ่งแวดล้อมที่เกิดจากภาคอุตสาหกรรมการผลิตควรพิจารณาดำเนินการดังนี้

o จัดตั้งกองทุนสิ่งแวดล้อม (Environment Fund) เพื่อบริหารจัดการค่าธรรมเนียมที่เก็บจากโรงงาน เงินกองทุนจะใช้จ่ายเพื่อการสร้างระบบบำบัดของเสียส่วนกลางหรือใช้ในการจัดการสิ่งแวดล้อมที่ถูกปนเปื้อนให้อยู่ในสภาพปกติหรือเป็นแหล่งเงินกู้ดอกเบี้ยต่ำ (Soft Loan) แก่โรงงาน ขนาดเล็กและกลางในการบำบัดมลพิษ

o จัดทำระบบตรวจสอบมลพิษอุตสาหกรรม (Pollution Audit) เพื่อเป็นข้อมูลพื้นฐานในการตรวจสอบและจัดเก็บค่าธรรมเนียมมลพิษ ทั้งนี้อาจให้เอกชนเป็นผู้จัดทำภายใต้การควบคุมของหน่วยงานของรัฐ

o ดำเนินการเก็บค่าธรรมเนียมมลพิษ (Pollution Charge) ตามปริมาณมลพิษที่โรงงานนั้นๆผลิต โดยเก็บในอัตราก้าวหน้าเพิ่มขึ้นเมื่อโรงงานปล่อยมลพิษเกินมาตรฐานและลดลงเมื่อโรงงานปล่อยมลพิษต่ำกว่ามาตรฐาน โดยเริ่มต้นจากนิคมอุตสาหกรรมและโรงงานขนาดใหญ่เป็นอันดับแรก ทั้งนี้ค่าธรรมเนียมมลพิษควรครอบคลุมค่าใช้จ่ายทุกอย่างตั้งแต่การลงทุนสร้างโรงบำบัด การเก็บขน การขนส่ง การบำบัด และการกำจัดขั้นสุดท้าย

o ในกรณีของอากาศเสียจากโรงงานอุตสาหกรรม ควรพิจารณามาตรการในด้านราคาเชื้อเพลิงซึ่งไม่ได้รวมต้นทุนภายนอก(ผลกระทบที่เกิดขึ้นต่อสิ่งแวดล้อม) โดยเฉพาะอย่างยิ่งถ่านหินลิกไนท์

ส่วนน้ำมันเตาควรพิจารณาปรับปรุงคุณภาพน้ำมันโดยการลดปริมาณกำมะถันลงจาก 3.5 เปอร์เซ็น เป็น 2.0 เปอร์เซ็น ในระยะสั้นและ 1.0 เปอร์เซ็น ในระยะยาว

o ปรับปรุงนโยบายการส่งเสริมการลงทุนของรัฐที่ก่อให้เกิดมลพิษสูง เช่น การให้การส่งเสริมการลงทุนอุตสาหกรรมที่ก่อให้เกิดกากสารพิษสูง ควรพิจารณาจัดลำดับให้การส่งเสริมการลงทุนอุต-สาหกรรมที่มีอัตราของกากสารพิษต่อมูลค่าการผลิตที่ต่ำเป็นหลัก ในการคัดเลือกให้การส่งเสริมแทนการพิจารณาเพียงด้านมูลค่าการผลิตเป็นหลัก

o ควรให้การสนับสนุนนิคมอุตสาหกรรมร่วมในการป้องกันและควบคุมมลพิษจากอุตสาหกรรมมากขึ้น โดยหลักการแล้วการจัดให้อุตสาหกรรมขนาดเล็กและขนาดกลางเข้าไปดำเนินการในนิคมอุตสาหกรรม ซึ่งนอกจากจะง่ายในการควบคุมแล้วยังสามารถลดค่าใช้จ่ายในการจัดการด้านสิ่งแวดล้อม

o นโยบายของรัฐที่จะให้มีการกระจายตัวของอุตสาหกรรมไปสู่ภูมิภาคเพื่อเป็นการบรรเทาปัญหาด้านความแออัดใน กทม.และจังหวัดปริมณฑลควรพิจารณาข้อดีและข้อเสียด้านสิ่งแวดล้อมเป็นประเด็นหนึ่ง ทางเลือกทางหนึ่งคือการกำหนดระดับการกระจายตัวให้ชัดเจนและรวมทั้งประเภทของอุตสาหกรรมที่จะกระจายตัว ทั้งนี้จะช่วยเสริมในด้านการกระจายตัวของมลพิษทางอุตสาหกรรมให้อยู่ในวิสัยที่ควบคุมได้ ตัวอย่างของการส่งเสริมการกระจายตัวของอุตสาหกรรมในประเทศไต้หวันเป็นกรณีหนึ่งที่แสดงให้เห็นถึงผลกระทบสิ่งแวดล้อมตามชนบท ซึ่งเกิดจากการขยายตัวอย่างรวดเร็วของอุตสาหกรรมที่ขาดการพิจารณาด้านสิ่งแวดล้อม

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Chapter 1

Introduction

Thailand, traditionally an agricultural country and a major food exporter, is undergoing rapid rates of structural change and industrial growth. The country's industrial output has grown at double-digit rates in recent years and is expected to continue to do so well into the twenty-first century. Already, the industry's[1] share of the gross domestic product (GDP) is more than twice that of agriculture's, and Thailand is well on its way becoming a newly industrialized country (NIC). However, both the rapid rate and the pattern of Thai industrialization are generating many environmental problems with which the country is ill-prepared to deal.

The heavy concentration of industry in the Bangkok Metropolitan Region (BMR) and the surrounding coastal provinces is accelerating urbanization and compounding urban problems. Traffic congestion; water shortages; solid waste; and air, water, and noise pollution problems have noticeably worsened during the last few years. Both environmental awareness and environmental legislation (setting of standards) have advanced considerably in recent years, but subsequent environmental enforcement is lagging. In the meanwhile very little is known about the environmental implications of (1) the changing structure of Thai industry, and (2) the government's industrial and trade policies, including industrial promotion.

Recent developments in the industrial sector have important environmental implications for Thailand. While technological advances in pollution control and abatement offer considerable potential for environmental improvement, technological development—compounded with a change in the structure of industry and in the types of materials used in production processes—is leading to a new type of pollution problem. The marked shift from traditional pollutants, such as biochemical oxygen demand (BOD), to more complex toxic pollutants included the introduction of heavy metals, toxic air and water pollutants, and hazardous waste into the environment. There also has been a substantial increase in the number and use of different kinds of chemical products, some of which may present risks health and environmental damage during their handling and disposal.

The purpose of this study is to analyze the relationship between industrial growth, structural change, and industrial policy for environmental problems and to propose policies that would both "minimize" and internalize the environmental cost of industrialization in Thailand, an advanced developing country. The study also attempts to demonstrate that the uncontrolled environmental problems generated by rapidly advancing and geographically concentrated industrialization ultimately become a constraint to industrial growth itself, apart from their impact on the quality of life.

The following research questions are addressed:

- What are the recent industrial pollution trends?
- Has the recent acceleration of industrial growth proportionally increased pollution levels?
- What are the present and projected effects of industrial growth and structural change within industry on industrial pollution levels?
- What is the geographic distribution of industrial pollution and how does it affect the industry's impact on the environment?
- Have the planning of industrial locations or zoning regulations reduced environmental problems?
- What are the impacts of industrial promotion policies on the level of hazardous waste generated by the Thai industry?
- What is the evidence of the impact of industrial pollution an human health?
- Are the present institutional structures and the enforcement activities of industrial and environmental agencies effective?

Finally, the study derives the implications of the analysis for industrial and environmental policies and examines the feasibility, cost, and effectiveness of alternative policy instruments such as incentives to influence industrial location, effluent charges, pollution permits, and environmental funds, bonds, and audits.

The study is divided into seven chapters. **Chapter 1** introduces the study, and **Chapter 2** presents the overall environmental perspectives of industry in Thailand over the last three decades. **Chapter 3** presents the overall geographic distribution of industry and the related distribution of industrial pollutants in terms of air quality, water quality, and hazardous waste. **Chapter 4** reviews the effect of Thailand's industrial activities on environmental quality with specific focus on human health effects. **Chapter 5** reviews the environmental policies and institutional aspects of industrial and environmental development in both the past and the present. Attempts are also made to assess the present effectiveness of environmental enforcement and the effect of industrial promotion on pollution. **Chapter 6** evaluates the economics of pollution control including the use of incentives, charges, and fees for the management of the industrial pollution. **Chapter 7** outlines appropriate policy recommendations based on findings from the analyses discussed in the previous chapters. Special attention is given to the elements of environmental strategy designed to deal with the problems of enforcement, monitoring incentives, charges, and industrial location.

End notes

1 The industrial sector discussed here includes manufacturing, mining, construction, and power. In later parts of the paper, industry is used in the more narrow sense of manufacturing.

Chapter 2

Industrial Development and Environmental Implications

OVERVIEW

Manufacturing has an impact on Thailand's natural resource base throughout the entire cycle of raw materials exploitation—from extraction, energy consumption, transformation into products, and waste generation to the use and disposal of products by consumers. While industry produces these wanted goods with numerous manufacturing processes, it also returns deleterious byproducts, or wastes, to the environment (see Figure 2.1). All industrial wastes affect, in some way, the normal life of an environment. When the effect is sufficient to render the environment unacceptable for its "best usage," the environment is said to be polluted. The term best usage encompasses diverse concepts and activities including the use of water for drinking and fishing, the use of air for healthy breathing and clear viewing, and the use of land for cultivating and housing.

THE EVOLUTION OF STRUCTURAL CHANGE

A Retrospective View

Industrialization and government policy to promote industrial growth began in the late 1950s. The average growth rate during the period from 1950 to 1959 was 5.3 percent (Tinakorn 1988). The 1960s became the decade of import substitution policy with an average growth rate of 11.2 percent (Watananukit 1989). The industries with the largest share in total manufacturing production were food processing, beverages, and tobacco (approximately 50 percent), followed by textiles and textile products, chemicals and chemical products, and transport equipment (see Table 2.1). Production growth during the period came largely from expanding domestic consumption. To foster and promote the industrial development during its embryonic stage, the government established the

Industrial Finance Corporation of Thailand (IFCT) and the Board of Investment (BOI) in 1959 and 1960, respectively. The Industrial Estate Authority of Thailand (IEAT), also

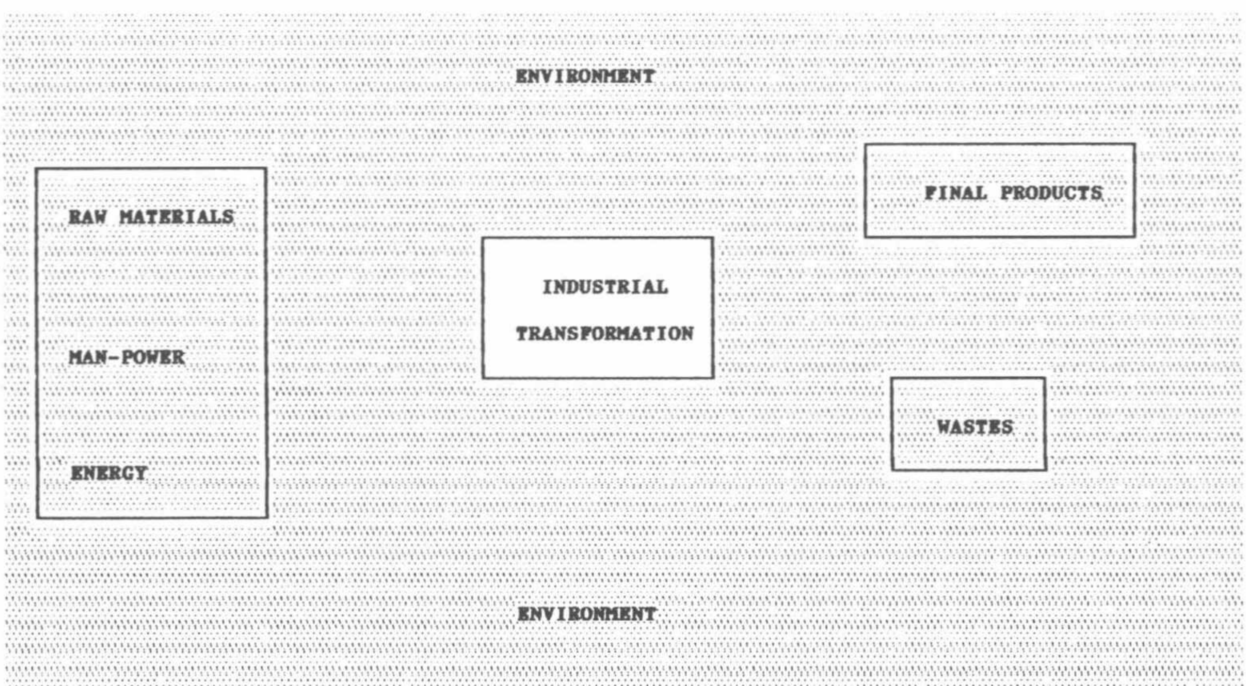


Figure 2.1 Conceptual Relationship of Industry and Environment

Table 2.1 Manufacturing Industry : GDP Share and Growth,1960 - 1989

		1960 - 1965		1970 - 1974		1975 - 1979		1980 - 1984		1985 - 1989	
TSIC [a]	Industry Group	Share	Growth	Share	Growth	Share	Growth	Share	Growth	Share	Growth
311-312	Food	34.5	25.7	15.3	8.2	15.6	10	15.4	8.8	14.9	9
313	Beverage	10.6	10.6	9.4	8	10.2	17.4	10.3	9.3	9.5	9.6
314	Tobacco	13	12.1	7.7	7	6.4	4.6	5.6	-1.3	4.2	6.7
321	Textiles	5.2	10.6	11.5	18.5	13.6	12.4	14	4.4	14.1	12.7
322	Wearing apparel	8	5.5	9.2	11.5	8.7	7.2	9.3	7.1	10.9	15.8
323-324	Leather products & footwear	0.69	0.6	2.1	4.6	1.9	0.8	2.2	11.9	2.8	19.3
331	Wood and cork	4.8	5.2	3.6	6.9	2.9	3.2	1.7	-1.4	1.2	-1.4
332	Furniture and Fixtures	1.2	1.4	1.6	0.7	1.3	7.6	1.2	4.4	1.2	14.1
341	Paper and paper products	0.2	0.4	1.4	10.9	1.3	24.8	1.7	3.1	1.6	11
342	Printing & publishing	3.2	2.6	1.4	10.8	1.5	10.8	1.7	8.6	1.5	3.2
352	Chemical products	6.8	5.8	3.6	8.7	3.6	13.6	4.2	7.3	4.4	9.7
353-354	Petroleum products	0.01	4.5	7.5	17.5	6.7	4.9	5.1	2.8	4.3	7.3
355-356	Rubber and plastic products	0.6	0.7	2.6	11.2	2.7	11.4	2.5	1.6	2.6	15.4
361-369	Nonmetal products	2.9	4	4	10.5	3.7	9.3	3.8	9	4.1	15.1
371-372	Basic metal industries	0.4	0.5	2.3	1.4	1.7	13.4	1.4	-4.7	1.4	4.3
381	Fabricated products	0.4	0.7	2.7	3.5	2	6.4	1.8	5.3	1.9	13.8
382	Machinery	0.6	1.3	2.8	7.6	2.9	10.2	4.2	12.5	3.7	14.7
383	Electrical machinery	0.6	0.8	1.8	8.9	2.4	18.7	3	9	3.3	18.4
384	Transport equipment	5.4	5.9	7.2	19.7	7.9	16.3	6.5	-1.3	5.7	26.8
385-390	Miscellaneous	0.9	1.1	2.3	25	2.9	15.1	4.6	11.3	6.6	22.3
	Average				10.1		10.9		5.4		12.4

Source: National Economic and Social Development Board (New Series).

Notes: Growth rates are computed by following formula:

Growth Rate = 1/t@ln(Yn/Yo)*100

[a] Thailand Standard Industrial Classification

founded in 1969, is of current interest because through its recent and future expansion, it will absorb a large number of factories into its administrative jurisdiction. Although one of the objectives in establishing the IEAT was to effectively control industrial pollution, as yet, there has been no apparent enforcement system or administering organization put in place.

At the end of 1969 there were approximately 600 factories in the whole kingdom, and as shown in Table 2.2, the dominant industries were nonhazardous organic waste producers such as the food-processing, wood and cork, and rubber industries. Although the fabricated products and transport equipment industries, which are considered potential hazardous waste generators, accounted for approximately 30 percent of total factories, their share in the GDP was only about 0.4 percent to 1.3 percent (see Table 2.1). The chemical industry—which is the most hazardous industrial sector—occupied an average position with respect to both the amount of factories, and the GDP shared. The quantity of chemical factories was quite low compared to later decades. Although environmental data from the 1960s is not available, it can be interpolated that the impact of industrial pollution was not severe at that time due to the low quantity of pollution loads and high assimilative capacity (or the naturally self-purifying capacity) of the environment.

In 1969 the Factory Act, in which regulations for industrial pollution control were first engendered, was decreed. The Ministry of Industry (MOI) has subsequently used this act for enacting a number of notifications for regulating industrial pollution.

In the 1970s government policy was redirected toward export promotion. The export-oriented industries that experienced high growth were mainly natural resource based and included some labor-intensive industries such as food processing (including sugar and tapioca products), textile and textile products, and electronics. However, trade policy in the 1970s did not totally abandon protection of some import-substitution industries. As a result, the industries which grew at an above-average rate under protection were transport equipment, paper and paper products, chemical products, rubber and rubber products, and machinery (see Table 2.1).

By the end of 1979 the total number of factories registered under the Department of Industrial Works (DIW) was about 20,000;—the number has increased 30 times since

Table 2.2 Major Industries Registered with the Department of Industrial Works (DIW) (by Decade End)

TSIC [a]	Major Industry Group	End 1969	End 1979	End 1989
311-312	Food	112	4,200	10,099
313	Beverages	3	60	232
314	Tobacco [b]	0	146	108
321	Textiles	30	764	1,793
322	Wearing apparel	4	226	1,989
323-324	Leather products & footwear	5	97	771
331	Wood and cork	59	1,713	3,353
332	Furniture and fixtures	11	405	1,586
341	Paper and paper products	7	162	537
342	Printing,publishing & allied	21	817	1,674
351-352	Chemical products	38	632	1,061
353-354	Petroleam products	2	21	32
355-356	Rubber and rubber products	35	1,089	2,643
361-369	Non-metalic mineral products	20	635	2,798
371-372	Basic metal industries	6	347	530
381	Fabricated products	98	2,859	6,107
382	Machinery	69	2,422	6,141
383	Electrical machinery	9	409	1,121
384	Transport equipment	30	1,028	6,553
385-390	Miscellaneous nec.	72	1,659	2,370
	Total	631	19,691	51,500

Note: These figures are an analysis of the Department of Industrial Works.

[a] Thailand Standard Industrial Classification.

[b] Tobacco factories at that time registered under the Department of Exise, Ministry of Finance.

the end of 1969. Of this group, the food-processing industry had the highest number of factories, 4,200, a number which had increased approximately 40 times since the end of 1969. The "runner-up" industries were the fabricated products and machinery industries, which were comprised of 5,000 factories, but generated only 5 percent of the GDP of the industrial sector. This phenomenon reflects the fact that most of the fabricated products and machinery factories were small- and medium-scale industries such as electroplating, furniture (not wood) and fixtures, and agricultural machinery. This same phenomenon for these two sectors—many factories producing a small amount of the GDP—was found in the 1980s and in the 1960s as well.

Currently, the small- and medium-scale industries are of concern. Their wastes are usually discharged without treatment, and because they are haphazardly located following the market location, economies of scale make waste treatment plants an unrealistic solution. Both concerns complicate the waste management scheme.

The environmental repercussions of the industrial activities during 1972 to 1973 were highly visible; effluent discharged from large-scale sugar mills located along the Mae Klong River transformed it from one of Thailand's clearest rivers into a highly polluted one. The wastewater from sugar mills contained a high concentration of biochemical oxygen demand (BOD), which depletes oxygen content in a water body. Following the Mae Klong environmental problem, Thailand's first Central Treatment Facility (CTF) was established at a cost of 21 million baht to treat wastewater from the sugar factories prior to their release to the river. The government initially paid for the design and construction of the CTF by using the sugar price stabilization fund and collected the money from the sugar companies in the following years (Watson Hawksley 1987). This cooperative CTF demonstrates how private sector resources can be effectively mobilized to meet pollution control requirements.

Other milestones in the early 1970s included the establishment of the Office of the National Environment Board (ONEB) in 1975 followed by the establishment of the DIW's Industrial Environment Division and Factory Inspection Division in 1975 and 1977, respectively. The ONEB has gone on to perform a significant role in planning, standards setting, and ambient environmental quality control, while the DIW was established to control all activities concerning industrial environmental services, and to control and enforce the Factory Act throughout the country.

In the 1980s the food-processing, beverages, tobacco, wood and wood products, and basic metal industries as a group continued to decline in terms of their share in total production (see Table 2.1). In the first half of the decade—a period of worldwide economic recession—the production of machinery and leather and footwear grew the most rapidly. In the last half of the 1980s—a period of economic recovery and prosperity—export-oriented industries such as electronics goods, jewelry, leather and leather products, plastic products, rubber products, and toys lead the way in terms of growth. Additional high-growth industries (mainly due to domestic demand) were transport equipment, paper and paper products, and chemical products. The most conspicuous event of the late 1980s was the discovery of natural gas in the Gulf of Thailand followed by the launching of heavy industrial development in the Eastern Seaboard Area.

The total number of factories in existence at the end of 1989 was about 50,000: three times higher than the number at the end of 1979. When the same comparison was made for all industrial sectors as shown in Table 2.2, the rate of establishing new factories in the 1980s was found to be coincident with the economic growth rate. During the 1980s the number of export-oriented industries increased by three to nine times, while an increase of two to six times was found in the chemical products, paper and paper products, and transport equipment industries. The food industry had the largest amount of factories (10,087), followed by the combination of fabricated products and machinery, with about 6,000 factories each.

While industrialization is believed to benefit the quality of life, records show that it can also consistently degrade the quality of the environment. Every year, the lower section of the Chao Phraya River receives approximately 20,000 tons of BOD released by industry (Phantumvanit et al. 1989), and the Gulf of Thailand receives about 14,000 tons of heavy metals sludge (including cadmium, lead, manganese, magnesium, and chromium) from 22 rivers (Mahabhol et al. 1989). Heavy metals can be a relevant indicator of industrial pollution because they are generally produced by two sources: industry and mining. Siwabaworn et al.(1990) reported the existence of lead, cadmium, and mercury in nine types of seafood. Although the findings showed permissible levels of contamination, the problem is understated. Once consumed these heavy metals can accumulate in human organs and tissues thereby causing chronic health problems.

Throughout the 1980s public awareness on environmental issues played a vital role in the nation's development. In 1986, a few years after the Bhopal disaster being headline news, a riot in the resort town of Phuket resulted in the burning of a brand new tantalum production plant: a lesson on how the public relations/environmental factors should be properly managed in large-scale project development (Arbhabhirama et al. 1988). Two years after the tantalum riot, toxic fumes of dimethoate (an insecticide) fumigated about 1,000 families of slum dwellers residing near the Bangkok Port and caused about 400 cases of acute morbidity (Food and Drug Organization 1989). This accident demonstrated the need for having risk-reducing plans involving the storage, transport, and disposal of the innumerable industrial chemicals currently in use. The government responded to these incidents by commissioning a number of studies regarding industrial waste management and by having the DIW construct the Bangkhuntien Industrial Hazardous Waste Treatment Center.

However, a number of conflicts between industrial development and environmental protection still require proper action so that any potential disasters can be avoided: for example, the siting of the tannery industry and the operation of rock-grinding plants.

INDUSTRIAL STRUCTURE IN AN ENVIRONMENTAL CONTEXT

The transformation of the industrial structure, from an environmental standpoint, is shown in Table 2.3, which presents the number of polluting factories with respect to the grouping system elaborated in Appendix 2.1. As Table 2.3 shows, the number of waste-producing firms increased from 211 in 1969 to 7,030 in 1979. By the end of 1980s the number had grown significantly to 26,235 factories and had doubled from 1979 statistics. The number of air- and water-polluting industries has risen dramatically and in proportion to the total number of factories. The water-polluting industries represented the largest held a major proportion of polluting factories throughout the three-decade period; the number was generally two to three times higher than that of the air-polluting industries.

The production of the polluting industries generated more than half of the total manufacturing GDP in the 1970s and 1980s as illustrated in Table 2.4. As expected, the GDP share of the water-polluting industries is higher than that of the air-polluting industries. An increase in polluting industries' GDP was found to correspond to the increase of factories.

Table 2.3 Number of Air- and Water-Polluting Industries (by Decade End)

Industry	End of 1969	End of 1979	End of 1989
Water-polluting industries	159	5,393	20,221
Air-polluting industries	68	2,241	8,120
Overlapping (Air + water industries)	16	604	2,106
Sum of Polluting Industries	211	7,030	26,235
	(33%)	(36%)	(51%)

Note: These figures derived from the Department of Industrial Works' database. Factories registered under the Industrial Estate Authority of Thailand and Provincial Industry Offices are not included.

Table 2.4 GDP Share of Air- and Water-Polluting Industries (by Decade End)

(1972 Prices: Million Baht)

Industry	End of 1979	End of 1989
Air-polluting industry	65,177	125,108
Water-polluting industry	180,648	362,242
Sum of polluting-industries	245,825	487,350
Total GDP of Industry	429,643	918,607

The grouping procedure was repeated following the hazardous waste ranking system presented in Appendix 2.1. Table 2.5 illustrates the fact that the ranking structure of the hazardous waste industries has not changed during three decades of industrial development. Rank 0, the highest number, is followed by Rank 2, Rank 1, and Rank 3, respectively. Rank 2 holds the highest number of potential hazardous-waste-generating industries (for example, spinning and dying textiles, fabricated metal products, manufacture and repair of engines and turbines, motor vehicle manufacture, electrical goods, etc.). By the end of 1989 approximately 17,000 firms accounted for about 33 percent of all factories when combined with the Rank 3 industries (for example, chemicals, fertilizer and pesticide manufacture, synthetic resins, plastics and fibers, drug and medicine manufacture, petroleum refineries, etc.).

Table 2.5 Number of Hazardous-Waste-Generating Industries (by Decade End)

	End of 1969	%	End of 1979	%	End of 1989	%
Rank 3	42	6.6	625	3.2	936	1.8
Rank 2	206	32.7	6,558	33.3	16,120	31.3
Rank 1	147	23.3	4,949	25.1	15,571	30.2
Rank 0	236	37.4	7,558	38.4	18,873	36.7
Total	631	100	19,691	100	51,500	100

The GDP share for all hazardous-waste-ranked industries varied between the 1970s and the 1980s. In the 1970s, Rank 0 (for example, saw mills, grain mill products, sugar, tobacco, distilleries, etc.) held the highest share (71%) followed by 11 percent of Rank 3 (see Table 2.6). In the 1980s, Rank 0 and Rank 2 shared almost the same percentage of the GDP, about 40 percent, while Rank 3 and Rank 1 shared an almost equal percentage of 9 percent. It can be concluded that, with respect to the GDP shared, the industrial structure has been significantly altered from an industry concentration in Rank 0 to a concentration in Rank 2. This finding corresponds to the recent BOI-promoted industries discussed in Chapter 5. The GDP share analysis below provides a basic framework for understanding who gained from industrial "development the expense of the environment∀—and who should pay for controlling industrial pollution and cleaning up the environment.

Table 2.6 GDP Share of Potential Hazardous Waste Generators (by Decade End)

(1972 price: Million baht)

Rank	End of 1979	End of 1989
Rank 3	45,396	81,764
	11%	9%
Rank 2	43,232	376,108
	10%	41%
Rank 1	34,770	78,215
	8%	8%
Rank 0	306,245	382,521
	71%	42%
Total	429,643	918,607

INDUSTRIAL POLLUTION: CURRENT TRENDS AND FUTURE PROJECTIONS

Air Quality

Air is an environmental and an economic resource that is essential to a number of important economic processes including forestry, agricultural and industrial production, and energy generation. Within Thailand's industrial sector, a variety of industries involved in extraction and processing undertake diverse industrial activities in which energy plays a fundamental role. However, the major environmental consequences of energy use in the industrial sector are the air pollution problems arising from oil and coal combustion.

Industrial Energy Demand and Air Pollution

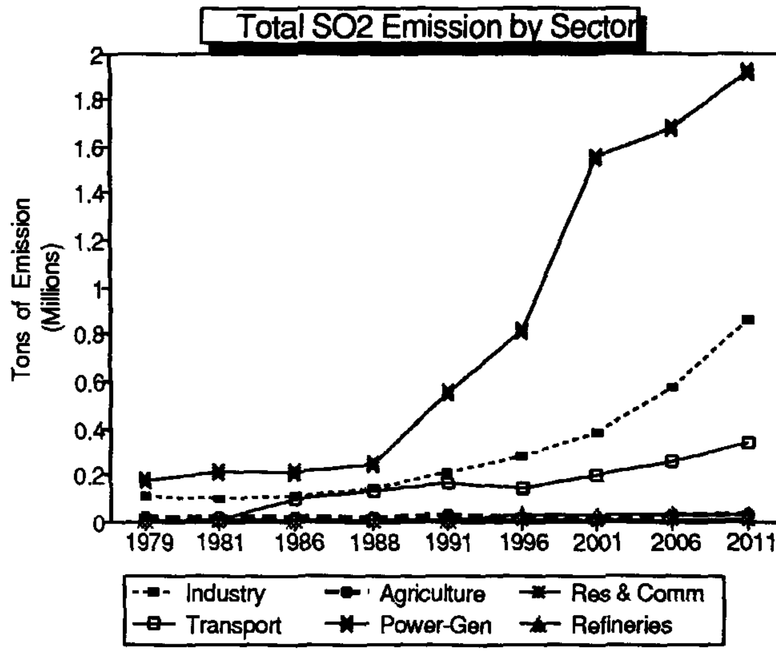
The industrial sector is an important user of energy and a major contributor to air pollution in Thailand. Industry accounted for 27 percent to 30 percent of total energy consumption from 1977 to 1988. The industrial's sector energy demand from 1990 to 2011 is projected to remain between 27.7 percent to 30.4 percent of the share of total energy consumption, and the demand by fuel type for this sector consists of lignite, imported coal, natural gas, fuel oil, electricity, and "renewable energy".

Fuel oil and renewable energy were the major energy sources used in the industrial sector until 1986. Although lignite and imported coal currently have a small share of total energy use when compared with fuel oil, the annual growth of consumption is considerably higher. From 1986 to 1988 lignite and imported coal usage increased by

75 percent, whereas fuel oil usage increased by only 20 percent. The growth rate of imported coal and lignite consumption in the industrial sector will definitely have significant implications for the air pollution situation over the next 10 years to 20 years. A recent study (King Mongkut Institute of Technology 1989) indicated that there are 3,366 industries using industrial boilers in Thailand, and of a total of 4,057 boilers, approximately 65 percent are located in the Bangkok Metropolitan Region (BMR) and in the Central Region. Nearly 90 percent of these boilers are used in the food and beverage, textile, wood products, and paper and chemical manufacturing industries. Most factories, except for those using coal, use heavy fuel oil, bagasse, or wood. By 1991, the cement industry will be the second-largest user of domestic lignite as part of their energy input (ranked next to industrial boilers).

Industrial Gaseous Emissions

Traditional gaseous pollution, which is a product of the combustion of fossil fuels and renewable energy, consists of sulfur dioxide, nitrogen oxide, suspended particulate matter, hydrocarbons (or volatile organic compounds), carbon dioxide, and carbon monoxide. There are four types of gaseous emissions from industry that are significant in terms of emission volume and that should be given priority consideration: sulfur dioxide, nitrogen oxide, carbon dioxide, and suspended particulate matter. Figures 2.2 through 2.5 present past statistics and future projections of gaseous emissions from the industrial sector compared with other sectors for sulfur dioxide, nitrogen oxide, carbon dioxide, and suspended particulate matter. The quantity of emissions of sulfur dioxide in the past—and in the foreseeable future—is dominated by the output of the power-generation sector's 245,340 tons, followed by the output of the industrial sector's 145,468 tons in 1988. Nitrogen oxide is mainly contributed by the transportation sector's 26,733 tons (60%), while the industrial sector, on the average, contributes only a small share of 43,236 tons (10%), The balance is contributed by electricity generation, refineries, and residential and commercial sources. Carbon dioxide accounted for 18.1 million tons or 21 percent of gaseous emissions in 1988 and will decrease to 6.9 million tons or 17 percent by 2011. The trend for suspended particulate matter emissions has increased from 200,000 tons or 25 percent in 1988 and is projected to reach 1.07 million tons or 45 percent by 2011.

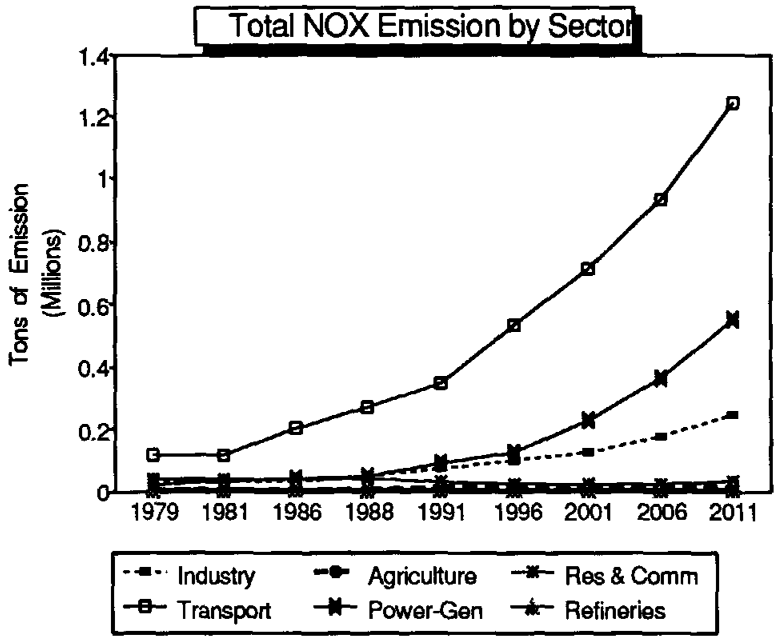


(Unit : Tons/Year)

Sector	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	111,390	99,901	106,644	145,468	208,548	279,736	385,038	570,149	854,430
Agriculture	19,143	18,379	16,514	15,455	31,509	18,278	21,126	24,461	28,354
Res. & comm.	6,652	7,007	7,256	7,250	5,435	5,213	5,553	6,087	7,315
Transportation	10,023	14,475	96,073	127,512	163,834	146,774	195,625	256,545	342,393
Power generation	177,763	212,205	206,816	245,340	547,877	815,637	1,557,034	1,681,241	1,922,519
Refineries	11,042	9,894	10,502	11,134	13,791	31,483	31,483	31,483	31,483
Total	336,013	361,861	443,805	552,159	970,994	1,297,121	2,195,858	2,569,966	3,186,493

WHOLE REGION
BASE CASE

Figure 2.2 Total Sulfur Dioxide (SO_2) Emission (by Sector and Year)

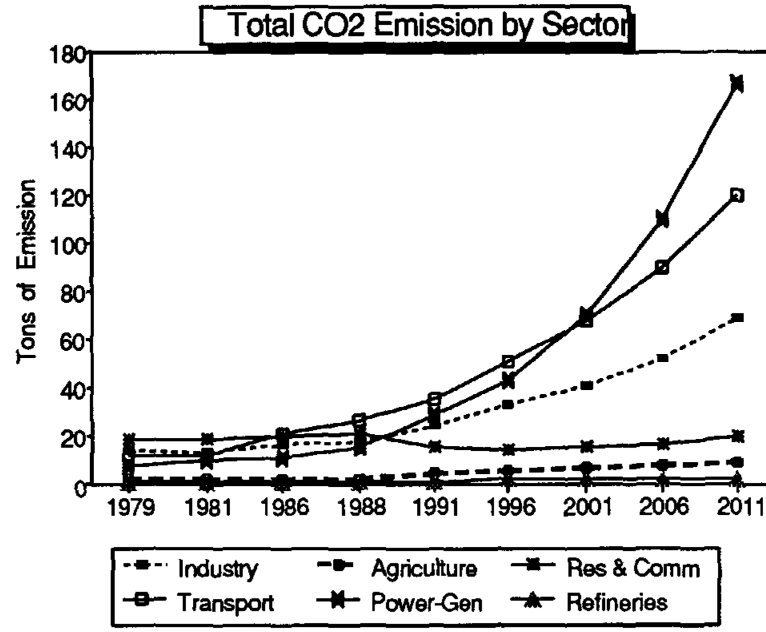


(Unit : Tons/Year)

Sector	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26,359	25,463	33,373	43,236	70,429	98,372	126,329	173,168	241,870
Agriculture	5,153	5,028	4,624	4,358	8,885	10,182	11,769	13,627	15,796
Res. & comm.	36,470	36,250	37,428	37,545	26,375	23,171	22,796	22,876	25,522
Transportation	115,726	118,135	199,365	267,333	344,328	532,186	709,316	930,206	1,241,483
Power generation	23,689	29,704	34,543	47,348	86,818	129,396	227,354	362,387	547,937
Refineries	1,640	1,470	1,560	1,654	2,048	4,676	4,676	4,676	4,676
Total	209,037	216,050	310,893	401,475	538,884	797,983	1,102,240	1,506,939	2,077,283

WHOLE REGION
BASE CASE

Figure 2.3 Total Nitrogen Oxide (NO_x) Emission (by Sector and Year)

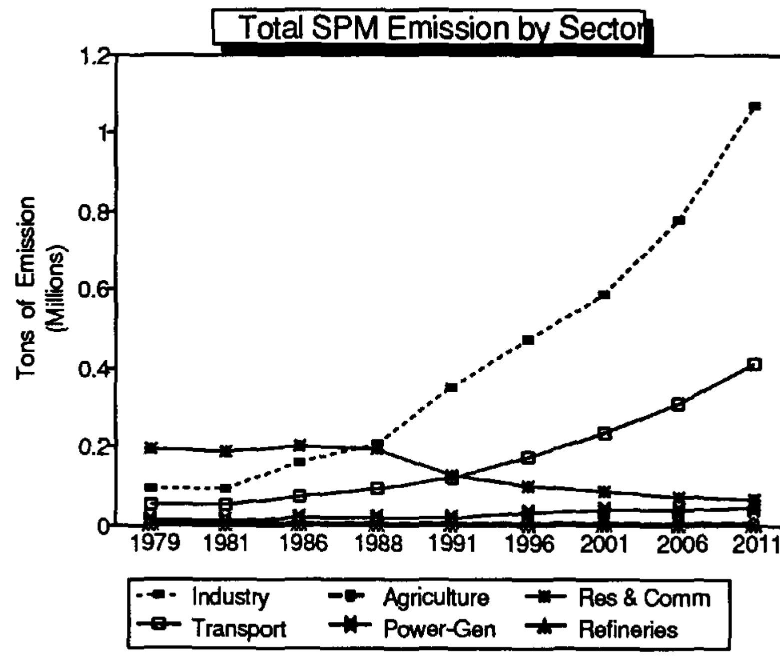


(Unit : Million Tons/Year)

Sector	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	14.262	13.458	16.365	18.187	25.282	33.897	41.049	52.488	69.607
Agriculture	3.096	2.983	2.608	2.465	5.026	5.759	6.657	7.707	8.934
Res. & comm.	19.200	19.183	20.416	20.886	15.496	14.803	15.660	16.993	20.195
Transportation	12.521	12.705	20.880	27.453	35.224	51.372	68.471	89.793	119.841
Power generation	7.925	9.923	11.481	16.252	28.780	43.293	70.014	109.874	166.929
Refineries	1.085	0.973	1.032	1.094	1.356	3.095	3.095	3.095	3.095
Total	58.090	59.225	72.783	86.338	111.163	152.219	204.945	279.950	388.601

WHOLE REGION
BASE CASE

Figure 2.4 Total Carbon Dioxide (CO_2) Emission (by Sector and Year)



(Unit : Tons/Year)

Sector	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	90,550	90,624	158,780	207,020	351,451	473,907	588,183	778,771	1,071,318
Agriculture	1,526	1,577	1,748	1,639	3,341	3,828	4,425	5,124	5,939
Res. & comm.	190,767	189,717	198,455	195,544	128,067	99,076	85,081	70,948	65,184
Transportation	52,081	49,029	69,493	92,000	120,174	175,284	233,624	306,378	408,902
Power generation	9,952	11,578	19,961	17,640	16,757	28,842	39,729	34,631	43,292
Refineries	594	532	565	599	742	1,694	1,694	1,694	1,694
Total	432,316	458,478	699,718	842,319	620,532	782,630	952,736	1,197,546	1,596,328

WHOLE REGION
BASE CASE

Figure 2.5 Total Suspended Particulate Matter (SPM) Emission (by Sector and Year)

Within the manufacturing sector, gaseous emissions vary in terms of manufacturing output and by the type of fuel used. Figure 2.6 through Figure 2.9 show the trend in gaseous emissions from the manufacturing sector. From 1986 to 1996 sulfur dioxide emission was contributed mostly by the nonmetal, food, textile, and paper industries. From 2001 to 2011 the structure of emission from manufacturing will change somewhat with textiles overtaking food in terms of sulfur dioxide emission. Similarly, with carbon dioxide and suspended particulate matter, the food and nonmetal manufacturing industries are the major contributors of gaseous emissions. The growth rate of gaseous emissions from the manufacturing sector from 1986 to 1988 was very high for sulfur dioxide, nitrogen oxide, and suspended particulate matter, averaging 17 percent per year, and was moderate for carbon dioxide, averaging 6 percent per year. Industrial processes can also emit particulates and other pollutants such as hydrogen sulfide, organic solvents, and heavy metals which are usually collectively called toxic air pollutants.

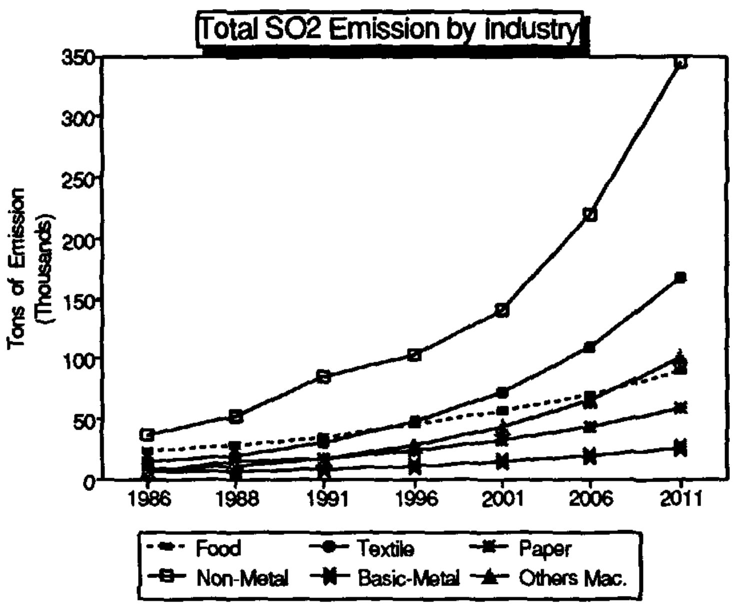
The emission perspective from 1990 to 2011, which is projected using a base case scenario of economic growth and existing environmental regulations on air quality standards, shows a great increase in the gaseous emissions from all manufacturing industries. Although the industrial sector does not dominate the emissions of gaseous pollutants when compared with other sectors such as electricity generation and transportation, it is a major contributor of sulfur dioxide, responsible for 21 percent of sulfur dioxide in 1990 and 29 percent by the year 2011.

Table 2.7 shows the fuel cost and the fuel type use in the industrial sector in comparison with pollutants (SO_2, NO_x, CO_2, and SPM) in tons of emission per one ton of fuel in kilo tons of oil equivalent (KTOE). The cost of fuel is based on kilo tons of oil equivalent, baht per KTOE. Among the eight types of fuel used in the industrial sector, lignite has the lowest cost per KTOE, but emits more gaseous pollution such as sulfur dioxide, nitrogen dioxide, and suspended particulate matter than other fuel type. Considering the energy demand in the industrial sector by energy sources from 1991 to 2011, the growth in lignite consumption will average 10 percent per year. The attractive, low price of lignite is driving industries to convert their boilers to lignite as a main

Table 2.7 Comparison of Gaseous Emission VS Fuel Cost in Manufacturing Sector (Fuel Cost 1988)

Fuel Type	Cost / Unit		Baht Per KTOE (x 1000)	Tons of Emission / Tons of Fuel in KTOE			
				SO2	NOx	CO2	SPM
Coal	1785	B/t	2,859.71	15.26	16.06	3,702.20	89.92
Lignite	550	B/t	1,261.64	68.47	27.95	3,692.30	167.69
LPG	9.9	B/kg	8,483.15	0.01	1.98	2,980.30	0.05
Distill (HSD)	6.2798	B/l	7,285.32	19.73	4.41	2,978.90	0.58
Fuel oil	2.9898	B/l	3,176.55	60.59	7.02	2,979.00	3.21
NG	70	B/MTU	2,834.71	0.00	3.31	2,129.80	0.06
Fuel Wood	0.7	B/kg	1,849.50	1.32	3.18	4,045.60	10.58
Bagasse	0.27	B/kg	1,513.96	1.69	3.37	4,044.60	44.94

Source: Thailand Development Research Institute (TDRI) , (1990).

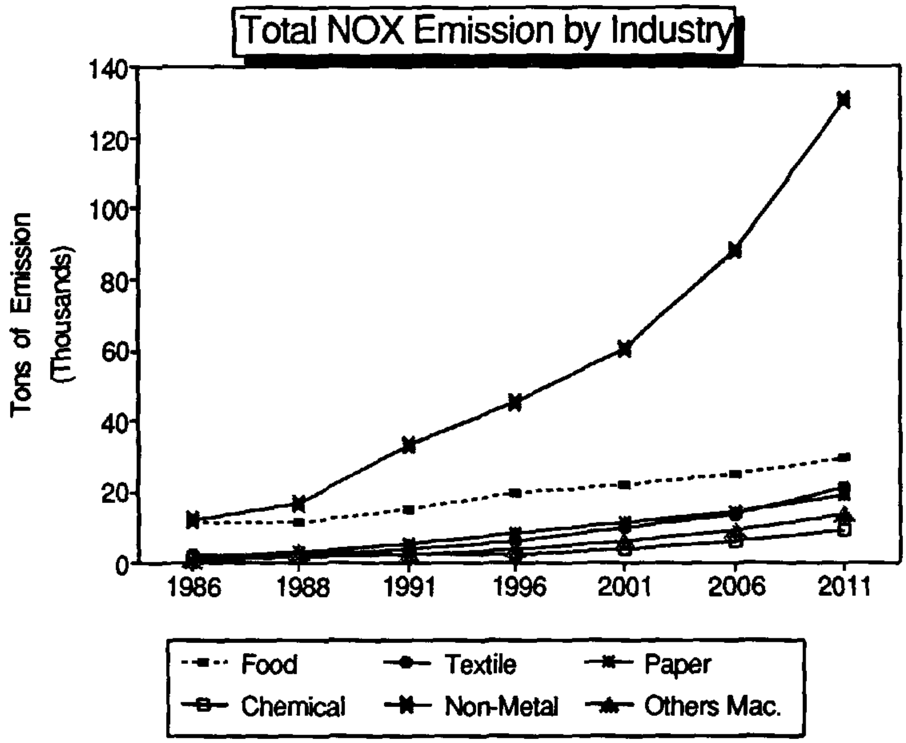


(Unit : Tons/Year)

Industry	1986	1988	1991	1996	2001	2006	2011
Mining	1,797	1,388	2,211	2,176	3,021	4,108	5,663
Manufacturing	101,678	141,469	201,681	272,023	376,768	560,191	844,304
Food	23,614	27,303	34,741	46,431	57,807	71,603	90,841
Textile	15,612	21,149	30,225	48,931	73,648	109,761	167,114
Wood	997	1,899	2,249	3,477	4,970	7,111	10,529
Paper	8,551	11,118	17,123	25,211	33,727	44,394	59,470
Chemical	3,246	7,152	7,049	4,059	7,142	21,525	44,830
Nonmetal	38,098	52,233	85,024	103,249	139,631	219,738	345,646
Basic metal	5,547	5,622	8,640	12,018	15,552	19,801	25,658
Others Mac.	6,014	14,992	16,630	28,647	44,292	66,257	100,216
Construction	3,169	2,611	4,656	5,538	5,249	5,850	4,463
Total industry	106,644	145,468	208,548	279,736	385,038	570,149	854,430

WHOLE REGION
BASE CASE:

Figure 2.6 Total Sulfur Dioxide (SO_2) Emission (by Industry and Year)

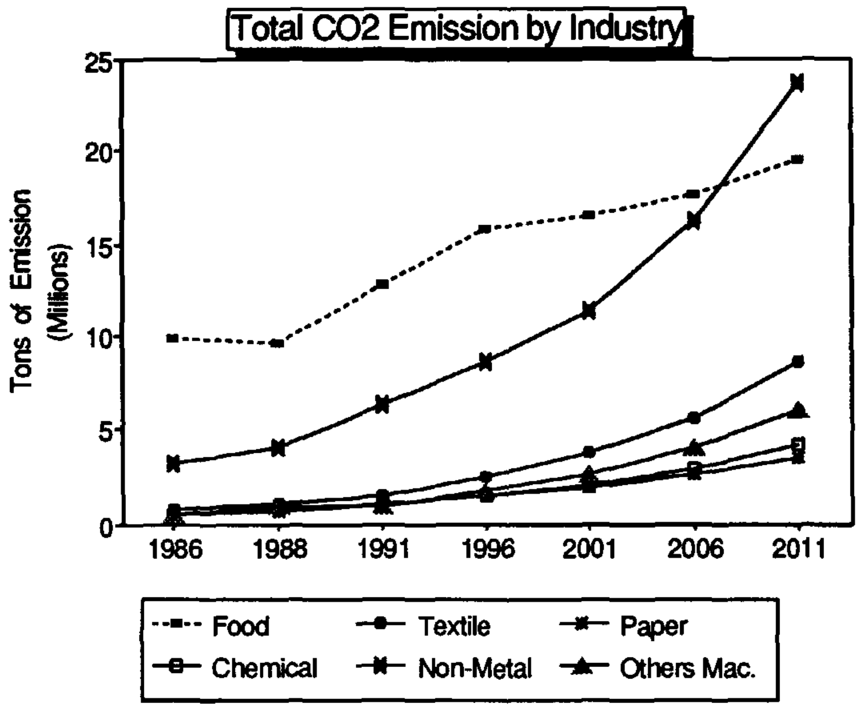


(Unit : Tons/Year)

Industry	1986	1988	1991	1996	2001	2006	2011
Mining	1,246	1,320	2,102	2,647	3,675	4,997	6,889
Manufacturing	28,618	39,173	63,435	88,022	115,353	160,033	228,773
Food	10,725	11,576	15,045	19,295	21,653	24,768	29,247
Textile	1,902	2,605	3,818	6,201	9,333	13,909	21,177
Wood	188	321	355	535	737	1,014	1,441
Paper	1,541	3,034	5,446	8,067	10,793	14,206	19,031
Chemical	900	1,617	1,886	2,511	3,629	5,814	9,261
Nonmetal	11,595	16,327	33,216	45,467	60,550	87,978	130,702
Basic metal	855	947	1,495	2,117	2,740	3,488	4,520
Others Mac.	912	2,745	2,173	3,829	5,920	8,855	13,394
Construction	3,510	2,743	4,893	7,702	7,301	8,137	6,208
Total industry	33,373	43,236	70,429	98,372	126,329	173,168	241,870

WHOLE REGION
BASE CASE:

Figure 2.7 Total Nitrogen Oxide (NO_x) Emission (by Industry and Year)

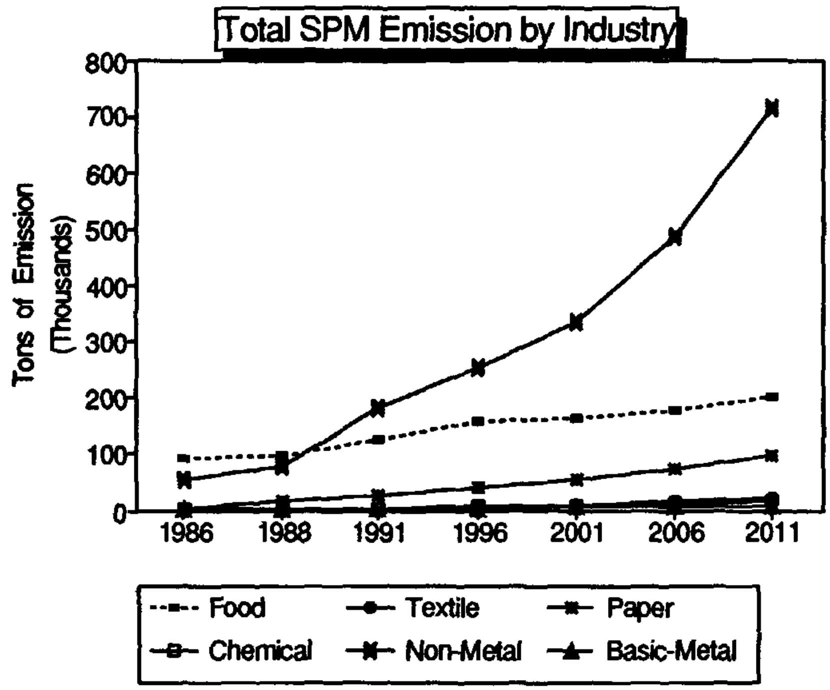


(Unit : Tons/Year)

Industry	1986	1988	1991	1996	2001	2006	2011
Mining	157,819	145,895	232,272	292,492	406,073	552,243	761,283
Manufacturing	15,840,775	17,749,697	24,529,024	32,785,346	39,866,703	51,070,498	68,185,295
Food	9,859,899	9,673,892	12,722,275	15,694,728	16,430,080	17,657,300	19,545,639
Textile	809,419	1,085,619	1,552,931	2,522,283	3,796,377	5,657,937	8,614,307
Wood	142,628	224,825	233,322	338,634	446,808	585,837	787,681
Paper	439,226	640,459	997,005	1,476,909	1,975,803	2,600,739	3,483,947
Chemical	573,698	785,465	1,094,753	1,534,417	2,093,229	2,969,251	4,270,930
Nonmetal	3,211,445	4,059,085	6,349,374	8,638,987	11,345,982	16,186,853	23,593,025
Basic metal	342,949	376,315	587,227	831,596	1,076,126	1,370,179	1,775,469
Others Mac.	461,511	904,036	992,136	1,747,791	2,702,298	4,042,402	6,114,297
Construction	366,211	291,782	520,442	819,273	776,542	865,533	660,328
Total industry	16,364,805	18,187,374	25,281,737	33,897,111	41,049,319	52,488,274	69,606,906

WHOLE REGION
BASE CASE:

Figure 2.8 Total Carbon Dioxide (CO_2) Emission (by Industry and Year)



(Unit : Tons/Year)

Industry	1986	1988	1991	1996	2001	2006	2011
Mining	310	313	498	628	871	1,185	1,634
Manufacturing	157,653	206,065	349,807	471,475	585,601	775,680	1,068,230
Food	93,573	96,936	127,353	157,627	166,040	179,500	199,990
Textile	1,316	2,101	3,780	6,140	9,242	13,774	20,971
Wood	283	436	430	603	763	950	1,196
Paper	4,877	14,245	28,294	41,914	56,072	73,807	98,872
Chemical	2,463	4,408	3,691	5,238	7,298	10,622	15,698
Nonmetal	52,732	78,049	181,402	252,488	335,769	482,730	711,473
Basic metal	1,447	1,895	3,153	4,465	5,778	7,357	9,533
Others Mac.	961	7,994	1,703	3,000	4,639	6,940	10,496
Construction	817	643	1,146	1,804	1,710	1,906	1,454
Total industry	158,780	207,020	351,451	473,907	588,183	778,771	1,071,318

WHOLE REGION
BASE CASE:

Figure 2.9 Total Suspended Particulate Matter (SPM) Emission (by Industry and Year)

energy source. The consequence of this conversion will be a significant rise in the emission of pollutants into the atmosphere without any emission control under the present regulation of air emissions standards. Lignite fuel pricing should be one of the alternative measures to control the emission of air pollutants in urban areas in addition to air emission standards and control technology standards.

Water Quality

Approximately 20,000 of the factories registered with the DIW are classified as water-polluting factories. Of this group, 1.4 percent generate highly hazardous wastewater (Rank 3), 52 percent generate medium-level hazardous wastewater (Rank 2), and the remaining 46.6 percent contribute minimally hazardous wastewater (Rank 1) and nonhazardous wastewater (Rank 0) (see Table 2.8). Hazardous wastewater is generated by several industries including the electroplating, dyeing, metal-smelting, chemical, and electronic industries. This section focuses on biodegradable wastewater, or wastewater containing BOD. Other hazardous waste byproducts (wastewater and sludge) are discussed later in this chapter.

Table 2.8 Number of Industries and Environmental Perspectives, Year-End 1989

Rank	(1) Water Pollution	(2) Air Pollution	(3) Over-lapping	(4) Others	(5) Total
Rank 0	5,153	3,564	506	10,662	18,873
Rank 1	4,360	779	-	10,432	15,571
Rank 2	10,417	3,388	1,340	3,655	16,120
Rank 3	291	389	260	516	936
Total	20,221	8,120	2,106	25,265	51,500

Source: Analysis of the Department of Industrial Works Data

Notes: (1) and (2) are classified in accordance with the Department of Industrial Works' Ordinance No. 147/1989; (3) is the number of overlapping industries between (1) & (2);
(4) is industries which are not classified as (1) or (2); and
(5) = [(1)+(2)]-(3)+(4)

The food and beverage industries are the two major BOD-generating industries; of the 516,381 tons of BOD generated in 1986, approximately 492,254 tons came from these two industries followed by the pulp and paper, textile, and chemical industries, which represent a much smaller output (see Table 2.9). According to the Factory Act of 1969, all factories must install suitable wastewater treatment facilities in order to obtain their annual operating permits from the DIW. In current practice, residual BOD is generally treated and discharged to natural water bodies, but in the past, releasing BOD-containing wastewater in excessive amounts has caused a serious reduction of dissolved oxygen (DO) in many water bodies. The severe aesthetic problems in the Mae Klong River from 1972 to 1973 were caused by wastewater released from sugar mills, and in 1988, one coastal area experienced severe water quality degradation as a result of the discharge of wastewater containing high levels of BOD from pineapple factories.

It can be seen from Table 2.10 that the Chao Phraya River—a major river which runs through the BMR—has experienced almost anaerobic water quality conditions (DO = 0 mg/l) particularly in the lower section, while the DO in the middle section has been lower than the set standard of the National Environment Board (NEB). Also, the total coliform count—the indicator for pathogenic bacteria—was higher than the set standards for all sections of the river. An analysis of water samples taken from twelve *khlongs* (canals) networking with the Chao Phraya River showed the existence of *Vibrio leptospira* (causing acute diarrhoea), *Candida albicans* (causing skin disease), and *Hepatitis virus A* (causing hepatitis).

The degraded water quality has also impacted aquatic life in the river. Some species of fish such as *Synaptura orientalis, Kryptopterus*, and *Cynoglossus sp.*, which had been found in the Chao Phraya River in 1981, disappeared from the lower section of the river in 1990 (Boonsom 1990).

The DO and coliform level problems were similar for the Thachin River, and although the DO in the Mae Klong and the Bang Pakong rivers was well within compliance standards, the total coliform count of the Mae Klong River exceeded the set standards of the NEB.

Water quality degradation in these rivers is not caused solely by BOD-containing wastewater from industry; wastewater from domestic and agriculture sources is an even more important cause of pollution in many rivers. The BOD load from domestic wastewater has accounted for 93 percent of the total load to the Mae Klong River (1990) and has accounted for 75 percent of the total BOD load in the case of the Chao Phraya

Table 2.9 Biochemical Oxygen Demand (BOD) Load from Industry, 1986

TSIC [a]	Industry	BOD (Tons)
311-312	Food	288,786
313	Beverages	203,468
314	Tobacco	0
321	Textiles	8,408
322	Wearing apparel	3
323-324	Leather products & footwear	0
331	Wood and cork	1,409
341	Paper and paper products	11,463
342	Printing, publishing & allied	0
351-352	Chemical products	2,138
353-354	Petroleam products	0
355-356	Rubber and rubber products	548
361-369	Nonmetalic mineral products	11
371-372	Basic metal industries	0
381	Fabricated products	0
382	Machinery	0
383	Electrical machinery	0
384	Transport equipment	38
385-390	Miscellaneous nec.	109
Total		516,381

Source: Department of Industrial Works (DIW).
Note: [a] Thailand Standard Industrial Code.

Table 2.10 Water Quality of the Major Rivers, 1987-1989

River	Standard			1987			1988			1989		
	DO (mg/l)	BOD (mg/l)	Total Coliform (MPN/100ml)	DO (mg/l)	BOD (mg/l)	Total Coliform (MPN/100ml)	DO (mg/L)	BOD (mg/L)	Total Coliform (MPN/100mL)	DO (mg/L)	BOD (mg/L)	Total Coliform (MPN/100mL)
Chao Phraya												
Upper	6	1.5	5,000	5.7	1.6	8,000	5.2	1.7	8,200	5.8	1.0	18,666
Middle	4	2	20,000	3.0	1.8	29,000	3.4	1.8	13,000	2.4	2.4	35,000
Lower	2	4	NA	0.3	4.0	71,000	0.8	3.8	242,000	0.2	2.8	705,000
Thachin												
Upper	6	1.5	5,000	5.1	2.7	91,666	5.0	2.0	24,000	5.0	2.9	24,000
Middle	4	2	20,000	1.0	2.4	93,500	1.6	2.8	160,500	1.6	2.6	240,000
Lower	2	4	NA	0.6	4.0	92,400	0.5	3.6	164,000	0.8	2.7	161,000
Mae klong	4	2	20,000	5.0	2.2	53,300	5.1	1.8	23,100	5.3	2.0	25,800
Bang Pakong	4	2	20,000	3.7	1.3	9,680	3.6	1.7	9,314	4.1	1.2	9,800

Source: National Environment Board (1990).

River (1988). Agriculture (for example, shrimp farming and pig raising) and municipal wastewater contributed a comparatively significant proportion of BOD load to the Thachin and the Bang Pakong rivers (1990). However, because one factory may discharge large quantities of wastewater containing several times the BOD content of domestic wastewater, the highly concentrated wastewater will immediately affect downstream water quality. This implies that because industry is a high-profile BOD polluter,t public attention will be focused on industry, although the public itself contributes a larger overall amount of the BOD load. Because the industrial sector produces the highest value added, it is in the financial position to invest in, and to strengthen, its wastewater treatment facilities—not only for society's quality of life, but also for its own image.

Focus: Industrial BOD Polluters

Nine agro-based industries were selected as target industries for a BOD-related study because they produce a large proportion of BOD wastewater. Due to inaccessibility of data, other BOD-producing industries such as noodle factories, palm mills, fruit-processing industries, monosodium glitamate industries, soy sauce factories, and textile industries were excluded; thus, the projection of industrial BOD is underestimated. The BOD polluters include the following:

1. Sugar factories
2. Pulp and paper industry
3. Tapioca mills
4. Beverage industry (including breweries, and distilleries and soft drinks)
5. Rubber factories
6. Tannery industry
7. Slaughter houses
8. Canned fish and crustacean industries
9. Canned pineapple industry

In 1989, these factories, which numbered approximately 1,300, accounted for approximately 2 percent of all the factories in Thailand. They employed about 154,442 workers and represented approximately 11.5 percent of total domestic manufacturing employment in the country. The sugar industry had the highest number of factories (508) followed by the rubber, tannery, and canned fruit and vegetables industries (which had a total of 234, 143, and 131 factories, respectively). When ranking industries by number of workers, the canned fruit and vegetable industries accounted for the highest portion

(33.4%), followed by sugar factories (19.7%), the rubber industry (11.6%), and the pulp and paper industry (11.3%).

It is estimated that 0.5 million tons of BOD load will be generated by these nine industries in 1991 as shown by Table 2.11: sugar factories (29.3%) followed by pulp and paper industries (19.6%), rubber industries (18.4%), and beverage industries (17.4%). The balance is contributed by tapioca mills, slaughter houses, the canned fish and crustacean industries, tannery factories, and the canned pineapple industry, in that order. Projections indicate that the BOD load will rise to 0.78 million tons by the end of the Seventh National Economic Development Plan (1996) and to 1.9 million tons in 2010, with a reduction inthe BOD share from beverage factories, rubber factories, slaughter houses, the canned fish and crustaceans, and the canned pineapple industry, and an increase in BOD share from sugar factories, the pulp and paper industry, the tannery industry, and the tapioca mills. (see Appendix 2.3) Compared with the daily residential loading of 53 grams of BOD/person (Panswad et al. 1987), the industrial BOD loads are equivalent to BOD loads from 27.2 millin people in 1991, 40.5 million people in 1996, and 98.9 million people in 2010.

The Hazardous Waste Problem

As technology has evolved, more chemicals have been discovered that are widely used in various economic sectors: pesticides in agriculture, heavy metals and acidic and alkaline compounds in manufacturing processes, plastics and other petrochemical products in industry and daily life, etc.

Since 1985 Stablex Canada Inc. has conducted studies on the hazardous waste situation and its management in Thailand—particularly in the BMR. The study found that a total of 682 factories, out of 862 possible producers, were identified as definite generators of hazardous wastes. However, this analysis is rather complicated due to the techno-economic conditions and types of activities of each category of industries. Therefore, the estimated annual volumes of hazardous wastewater, sludge, and solids generated in 1983 has been estimated by type of industry as shown in Table 2.12. The annual volume of hazardous waste generated in 1983 by factories is estimated at 64,110 metric tons of solids and slurries and 84,000 cubic meters of inorganic wastewater.

In 1987 a prefeasibility study was completed which assessed the possibility of setting up a combined industrial wastewater treatment and hazardous waste treatment facility in the heavily industrialized province of Samut Prakan (Watson Hawksley 1987).

Table 2.11 Projection of Industrial BOD Loading, 1991-2010

(Tons Unless Indicated Otherwise)

Industry	1989 [a]		1991	1996	2001	2006	2010
	Number	Worker					
Sugar	508	30,443	153,740	232,425	321,089	436,445	565,811
Pulp & paper	234	17,849	102,711	161,991	233,460	331,051	443,955
Rubber	44	10,381	96,526	137,525	177,664	225,155	276,039
Beverages	31	17,376	91,277	130,947	171,303	220,496	273,656
Tapioca	142	14,249	40,245	61,780	86,661	119,610	156,972
Slaughter	57	5,018	15,482	18,211	19,575	20,702	21,957
Canned fish & crustaceans	50	5,902	10,910	15,619	20,432	26,300	32,641
Tannery	143	1,627	10,628	20,863	40,341	78,353	136,258
Canned pineapple [b]	131	51,597	3,716	4,642	5,299	5,952	6,625
Total	1,340	154,442	525,235	784,003	1,075,825	1,464,065	1,913,913
Whole Kingdom	51,500	1,345,622					

Note: [a] Data taken from the Department of Industrial Works database.
[b] Number of factories and workers represents all canned fruit & vegetables industries.

Watson Hawksley found that the volume of industrial hazardous waste being generated in this province alone was about 25,000 metric tons per annum.

A recent study by Engineering Science Inc. (1989) divided hazardous waste generators into ten groups as follows:

1. Agriculture
2. Commercial/service
3. Municipal solid waste
4. Electrical utilities
5. Hospitals and laboratories
6. Manufacturing
7. Marine/harbor
8. Coal and lignite based
9. Petroleum-based
10. Metal smelting

The metal-smelting group contributed about 730,000 tons of hazardous waste in 1986—more than half of total amount of hazardous waste generated—while the manufacturing group was the second largest contributor. The majority of hazardous wastes are currently generated in the BMR (71%), while the Central Region accounts for an additional 12.5 percent.

Appendix 2.2 presents a summary by industry of potentially serious hazardous wastes that were generated in Thailand in 1986 including oils, halogenated organic sludges, still bottoms (or solids), heavy metal sludges (or solids), halogenated solvents, acid waste streams, and alkaline waste streams. It is estimated that a little over one-quarter of a million metric tons of these potentially serious wastes were produced in 1986. While human exposure, through ingestion, to any hazardous waste constitutes a health risk, the types of wastes listed are those that present the highest level of concern.

At present, the management of hazardous waste in Thailand is as follows: some material is recycled; some is treated as a wastewater constituent; part is used as a source of fuel, and burned; part is improperly disposed of with other solid waste materials; and the remainder is released to the environment without any processing.

Table 2.12 Estimated Annual Volume of Thailand's Industrial Hazardous Wastes, 1983

Type of Industry	Number of Factories	Volume (Tons/Yr)	Remarks
Textiles	210	38,300	Sludge
Tanneries	122	3,700	Sludge,High Mositure
Caustic soda	4	9,360	Sludge 30-40% Humidity
Paint	72	2,200	Sludge 30-40% Humidity
Lead smelting	2	1,500	Slag
Steel galvanizing	15	2,000	Sludge,muddy
		900	Sludge
Electroplating	200	84,000	Wastewater
Fluorescent lamp	5	50	Solid
Car batteries	16	50	Solid
Drycell batteries	16	100	Solid
Integrated circuits	5	50	Solid
Car assembly	15	5,900	Sludge, 30-40% Solid
Total	682	64,110	Sludge and Solid
		84,000	Wastewater

Source: Stablex Canada Inc./CIDA Study[1], (1985).

As industry in Thailand continues to grow and evolve, the current industrial mix, and its hazardous waste problems, will undoubtedly involve new control and remedial technologies to deal with the more exotic waste streams. A major objective of the Sixth Plan (1986-1991), which is discussed more fully in Chapter 5, is to promote higher growth rates in the export sector. Industries with high hazardous-waste-generating potential—those targeted for intensive development under the Sixth Plan and the upcoming Seventh Plan—are of particular interest. The very high rate of economic growth (10%) now enjoyed in Thailand, which is due in large part to the increase in the industrial manufacturing sector's GDP, raises concerns about adequate hazardous waste management.

Hazardous-Waste-Generating Projections

Tthe future growth of the hazardous-waste-generating industries will be influenced by various factors depending on sources of demand and government promotion policies. The export-oriented industries are almost totally dependent upon future world market demand for minerals for their products, while the growth of activities aimed at satisfying local consumer demand is linked to population growth and general affluence levels. Those industrial activities targeted for special incentives under the Investment Promotion Act (IPA) can be expected to grow at a faster rate than other sectors.

According to the projections of industrial output, it is clear that the hazardous-waste-producing industries such as steel, textiles, electronics, and chemicals and petrochemicals will be an equally important, or a more serious, threat in terms of environmental impact than the traditional polluting industries (that produce BOD loading). The projections presented in Table 2.13 and Table 2.14 are based on studies done by Engineering Science Inc. (1989) for the estimation of various types of hazardous wastes. Metal sludges and solid and oil wastes account for the bulk of hazardous waste generated by manufacturing, municipalities, electrical utilities, hospitals and laboratories, and the coal- and lignite-based industries. The trend in hazardous waste generation will almost double from 1986 to the 1991 and will increase almost six times by the year 2001.

The detailed projections of industrial hazardous waste quantities based on Engineering Science Inc. (1989) are presented in Tables 2.15, 2.16, and 2.17 for the years 1991, 1996, and 2001. By generator group, manufacturing is expected to account for the bulk of hazardous waste generation (95%) and the basic metal industries are expected to share the largest portion (70%) of hazardous waste generation from 1991 through 2001.

Table 2.13 Summary of Real and Projected Hazardous Waste Quantities (by Waste Type and Year)

Waste Type	Hazardous Waste Quantity (Tons/Yr)			
	1986	1991	1996	2001
Oils	124,194	219,467	387,893	686,358
Liquid organic residues	187	311	522	876
Organic sludge & solids	3,737	6,674	11,951	24,533
Inorganic sludge & solids	11,698	19,254	32,043	54,080
Heavy metal sludge & solids	823,869	1,447,590	2,536,030	4,418,030
Solvents	19,783	36,163	66,532	124,306
Acid wastes	81,054	125,428	196,510	311,714
Alkaline Wastes	21,952	34,235	54,024	86,198
Off-spec products	12	25	52	107
PCB	*	*	*	*
Aqueous organic residues	116	242	499	1,037
Photo wastes	8,820	16,348	30,398	57,809
Municipal wastes	7,231	11,787	19,090	31,093
Infectious wastes	46,674	76,078	123,219	200,699
Total	1,151,729	1,993,602	3,458,763	5,993,840

Source: Engineering Scince Inc. et al.(1989).
Note: * Assumes no PCB materials are imported into Thailand after 1975.

Table 2.14 Summary of Projected Hazardous Waste Quantities (by Generator Group)

	Hazardous Waste (Tons/Yr)					
Hazardous Waste Generator Group	1991	% Generated	1996	% Generated	2001	% Generated
Manufacturing	1,904,459	95.54	3,314,600	95.83	5,759,571	96.09
Municipal solid waste	11,787	0.59	19,091	0.55	31,093	0.52
Electrical utilities	x	0.00	x	0.00	x	0.00
Hospital & laboratories	76,078	3.82	123,219	3.56	200,699	3.35
Coal & lignite based	1,278	0.06	1,854	0.05	2,477	0.04
Total	1,993,602	100.00	3,458,763	100.00	5,993,840	100.0(

Source: Engineering Science,Inc. et al. (1989).

Table 2.15 Projected Hazardous Waste Quantities for 1991

Unit : Tons

TSIC [a]	Industry	Oils	Liquid Organic	Organic Sludge	Inorganic Sludge	Heavy Met. Sludge	Solvent	Acid Waste	Allkaline Waste	Off Spec. Prod.	PCB	Aqueous Organic Residues	Photo Waste	Total
371-372	Basic metal industry	0	0	0	0	1,310,720	0	0	0	0	0	0	0	1,310,720
381	Fabricated products	1,860	0	0	6,991	80,305	831	80,868	20,838	0	0	0	0	191,693
384	Transport equipment	102,663	0	0	2,209	0	5,397	660	0	0	0	0	0	110,929
383	Electrical machinery	1,261	0	0	3,166	35,463	778	36,686	9,500	0	0	0	0	86,854
351-352	Chemical products	27,462	311	4,830	1,540	17,656	3,984	5,822	3,311	25	0	242	0	65,183
382	Machinery	44,340	0	0	281	0	6,364	6	288	0	0	0	0	51,278
321	Textiles	30,702	0	0	0	0	0	0	0	0	0	0	0	30,702
342	Printing, publishing, allied	0	0	1,342	0	0	8,652	0	0	0	0	0	16,348	26,342
356	Rubber-rubber products	7,869	0	0	0	0	6,950	0	0	0	0	0	0	14,819
341	Paper and paper products	2,357	0	75	0	0	2,870	0	0	0	0	0	0	5,301
353-354	Petroleum products	930	0	427	1,224	1,031	327	0	0	0	0	0	0	3,939
385-390	Miscellaneous nec.	23	0	0	92	1,137	10	1,386	298	0	0	0	0	2,946
332	Furniture - fixtures	0	0	0	2,678	0	0	0	0	0	0	0	0	2,678
331	Wood - cork	0	0	0	1,076	0	0	0	0	0	0	0	0	1,076
361-369	Nonmetallic mineral	0	0	0	0	0	0	0	0	0	0	0	0	0
313	Beverage	0	0	0	0	0	0	0	0	0	0	0	0	0
322	Wearing apparel	0	0	0	0	0	0	0	0	0	0	0	0	0
314	Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0
323-324	Leather prod. - footwear	0	0	0	0	0	0	0	0	0	0	0	0	0
311-312	Food	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	219,467	311	6,674	19,254	1,446,312	36,163	125,428	34,235	25	0	242	16,348	1,904,459

Source: Engineering Science,Inc. et al. (1989).
Note. [a] Thailand Standard Industrial Classification.

Table 2.16 Projected Hazardous Waste Quantities for 1996

Unit : Tons

TSIC [a]	Industry	Oils	Liquid Organic	Organic Sludge	Inorganic Sludge	Heavy Met. Sludge	Solvent	Acid Waste	Allkaline Waste	Off Spec. Prod.	PCB	Aqueous Organic Residues	Photo Waste	Total
371-372	Basic metal industry	0	0	0	0	2,298,095	0	0	0	0	0	0	0	2,298,095
381	Fabricated products	2,937	0	0	9,955	126,474	1,167	115,801	29,451	0	0	0	0	285,785
384	Transport equipment	175,362	0	0	3,827	0	9,197	1,152	1,155	0	0	0	0	190,693
383	Electrical machinery	2,234	0	0	5,671	70,923	1,225	66,268	16,633	0	0	0	0	162,954
351-352	Chemical products	55,906	522	8,456	2,270	34,057	6,473	10,397	5,700	52	0	499	0	124,333
382	Machinery	77,005	0	0	504	0	11,112	10	500	0	0	0	0	89,131
321	Textiles	53,784	0	0	0	0	0	0	0	0	0	0	0	53,784
342	Printing, publishing, allied	0	0	2,761	0	0	17,708	0	0	0	0	0	30,398	50,867
356	Rubber-rubber products	14,792	0	0	0	0	14,096	0	0	0	0	0	0	28,889
341	Paper and paper products	4,123	0	132	0	0	4,951	0	0	0	0	0	0	9,207
353-354	Petroleum products	1,696	0	602	2,242	2,074	581	0	0	0	0	0	0	7,195
385-390	Miscellaneous nec.	51	0	0	207	2,553	22	2,881	585	0	0	0	0	6,300
332	Furniture - fixtures	0	0	0	5,474	0	0	0	0	0	0	0	0	5,474
331	Wood - cork	0	0	0	1,893	0	0	0	0	0	0	0	0	1,893
313	Beverage	0	0	0	0	0	0	0	0	0	0	0	0	0
311-312	Food	0	0	0	0	0	0	0	0	0	0	0	0	0
322	Wearing apparel	0	0	0	0	0	0	0	0	0	0	0	0	0
361-369	Nonmetallic mineral	0	0	0	0	0	0	0	0	0	0	0	0	0
314	Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0
323-324	Leather prod. - footwear	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	387,893	522	11,951	32,043	2,534,176	66,532	196,510	54,024	52	0	499	30,398	3,314,600

Source: Engineering Science,Inc. et al. (1989).
Note: [a] Thailand Standard Industrial Classification

Table 2.17 Projected Hazardous Waste Quantities for 2001

Unit : Tons

TSIC [a]	Industry	Oils	Liquid Organic	Organic Sludge	Inorganic Sludge	Heavy met. Sludge	Solvent	Acid Waste	Alkaline Waste	Off spec. Prod.	PCB	Aqueous Organic Residues	Photo Waste	Total
371-372	Basic metal industry	0	0	0	0	4,070,027	0	0	0	0	0	0	0	4,070,027
381	Fabricated products	3,829	0	0	14,259	165,971	1,702	165,888	42,248	0	0	0	0	393,896
384	Transport equipment	297,733	0	0	5,397	0	12,754	1,631	1,632	0	0	0	0	319,147
383	Electrical machinery	4,044	0	0	10,194	116,809	2,282	119,494	29,876	0	0	0	0	282,699
351-352	Chemical products	103,883	876	14,727	3,141	54,705	10,599	18,505	9,987	107	0	1,037	0	217,566
382	Machinery	141,873	0	0	2,130	0	21,021	382	1,221	0	0	0	0	166,627
342	Printing, publishing, allied	0	0	5,742	0	0	36,881	0	0	0	0	0	57,809	100,432
321	Textiles	95,558	0	0	0	0	0	0	0	0	0	0	0	95,558
356	Rubber-rubber products	29,048	0	0	0	0	29,111	0	0	0	0	0	0	58,159
341	Paper and paper products	7,345	0	232	0	0	8,885	0	0	0	0	0	0	16,462
385-390	Miscellaneous nec.	110	0	0	429	4,798	45	5,814	1,235	0	0	0	0	12,431
353-354	Petroleum products	2,936	0	832	3,825	3,242	1,025	0	0	0	0	0	0	11,861
332	Furniture - fixtures	0	0	0	11,381	0	0	0	0	0	0	0	0	11,381
331	Wood - cork	0	0	0	3,324	0	0	0	0	0	0	0	0	3,324
313	Beverage	0	0	0	0	0	0	0	0	0	0	0	0	0
311-312	Food	0	0	0	0	0	0	0	0	0	0	0	0	0
322	Wearing apparel	0	0	0	0	0	0	0	0	0	0	0	0	0
361-369	Nonmetallic mineral	0	0	0	0	0	0	0	0	0	0	0	0	0
314	Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0
323-324	Leather prod. - footwear	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	686,358	876	21,533	54,080	4,415,553	124,306	311,714	86,198	107	0	1,037	57,809	5,759,571

Source: Engineering Science,Inc. et al. (1989).
Note: [a] Thailand Standard Industrial Classification.

Chapter 3

Industry's Geographic Distribution: An Environmental Perspective

INDUSTRY DISTRIBUTION AND CONCENTRATION

Industrial Concentration—The Bangkok Metropolitan Region

A major and growing issue in planning for economic development over the next few decades is the relationship between economic growth and environmental degradation. The rapid industrial growth, congestion, and urban environmental degradation of the Bangkok Metropolitan Region (BMR) is a serious problem in Thailand's economic development (Figure 3.1). As in the majority of developing countries, industrial development is most prevalent in and around the capital city. In Thailand, Bangkok and the adjoining Central Region account for 75 percent (1981 to 1988) of the value added in manufacturing (see Table 3.1) The distribution of registered factories by region, described in Table 3.2, indicates that more than 50 percent of registered factories industries are highly concentrated in the BMR. Another 17 percent are located in the Central Region surrounding the BMR in 1989.

Bangkok's rapid growth and the industrialization of outlying areas are producing many signs of stress in terms of water quality, even well out into the Gulf of Thailand. Two-thirds of the wastes that effect water quality come from domestic sources, and the rest come from industries. There are 51,500 factories registered with the Department of Industrial Works (DIW) of which 23,703, (52 percent), excluding rice mills, are located in the BMR.

According to DIW factory registration data for 1985 to 1987—a period of rapid growth with rising export activity—the BMA lost its share of factory establishments drop relative to that of other regions. (see Table 3.3). All regions had a net gain of factory establishments in 1989 with a growth rate higher than the national average of 9.2 percent

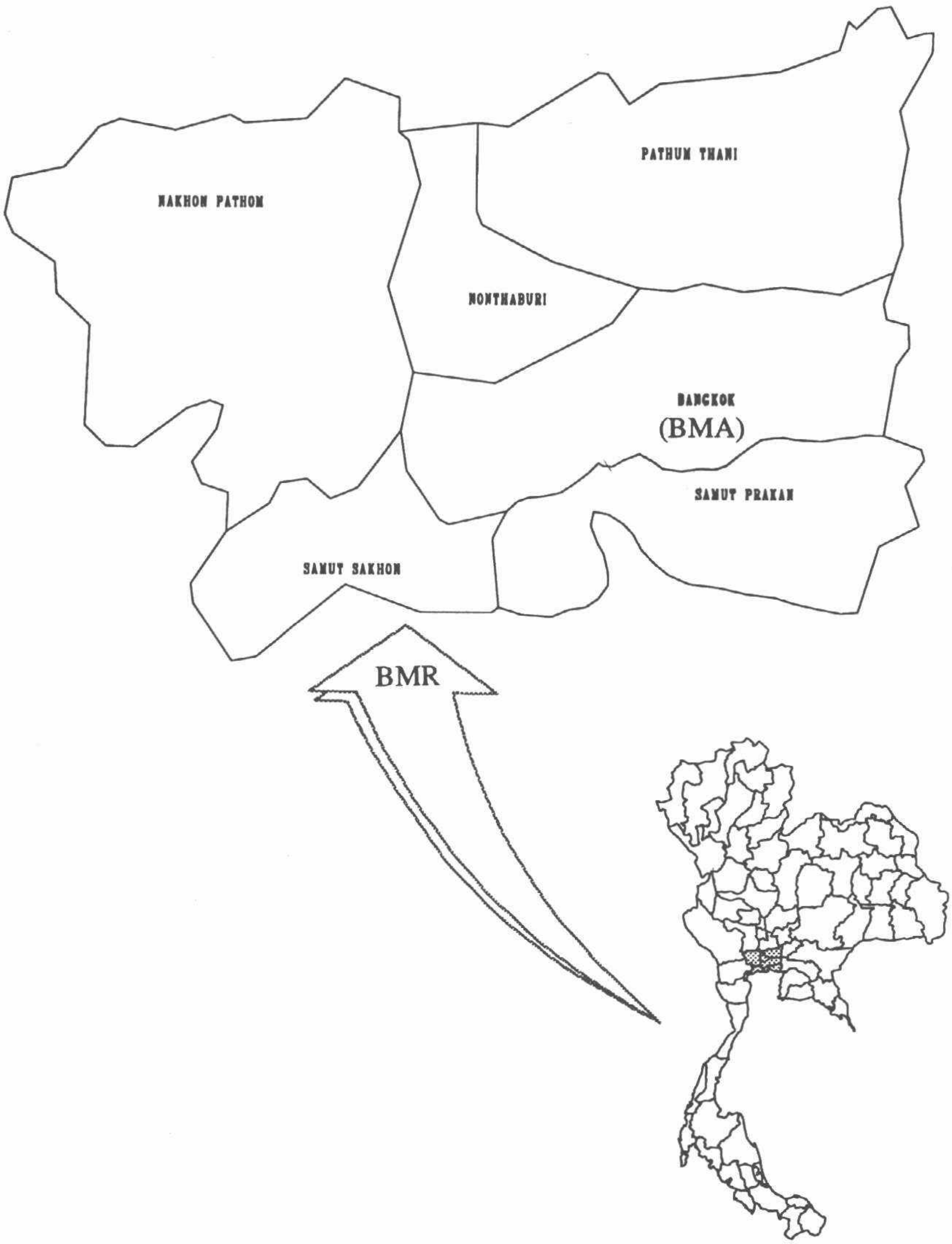


Figure 3.1 The Bangkok Metropolitan Region (BMR)

Table 3.1 Value Added in Manufacturing by Region, 1980s

Region	1981	1982	1983	1984	1985	1986	1987	1988
BMR	75.25	73.57	74.86	74.58	73.79	75.22	76.80	76.44
Central	12.24	13.86	13.04	13.15	13.62	13.02	12.32	11.22
North	3.92	4.09	3.95	3.92	4.54	3.98	3.79	4.11
Northeast	5.58	5.69	5.58	5.78	5.40	5.51	5.02	4.87
South	3.01	2.78	2.57	2.58	2.66	2.29	2.08	3.36
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: At 1972 constant prices.
source: National Economic and Social Development Board

Table 3.2 Distribution of Registered Factories by Region, 1978-1989

Region	1978	1981	1984	1987	1988	1989
Greater Bangkok	54.15	52.03	52.62	54.31	52.24	51.91
Central	20.03	19.50	18.20	16.42	16.86	16.82
North	7.44	7.99	8.92	9.22	9.56	10.00
Northeast	11.42	12.99	12.66	12.64	14.18	14.10
South	6.96	7.49	7.60	7.40	7.15	7.17
Total a	100.00	100.00	100.00	100.00	100.00	100.00

Source : Computed from data of Factory Control Division,Ministry of Industry
Note : a Excluding rice mills.

Table 3.3 Change in Regional Distribution of Manufacturing Establishments

Region	Number of Factories				%				Average Annual Growth Rate		
	1985	1987	1988	1989	1985	1987	1988	1989	1987	1988	1989
BMA (Bangkok)	17,022	17,754	18,993	20,432	45.02	42.27	40.32	39.72	2.13	6.98	7.58
BMR excluding BMA[a]	4,136	5,060	5,615	6,272	10.94	12.05	11.92	12.19	10.61	10.97	11.70
Central	6,166	6,898	7,941	8,651	16.31	16.42	16.86	16.82	5.77	15.12	8.94
North	3,280	3,872	4,505	5,144	8.67	9.22	9.56	10.00	8.65	16.35	14.18
Northeast	4,484	5,311	6,681	7,252	11.86	12.64	14.18	14.10	8.83	25.80	8.55
South	2,722	3,110	3,369	3,690	7.20	7.40	7.15	7.17	6.89	8.33	9.53
Total	37,810	42,005	47,104	51,441	100.00	100.00	100.00	100.00	5.40	12.14	9.21

Source: Factory Control Division, Ministry of Industry.
Note: [a] The Bangkok Metropolitan Region (BMR) includes the Bangkok (BMA) and five surrounding provinces.

Table 3.4 Change in Distribution of Manufacturing Establishments by Province within the Bangkok Metropolitan Region (BMR)

Province	Number of Factories				%				Average Annual Growth Rate		
	1985	1987	1988	1989	1985	1987	1988	1989	1987	1988	1989
BMA (Bangkok)	17,022	17,754	18,993	20,432	80.45	77.82	77.18	76.51	2.13	6.98	7.58
Nakhon Pathom	516	638	686	778	2.44	2.80	2.79	2.91	11.20	7.52	13.41
Nonthaburi	518	611	675	727	2.45	2.68	2.74	2.72	8.61	10.47	7.70
Pathum Thani	358	469	533	633	1.69	2.06	2.17	2.37	14.46	13.65	18.76
Samut Prakarn	2,086	2,547	2,843	3,152	9.86	11.16	11.55	11.80	10.50	11.62	10.87
Samut Sakhon	658	795	878	982	3.11	3.48	3.57	3.68	9.92	10.44	11.85
Total	21,158	22,814	24,608	26,704	100.00	100.00	100.00	100.00	3.84	7.86	8.52

Source: Factory Control Division, Ministry of Industry.

percent while the Bangkok Metropolitan Area (BMA), Central, and Northeast regions experienced a below average growth rate of 7.58 percent 8.94 percent, and 8.55 percent respectively. The BMR (excluding the BMA) and the North Region attracted manufacturing establishments at a rate higher than the national average with an annual growth rate of 11.7 percent and 14.2 percent, respectively. Although the BMR was gaining manufacturing establishments at an annual average rate of 8.5 percent (Table 3.4), which was less than the national average of 9.2 percent, the industrial growth in the five provinces surrounding Bangkok had the highest annual average growth rate in the country—(11.7 percent). Within the BMR, excluding the BMA, the growth of factory establishments was highest in the provinces of Samut Prakan, Pathum Thani, Nakhon Phatom, and Samut Sakhon. These trends are the combined outcome of the location decisions of individual firms in response to land and other markets, rather than to the explicit spatial policies such as the BOI incentive schemes. Table 3.4 shows that Samut Prakan Province has the highest share of industries among the five provinces surrounding Bangkok, and the relative share of manufacturing establishments in the BMR (excluding BMA) has been rising, while that of BMA has been declining. This is indicative of the strong decentralization movement of manufacturing employment from Bangkok to the surrounding provinces.

The Regional Distribution of Industry

Generally speaking, the number of industries decreases the greater the distance from the BMR (especially in areas such as the North and South regions which are located the farthest away from the BMR), and the diversity of types of industries is less in other regions than in the BMR (see Appendix 3.1). The type of industry that has the highest number of factories is the food industry which generates a traditional pollutant, BOD, which affects water quality. The wood product, furniture, nonmetallic mineral products, metal and machinery, and transportation equipment industries are ranked second to the food industry in share of factories. The last two groups—the metal and machinery and transportation equipment industries—are classified as hazardous waste generators. Other industrial groups have a very low number of factories compared to the BMR.

When considering a region-by-region breakdown by industry, the BMR has the highest share of industries which are the major sources of toxic and hazardous waste: metal products and machinery, textiles and wearing apparel, plastic products, transport equipment, and printing. The food industry has the highest share of factories in the North. In the South, apart from the food and wood industries, rubber products are a major industry. In the Northeast almost half of the industry is food based followed by machinery, nonmetallic minerals and wood products, and fabricated metal products.

The pattern of regional distribution of industry from 1987 through 1989 remained very stable with the food processing industry located primarily outside of the BMR. Currently within the BMR the industries with the highest number of factories are the fabricated products and transportation equipment industries followed by the food industry. In terms of industrial waste, the BMR generates a higher concentration of hazardous waste, whereas regional industry is a more BOD-oriented waste generator.

INDUSTRIAL ESTATES

An industrial plant should ideally be located in an area which will tend to minimize its environmental effects. The proper location of a plant will not eliminate the need for final treatment for environmental protection, but it may lessen the degree of treatment needed. Even in the most developed countries, it is recommended that all industries locate in specifically zoned areas. The plant locations should be chosen so that prevailing winds and waters lead wastes away from high concentrations of people, but the locations should also be convenient to raw materials and transportation systems for production and efficient product distribution. The plants operating in industrial zones should be as compatible as possible. In fact, the best possible environmental scenario would be a symbiotic relationship in which each plant would be able to utilize its neighbor's output and wastes as inputs in its production thereby minimizing environmental control costs. This, however, is not always economic because the sums of labor and the location of final market differs economy industries.

There are both advantages and disadvantages to locating plants in industrial zones. On one hand, a concentrated development of industries enhances the control of environmental contamination—assuming that there are adequate, enforceable legal means for restraining factories from polluting. The proper types of industries can be selected on a prearranged scheme in order to contain pollution effects. Carefully planned industrial zoning would remove potential sources of environmental contamination from residential and recreational areas.

On the other hand, if enforceable laws do not exist, or if the economic load of pollution control is too great, one factory might pollute a nearby industrial neighbor and the entire zone. While industrial wastes and byproduct uses may be matched, it may be much more difficult to interest each complimentary plant to locate in a specific area for several reasons including the market for the plant's products at the time. More over, there are also costs to regid planning. A more flexible system of these indicative zoning and location incentives may be preferable.

The Industrial Estate Authority of Thailand

The first industrial estate in Thailand, Bangchan Industrial Estate, was established in 1972 as the joint responsibility of the DIW, the Ministry of Industry (MOI). The objective in establishing this estate was to provide industries with land and infrastructure services.

As the concurrent problems of industrial pollution, an unorganized industrial sector, the public sector efficiency, and the need for export zones emerged, the government issued a Revolutionary Decree to establish the Industrial Estate Authority of Thailand (IEAT) in 1972. The government granted the IEAT the power to organize industrial estates which would provide land and infrastructure and estate management services to industries. In 1979 the IEAT Act was promulgated which empowered the IEAT to reclaim land according to the Land Reclamation Act. In addition, the IEAT was given the power to oversee private industrial estates. The Investment incentives for factories locating in all industrial estates are granted under the Investment Promotion Act of 1977 which is Board of Investment's (BOI) jurisdiction.

At present, there are twelve industrial estates located within a 30 to 40 kilometer radius of Bangkok. Six of the estates are owned and operated by the IEAT, and the other five are owned and operated by the private sector (see Tables 3.5 and 3.6). In 1988 many private industrial estates were established in order to provide land for industrial estates' needs during the subsequent economic boom. The present demand for industrial estates is still concentrated in the BMR where foreign investment is more concentrated, and there are more large-scale industries.

Environmental Concerns

The industrial estates operated by the IEAT and those operated by the private sector are controlled by two separate government bodies. Under the IEAT Act of 1979, the industrial estates operated by the IEAT are subjected to the environmental regulations posted by the IEAT. The IEAT is the single agency responsible for overseeing the

Table 3.5 Industrial Estates Operated by Industrial Estate Authority of Thailand

Industrial Estate (by Region)	Year Operational	Province	Land Area (Rai)	No. of Factories (Year-End 1989)
BMR				
Bangchan	1972	BMA	510	68
Bangpoo 1 [a]	1977	Samut Prakan	2,881	152
Bangpoo 2 [a]	1978	Samut Prakan		24
Ladkrabang 1,2	1983	BMA	949	79
Bangpli	1984	Samut Prakan	797	77
Ladkrabang 3 [a]	1989	Bangkok	1,769	13
Samut Sakhon	In process	Samut Sakhon	1,000	-
Central				
Laemchabang	1989	Chon Buri	3,410	4
Map Ta Put	1989	Rayong	5,030	12
Chon Buri	1991	Chon Buri	1,208	-
Well Grow	1991	Chachoengsao	2,160	-
North				
Northern	1985	Lumpoon	1,142	42
South				
Kanchanavanich	1989		340	-
Phuket	In process	Phuket	500	-

Source: Industrial Estate Authority of Thailand , Board of Investment.
Note: [a] Private industrial estate operated by the Industrial Estate Authority of Thailand.

Table 3.6 Industrial Estates Operated by the Private Sector, 1980s

Industrial Estate (by Region)	Year Operational	Province	Land Area (Rai)	No. of Factories (Year-End 1989)
BMR				
Navanakorn	1984	Pratumthani	7,245	161
Bangkradi	1988	Pratumthani	954	40
Maboonkrong	1988	Samut Sakhon	1,410	-
Emthai	1988	Samut Prakan	826	-
Minburi	1988	Bangkok	570	n/a
Central				
Rojana	1987	Ayuthaya	820	-
Sriracha	1988	Chonburi	599	40
Bangprakong	1989	Chonburi	216	-
Northeast				
Suranaree	1987	Nakhon Ratchasima	530	n/a

Source: Thai Factory Development Company Limited , Board of Investment.

environmental control of registered industries within its estates, although all industries are ultimately registered under the DIW. The approval process for newly established industrial estates is through the submittal of an environmental impact assessment (EIA) via the IEAT to the National Environment Board (NEB). During the operational phase of the estate, neither the NEB nor the DIW have the authority to enforce or monitor the conditions of the EIA within the estates according to the promulgated act of the IEAT.

The approval process for an EIA for a private industrial estate is somewhat different: initial approval is from the BOI which passes the EIA application on to the NEB for final approval. During the operational phase, the DIW is not able to perform enforcement monitoring within the new estate—specifically because it is registered as an estate and not as an industry.

Generally, the industrial estates established in Thailand are relatively small and only provide land and infrastructure services rather than a full range of services such as housing, public parks, or entertainment and commercial complexes. Some basic water pollution control systems are provided, but these systems do not cover the full range of industrial pollution including: air pollution, hazardous wastes, and solid wastes. (Loha-unchit 1989) In concept, industrial estates should select the types of industries to be established in a specific location so that they will have minimal impact on the surrounding environment. In practice, however, locating industrial estates and providing land and infrastructure services is based on narrow economic rather than environmental or social welfare criteria.

In fact, the industrial estates in Thailand are small and spread out in different areas, and there are no apparent zoning plans or policies on the government's part (Loha-unjit 1989). The result of this lack of planning, has lead to both the unsystematic growth and congestion of Bangkok and, places a heavy burden on the government which is faced with the problem of providing public infrastructure over a spread-out area, at substantial loss of economies of scale and concentration. While there are also economic benefits to the decentralization of industry, the pattern observed in and around BMR is one of a scattered but not decentralized distribution of industries. Environmentallly, it means high concentration of pollutants without the benefits of economics of scale in pollution control.

POLLUTANT DISTRIBUTION

The Distribution of Air Pollution by Region

As discussed in Chapter 2, the industrial sector is one of the major users of energy, and it is also a major contributor to air pollution. The geographic area for this study has been divided into five regions: the Bangkok (BMR), Central, North, Northeast, and South regions. The geographic distribution of air pollutant emissions including sulfur dioxide, nitrogen oxide, carbon dioxide, and suspended particulate matter from all of Thailand's economic sectors is presented in Appendix 3.2.

In the North Region, where the major power-generating plants using lignite are located, sulfur dioxide has been emitted in the range of 27 percent to 49 percent of total emissions—a trend which will probably continue from 1990 to 2011. The BMR—which has a high concentration of industry— accounted for 37 percent of total sulfur dioxide emissions up to 1988. The share of BMR originated emissions is expected to increase to 40 percent by 1991, and drop to 25 percent in 2011 due to the increase of electricity generation from lignite in the Northern Region. The distribution of nitrogen oxide is mainly concentrated in BMR. Its main source is the transportation sector—which accounted for 54 percent of total emission, a share is expected to persist until 2001, and gradually decrease thereafter. The situation with carbon dioxide is similar to that of nitrogen oxide. From 1991 to 2011, the distribution of suspended particulate matter will predominantly be in the BMR—50 percent of the country's total emissions—followed by the Central Region, which will gradually increase its emissions toward the year 2011.

Bangkok Region (BMR): Since 1986, the transportation, industrial, and power-generating sectors have contributed 35.67 percent, 35.36 percent, and 25.29 percent of sulfur dioxide, respectively. The comparison of emission trends (as shown in Appendix 3.2) indicates that there will be a steady increase of sulfur dioxide by industrial sector from 1996 to 2011 in the Bangkok area. These industries will emit between 8 to 9 percent and 16 percent of nitrogen oxide throughout the same period, and will emit a 12 percent to 32 percent share of carbon dioxide. The industries will also contribute 49 percent to 69 percent of the total suspended particulate matter emitted in the BMR.

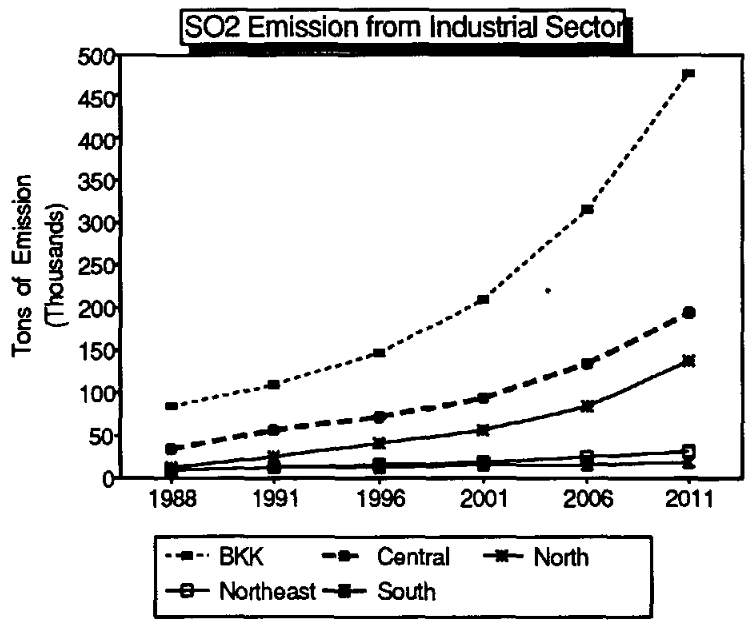
Central Region: Appendix 3.2 shows the gaseous emission trend in the Central Region. The most critical emission is suspended particulate matter from the industrial sector which is projected to be in the range of 82 percent to 87 percent during the period 1991 to 2011. The highest sulfur dioxide emission will occur in 1991 (a 69 percent share), and the share will decrease to a 26 percent level by 2011 due to the increase of sulfur dioxide from electricity generation. The pattern for nitrogen oxide and carbon dioxide during this time period is very similar, with the share of emissions ranging from 10 percent to 25 percent.

Northern Region: The gaseous emission from the Northern Region's industrial sector is a less significant contribution as shown in Appendix 3.2. The sulfur dioxide, nitrogen oxide, and carbon dioxide emissions are projected to be in the range of 5 percent to 20 percent in most years from 1991 to 2011. However, suspended particulate matter will tend to increase slightly and the Northern Region will contribute 20 percent of total emissions in the next 20 years.

Northeast Region: In this region, industry contributes a significant amount of sulfur dioxide emission. The present share of 35 percent will increase to as high as 81 percent toward to the year 2011. However, in terms of emission volume, this amount is considered to be small compared to other regions. The other gaseous emission—nitrogen oxide, carbon dioxide, and suspended particulate matter—are considered small, both in terms of volume and percent share. (see Appendix 3.2).

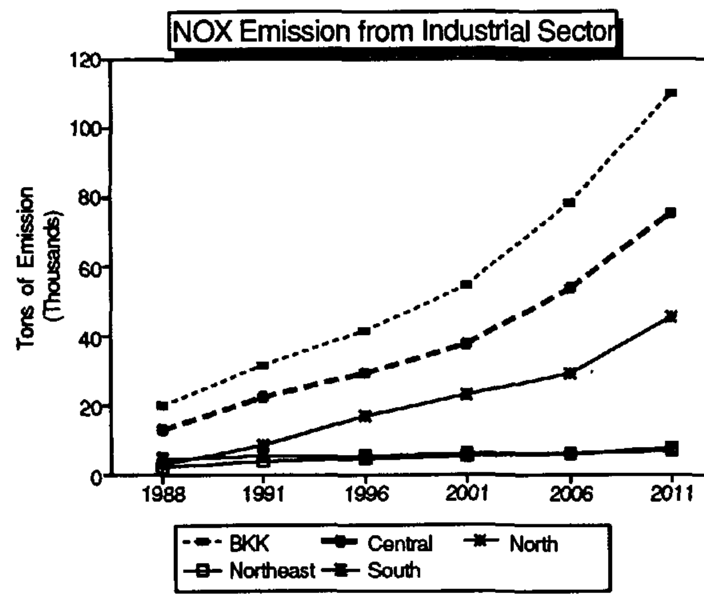
South Region: This region has the smallest share of industrial GDP, and it has generated a small volume of gaseous emission to date. Over the next 20 years, the volume of sulfur dioxide, nitrogen oxide, carbon dioxide, and suspended particulate matter will increase very slightly where as its share of gaseous emission decrease.

In the future, gaseous industrial emissions will be concentrated mostly in the BMR and Central regions. From 1991 on, the sulfur dioxide and carbon dioxide emissions from the industrial sector will be approximately 55 percent in the BMR, and 25 percent in the Central Region which accounted for 80 percent of sulfur dioxide emissions (see Figure 3.2 and Figure 3.4). The situation for nitrogen oxide and suspended particulate matter is similar: the Bangkok Region will contribute approximately 40 percent, and the Central Region will contribute approximately 30 percent to a combined total of 70 percent of total nitrogen oxide and suspended particulate matter emissions from industries. (see Figure 3.3 and Figure 3.5)



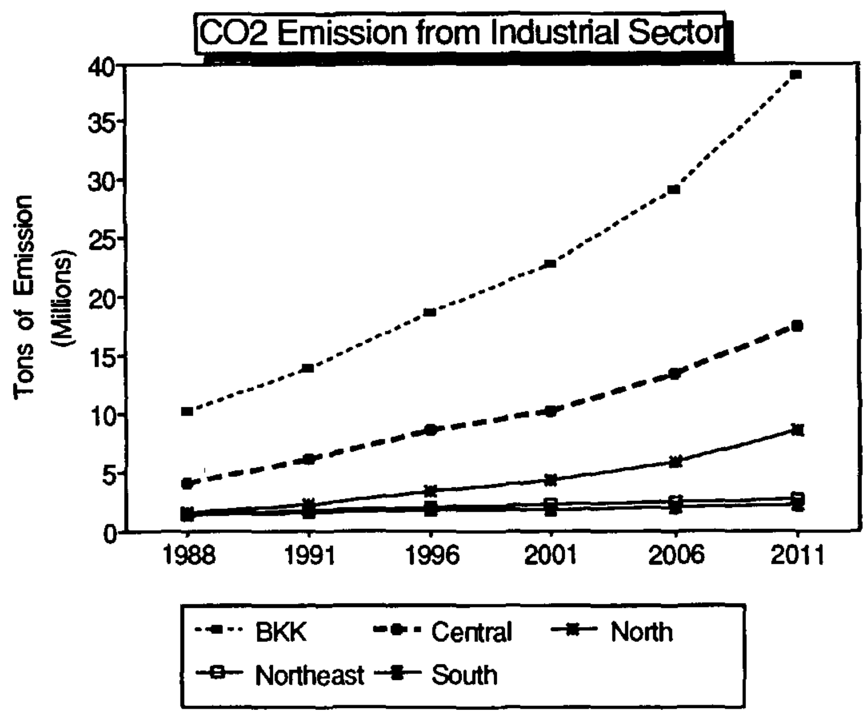
Region	1988	%	1991	%	1996	%	2001	%	2006	%	2011	%
BMR	83,845	58	108,784	52	146,822	52	208,663	54	315,210	55	476,586	56
Central	32,779	23	55,417	27	70,166	25	91,151	24	132,912	23	194,363	23
North	12,068	8	23,084	11	38,298	14	55,624	14	84,641	15	135,389	16
Northeast	8,785	6	11,549	6	14,355	5	17,859	5	23,186	4	30,398	4
South	7,907	5	9,709	5	10,335	4	12,126	3	14,918	3	18,808	2
Total	145,384	100	208,543	100	279,976	100	385,423	100	570,867	100	855,544	100

Figure 3.2 Sulfur Dioxide (SO_2) Emission (from Industrial Sector by Region)



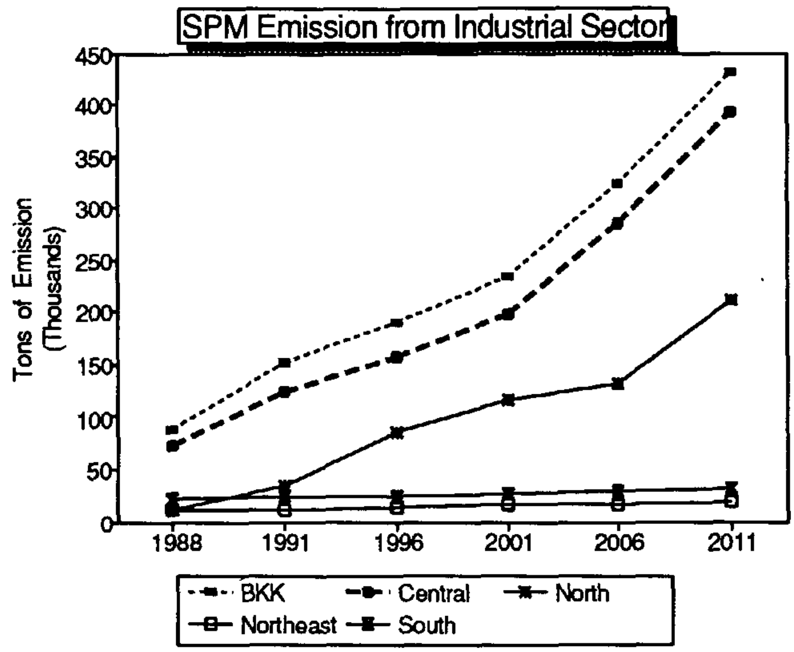
Region	1988	%	1991	%	1996	%	2001	%	2006	%	2011	%
BMR	20,003	46	31,179	44	41,685	42	54,808	43	78,083	45	109,255	45
Central	13,215	31	22,336	32	29,503	30	37,630	30	53,904	31	74,962	31
North	3,185	7	8,110	12	16,995	17	23,223	18	29,270	17	45,146	19
Northeast	2,548	6	3,592	5	4,884	5	5,444	4	6,554	4	7,405	3
South	4,261	10	5,163	7	5,484	6	5,762	5	6,501	4	7,226	3
Total	43,212	100	70,380	100	98,551	100	126,867	100	174,312	100	243,994	100

Figure 3.3 Nitrogen Oxide (NO_x) Emission (from Industrial Sector by Region)



Region	1988	%	1991	%	1996	%	2001	%	2006	%	2011	%
BMR	10,217,317	56	13,771,609	54	18,516,918	55	22,775,503	55	29,279,028	56	38,910,667	56
Central	3,902,476	21	6,087,533	24	8,510,385	25	10,285,749	25	13,224,034	25	17,372,479	25
North	1,431,851	8	2,201,686	9	3,241,718	10	4,179,912	10	5,751,795	11	8,535,255	12
Northeast	1,301,154	7	1,625,722	6	1,903,480	6	2,021,255	5	2,285,034	4	2,630,525	4
South	1,329,467	7	1,582,810	6	1,728,288	5	1,804,994	4	1,978,467	4	2,218,061	3
Total	18,182,265	100	25,269,360	100	33,900,789	100	41,067,413	100	52,518,358	100	69,666,987	100

Figure 3.4 Carbon Dioxide (CO_2) Emission (from Industrial Sector by Region)



Region	1988	%	1991	%	1996	%	2001	%	2006	%	2011	%
BMR	89,174	43	153,114	44	190,476	40	235,217	40	323,962	41	432,159	40
Central	74,551	36	124,184	35	158,377	33	198,145	33	285,398	36	392,281	36
North	11,373	5	35,748	10	85,828	18	116,651	20	131,825	17	210,608	19
Northeast	10,372	5	12,842	4	14,855	3	15,543	3	17,022	2	19,486	2
South	21,438	10	25,271	7	25,713	5	26,798	5	29,499	4	33,438	3
Total	206,908	100	351,159	100	475,249	100	592,354	100	787,706	100	1,087,972	100

Figure 3.5 Suspended Particulate Matter (SPM) Emission (from Industrial Sector by Region)

The Distribution of Water Pollution by River

As shown in Table 3.7, the Bang Pakong River, the Chao Phraya River, the Mun River, and the Thachin River, all of which drain into the East Coast Gulf area, were the watercourses which received the largest amount of BOD load in 1986. Each river accounted between 11 percent to 17 percent of the total BOD load from factories under the monitoring scheme of the DIW. The Mae Klong River, the Ping River, the Nan River, the Chi River, and the Khong River assimilated BOD at a rate of 10 percent, 6 percent, 4 percent, 3.6 percent, and 2 percent of total BOD load, while the BOD load to the Prachinburi River, the Wang River, the Yom River and the Kok River was assimilated at a rate of less than 1 percent.

The data in Table 3.7 indicate, in descending order, the BOD load in rivers that receive biodegradable waste from industry However, these figures do not indicate what level of BOD load would create an anaerobic conditions, or where such a situation would arise. Understanding these two variables is a critical element in attaining the desired ambient water quality standards. This is important since, in its current day-to-day practice, the DIW aims at maintaining effluent standards which may be too high for

Table 3.7 Biochemical Oxygen Demand (BOD) Load to Major Rivers, 1986

# River or Area Name	No. of Factories	Flow (1,000 cu.m.)	BOD Load (Tons)
1 Bang Pakong	135	13,997	86,761
2 Chao Phraya	351	53,224	81,426
3 East Coast Gulf	123	16,345	80,427
4 Mun	84	7,350	75,867
5 Thachin	376	166,757	56,033
6 Mae Klong	22	47,741	48,910
7 Ping	17	125,087	30,254
8 Nan	19	101,866	21,819
9 Chi	82	18,015	19,106
10 Khong	55	1,532	7,091
11 Prachinburi	27	281	4,618
12 Wang	13	1,517	3,719
13 Yom	5	102	296
14 Kok	2	18	55
Total	1,311	553,833	516,381

Source: Department of Industrial Works industries located in remote areas, and may be too low for industries located adjacent to communities. Although effluent standards are easy to monitor, the standards should only be considered a tool for obtaining ambient standards. The Office of the National Environment Board (ONEB) has applied this discipline to the Chao Phraya River to protect the raw water supply of the BMR population from being polluted (National Environment Board 1988), but this is the only application in Thailand to date.

In attempting to coordinate effluent and ambient standards for industrial pollution control, inevitable problems arise because these standards are controlled by different authorities, as discussed in Chapter 5. To properly manage the industrial, domestic, and agricultural wastewater to achieve the desired water quality would be even more difficult because proper management would require dealing with all sources of pollution. For this reason, a river basin authority is needed, although the justification and the task of such a body would need to be further investigated and identified.

The Distribution of Hazardous Waste by Region

Under the Sixth National Economic and Social Development Plan, the current government policies and programs focus on controlling industrial development in the BMA and on promoting growth in other parts of Thailand. The Investment Promotion Act of 1977 (IPA) is one of the major vehicles with which the government is seeking to implement its growth distribution policy. The IPA, which is implemented by the BOI, offers more attractive incentives to business ventures that decide to locate outside of the BMA. The IEAT is implementing a number of projects in conjunction with the IPA to encourage private sector investment in selected areas. There are five industry development projects being promoted by the IEAT within the BMR, and other projects are located outside of the BMR. The sheer magnitude of the government's efforts to modify present industrial growth patterns through industrial estates, investment incentives, and infrastructure development projects virtually guarantees a substantial impact on industrial activities which will be felt especially in the Eastern Seaboard and the upper South development areas.

The current bulk of hazardous waste generation related employment (76.2 %) is in the BMR, and the highest recent growth rates have been in the BMR and in the Central Region. A summary of hazardous waste distribution by industry and region (from 1986 to 2001) is presented in Table 3.8 which shows that the majority of current and future hazardous wastes are, and will be, generated in the BMR (70.9%), while the Central

Table 3.8 Projected Quantity of Hazardous Waste by Region, 1986-2001

Unit : Metric Tons

Region	1986	%	1991	%	1996	%	2001	%
BMR	817,084	71.09	1,413,701	70.91	2,447,943	70.78	4,236,332	70.68
Central	183,950	16.01	322,252	16.16	563,481	16.29	982,063	16.38
North	75,706	6.59	132,247	6.63	230,580	6.67	400,713	6.69
Northeast	14,488	1.26	24,557	1.23	41,779	1.21	71,615	1.19
South	58,096	5.05	100,845	5.06	174,980	5.06	303,117	5.06
Total	1,149,324	100.00	1,993,602	100.00	3,458,763	100.00	5,993,840	100.00

Source: Engineering Science,Inc,et al. (1989).

Region will account for 16.2 percent of hazardous waste generated in 1991. In 1986 the top five hazardous-waste-producing industries—basic metal, fabricated products, transport equipment, electrical machinery, and chemical products—were located in the BMR, with a total of 10,152 factories, followed by the Central, North, Northeast, and South regions, respectively (see Appendix 3.3). In terms of distribution, the BMR shared 71 percent of hazardous-waste-generating industries in 1986. The combined BMR and Central Region figures, account for 87 percent of the country's hazardous waste from industrial sources. (see Table 3.8). Of the top ten hazardous-waste-producing provinces shown in Table 3.9, the BMA is ranked first in terms of registered factories followed by Samut Prakan Province. The top five hazardous-waste-producing industries by region in 1989 are shown in Table 3.10. From 1990 through 2001 and beyond the manufacturing sector will be by far the major contributor to hazardous waste the back of it concentrated in the BMR—especially in the BMA, the most densely populated area of the country.

Table 3.9 Ranking of Ten Hazardous-Waste-Producing Provinces, 1989

No.	Province	Basic Metal	Fabricated Products	Transport Products	Electrical Machinery	Chemical Products	Total
1	Bangkok	67	4,252	2,300	811	555	7,985
2	Samut Prakan	89	537	302	125	174	1,227
3	Samut Sakhon	18	154	89	20	46	327
4	Udon	3	60	181	11	2	257
5	Nakhon Ratchsima	2	54	180	8	5	249
6	Nonthaburi	1	84	100	23	34	242
7	Kanchanaburi	0	29	168	24	9	230
8	Khon Kaen	1	48	149	8	10	216
9	Nakorn Pathom	9	48	84	11	37	189
10	Petchabun	0	22	146	16	0	184
	Total 10 provinces	190	5,288	3,699	1,057	872	11,106
	Total 73 provinces	223	6,235	6,374	1,204	1,090	15,126
	Share of top ten provinces (%)	85.2	84.8	58.0	87.8	80.0	73.4

Table 3.10 Ranking of Top Hazardous-Waste-Producing Industris by Region, 1989

Region	No. of Industries	% Concentration
BMR	10,152	67.12
Central	1,525	10.08
North	1,244	8.22
Northeast	1,420	9.39
South	785	5.19
Total	15,126	100.00

Note: The top five hazardous-waste-producing industries include :

1. Basic metal industry
2. Fabricated products
3. Transport equipment
4. Electrical machinery
5. Chemical products

Chapter 4

Industrial Pollution: Health and Environmental Effects

Pollution is defined as the addition, (from either man-made or natural sources), of any foreign substance to the air, water, or land media in such quantities that the resource is rendered unsuitable for specific or established uses. With increasing economic development in Thailand, during the past ten years in particular, the management of industrial operation's residues has assumed a critical role in the protection of the environment. Since the industrial sector has overtaken other sectors in terms of the gross domestic product (GDP), the early consideration of the total environment as an entity will permit the coordinated management and protection of the air, water, and land resources affected by such development.

POLLUTION AND ENVIRONMENTAL QUALITY

Air Quality

Industrial activities, along with the combustion of fuels for heating and energy production, are the major sources of air pollution in most locations throughout Thailand. The effect of stationary pollutants from industrial plants depends on a number of local factors including topography, meteorological conditions, stack height, control equipment, location, fuel used, and type of manufacturing process. Air pollution is defined as the presence of one or more contaminants in the atmosphere which singly, or in combination, are present in such quantities or have such characteristics and duration as to make them actually, or potentially, injurious to human, plant, or animal life or to property. In addition, air pollution may unreasonably interfere with the comfortable enjoyment of life and property. Industrial air contaminants may originate from a number of sources including: (1) the burning of industrial refuse, (2) the production of a power stream involving combustion of fossil fuels, or (3) the treatment of liquid wastes resulting in the release of gaseous byproducts. The specific substances produced by the above sources are numerous and depend upon the individual operation or activities involved. The more common contaminants originating from industrial operations are sulfur dioxide, nitrogen oxide, hydrogen sulfide, carbon monoxide, dust particulates and particulate matter of carbon origin, chlorine, methane, and various organic solvents. (WHO, 1987).

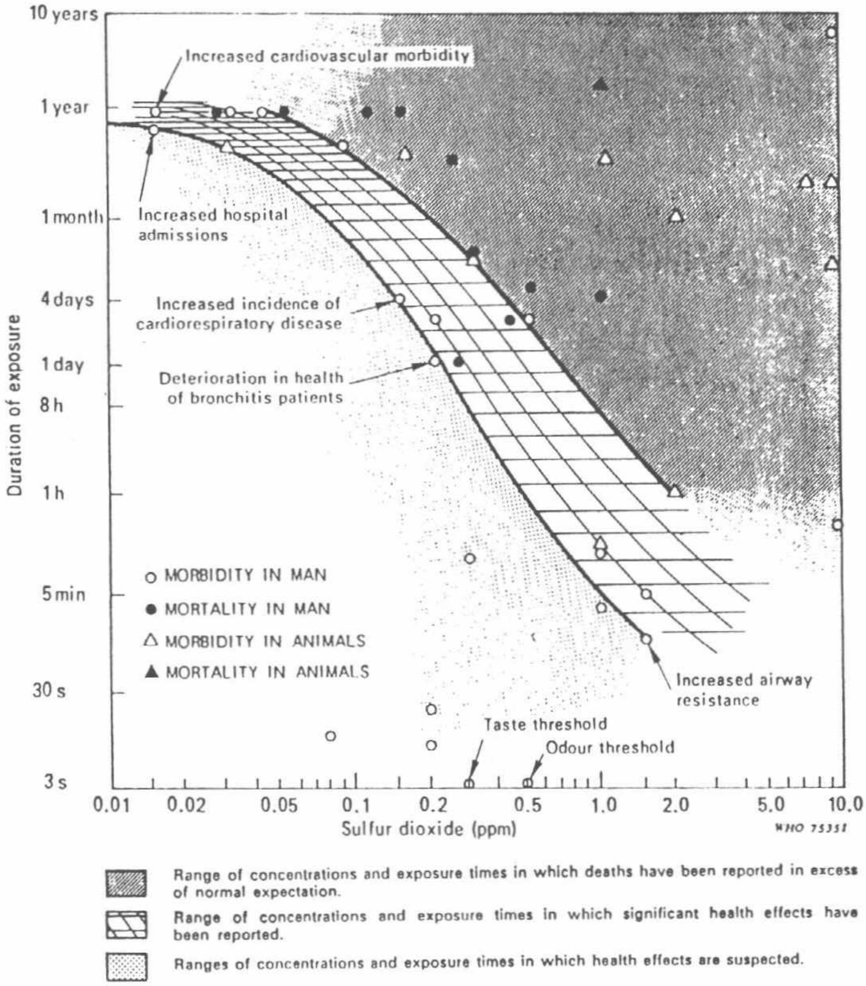
The readily identifiable sufferers from the effects of air pollution are as follows:

- Human beings through the effect on health, visibility, and aesthetics
- Physical structures through corrosion and deterioration of clothing, art, metal, rubber, and paint
- Agricultural plants and forests
- Livestock and wildlife

Air pollution largely affects humans via the respiratory system, and most of the affected persons are often already suffering from respiratory or cardiovascular disease. Normally, inhaled gaseous pollutants can be absorbed along the pharynxes of bronchioles, and inhaled particulates can be deposited in the mucus layer already surrounding the bronchial cilia. In many persons this natural function may be changed by smoking or by the presence in the lungs of other irritants. Figure 4.1 illustrates the effects of various sulfur dioxide levels on human health, while Figure 4.2 presents the typical effects of sulfur dioxide on vegetation.

In contrast to traditional air pollutants, which are few in number, relatively easily controlled, and comparatively well-understood in terms of environmental impact, unconventional trace pollutants are numerous and are not controlled systematically. Many trace pollutants continue to be the subject of controversy regarding their environmental impacts and their effects on human health. Much uncertainty remains regarding the effect of their total daily intake on human health. There are various lists of toxic and potentially toxic substances, the United States. Environmental Protection Agency (U.S. EPA) has listed hazardous air pollutants which are also a major concern of developed countries members of the Organization for Economic Cooperation and Development (OECD).

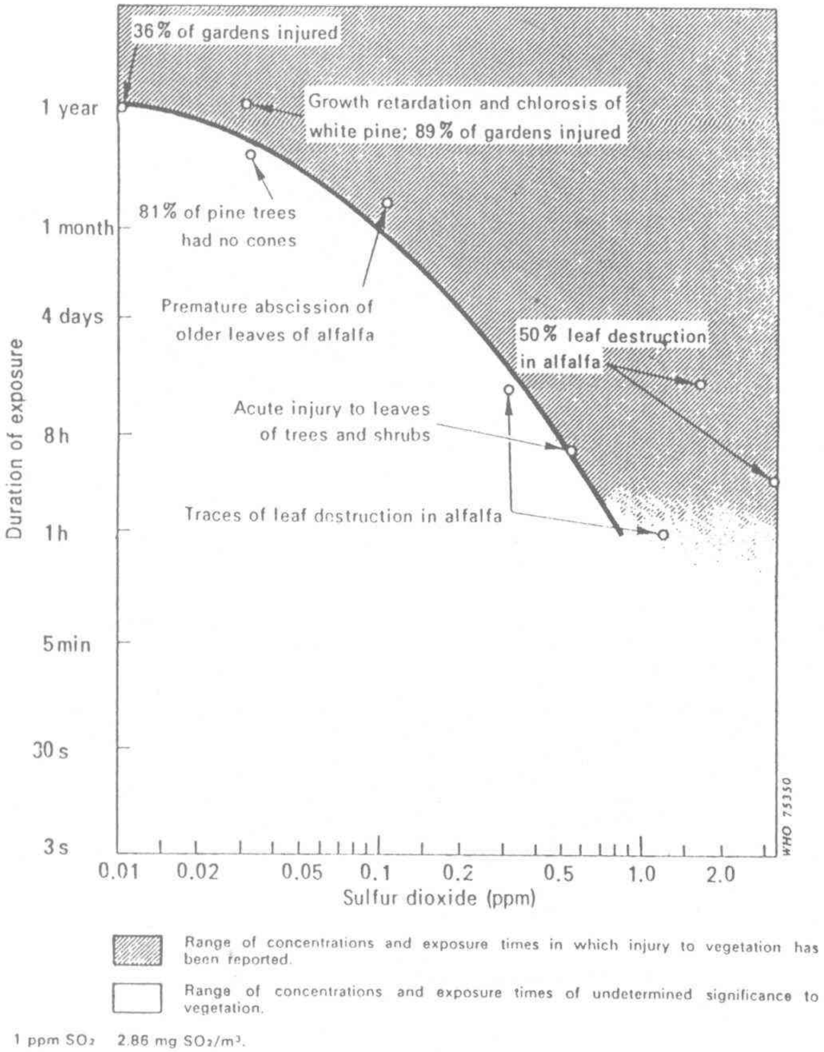
There are three groups of atmospheric trace pollutants: metals, fibers, and organic compounds. It is beyond the scope of this study to analyse and project all trace pollutants



* 1 ppm SO_2 . 2.86 mg SO_2/m^3.

Source : World Health Organization

Figure 4.1 Effect of Sulfur Dioxide on Health



Source : World Health Organization

Figure 4.2 Effect of Sulfur Dioxide on Vegetation

from industrial activities. Here we simply review the effects of trace pollutants on human health and the environment.

Many metals that are emitted into the atmosphere as fine particles or vapors affect human health either directly or by "bio-accumulation," and some are known or potential carcinogens and mutagens. Metals such as arsenic, cadmium, lead, and mercury cause kidney and/or liver damage and disorders of the central nervous system. (OECD 1985) In addition, some metals have detrimental effects on the aquatic and terrestrial ecosystem. Appendix 4.1 presents information comparing toxic metals and their effects and sources.

Toxic fibers are defined as elongated particles that are at least three times longer than they are wide. Fibers may be inherently toxic or may be inert but carry dissolved or absorbed vapor contaminants. While in general, the chemical composition of a substance determines its toxicity, the biological activities of fibers are believed to depend mainly on fiber dimensions; fibers with a diameter of less than 1.5 micrometers and a length of greater than 8 micrometers are known to cause cancer. (OECD 1985)

Organic compounds, including the entire class of hydrocarbons, have long been considered air pollutants because of the role they play in photochemical oxidation formation—not because they constitute a class of pollutants exhibiting intrinsic health or ecological effects. Appendix 4.2 lists a number of such potentially toxic organic compounds, their main emission sources, and environmental presence. Organic substances are primarily emitted by the chemical industry during solvent use, by incineration plants, and through incomplete fuel combustion.

Water Quality

Water pollutants consist not only of natural or man-made physical contaminants but also of measurable heat and radiation. The major sources of industrial water pollution include leaching of contaminants from industrial refuse dumps, manufacturing of goods, condensation and/or absorption of gaseous wastes by water, and cleaning of facilities and/or equipment used in manufacturing products. The categories of contaminants which could have a deleterious effect on water quality include the following:

- Alkalinity and acidity
- Colored matter

- Heated liquid
- Toxic chemicals
- Detergents
- Floating materials
- Nonbiodegradable organic materials
- Organic matter
- Suspended solids
- Mineral salts
- Algal nutrients
- Foaming agents
- Bacteria and viruses

Although the discharge of industrial contaminants to receiving waters generally produces unpleasing aesthetic effects, the primary concern is the water quality deterioration which is harmful to aquatic life and impacts human uses. At each level of receiving water quality, there exists a given environmental cost and associated total benefits to society. While many of these costs, damages, and benefits are measurable, others definitely exist but, at present, are quantitatively nonmeasurable. As long as the measurable benefits equal or exceed the direct cost of industrial pollution control, waste treatment facilities should be provided.

Land Quality

Land may become polluted (1) through the addition of specific contaminants, and (2) through alteration to such a degree and/or in such a manner as to render it unsuitable for its best zoned use. The land could become a hazard or nuisance to the adjacent population under conditions of uncontrolled industrial use such as on-site burning of solid wastes, disposal of solid wastes, and storing of materials which may be hazardous to humans and the living environment. Many industrial contaminants contribute to land quality degradation, but the major concerns are hazardous wastes, concentrated organic sludges, and slag heaps from smelting operations. The result of the discharge or deposition of waste materials (stored organic matter or toxic sludges) on land areas is contaminated groundwater and surface water through leaching and runoff during rains.

When land is preserved or used beneficially in a "no impact" manner, the local inhabitants are recognized as obvious "beneficiaries". People living and working near a properly utilized solid waste disposal or land utilization area will not suffer from unsightliness, odors, or subsurface leachate contaminants.

POLLUTION AND HUMAN HEALTH

Thailand's industrial development has brought several newly synthesized chemicals and industrial processes into use—in ever-increasing amounts and numbers. Many of these substances are hazardous not only to the environment, but also to human health, and consequently require proper management.

As a result of increasing levels of exposure to toxic chemicals, Thailand's workers have historically experienced conspicuous occupational health problems. A survey of five regional hospitals in 1983 identified that 14 cases (7.7%) of the total of 182 poisoning incidences were occupationally related.

Occupational Health Hazards: Lead and Manganese

Lead poisoning has consistently been one of the most important occupational diseases, and a common health hazard that is presently encountered in workers is adverse neurophysiological effects. The lead-in-blood indicator (PbB) is the best existing exposure indicator because it takes into account all exposure routes as well as long retention periods.

According to the investigation of Ecro et al. (1984), the average PbB levels of the workers by various tasks in a Thai battery plant was in the range of 12 to 48 mg/100 ml (see Table 4.1). In the above study the investigated groups also included some less-exposed workers such as administrative personnel. Consequently, the actual levels should be higher. In comparison with the PbB levels in nonoccupationally exposed people, which should not exceed 25 to 30 ug/100 ml (International Labor Organization 1983), the results indirectly suggest that occupation may ostensibly be the severe risk attribution.

Table 4.1 Lead-in-Blood Concentration by Work Task

Type of Work	No. of Samples	Concentration (ug/100 ml)
Battery assembly	24	48.0
Plate formation	4	44.0
Pasting and plate finishing	8	41.0
Grid casting	48	37.0
Support services	36	25.0
Battery container manufacturing	7	37.0
Lead smelting	9	33.0
Finance & marketing	18	12.0

Source : Ecro et al., 1984.

An investigation by the Department of Health (DOH) in 1987 for 11 lead-associated plants in the province of Samut Prakan reported lead-in-air measurements in the range of 0.002 to 0.29 mg/m^3 with an average measurement of 0.063 mg/m^3 (see Table 4.2). Only one air sample (out of the 36 taken) exceeded the national ambient air quality standard of (0.2 mg/m^3) set by the Department of Labor (DOL). However, 6 out of 11 investigated plants yielded remarkably high levels of lead in comparison with the 0.05 mg/m^3 standard set by the United States' Occupational Safety and Health Administration (OSHA) and the National Institute of Safety and Health (NIOSH).

In another 1987 sampling for rates of occupational exposure to lead, 14.2 percent (twice the 1986 record) of the whole blood samples of workers had relatively high lead-in-blood (>60 ug/100 ml), whereas 0.5 percent of blood samples reached the severe risk level (>100 ug/ 100 ml) (see Table 4.3). This pattern was also repeated with the detection of lead-in-urine; 64.6 percent (four times the 1986 record) and 19.8 percent of urine samples possessed high levels exceeding the health-based limit (120 ug/l) and the severe risk attribution (200 ug/l), respectively.(DOH 1987).

Thailand's mining and dry-cell battery industries are among the industries reporting intoxication by manganese. The initial physical effects of manganese intoxication are generally nervous and pulmonary, but mortality may prevail after a sufficient latency period. In 1964, 41 workers in a dry-cell battery plant in Thonburi apparently became severely ill from inhalation of manganese dust. All of these victims were reported dead by 1984.

Table 4.2 Concentration of Lead in Air at Eleven Lead-Associated Plants in Samut Prakarn (DOH, 1987)

No. of Workers	No. of Air Sample	Lead in Air (mg/m^3) Range	Average	No.of Exceeding Standard
54	3	0.048-0.150	0.088	0
56	3	0.027-0.096	0.057	0
180	4	0.022-0.058	0.045	0
241	5	0.031-0.088	0.072	0
100	4	0.004-0.044	0.015	0
67	2	0.040-0.050	0.045	0
20	4	0.005-0.189	0.062	0
13	2	0.096-0.145	0.121	0
6	2	0.002-0.003	0.002	0
14	4	0.002-0.020	0.009	0
40	3	0.139-0.290	0.200	1

Note: DOL Standard for Lead in Air is 0.20 mg/m^3

Source: DOH, 1987

Table 4.3 Concentration of Lead in Blood and Urine of Workers at Eleven Lead-Associated Plants in Samut Prakarn, 1987

Blood				Urine			
Concentration (u g/100 ml) Range	AVG.	No. of Samples	No. of Samples >Normal	Concentration (u g/100 ml) Range	AVG.	No. of Samples	No. of Samples >Normal
21.38 - 78.69	48.47	46	12	57.95 - 486.53	173.05	46	10
13.82 - 35.01	24.40	34	0	53.87 - 308.97	140.98	34	5
8.89 - 95.89	26.82	258	17	15.26 - 391.09	166.32	258	57
24.33 - 60.73	44.23	19	1	69.38 - 206.72	138.71	19	1
16.33 - 30.74	23.71	11	0	109.79 - 196.73	152.87	11	-
44.21 - 100.83	70.11	34	27	-	-	-	
		100%	14.18%			100%	19.84%

Source: Deprtment of Health, 1987
Note: Normal Pb in Blood is 60 g/100 ml
Normal Pb in Urine is 200 g/100 ml

Generally, manganese levels are measured in blood (MnB), urine (MnU), stools, and hair. In fact, these readings cannot absolutely assess individual exposure but rather are used as the *mean* of exposure. The average MnB and MnU in exposed workers seems to be at the same level as that in nonexposed workers (between 1-8 ug/l). To date, there is no other viable biological parameter and assessment must rely upon manganese-in-air levels.

In 1987 the Ministry of Public Health (MOPH) attempted to investigate the manganese concentration in the air in the workplace as well as the manganese level in the workers by testing for MnB and MnU. Based on the information shown in Table 4.4 and Table 4.5, the manganese-in-air (0.013-1.28 mg/m^3) did not exceed the current DOL air quality standard for the working environment (5 mg/m^3). Compared with the normal level of 8 ug/100 ml, the detection of manganese in blood samples in these plants reportedly showed a low level of MnB (0.69-6.30 ug/100 ml (see Table 4.5). On the other hand, the fact that a great number of the overall urine samples (81.4%) possessed comparatively high levels of MnU indicated the relative risk associated with this industry for occupationally exposed people.

The Increase in Occupational Disease

During the past decade, the increasing number of occupational diseases has been a matter of principal concern to the government, and seven diseases were selected for investigation from a group of nine established diseases related to the industrial sector. An overview of industrial disease incidences monitored by the Occupational Health Division of the MOPH is presented in Table 4.6.

From 1978 to 1987, the incidence rate of environmental health cases increased tremendously—from 2.00 to 8.88 per 100,000 of population.

The complex mixture of air pollutants inherent in industrial expansion is potentially more efficient in inducing respiratory diseases. Many industrialized countries have experienced the consequences of industrial expansion including the potential threat to human health due to degraded ambient air quality (see Appendix 4.3).

Table 4.4 Manganese Concentrations in the Air of Three Dry-Cell Plants, Samut Prakarn (DOH, 1987)

	No. of Workers	No. of Air Samples	Mn (mg/m^3) Min-Max	Avg.	No. of Samples Exceeding Standard
Plant1	62	5	0.042-1.28	0.577	0
Plant2	64	4	0.013-0.816	0.376	0
Plant3	1300	3	0.078-0.230	0.157	0

Note: DOL standard for Manganese in Air is 5 mg/m^3

Source: DOH, 1987

Table 4.5 Manganese Concentrations in the Air of Three Dry-Cell Plants in Samut Prakarn (DOH, 1987)

	Blood				Urine			
	Concentration Min-Max	(ug/100 ml) AVG.	No. of Samples	No. of Samples > Normal	Concentration Min-Max	(ug/100 ml) AVG.	No. of Samples	No. of Samples > Normal
Plant 1	1.58 - 5.50	2.34	62	0	-	-	-	-
Plant 2	1.58 - 4.60	2.98	20	0	15.47 - 52.62	32.4	16	12
Plant 3	0.69 - 6.30	1.98	30	0	9.20 - 92.64	43.5	27	23

Source: Department of Health, 1987

Note: Normal Manganese in Blood (MnB) is 8 g/100 ml.
Normal Manganese in Urine (MnB) is 25 g/100 ml.

Table 4.6 Incidence of Occupational Diseases, 1978-1987

(Unit : per 100,000 Population)

Item	Type	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1.	Insecticide poisoning	1.970	4.040	3.980	4.550	4.510	4.76	6.37	5.03	5.90	8.64
2.	Lead poisoning	0.013	0.020	0.020	0.040	0.020	0.03	0.07	0.03	0.10	0.10
3.	Manganese, mercury and arsenic poisoning	0.009	0.002	0.020	0.008	0.006	0.02	0.02	0.02	0.02	0.04
4.	Petroleum products poisoning	-	-	0.004	-	-	-	0.03	0.01	0.01	0.02
5.	Gas, vapor poisoning	0.005	0.020	0.013	-	0.010	0.02	0.04	0.09	0.05	0.06
6.	Caisson's disease	-	0.070	0.070	0.070	0.030	0.01	0.008	0.02	0.02	0.01
7.	Silicosis	0.002	0.013	-	-	-	-	-	-	-	-
	Total	2.00	4.14	4.11	4.66	4.58	4.84	6.55	5.21	6.10	8.88

Source: Department of Health (1990)
"Review of the Occupational Health Status and Problems in Thailand", 1990
The Occupational Health Division, Department of Health, (1990).

OTHER NEWLY INDUSTRIALIZED COUNTRIES: AN INTERNATIONAL COMPARISON

Taiwan

Over the last three decades Taiwan's economy has grown rapidly with an average GDP growth rate of more than 6 percent from 1982 to 1988. The GDP growth rate has increased steadily from 5 percent in 1986. By 2000 the growth rate is projected to reach 7.68 percent, averaging a 6.5 percent rate over the period 1986 to 2000. Between 1952 and 1985 the number of officially recorded factories also increased rapidly, from 9,966 to 68,145, but the actual figure may be considerably higher because many factories avoid official registration. The variety of products and byproducts produced has increased at a similar rate in industries known for their production of hazardous wastes including plastics, petroleum refining, pesticides, leather tanning, and diverse chemical manufacturers (Council for Economic Planning and Development, Taiwan 1986).

The degradation of Taiwan's environment is, in part, a result of Taiwan having a "good investment climate." This term means that highly polluting industries that find it expensive or difficult to operate in the United States, Europe, or Japan, because of government restriction on pollution control, have chosen to locate in countries such as Taiwan where they do not have to comply with strong environmental standards. This good investment climate is a competitive advantage for industries that pose serious environmental problems wherever they locate.

The result of industrial development in Taiwan has both a positive side and a negative side. On the positive side, Taiwan is on the verge of becoming an advanced industrial society; material amenities are enjoyed by a large fraction of the population; life expectancies have increased to those seen in developed countries; and high technology benefits and a well-developed communication and transport infrastructure are all part of everyday life. On the negative side, facilities to protect humans and natural resources from the toxic, mutagenic, carcinogenic, unsanitary, and generally dirty and unpleasant consequences of industry are, at best, primitive. Development planning generally encourages growth, particularly the growth of high technology industries, without a selective process to favor clean industries over dirty industries.

Taiwan's environmental management has developed slowly and unevenly, and the country has not yet fully developed the capital, information, and institutional infrastructure needed to manage the undesirable, polluting, and ecological disruptive byproducts of its crowded industrial society. The resulting gap has meant degradation of the environment and national resource base, popular discontent, and the lack of a firm basis for preventing further environmental degradation or gaining public confidence. The regional distribution and relatively small-scale features of Taiwan's industrialization have proved a mixed blessing because of the spread of and difficulty of controlling industrial pollution.

This situation has only recently begun to change. In 1987, Taiwan established the cabinet—level Environmental Protection Administration to replace an earlier department in the Ministry of Health. According to the current plan, Taiwan plans to build 12 incinerators over the next five years and 11 more by the year 2000. There are additional toxic waste disposal facilities on the drawing board that will be run by foreign companies that are qualified to handle these materials.

Hong Kong

With its population of 5.7 million and its 50,000 factories, Hong Kong produces some 22,500 tons of waste per day including household and industrial waste and by 2001 this amount is expected to grow to 30,000 tons. The waste stream includes hazardous wastes such as cadmium, mercury, lead, zinc, polychlorinated biphenyls (PCBs), acids, alkalis, and oily wastes, which generally come from industries. Most of Hong Kong's chemical waste output of 101,000 tons per year (1988), which is generated by an estimated 10,000 factories, is disposed of without any environmental control.

Like other newly industrialized countries (NICs), the regulatory framework that ought to ensure environmental safe waste disposal is also weak. Only recently has this situation begun to change. In September 1989 Hong Kong, in an effort to enhance environmental protection's role in the planning process, inaugurated a new Planning Environment and Lands Branch.

Hong Kong is still deciding how to best apply the "polluter pays principle," which calls for waste-management costs to be borne by the waste-producing companies and indirectly by the consumers of their products. The wastes produced will be handled by an outside waste-management company which will build and operate the plant and will be responsible for managing the waste. The Environmental Protection Department (EPD) under the government is also planning to levy a charge on factories' purchase of chemicals at the wholesale price in order to facilitate optimal chemical usage.

To apportion the costs of control, the EPD will target those industries which have the highest levels of hazardous materials, for example the electronics, electroplating, and chemical industries. The EPD also intends to develop an effective monitoring system for recording the movement of each shipment of hazardous material—from producer, to collector, to disposal—which is similar to the manifest system now in use in the United States.

South Korea

South Korea generates 17.9 million tons of industrial waste per year including 733,000 tons of hazardous waste, which is growing at a rate of 22 percent annually. There are 7,000 government-recognized sources of industrial waste, most of which are concentrated around the major urban areas of Seoul and Pusan, and the situation with toxic and hazardous waste is currently approaching a crisis level in the country's industrial areas.

Although South Korea has tough environmental laws similar to those in Japan or in the United States, there is a deficiency between the law and the actual enforcement of the law. The Environmental Administration (EA)—which does not have the status of a full ministry—is short of staff (particularly technically qualified staff) and is underfunded. Moreover, the EA relies on an approach which discourages voluntary disclosure of accidental or improper discharges of industrial waste.

Chapter 5

Policy and Development

ENVIRONMENTAL POLICY AND THE NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN

Thailand is currently operating under the Sixth National Economic and Social Development Plan or NESDP (1987-1991) which is the latest in a series of five-year macroeconomic plans prepared since the early 1960s by the National Economic and Social Development Board (NESDB).

Since its inception the NESDB has alternately focused its planning activities on issues including the development of private investment, economic infrastructure, export industries, and import substitution. But it was not until 1972, under the Third Plan, that environmental concerns entered the planning arena and the Ministry of Industry (MOI) expanded its activities in the areas of industrial pollution (including air and water pollution) and occupational health.

The Industrial Estate Authority of Thailand (IEAT) was set up under the Third Plan in 1972 to promote the establishment of industrial estates, and by 1977, the Fourth Plan had devoted a total budget of 2 percent to environmental projects. The Fourth Plan also urged the strict enforcement of existing laws to prevent or reduce the causes of environmental problems and to minimize environmental deterioration. This applied particularly to the Factory Act (FAC) which was initiated in 1969 and the City Planning Act which was passed in 1975. The Fourth Plan called for measures including the issuance of an environmental impact assessment (EIA) as part of the procedure for issuing industrial permits and for better coordination of government agencies in controlling environmental problems.

The policies and measures for the development of environmental control that had been drawn up in the Fourth Plan (1977-1981) were used as a guideline for preparing work plans and for developing projects directed at clearer targets for the Fifth Plan. One important measure was to set a minimum standard for environmental quality.

Under the Fifth Plan (1982-1986) the promotion of export industries was intensified by increasing the level of economic incentives relative to import substitution. The plan's industrial development objective was to support the development of export-oriented basic facilities through promotion privileges in order to strengthen the competitiveness of the export industries in the international market. The Eastern Seaboard Development Program was initiated in 1979 to divert industrial concentration away from Bangkok, to promote export industries, and to increase Thailand's energy self-sufficiency.

Also during this period, environmental problems related to industry were identified: air and water pollution, noise, and hazardous and toxic waste pollution. The policy laid down under the Fifth Plan emphasized various public and private agencies' participation (particularly public enterprises) in the development of environmental problem-solving measures.

One of the objectives of the current Sixth Plan is to shift from project-oriented planning to program-oriented planning. Thailand's agro-based and engineering industries have been singled out as the two broad groups to be promoted. The Sixth Plan has initiated a program for natural resources and environmental development as a separate chapter entitled "Strategies for Increasing the Efficiency of Development." One of the major objectives of the plan is to promote efficient use of deteriorating and diminishing natural resources consistent with the protection of the environment.

LEGISLATION AND POLLUTION CONTROL

Politically speaking, the Thai government did not seriously enter the environmental field until 1971 when pollution of the Mae Klong River by sugar mill wastes became a source of controversy. Although the MOI used the Factory Act of 1969 as a threat to the industry, the government's real action was to set up an Environmental Quality Committee. The concept of industrial pollution control for manufacturing, however, did not enter the national plans until the Third Plan. According to the Fourth Plan, areas with a high population density and heavy industrial concentration, such as the Bangkok Metropolitan Region (BMR), are given priority in pollution control policy. The

Fourth Plan focused on problems including the deterioration of water quality, pollution from industrial plants, and noise and pollution.

Within the general legislative framework for the control and management of the environment, the following acts have direct relevance to industry:

The Improvement and Conservation of National Environmental Quality Act of 1975 (NEQA): The NEQA, which was amended in 1978, created the National Environment Board (NEB) and the Office of National Environment Board (ONEB) as its secretariat. The act also introduced the concept of environmental quality standards, the requirement for EIAs in industrial permitting, and the use of "emergency powers." The NEQA established two sets of policy guidelines on water pollution which are formulated for specific areas and industrial activities: one for inland waters and the other for marine coastal waters. Policy guidance is also included on the use of the EIA for industrial projects and industrial estates.

The Public Health Act of 1941 (PHA): The PHA was enacted for the prevention of diseases and the provision of national healthcare. Some of its sections also provide legal authority for the prevention and abatement of water pollution. Environmental public nuisances, as defined by the PHA, are broad in concept, and embrace all sources of water, air, and noise pollution which are potentially harmful to the safety or rights and liberty of the public. The enforcement mechanisms contained in the PHA are currently the most effective legal controls for general pollution, and include abatement orders, judicial injunction, and criminal prosecution. Abatement orders, prohibition orders, or closing orders can be made by court injunction.

The Factory Act of 1969 (FAC): The FAC provides the legal basis for establishment and control of industrial plants, and the MOI is vested with the power to administer the FAC through issuing ministerial regulations and notifications. The FAC was first amended in 1975, which strengthened the environmental dimension of the original act. Now the FAC is the principle legislative mechanism providing the legal basis for industrial wastewater pollution control. By virtue of the FAC, the MOI can exert the power to issue notifications for treatment of wastewater and legal sanctions against violators.

PROBLEM IDENTIFICATION AND ANALYSIS

Legal and Institutional Aspects and Perceptions

While the PHA, the FAC, and the NEQA constitute the main framework of existing environmental legislation, the PHA is the oldest law, and its regulatory approach is the most comprehensive and adequate to meet present requirements for environmental control. A detailed summary of the functions of all current planning and policy agencies, from both the public and the private sectors, is included in Appendix 5.1. The FAC provides the authority for control of industrial waste through the factory licensing system, although there is no provision for FAC separation of licensing for factory operation and permitting of factory waste discharges—which is a major constraint to the law's overall effectiveness. Without a separate permit system for waste discharges, the responsible authority, the Department of Industrial Works (DIW), is in a relatively weak position to ensure environmental protection through routine monitoring and enforcement.

The NEQA is considered the most important legislation for providing mechanisms for comprehensive, integrated environmental management. However, at the implementation level, the NEQA is considered inadequate in terms of providing a means for implementation due to the ambiguity of some of its provisions. For instance, the NEB is empowered to recommend environmental standards that are not within the scope of other government agencies, but there is no clear mechanism for implementation and enforcement.

The NEQA requirements for an EIA, considered the most powerful tool for the environmental protection efforts of the NEB, do not empower the ONEB to directly monitor and enforce the EIA findings and recommendations. The procedure for the review and approval of an EIA report on an industrial project requires that the EIA is submitted (1) to the DIW, (2) to the Board of Investment (BOI) for a project with a promotion certificate, (3) to the IEAT for an industrial estate project, and (4) to the ONEB for review. The ONEB will, in turn, respond with recommendations for approval, approval with conditions, or disapproval of the project. Usually, the conditions require that the industry make certain improvements in pollution control engineering design and implement or strengthen monitoring results or techniques. The ONEB has no specific mandate for enforcing areas covered under the provisions of the FAC. If the industry does not implement the recommended changes, the ONEB can disapprove the subsequent EIA which is submitted with a licence renewal application, but this does not prevent environmental damage which may be caused by earlier noncompliance. Aside from the above constraints the NEB is not vested with the direct authority to prevent implementation of projects with unsatisfactory EIA submissions.

The IEAT Act of 1979 authorizes the IEAT to approve the establishment of industrial estates. The IEAT is authorized to conduct permit approval for the establishment of a factory within an industrial estate and is responsible for the operation and monitoring of the water treatment systems within an industrial estate. The DIW has no authority in monitoring or enforcing the FAC for factories in an industrial estate, and it is of particular interest that while environmental quality is emphasized in the IEAT objectives, there is no environmental unit within the IEAT's organizational structure, for either the environmental planning or the implementing phase.

The Coordination of Enforcement and Implementation

The ONEB is the central agency coordinating environmental management among government agencies including The Office of the National Economic and Social Development Board (ONESDB) and the Ministry of Science, Technology, Energy (MOSTE). These three agencies, with the ONEB providing a coordinating role, have been responsible for the considerable progress of policy formulation and planning at a central level over the past ten years. The ONEB's responsibility for environmental management at the local level is represented by provincial governors, but coordination at this level leaves much to be desired, mainly due to a current lack of representation from the ONEB. In the final analysis, environmental control and management in Thailand involves a large number of agencies, and its success depends on effective coordination at all levels of planning and implementation.

For practical reasons, many industrialized countries have established a central environmental agency to consolidate policy formulation and implementation through laws and standards. The agency activities in these countries include permit control for pollution discharges, evaluation of EIA's, environmental monitoring and compliance inspection. In Thailand the ONEB has authority only in policy coordination while implementation and enforcement is the responsibility of other agencies.

Currently, the enforcement of industrial pollution regulation rests with the DIW's Industrial Environment Division (IED) which operates from Bangkok headquarters. The IED is responsible for EIA report approval, based on ONEB recommendations, and for pollution control measures proposed in factory license applications. The IED which had a total of 143 employees on staff in 1989, has difficulty performing both its operational and enforcement functions on a nationwide basis.

The FAC and its various notification procedures provides authority for the control of industrial waste only through the factory licensing system. There is no provision for separate permitting for factory waste discharges. The factory licenses are renewable only every three years, which leaves the DIW in a relatively weak position for enforcing pollution control on a day-to-day basis.

Industries with promotion certificates can apply for permits under the BOI to reduce the time required for permit processing through the DIW. As a result, much of the actual authority is left with the BOI although there is some technical coordination among the BOI, the ONEB, and the DIW. At this point, the question is how effective is the BOI operation for environmental review for industrial permitting. The BOI has the power to promote and control industry and is broadly empowered to perform a one-stop service on investment matters. However, due to bureaucratic procedures, BOI has been weak in monitoring and evaluating the projects which it has promoted (Cusripituck 1989).

Under the IEAT Act, the DIW has no authority in the implementation of monitoring or the enforcement of industry operation. The overall organization of the IEAT does not show a real commitment to environmental responsibility, although there are site offices that perform waste analysis for the IEAT's own operational purpose. The ONEB is involved in EIA recommendation for approval, approval with contingencies, or disapproval for the establishment of industrial estates.

A summary of environmental institutions status is shown in Table 5.1.

Table 5.1 Status of Environmental unit by Institutions

Institution	Status
Office of the National and Social Development Board (NESDB)	Division level
Office of the National Environment Board (ONEB)	Department level
Office of the Board of Investment (OBOI)	Coordination with (OBOI) ONEB for environmental activities.
Department of Industrial Works (DIW)	Division level
Department of Public Health (DPH)	Division level
Industrial Estate Authority of Thailand (IEAT)	Coordination with ONEB for environmental activities
Industrial Finance Corporation of Thailand (IFCT)	Partially involved with waste treatme through project funding

THE EFFECTIVENESS OF ENVIRONMENTAL ENFORCEMENT

Environmental control and management in Thailand involve a large number of agencies. The success of these combined efforts depends on effective environmental enforcement, planning, and coordination at all levels. The responsibility for the execution of laws and regulations is divided among the ONEB, the DOH, and the DIW, and at present, the enforcement of industrial pollution regulations rests with the IED (a division of the DIW which operates from Bangkok headquarters). Policy and planning for the control of environmental pollution has progressed well at the central level over the last ten years, but coordination at the provincial and local levels leaves much room for improvement.

Manpower as an Environmental Resource

The control of industrial pollution under the mandate of the FAC has not been fully enforceable due to factors including a deficiency in administrative provisions, a shortage of staff, and a lack of expertise. Presently, there are about 51,441 registered industrial plants (excluding rice mills) in Thailand. Within the DIW there is a total of 699 staff which is the third largest staff in the MOI (see Table 5.2s and 5.3). Of these, 25 percent have a bachelor's degree in engineering and 6 percent have a higher degree.

Table 5.2 Department of Industrial Works (DIW) 1989 Workforce

Division	No. of Staff	% in DIW	% in MOI
Office of Secretary Department	49	7.01	1.09
Budget Division	42	6.01	0.94
Industrial Control Division	153	21.89	3.41
Office of Machinery Registration	53	7.58	1.18
Technical and planning Division	37	5.29	0.82
Industrial Inspection Division	89	12.73	1.98
Industrial Environment Division	114	16.31	2.54
Investment Services Center	29	4.15	0.65
Office of Hazardous Substances	40	5.72	0.89
Office of Industrial Service & Waste Treatment	29	4.15	0.65
Industrial Security Division	64	9.16	1.43
Total	699	100.00	15.58

Source: Department of Industrial Works (1989).

Table 5.3 Ministry of Industry (MOI) 1989 Workforce

Department	No. of Staff	%
Office of the Permanent Secretary	951	21.20
Department of Mineral Resources	1,814	40.45
Department of Industrial Works	699	15.58
Thai Industrial Standards Institute	392	8.74
Department of Industrial Promotion	629	14.02
Total	4,485	100.00

Source: Ministry of Industry (1989).

The majority of the staff with higher than a bachelor's degree are involved with environmental enforcement work as shown in Table 5.4. There are three divisions within the DIW that are both directly and indirectly related to industrial environment work: the Industrial Control Division, the Industrial Inspection Division, and the Industrial Environment Division, which have 89, 153, and 114 staff, respectively (see Table 5.2). The ratio of staff to number of registered factories is about 1:100 which is considered to be insufficient. To handle the large amount of monitoring and enforcement work at hand. Because the environmental monitoring and enforcement programs are centrally operated from Bangkok and there are no staff operating regionally, the frequency of monitoring activities and the quality of work produced are affected. In fact, much of the time consumed is lost through travelling from site to site.

Financial Aspects

Financial resources are another major constraint in environmental enforcement. The annual budget allocation during 1982-1989 for five MOI departments is shown in Table 5.5. Although the DIW ranks third in terms of staff within the MOI, the budget allocated for its annual operation ranked fourth during the past nine years. In the 1989 budget alone the annual operating cost is 0.13 million baht per staff and the annual operating cost was 1,900 baht per factory. Based on the annual operating cost per staff, the DIW ranked last when compared with the Department of Mineral Resources (DMR), the Office of the Permanent Secretary (OPSI), the Department of Industrial Promotion (DIP) and the Thai Industrial Standards Institute (TISI), which had costs per staff of 0.44, 0.30, 0.22, and 0.135, respectively. In comparison, the share of the GDP from mining and quarrying, in which the DMR has more direct management, is 2.4 percent, whereas manufacturing, under DIW direct management, is 23.0 percent. This demonstrates the imbalance of budget allocation in terms of production output by industrial subsector.

Table 5.4 Staff Education Level within the Ministry of Industry (MOI)

Department in MOI	No. of Staff	Educational Background								
		Engr.		Econ.		Bus. Adm.		Other *		
		B	>B	B	>B	B	>B	B	<B	>B
Office of the Permanent Secretary	916	198	20	50	24	46	11	440	121	11
Department of Industrial Promotion	570	42	15	24	6	29	13	204	208	29
Department of Industrial Works	666	173	41	1	1	26	1	254	142	27
Thai Industrial Standards Institute	410	149	26	8	1	8	2	101	95	20
Department of Mineral Resources	1,843	592	207	-	-	-	-	1,044	-	-

Notes * Other than Engineering, Economic, Business Administration and those below bachelor's degree.
** Approximate number only

B = Bachelor's Degree

Source: Ministry of Industry (September 1988).

Table 5.5 Department Budget Allocation within The Minsitry of Industry (MOI)

Fiscal Year	Ministry of Industry									
	Office of the Permanent Secretary		Department of Mineral Resources		Department of Industrial Works		Department of Industrial Promotion		Thai Industrial Standard Institute	
	Million baht	% growt	Million baht	% growt	Million baht	% growt	Million baht	% growt	Million baht	% growt
1982	66.5	-	535.0	-	37.0	-	73.6	-	26.0	-
1983	79.6	19.7	579.0	8.2	43.6	17.8	83.5	13.0	32.0	23.1
1984	88.6	11.3	598.4	3.4	57.2	31.2	87.6	4.9	34.0	6.3
1985	88.9	0.3	564.0	-5.7	57.7	0.9	82.7	-5.6	33.5	-1.5
1986	104.6	17.7	560.0	-0.7	56.9	-1.4	88.6	7.1	36.5	9.0
1987	130.4	24.7	538.6	3.9	58.7	7.2	93.0	5.0	37.2	1.9
1988	184.6	41.6	622.9	15.7	68.8	17.2	117.5	26.3	44.3	19.1
1989	275.2	49.1	814.6	30.8	93.6	36.0	127.4	8.4	53.1	19.9

Source: Ministry of Industry (1989).

The budget allocation during 1986 to 1989 for the DIW shows a sharp increase in 1989 of 36 percent, but even allowing for this 700-baht-per-factory increase over 1986 to 1988 operating costs, the budget of 1,900 baht per factory seems too small an amount to allow effective monitoring and enforcement. Realistically, monitoring of industrial waste emission should be carried out on a monthly basis but with the available budget and workforce, the task of environmental monitoring and enforcement is undoubtedly inadequate for the enforcemane of effluent standards and other pollution control regulations.

The Import of Pollution to Thailand

The BOI is an agency which has served as an important role in national, economic, and social development, and its main tasks are to promote and control investment. The BOI plays a major role in attracting foreign investment for the industrial sector. However, environmental damage has accumulated in the wake of economic growth, and limited natural resources have been used or overburdened at practically no cost to the industrial sector. An environmentally unsound industrial structure has emerged that must now be quickly redesigned and reorganized to operate on a sustainable basis for the long run. Based on the overall foreign direct investment for 1980 to 1989, the industrial sector had the major share of investment, especially during 1986 to 1989 when it shared approximately 50 percent of total foreign direct investment (see Appendix 5.2). Foreign investment in Thailand has been dominated by Japan, the Asian Newly Industrialized Economies (NIEs—Hong Kong, Singapore, Korea, and Taiwan), the United States, and the European Economic Community (EEC) with a share of 50 percent, 20 percent, 14 percent, and 9 percent, respectively, as shown in Appendix 5.2.

Based on BOI promotion records from 1986 to 1989, shown in Appendix 5.3, the BOI has given promotion privileges to industries which are classified as potential hazardous waste generators including chemical products, electronics, metal transformation, textiles, machinery, and engines. These industries generate hazardous wastes which are difficult and expensive to handle and to treat. As the structure of industry changes, environmental effects will accumulate and will cause future environmental degradation if there are no countermeasures. An analysis of BOI-promoted industries indicated that the proportion of approved investment for hazardous-waste-generating industries has increased from 25 percent in 1987 to 55 percent in 1989. Handling the treatment of increasing amounts of hazardous waste will place a burden on the government's budget unless pollution charges or treatment fees for industrial wastes are introduced.

At present the government has not overcome the problem of traditional pollution in terms of water quality and BOD. Hazardoüs waste presents a new and some ways a more serious challenge. The BOI promotion privileges need to be reconsidered in light of their environmental implications. Otherwise, the BOI is inadequately promoting the investments of highly polluting industries that are attracted to Thailand by the tax enforcement of environmental standards. The level and type of potential pollutants generated by promoted industries and the corresponding environmental risk factor, given their location, should be upgraded from an incidental BOI consederation into 2 primary criterion in determining what industries to promote.

Chapter 6

The Economics of Pollution Control

THE MACRO PICTURE

The pollution of air, water, and land is an inevitable by product of economic activity. Industry is not unique in its environmental impact, nor is it necessarily the largest or most hazardous polluter. "Green" economic activities such as agriculture and tourism may be just as damaging to the environment as industrial activities; for example, the use of agrochemicals is a major and often pervasive source of toxic water pollutants (although this source of pollution is presenting not a problem in Thailand). Hospitals and municipalities also generate large quantities of hazardous waste. What makes industrial pollution in Thailand of particular concern is the rapid growth of the industrial sector and its capacity to introduce new and increasingly hazardous pollutants into the environment at a time when the country lacks the necessary knowledge and experience to deal with them.

Free disposal of untreated industrial wastes into the air, water, or land impose(s) risks and costs: (1) on other activities that may require these unpolluted resources and (2) on individuals who are not parties in the industry's decisions of what and how to produce. These pollution activities amount to industry's appropriation of a common or public resource to keep down its own cost and to enlarge its profits, which, apart from being unfair to those affected, is also inefficient in terms of the use of scarce resources. When safe waste disposal costs are not being paid by those who generate, industrial pollution, an implicit subsidy from the environment.

In fact, the more pollution an industry generates, the higher the implicit subsidy it receives from society in terms of free use of a scarce public resource for the free disposal of waste. This in turn biases the allocation of resources in favor of the heavier polluters and against the lighter ones. Under these circumstances, the industry has no incentive to select its technologies or inputs or to conduct its production activities in a manner that minimizes waste. Thus, the problem is not only that untreated waste has been released into the environment with potentially damaging effects, but also that far too much waste is being generated. The ultimate result, as the industry grows and pollution accumulates, is the destruction of the assimilative capacity of the environment: a scarce and valuable resource.

Although staunch environmentalists and purists argue on behalf of "zero pollution," this is not an efficient solution because: (1) zero pollution would take an inordinate amount of effort and cost to accomplish that would exceed the expected benefits, and (2) there is an opportunity cost realized by underline using the assimilative capacity of the environment, which is a flow resource that can be used sustainably (without damaging the stock).

For pollution abatement to be socially beneficial, the ensuing benefits should exceed the associated costs, which include both the cost of abatement and any reduction in the (net value of) output produced by the industry. The optimum pollution abatement occurs when the additional benefits just cover the additional costs, and this is reached at a positive level of pollution. Therefore, to determine the optimum level of pollution, the marginal benefits and marginal costs of pollution abatement must be estimated. The costs, which are easier to determine than the benefits, mainly consist of expenditures on collection, treatment, and disposal of waste, plus regulatory and enforcement costs, plus any reduction in industrial output. The benefits consist of (1) damage averted or (2) the value of enhanced uses of the environment as a result of pollution abatement. As shown in chapters 2, 3, and 5, there is evidence of the increasing impact of industrial pollution on other uses of the environment (particularly water and air) and on human health, although estimating the damages or benefits from pollution abatement is not feasible at this point in time.

Therefore, instead of attempting to determine the optimum level of pollution abatement, the more viable approach is to determine the most cost-effective means of attaining an ambient standard which is judged desirable in Thailand.

In the case of hazardous waste, which is quantitatively a small percentage of the waste stream but is none the less potentially very damaging, the ambient level is closer to the zero pollution level than in the case of biodegradable waste. Ambient levels also may vary with regard to location, proximity to population centers, and other uses of the resources being affected. But whatever then ambient standards, they should be attained at the minimum possible cost to the industry at large.

The threefold purpose of Chapter 6 is to:

1. review the projections of industrial pollutants (made in earlier chapters) and to estimate the associated cost of treatment assuming no change in the environment policy, except the enforcement of treatment and safe disposal of waste by the industry;
2. to assess the current policy response to regulating pollution externalities; and
3. to propose more cost-effective policy alternatives based on the cost-minimization and polluter pays principles; the concept of an environmental fund is developed which would consist of waste charges and bonds that would enable the industry to deal effectively with industrial pollution at the lowest possible cost, within the Thai context.

The rapid growth of industrial pollution in Thailand in recent years is a reflection of five factors as follows:

1. The rapid rate of economic growth
2. The equally rapid rate of the economy's structural transformation away from agriculture and toward industry
3. The structural change of industry away from traditional food-processing industries, which generate biodegradable waste toward large-scale, heavy industries, such as petrochemicals, which generate heavy metals and other hazardous wastes
4. The heavy concentration of industry in the Bangkok Metropolitan Region (BMR) and its satellite provinces
5. The ineffectiveness or lack of enforcement of industrial pollution control regulations.

On the positive side, the shift from import substitution industrialization in earlier years to export promotion more recently has meant more reliance on the low-cost-labor industries, which may also pollute less per unit of value added. The concentration of industry also implies certain economies of scale in pollution control and treatment that may partially offset the loss of natural assimilative capacity by overloading. Finally, the high profitability of much of Thai industry suggests a degree of affordability of pollution control expenditures without a significant loss of international competitiveness. Given Thailand's relatively large size and the considerable assimilative capacity of its environment, the current level of industrialization and implied pollution load would not present a serious problem if it was evenly distributed throughout the country. While hazardous waste always presents a problem, most other pollutants—especially biodegradable wastes—could be assimilated if widely distributed. In Thailand, however, (unlike Taiwan, for example), industry is highly concentrated in the BMR and its surrounding provinces, whose landscape, air and water bodies are receiving pollution levels far in excess of their assimilative capacity. Fifty-two percent of industries (76 percent in terms of the GDP) are located in the BMR (Figure 6.1). This area also embraced twelve industrial estates out of twenty-three in 1989 (Figure 6.2). In addition, analysis of five heavily hazardous-producing industries (including basic metal, fabricated product, transport equipment, electrical machinery and chemicals) showed that 10,152 out of 15,126 factories are located in the BMR area and employ about 88 percent of the total number of workers occupied in these five industries. In term of air pollution, about 30 percent of total emitted sulfur dioxide (SO_2) is attributed to industrial activities and approximately 54 percent of industrial emissions of SO_2 are released within BMR.

The concentration of industry has two negative and two positive implications for the environment. On the negative side, the concentration of industrial waste in a limited space destroys the environment's natural assimilative capacity through overloading. The proximity of this waste to the country's larger urban centers increases the potential damage from industrial pollution as well the cost of treatment due to the mixing of heavy metals from industry with biodegradable waste from households. On the positive side, the concentration of industry and, hence, industrial waste in and around Bangkok means (1) economies of scale in pollution control and treatment, and (2) that the rest of the country is virtually free of industrial pollution.

The government's policy to decentralize industry into the rural areas, to reduce congestion, and to spread the benefits of industrialization should also take into account the inherent environmental pros and cons. It may prove wiser in the long run to promote a limited number of clusters of industry immediately outside the BMR, rather than throughout the countryside. Taiwan, for example, is now experiencing problems with its comprehensive rural industrialization policies and programs.

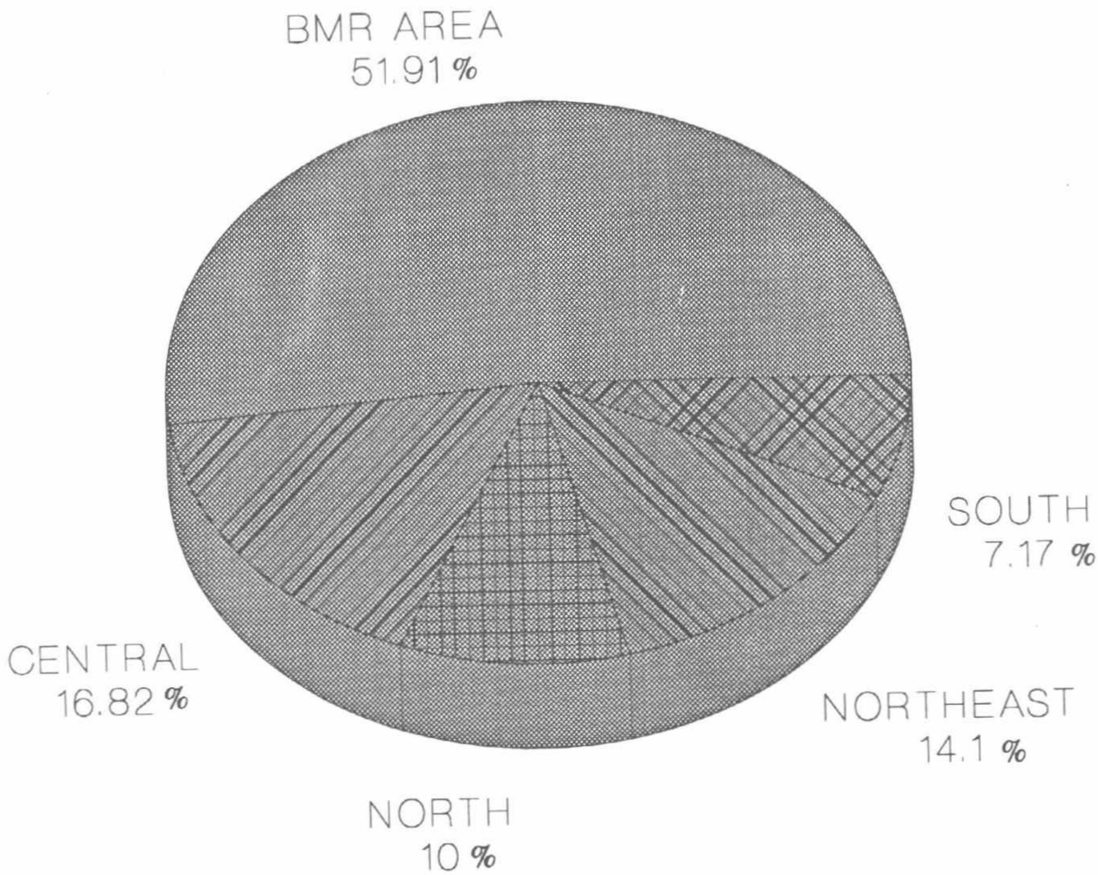


Figure 6.1 Distribution of Registered Factories by Region (1989)

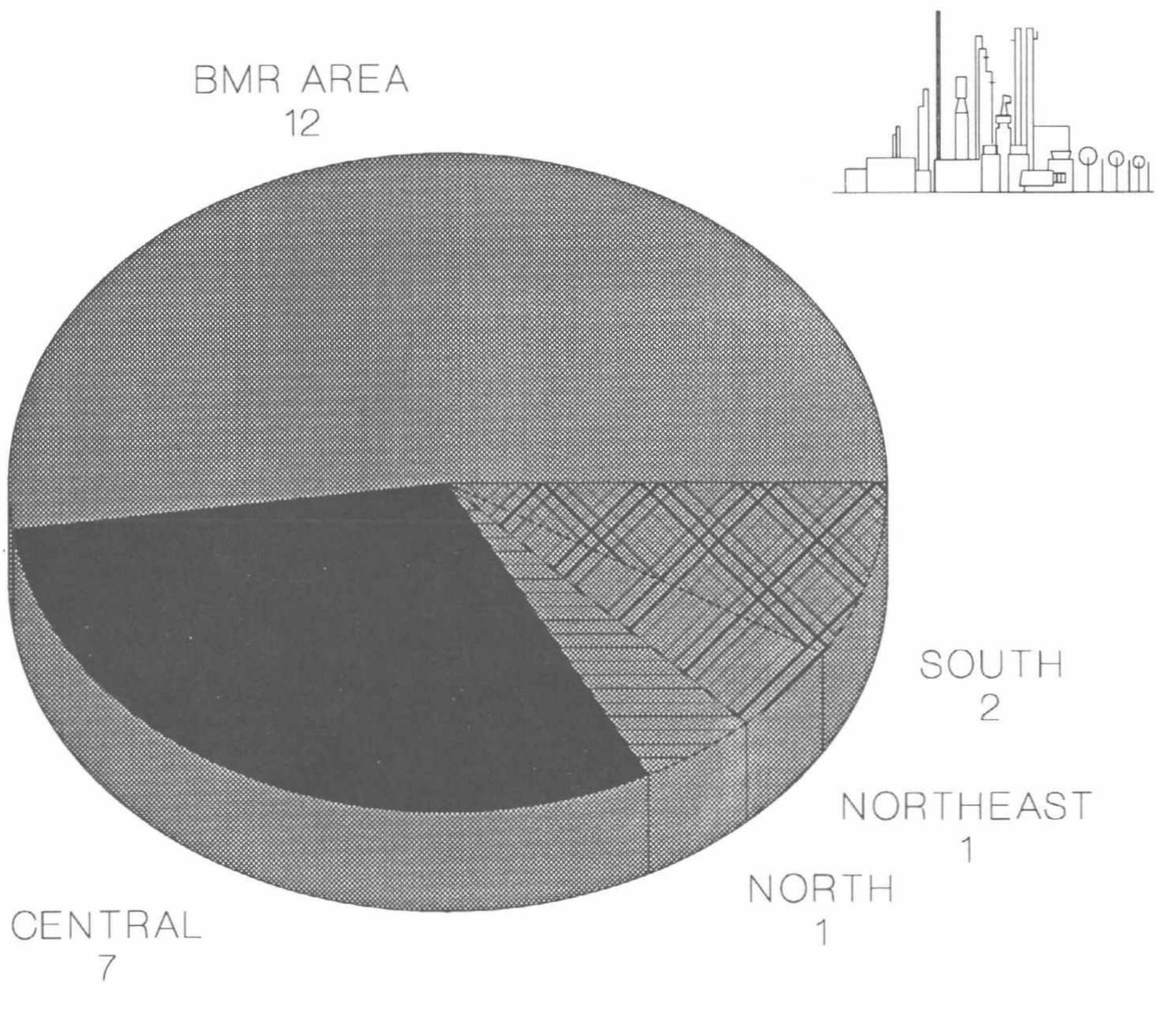


Figure 6.2 Number of Industrial Estates by Region (1989)

PROJECTION OF INDUSTRIAL POLLUTANTS

Industrial Hazardous Waste

The manufacturing sector is by far the largest generator of hazardous waste, ranging from heavy metals to toxic chemicals and from solvents and acid waste to organic and inorganic sludge. In terms of volume, 90 percent of all hazardous waste is generated by manufacturing, 4 percent is generated by hospitals and laboratories, and 1 percent is generated by municipalities. In terms of risk and likely impact on health, hospital waste is more significant than its small share suggests, because of the far larger numbers of people that are exposed to it.(see Table 6.1) However, what is particularly alarming about industrial hazardous waste is the projected rapid growth of such waste both in quantity and hazard as Thailand becomes further industrialized. In the absence of effective controls, what determines the volume of hazardous waste is the profitability of the hazardous waste producing industry vis-a-vis other industries. Since most industrialized countries require and enforce proper treatment and disposal of such waste, the industry tends to have a comparative advantage in, and to flow to countries with lax environmental regulations. As an export-oriented, rapidly industrializing country, Thailand is inherently at risk of attracting the "wrong" type of industry.

With the notable exception of the Bang Khuntien treatment center in Thon Buri, the bulk of hazardous waste that is generated in Thailand is currently dumped freely into rivers and landfills or stored in drums on site with little or no treatment. While no assessment of the risks involved have yet been made, the experience in other countries, such as the US suggests considerable risk to both public health and groundwater supplies. The Public health statistics in Thailand indicate that the incidence of occupational diseases, adjusted for population growth has increased 4.4 times between 1978 and 1987 (Ministry of Public Health, 1990).

Industrial Biodegradable Waste

It is estimated that approximately 0.5 million tons of BOD load will be generated in 1991 by selected industries that are major generators of biodegradable waste: sugar factories (29.3%), pulp and paper industries (19.6%), and rubber industry (18.4%). The balance is contributed by beverage industry, tapioca mills, slaughter houses, canned fish and crustacean industries, tannery factories and the canned pineapple industry, in that order. Projections indicate that the BOD load would rise to 0.78 million tons by the end of Seventh Plan (1996) and to 1.9 million tons by 2010, with the BOD share of beverage, rubber, slaughter houses, the canned fish and crustaceans and canned pineapple industries reduced, and that of sugar factories, pulp and paper industries, the tannery and tapioca

Table 6.1 Hazardous Waste: Environmental Risk Factors and Cost Effectiveness of Treatment, 1991

Hazardous Waste Type	Waste Tons (a)	Relative Risk Factor	Exposed Population Million(b)	Environmental Risk Factor(c)	Cost of Treatment Baht per ton	Cost of Treatment 1,000 Baht	Risk Reduction Per Mill of Baht	Risk Reduction Rank
Oils	219,467	1	57	13,000	637	139,822	100	9
Liquid organic residues NH	21	1	17	0	577	12	0	12
Liquid organic residues H	290	1,000	17	5,000	8,343	2,419	2,100	6
Organic sludges - NH	1,563	1	16	0	577	902	0	11
Organic solids NH	1,759	1	16	0	8,343	14,675	0	11
Organic sludges and solids H	3,352	1,000	16	54,000	8,343	27,966	2,000	7
Inorganic sludges and solids	19,254	1	42	1,000	146	2,811	500	8
Heavy metal sludges & solids	136,810	10,000	13	17,785,000	158	21,616	823,000	1
Solvents - H	6,806	100	41	28,000	1,976	13,449	2,100	6
Solvents - NH	29,357	10	41	12,000	3,195	93,796	100	10
Acid waste	125,428	100	32	401,000	257	32,235	12,500	4
Alkaline wastes	34,235	100	33	112,000	77	2,636	42,800	3
Off spec products	25	1	7	0	2,907	73	0	11
PCB	247	10,000	11	27,000	*	*	*	*
Aqueous organic residues	242	100	10	0	146	35	0	11
Photo wastes	16,345	100	52	85,000	54	883	96,300	2
Municipal wastes	11,757	1	75	1,000	2,410	28,334	10	10
Infectious wastes	76,075	100	57	434,000	577	43,895	9,900	5
Total	683,003	-	-	-	626	427,620	-	

* Thailand has stopped importing PCBs, since 1985. PCB waste from past imports is currently sent abroad for treatment.
H = halogenated
NH = nonhalogenated
(a) Estimated quantities in 1991
(b) 1991 population in provinces where specific waste type is being generated
(c) Waste quantity x relative risk factor x exposed population/1,000 rounded off to nearest 1,000.
Source : Engineering Science,Inc,(1989)

Table 6.2 Biochemical Oxygen Demand (BOD) Load to Major Rivers in Thailand, 1986

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
No.	River Name	DO of River (mg/l)	Std. DO (mg/l)	No. of Factories	Flow 1000 cu.m (Per Year)	BOD Load (Tons/Yr)	70% Cost of Treatment (Million B.)	Treatment Residual BOD (Tons/Yr)
1	Bang Pakong	4		135	13,997	86,761	60.73	26,028
2	Chao Phraya	0.3	2	351	53,224	81,426	57.00	24,428
3	East Coast Gulf			123	16,345	80,427	56.30	24,128
4	Mun	3		84	7,350	75,867	53.11	22,760
5	Thachin	< 2	2	376	166,757	56,033	39.22	16,810
6	Mae Klong	> 4		22	47,741	48,910	34.24	14,673
7	Ping			17	125,087	30,254	21.18	9,076
8	Nan			19	101,866	21,819	15.27	6,546
9	Chi			82	18,015	19,106	13.37	5,732
10	Khong			55	1,532	7,091	4.96	2,127
11	Prachinburi			27	281	4,618	3.23	1,385
12	Wang			13	1,517	3,719	2.60	1,116
13	Yom			5	102	296	0.21	89
14	Kok			2	18	55	0.04	16
	Total			1,311	553,833	516,381	361.47	154,914

Source: Department of Industrial Works, Office of the National Environment Board(1986), Department of Health (1986).

Note: (3) This amount of load covers only factories under monitoring scheme of the Department of Industrial Works.
(6) Assuming cost of treatment = 1000 baht / ton.

mills increased. Most of this above-mentioned biodegradable waste is discharged untreated in the form of industrial effluent into public water bodies. The Industrial effluent combines with wastewater from households to reduce the dissolved oxygen (DO) in rivers to levels below ambient standards. Chao Phraya and Tachin rivers are already below the ambient standard set by the National Environment Board (NEB) and are at risk of becoming anaerobic in certain heavily polluted sections for part of the year. The monitoring data of the Department of Industrial Works (DIW) for 1986 (the year for which data are most complete) indicate that the total BOD load in 14 rivers has reached 516,000 tons. At a cost of 1,000 baht per ton of BOD, a 70 percent level of treatment (using waste stabilization pond system), would cost about 368 million baht. The treatment of the projected industrial BOD load for 1991 at a 70 percent level would cost as much as 367 million baht which is 1 percent of the 1991 GDP of the BOD-generating industries (See Tables 6.3 and 6.4). This could be an overestimate despite the use of conservative figures. In addition to wastewater treatment costs, some measures that will contribute to controlling industries wastewater include the following:

- The proper use of water pricing would reduce the amount of wastewater discharge.
- charging waste-generators for wastewater treatment would induce efforts to minimize waste.
- Unlike hazardous waste, central water treatment is not always the lowest-cost approach to water pollution control.

Industrial Gaseous Emissions

There are four gaseous emissions from industry that are significant in terms of emission volume and that should be given priority consideration: sulfur dioxide (SO_2), nitrogen oxide (NO_x), carbon dioxide (CO_2), and suspended particulate matter (SPM).

Within the manufacturing sector, gaseous emissions vary both in terms of manufacturing output and by the type of fuel used. From 1986 to 1996, SO_2 emission was contributed mostly by the nonmetal, food, textile, and paper industries. From 2001 to 2011 the structure of emissions from manufacturing will change somewhat, with textiles overtaking food in terms of SO_2 emission.

The emission perspective from 1991 to 2011, which is projected using a base case scenario of economic growth and assuming existing environmental regulations on air quality standards, shows a large increase in gaseous emissions from all manufacturing industries. Although the industrial sector does not dominate the emissions of gaseous

Table 6.3 Cost of Treatment at 70% Level

				(Million Baht)	
Industry	1991	1996	2001	2006	2010
Sugar	107.6	162.7	224.8	305.5	396.1
Pulp & paper	71.9	113.4	163.4	231.7	310.8
Rubber	67.6	96.3	124.4	157.6	193.2
Beverages	63.9	91.7	119.9	154.3	191.6
Tapioca	28.2	43.2	60.7	83.7	109.9
Slaughter	10.8	12.7	13.7	14.5	15.4
Canned fish & crustaceans	7.6	10.9	14.3	18.4	22.8
Tannery	7.4	14.6	28.2	54.8	95.4
Canned pineapple	2.6	3.2	3.7	4.2	4.6
Total	367.7	548.8	753.1	1,024.8	1,339.7

Note: Assuming that a waste stabilization pond system is employed with a cost of 1,000 B/tonBOD.

Table 6.4 Cost of Treatment per Industrial GDP

					(%)
Industry	1991	1996	2001	2006	2010
Sugar	3.33	3.35	3.37	3.39	3.40
Pulp & paper	2.82	2.82	2.82	2.82	2.82
Rubber	1.42	1.23	1.06	0.91	0.81
Beverages	0.44	0.44	0.44	0.44	0.44
Tapioca	5.29	5.29	5.29	5.29	5.29
Slaughter	0.60	0.60	0.60	0.60	0.60
Canned fish & crustaceans	0.12	0.12	0.12	0.12	0.12
Tannery	0.57	0.57	0.57	0.57	0.57
Canned pineapple	0.17	0.17	0.17	0.17	0.17
Average	1.05	1.05	1.04	1.03	1.02

Table 6.5 Comparison of Gaseous Emission vs. Fuel Cost in the Manufacturing Sector

Fuel Type	Cost / Unit		Baht Per KTOE (x 1,000)	Tons of Emission / Tons of Fuel in KTOE			
				SO2	NOx	CO2	SPM
Coal	1785	B/t	2,859.71	15.26	16.06	3,702.20	89.92
Lignite	550	B/t	1,261.64	68.47	27.95	3,692.30	167.69
LPG	9.9	B/kg	8,483.15	0.01	1.98	2,980.30	0.05
Distill (HSD)	6.2798	B/l	7,285.32	19.73	4.41	2,978.90	0.58
Fuel oil	2.9898	B/l	3,176.55	60.59	7.02	2,979.00	3.21
NG	70	B/MTU	2,834.71	0.00	3.31	2,129.80	0.06
Fuel Wood	0.7	B/kg	1,849.50	1.32	3.18	4,045.60-	10.58
Bagasse	0.27	B/kg	1,513.96	1.69	3.37	4,044.60	44.94

Source: Thailand Development Research Institute, 1990.

Table 6.6 Industrial Use of Fuels, 1988

Fuel Type	Quantity (KTOE)	(%)
Coal	239	4.82
Lignite	568	11.45
LPG	90	1.82
Distill (HSD)	184	3.71
Fuel Oil	1,512	30.50
NG	60	1.22
Fuel Wood	558	11.25
Bagasse	1,746	35.22
Total	4,957	100.00

Source: Thailand Development Research Institute, 1990 pollutants when compared with other sectors such as electricity generation and transportation, it is a major contributor of SO_2, and is responsible for 21 percent of SO_2 pollution in 1990 and 29 percent by the year 2011.

Table 6.5 compares the relative costs of various fuels used by the industry to the corresponding rates of pollutants (SO_2, NOx, CO_2 and SPM) in tons of emissions per thousand tons of oil equivalent (KTOE). Among the eight types of fuel used in the industrial sector (see Table 6.6), lignite has the lowest cost of 1,262 baht per KTOE (1988), but in terms of gaseous emissions, it generates higher levels of SO_2, NO_x, and SPM than any other fuel. The attractive, low price of lignite is driving industries to convert their boilers to use lignite as their main energy source. The consequence of this conversion will be a sharp rise in the emission of pollutants into the atmosphere given the current lack of emission controls. A number of policy options exist for controlling emissions by the industry ranging from emission standards and control technology to comparative fuel pricing.

REGULATING POLLUTION EXTERNALITIES

While industrial waste is an inevitable byproduct of industrialization, industrial pollution need not grow in proportion with industrial growth and can be minimized by the implementation of several measures as follows:

1. A shift toward less heavily polluting industries would reduce the growth of industrial pollution below the rate of industrial growth.
2. A shift to more efficient industrial production and energy-generating technology would further reduce industrial pollution per unit of the GDP.
3. A switch toward less polluting or less hazardous raw materials would also reduce industrial waste in both quantity and toxicity.
4. The geographical dispersion of polluting industries would reduce the ambient concentrations of hazardous pollution and would increase the effective assimilative capacity of the receptors (except at very low levels of hazardous waste, concentration of hazardous-waste-generating industries may, in fact, reduce the problem by facilitating control, collection, treatment and disposal).
5. The application of waste treatment reduces the quantity and toxicity of industrial waste, while proper disposal reduces the associated damage to both human health and the natural environment.

The waste- or damage-minimizing changes in production technology, plant location, or waste treatment and disposal will not be taken voluntarily by the individual firms that generate the waste firms for the following reasons:

1. Industrial pollution and its associated damage to other individuals, activities, or the environment is an "externality" that does not perceptively affect the waste-generating firm's operations.
2. Waste reduction or treatment involves additional expenditures, which increase production costs and reduce competitiveness. Thus, in the absence of some form of regulation, free disposal of uncontrolled and untreated waste is the most "economical" and therefore preferred option of private industry.

The Current Policy Response

The Thai government, cognizant of this fact and of the potential hazards from industrial pollution, has over time enacted several laws and regulations introducing effluent and emissions standards as well as ambient standards for various industrial pollutants. The National Environmental Quality Act (NEQA), the Public Health Act (PHA), and the Factory Act (FAC) are aimed at controlling industrial pollution and are fully discussed in Chapter 5.

Several government agencies are involved implementing environmental laws and regulations, most notably, the DIW which is a part of the Ministry of Industry (MOI); the Industrial Estate Authority of Thailand (IEAT); and the Department of Health (DOH) which is a part of the Ministry of Public Health (MOPH); The DIW, which administers the Factory Act, has instituted licensing schemes for industrial discharges, effluent standards, factory monitoring and central treatment facilities for hazardous waste. Enforcement is done by controlling the issuing of licenses for construction, operation, renewal and expansion, based on the adequacy of the waste treatment facilities. The DIW also provides assistance with the design of private treatment facilities as well as the construction of central facilities and it investigates industrial-pollution-related complainants. The IEAT, a public enterprise under the Ministry of Industry, is responsible for pollution control and treatment within the industrial estates, all of which are outside the jurisdiction of the DIW. While all industrial estates provide wastewater treatment facilities, the IEAT does not have a formal environmental unit—which makes pinpointing the potentially key role of industrial estates in pollution control a difficult task.

Similarly, the Board of Investment (BOI), which has wide discretionary powers to promote both domestic and foreign investments, especially in industry, has not used environmental impact assessments (EIAs) (for example, level of pollutants or quantity of hazardous waste per unit of value added) among its selection criteria for targeted industries that receive investment incentives. The result has been the inadvertent promotion of the increasingly polluting industries over the less polluting ones. An analysis of BOI-promoted industries indicates that the proportion of approved investment for hazardous-waste-generating industries has increased from 25 percent in 1987 to 55 percent in 1989 (as discussed more extensively in Chapter 5).

Although the existing regulations and institutions, though appearing to be adequate on paper, have been largely ineffective in controlling industrial pollution for reasons ranging from diffusion of authority to lack of coordination and lax enforcement. Consider, for instance, the procedure for jointly implementing the Factory Act and the NEQA. The law requires that applications to the DIW for the establishment and operation of new factories above a certain size must be accompanied by an environmental impact assessment (EIA), which should be submitted for review to the NEB before licensing by the DIW. The NEB, in turn, conducts an internal review of the EIA, with no public participation (EIAs are treated as confidential) and recommends approval, modifications or disapproval to the DIW. The NEB is not vested with the authority to prevent implementation of projects with an unsatisfactory EIA or to monitor and to enforce its recommendations or the agreed EIA provisions; it can only recommend disapproval of a subsequent EIA submitted with a license renewal application. Even if the license is not renewed, the environmental damage caused by the failure to implement the earlier conditions remains.

Factory licensing often proves to be too blunt an instrument for industrial pollution control. The most notable application has been the case of a heavily polluting pineapple factory in Cha Am, whose license of operation was withdrawn after two years of ignoring warnings against waste water dumping. Violation of effluent standards by failing to treat waste does not carry fines but warnings, which rarely materialize, even following repeated violations.

The same difficulties hold for BOI-promoted investments and industrial estate projects under the IEAT, which also require prior approval of an environmental impact assessment (EIA) by the ONEB. Furthermore, IEAT's overall organization does not indicate a real commitment to environmental responsibility, despite the existence of a site office for waste analysis. As earlier, the IEAT does not have an environmental unit, and of the 23 industrial estates in operation in 1989, none are known to have an operating hazardous waste treatment facility. While all industrial estates report having waste water treatment facilities, it is still not known how many actually operate, and at what level of treatment efficiency.

It is often argued that the problem is a lack of technical manpower and financial resources (e.g., White and Emani 1990). This is true to some extent. For example, the Industrial Environment Division of the DIW has only 143 staff for some 50,000 industrial plants (one staff for 350 factories) and a budget of only 1,900 baht per factory. These resources are grossly inadequate for implementation of regulations, monitoring, and enforcement.

The existing institutions and regulations for dealing with industrial pollution, designed under entirely different circumstances, are clearly inadequate for dealing with emerging industrial pollution problems. One problem is that existing institutions and regulations were put in place at a time when the country had less than 500 factories and was struggling to industrialize through generous incentives for import substitution. Thailand now has more than 50,000 factories and is one of the world's most rapid and successful export-oriented industrializing economies. In the 1960s there were hardly any factories producing hazardous waste; today, 33 percent of all the factories in the country are hazardous producers. Even in the 1970s there was a river with a BOD load with a BOD load exceeding its assimilative capacity. Today, virtually every river in and around the BMR is at risk of becoming anaerobic.

The times have changed dramatically, but the institutions and regulations have changed only marginally. In addition, Thailand existing environmental regulations, which replicas of foreign regulations with a considerable time lag, have little grounding in Thai reality and culture and are, therefore, largely unenforceable. The fact that agencies responsible for their enforcement are not given in the authority and the means for enforcement is symptomatic of this problem. Like many other developing countries that followed the environmental regulation example that developed countries set some 10 years to 15 years ago, Thailand based its environmental regulations on "command-and-control" standard-setting instruments. These instruments set inflexible effluent standards or waste treatment requirements coupled with sanctions for non-compliance, rather than setting, flexible, market-based mechanisms and incentives (such as proper pricing, pollution charges), which are now increasingly being used by the developed countries. While the conventional view is that market-based mechanisms are not as suitable for developing countries as command-and-control machenisms, the reality is that, "...for cultural reasons, the Thai society is not given to litigation, and courts are used only when everything else fails. Each of the major environmental regulations nonetheless stipulates a term of imprisonment and/or fine for a violation of that regulation. ..." (White and

Emani 1990). In Thailand, very few environmental violations reach the courts, and fines are negligible in comparison to the benefits gleaned from violations. On the other hand, the imperatives of the market are laws that one can only ignore to his peril. Therefore, internalizing industrial pollution though proper pricing and other market-based incentives is even more necessary and suitable for developing countries such as Thailand than for developed countries, especially if the objective is a measurable improvement of environmental quality.

With pollutants becoming increasingly hazardous, and accumulating at an exponential rate of at least 15 percent per year, no piecemeal patching up of existing regulations will reverse the trend. Without an effective mechanism of industrial pollution control, Thailand is likely to acquire the dubious reputation of being a "pollution haven," and will increasingly attract heavily polluting industries rather than low-labor-cost industries spun off from other countries. The structural change of Thai industry toward pollution-intensive industries, the continued rapid acceleration of industrialization for the next two decades, and the declining assimilative capacity of an already overloaded environment will accelerate environmental degradation—lead to a reduction in the quality of life, and ultimately constrain growth itself. The risks in this scenario include the discouragement of foreign investors in the long run, damage to the thriving tourist industry, and retaliatory tariffs being set by countries with higher effective environmental standards in response to perceive unfair trade

Policy Alternatives for Industrial Pollution Control: The Five Principles

In designing effective policy instruments for industrial pollution control, the following five principles need to be observed:

The Ambient Quality Target: Ambient quality is the ultimate objective in pollution control, and it can be achieved to various means; uniform effluent standards and level of waste treatment are only two instruments, and they are rarely the most efficient. The target ambient quality standard should design to be specific, monitorable, and verifiable.

The Minimum Cost Principle: The desired ambient quality standard must be attained at lowest possible cost to the economy including: (1) cost to the regulatory agency, such as monitoring and enforcement costs; and (2) costs to the industry, such as a reduction in output and an increase in the pollution control costs. This implies that the chosen policy instrument must be enforceable in the Thai context, at a relatively low cost, and with a minimal "leakage" and distortions.

The Polluter Pays Principle: The polluter pays principle is now widely accepted throughout the world, and it is critical that the chosen policy instrument be self-financed and perceived to be equitable to all parties involved. While the payment is collected from the industrial producer, the ultimate pollution charge is shared between the producer and the consumer in a proportion determined by the elasticity of product demand. In the case of an exported commodity sold in competitive world markets and facing infinitely elastic demand, the full burden is assumed by the producer; therefore, his competitive position may be affected. Hence, the following two principles should be considered:

The Competitiveness Imperative: The policy instrument chosen should not significantly reduce the **overall** competitiveness of Thai industry, although it would unavoidably change the industrial mix in the medium-to-long run, if it is effective at all. Maintaining competitiveness while controlling pollution implies the existence of inefficiencies that the chosen instrument should seek to reduce.

Policy Transitions: Changing the industrial mix from high- to low-polluting industries is one of the goals of an effective pollution control instrument. However, because investments have already been made under "pollution haven" conditions that will take time to depreciate, structural changes will also take time. Therefore, for both fairness and efficiency, allowance must be made for adjustment during the transition period. The new policy is also likely to be more acceptable to the industry if it is gradually phased in over an appropriate period. **The stability and predictability** of the policy is critical if industrial investment is to be gradually shifted from high- to low- polluting industries.

ECONOMIC INCENTIVES FOR INDUSTRIAL POLLUTION CONTROL

In choosing an appropriate pollution control instrument that fulfills all these conditions, consideration must be given to the type of industrial waste and to the scale and geographic distribution of industry. A central treatment facility is likely to be suitable for hazardous-waste-producing industries because hazardous waste cannot be assimilated by the environment and is harmful even in small quantities. To ensure that such waste is properly treated and safely disposed of, as well as to benefit from economies of scale in treatment, a central treatment facility can best fulfill the stipulated conditions, provided it is appropriately financed and operated as discussed below. Another case where a central treatment facility might be suitable is for small-scale industries concentrated in a given location. This type of facility would afford them economics of scale in joint waste treatment.

A Move in the Right Direction: The Bang Khuntien Experiment

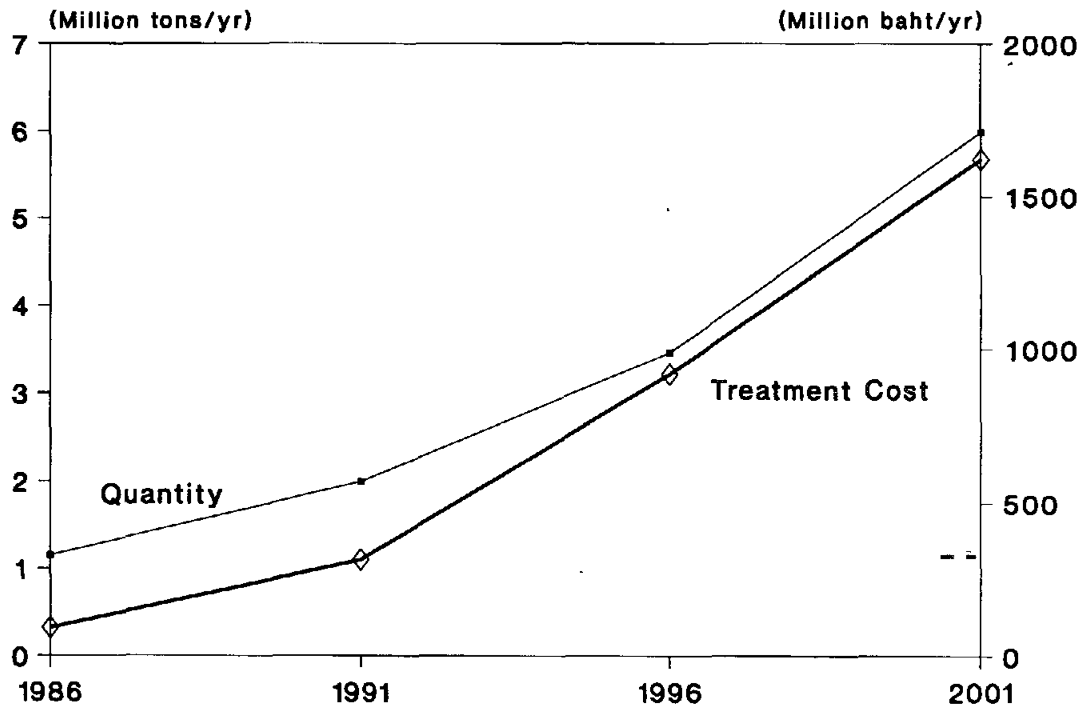
The Bang Khuntien Treatment Center was established in 1988 by the MOI to deal with the problem of the heavy-metal-contaminated wastewater that was generated by 200 small- and medium-scale electroplating factories scattered around Bangkok. The operation of the Bang Khuntien facility was leased for five years to a private company, Siam Control Co. (SCC), which is solely responsible for all waste collection, transportation, treatment, and disposal activities associated with the facility. Between September 1988 and May 1990, the company received and treated 8,300 tons of hazardous waste from 46 electroplating factories, 20 electronics factories and a few automobile and lamp manufacturers. A "waste manifest system" is used to track the waste from the factory to the treatment facility to ensure no discharge along the way. A service fee for waste treatment (450 baht per ton) is assessed and charged to the factory generating the waste treated, and the charge varies according to the type and quantity of waste and the distance of the factory generating the waste treated, and the charge varies according to the type and quantity of waste and the distance of the factory from the facility. Despite the risks of transporting hazardous waste on congested roads and the difficulty of finding appropriate disposal sites, the facility is considered a successful experiment. The key to the operation's success has been a contracting arrangement between the MOI and the factories involved to supply a given quantity of waste to the Bang Khuntien treatment center at an agreed upon cost which is sufficient to cover the facility's operating costs. What is less clear in this plan is the issue of what happens to the hazardous waste that is produced in excess of the contracted quantity. If this excess is a substantial amount, and it is illegally disposed of, a hidden "subsidy" is involved which should be added to the explicit subsidy from not recovering the capital and land cost of the facility and disposal site. Yet the Bang Khuntien treatment center is an innovative model to try to improve upon.

An Environmental Fund Initiative for Hazardous Waste Management

Building on the Bang Khuntien treatment center experiment, the establishment of an environmental fund is proposed for the central treatment of hazardous waste throughout Thailand. Hazardous waste was projected, in an earlier chapter, to reach 1.9 million tons by 1991. However, not all hazardous waste can be cost-effectively managed through central treatment facilities. In the following discussions, metal smelting, the single largest producer of heavy metals is excluded from consideration, because smelter generated hazardous wastes "are relatively stable and can usually be kept on site by appropriate containment measures" (Engineering Science Inc. et.al. 1989). Even with the exclusion of metal smelting, heavy metals from other industrial processes present the greatest environmental risk because of both their large quantities and high relative risk factor (see Table 6.1). Infectious waste is the second largest threat in terms of environmental risk, but it will also be excluded because the focus on the study is on manufacturing waste. This leaves 595,000 tons of industrial hazardous waste (in 1991 figures) that require proper collection, treatment and disposal—at the minimum possible cost. In terms of cost effectiveness (i.e.. that is, risk reduction per million baht of expenditure), the priority for collection, treatment, and disposal should go to heavy metals, photo wastes, alkaline wastes, and acid wastes (see Table 6.2). Not only should the generated waste be traced, recovered, treated, and disposed at the minimum possible cost without sacrificing safety standards, but the generation of the waste itself must be minimized. Therefore, an ideal hazardous waste management system should provide generators of waste with the incentive to both minimize waste and fully declared it for treatment and safe disposal.

The objective of the proposed environmental fund is not only to fund treatment and proper disposal for waste, but also to encourage waste minimization. The environmental fund would be financed from charges to hazardous waste generators in proportion to their type and quantity of waste and its transport distance from the treatment facility. The charge should be set at the clean-up cost, which is about two times the treatment and disposal cost. The latter cost was estimated at an average of 1,000 baht per ton, including transport, treatment and disposal costs. In actual implementations, the charge would vary according to type and quantity of waste and the transport distance involved (see Table 6.1). At a 1991 projected level of industrial hazardous waste of (600,000 tons), a 2,000 baht per ton charge would raise 1.2 billion baht. Fifty percent of this amount would constitute an environmental fund for hazardous waste and the rest would be deposited into an escrow account earning interest on behalf of hazardous waste generators. Once the contracted waste delivery for treatment was made in full, the funds and interest in escrow would be returned to the waste generator concerned. In essence, the environmental fund would be used to treat and properly dispose hazardous waste while the Escrow Account acts as a bond to ensure delivery of waste, while the escrow account would act as a bond to ensure delivery of waste and additional funds for clean-up of any untreated waste that was disposed by generators or not delivered for treatment. The implementation of the proposed scheme would help arrest the exponential growth of hazardous waste and the even faster growth of the cost of treatment presented in Figure 6.3.

Figure 6.3 Projected Hazardous Waste Quantities and Treatment Cost



preliminary estimates;treatment cost not including collection, transport and disposal cost

Two related problems arise as a result of the proposed environmental fund. First, how is each factory's hazardous waste output determined given the obvious incentive to underreport? There are a number of options that can be used individually or in combination to solve this problem. There are fairly accurate parameters for hazardous waste generation by type, production process, and output capacity (for example, see Engineering Science, Inc. 1989). The deliverable waste could be set based on these parameters on the average for the whole industrial group's previous year's statistics and/or monitoring results.

This raises the second issue: how to detect a factory that produces more waste than the industry average and illegally disposes of the excess quantity to avoid additional payments. At the other extreme, a firm may contend that it generates less waste.

To deal with these two issues, an environmental auditing system is recommended. This proposed system, when combined with random inspection of the production process, should minimize unreported wastes, verify claims of reduced waste generation that would qualify generators for rebates, and lower waste coefficients during subsequent years.

The implementation of the proposed system would be consistent with, facilitated by, the introduction of a value-added tax system. The contribution of the industry to the environmental fund through the hazardous waste charge amounts to about 0.2 percent of the industry's valued added (see Tables 6.7 and 6.8) or one percent of its profits, assuming a conservative 20 percent profit rate. The more efficient the industry is in its production process, the less waste it generates, and the less it has to pay for waste treatment and disposal. The industry thus has the incentive to reduce waste which should further reduce its expenditure on hazardous waste management.

Factory Licensing and Environmental Auditing

The implementation of the proposed environmental fund consisting of a hazardous waste charge and a waste delivery bond would be based on six elements in which environmental auditing plays a central role. The six elements are as follows:

1. **Presumptive waste generation rate** by type and size of industry would be based on technical engineering parameters, historical data, and monitoring statistics. It is important that such rates be set at the maximum rather than the average for the industry to induce efforts to reduce waste and qualify for rebates and reduction of charges.

Table 6.7 Total Cost of Treatment, 1991

(Unit: Baht)

Tsic [a]	Industry	Cost of Treatment: Treatment	Disposal	Transport	Total Cost	Hazardous Waste Industries GDP [b]	Cost/GDP (%)
321	Textiles	19,557,295	378,865	2,463,851	22,400,011	15,633,158,580	0.14
331	Wood - cork	157,053	265,484	193,627	616,163	3,004,315,200	0.02
332	Furniture - fixtures	390,943	660,854	481,984	1,533,780	12,191,600,000	0.01
341-342	Paper and printing	34,396,091	928,100	2,768,116	38,092,308	12,023,752,860	0.32
351-352	Chemical products	62,099,871	1,378,354	5,475,123	68,953,348	24,461,300,000	0.28
353-354	Petroleum products	4,366,113	343,657	441,598	5,151,368	36,284,400,000	0.01
356	Rubber-rubber products	18,745,721	131,405	1,167,315	20,044,441	21,616,800,000	0.09
381	Fabricated products	38,970,205	3,876,260	16,026,107	58,872,571	16,549,000,000	0.36
382	Machinery	40,884,136	648,580	4,121,796	45,654,512	16,736,100,000	0.27
383	Electrical machinery	18,586,364	1,741,773	7,255,075	27,583,212	17,461,100,000	0.16
384	Transport equipment	76,553,499	1,840,253	9,102,613	87,496,365	9,886,587,750	0.89
385-390	Miscellaneous nec.	607,615	53,610	243,726	904,951	5,362,728,930	0.02
	Total	315,314,905	12,247,195	49,740,930	377,303,030	191,210,843,320	0.20

Source: Engineering Science,Inc.et al (1989).
Note: [a] Thailand Standard Industrial Classification
[b] GDP at current price

Table 6.8 Treatment Cost of Treatment, 2001

(Unit: Baht)

Tsic [a]	Industry	Cost of Treatment: Treatment	Disposal	Transport	Total Cost	Hazardous Waste Industries GDP[b]	Cost/GDP (%)
321	Textiles	60,870,589	1,179,188	7,668,548	69,718,325	55,446,223,230	0.13
331	Wood and cork	485,304	820,363	598,320	1,903,987	18,365,212,800	0.01
332	Furniture - fixtures	1,661,626	2,808,831	2,048,580	6,519,037	36,535,800,000	0.02
341-342	Paper and printing	137209305.4	3304720.53	10173021.14	150,687,047	38,731,686,840	0.39
351-352	Chemical products	199,271,957	4,271,028	18,134,556	221,677,542	93,799,300,000	0.24
353-354	Petroleum products	10,397,369	1,069,753	1,344,666	12,811,788	118,492,000,000	0.01
356	Rubber-rubber products	76,027,318	502,149	4,575,598	81,105,065	116,144,500,000	0.07
381	Fabricated products	80,088,936	7,959,327	32,928,482	120,976,746	106,600,200,000	0.11
382	Machinery	132,413,831	2,384,109	13,511,301	148,309,241	66,428,800,000	0.22
383	Electrical machinery	60,108,060	5,669,981	23,614,717	89,392,757	69,839,600,000	0.13
384	Transport equipment	216,191,359	5,077,011	26,096,021	247,364,392	33,187,962,960	0.75
385-390	Miscellaneous nec.	2,572,621	236,765	1,033,088	3,842,474	23,967,318,360	0.02
	Total	977,298,277	35,283,226	141,726,899	1,154,308,401	777,538,604,190	0.15

Source: Engineering Science,Inc.et al (1989).
Note: [a] Thailand Standard Industrial Classification.
[b] GDP current price.

2. **An annual operation licensing system** which would require firms to apply annually for a license and to deposit an advance payment in the environmental fund for the collection, treatment, and disposal of the

hazardous waste. This deposit would be based on the projected amount of hazardous waste generated during the year based on the presumptive rates set for the type of industry, technology, and level of output. To guarantee delivery of waste, an equal amount of money would have to be deposited in the escrow account of the fund in the form of a bond or a bank guarantee (the bond would earn interest on behalf of the firm; but the bank guarantee would not). The current licensing system, which requires license renewal once every three years, is too blunt an instrument to control hazardous wastes in the rapidly growing and industrializing economy of Thailand. The licensing could continue to be done by the MOI following certification that the waste charge and bond had been deposited with the fund. Since licensing is an important component of the proposed fund, and many small firms are unregistered and unlicensed, the fund would initially focus on the large companies.

3. **The establishment of an industrial environmental fund** as an autonomous entity would be accomplished with the participation of the DIW, the Federation of Thai Industries (FTI), NEB, and the IEAT. The fund's management would set the presumptive rates, type, and size of industry; receive payments and bonds according to these rates; invest the funds in interest-bearing accounts; return the bond to the firm at a rate corresponding to the rate of delivery of waste; and finally pay the treatment facility for the treatment and disposal of delivered waste. The waste charge and bond for any undelivered waste at the end of the operation year would be withheld pending environmental auditing.

4. **Environmental auditing** would be facilitated by the advantage of environmental bonds, which would minimize the monitoring and enforcement requirements which are prohibitively costly and difficult to implement in developing countries. Compared to the high monitoring and enforcement requirements of regulations such as effluent standards, environmental bonds are largely self-enforced. But there is still some need to verify any claims of waste generation that are lower than the presumptive rates. Since the environmental auditing system aims to encourage firms to minimize the amount generated as well as to deliver all the amount they generate for proper treatment and disposal, it is important that the system have a means to verify a firm's claims that they produce lower amounts of wastes than the worst polluters in the industry (who, in effect, set the presumptive rates). The proposed environmental audit system would work very much like a combination of account auditing and tax auditing. However, it would be easier to implement and much less liable to underreporting or multiple record keeping because of the physical manifestations of waste generation, which (unlike revenue costs and profits that can be hidden) are subject to physical inspection and random monitoring.

Basically, the firm would be required to supply an accredited environmental auditor's report on its waste generation, management, treatment, and disposal before the end of each operating year. In the case of hazardous waste, the auditors' report would be submitted by the firm to the environmental fund as a means of clearing any remaining balance in its waste charges and bonds deposited at the beginning of the operating period. Even if no balance remained, the firm would have to submit the auditors report as a prerequisite for the return of the last month's bond. If the auditors' report showed waste generation within ± 5 percent of the presumptive rate, the firm would be entitled to return of the bond in full, with interest. No refund of, or additional payment for, a 5 percent discrepancy would need to be made, as long as any additional waste had been delivered. If the auditors report indicated more than a 5 percent deficit in the quantity of delivered waste, the firm would have a choice of (1) forgoing a refund beyond the 5 percent bond, or (2) filing for a rebate with interest. In the second case the fund would verify the firm's claim through at least two random inspections, or conduct its own audit, or both. If the firm's claim was verified, the balance of both the bond and waste recharge would be refunded to the firm in full, with interest, and the firm's presumptive rate of waste generation and, hence, payment for subsequent years would be reduced to the new rate established by this process.

The new rate would be valid for as long as the firm did not change its technology, and random inspections would not establish a new rate.

Environmental auditing could also be employed to verify that firms produce no more than the level of output for which they are licensed. Violations could result in a retroactive increase of waste charges and bonds, or in a suspension of the operation license.

Disputes are likely to arise, especially when the auditors or inspectors determine that hazardous waste has been generated and not delivered. The firm may challenge the auditors' assessment and protest against the withholding of its payments and bond for undelivered waste. In such cases, auditing by an independent, randomly selected auditor from among the accredited auditing firms would be binding to both parties.

Environmental auditing firms would be accredited by the fund and would also place a bond with the fund at a level of the highest individual presumptive payment within the group of industries they are accredited to audit. For example, to be eligible to audit a firm that is presumed to generate waste whose collection, treatment and disposal would cost 1.0 million baht, the audit firm would first deposit a bond of 1.0 million baht with the fund. An auditing firm found to behave contrary to the terms of the accreditation (including underreporting waste) would loose both its bond and accreditation. In all other respects, auditing firms would be private businesses, like accounting or consulting engineering firms. The demand for their services would be from two sources: (1) factories that would need to file annual environmental auditor's reports and (2) the fund itself, which would conduct its own random audits and inspections. Private firms would pay the costs of their annual auditing as well as the costs of random inspection needed to establish claims of lower rates of waste generation. Other audits initiated by the fund would be paid by the fund. Firms that were found in violation of their presumptive rates by more than 5 percent would be liable for both retroactive charges and for payment of auditing costs.

5. **Central treatment facilities** would be financed by the fund for hazardous waste control in such numbers and locations that each facility would be located within 50 kilometers from the industrial plants it intended to serve, and within 150 kilometers from the disposal facilities. These maximum allowable distances would be necessary to minimize the transportation costs and the risks of accidents and spillage of hazardous material. The construction and equipment of the facilities could be financed first through a loan from domestic or international financial institutions. The Industrial

Finance Corporation of Thailand (IFCT) and the International Finance Corporation (IFC) of the World Bank have environmental lending facilities which could be tapped for this purpose. The loan would be serviced and repaid by the fund using a part of the collected waste charges. The operation of the facility would be annually awarded to private waste management companies through competitive bidding. The bidders would bid for collection, treatment, and disposal of specified quantities of hazardous waste. For example, a company could offer to treat 50,000 tons per year at 500 baht per ton, or 100,000 tons per year at 400 baht per ton. The lowest bidder would win the bid provided that they met all other required qualifications. The successful bidder would operate the treatment facility, collect the waste, treat it, and dispose of it at a disposal site also specified by the fund. The operation of the site also would be auctioned and be separate from the waste treatment facility. Both the treatment and disposal facilities would keep records and would be subject to environmental auditing and random inspection. The companies operating these facilities also would be accredited and bonded with the fund. The independent environmental auditors' reports must be in agreement for: (1) the firms generating the waste, (2) the treatment facility, and (3) the disposal site. The overall capacity of the disposal facility, the efficiency of the treatment facility, and the licensed output (and hence waste) of the hazardous-waste-generating industries would provide the parameters for a cross-check and verification, of the auditors' reports. Any discrepancies over ±5% would be investigated by the fund.

For a hypothetical example of how the environmental fund and environmental auditing would work in practise, see Appendix 6.1.

6. **Special provisions for small, unregistered generators of hazardous waste should be taken into consideration.** The hazardous waste generated by small, unregistered firms should be accepted free of charge and "anonymously" (without indication of source) for treatment at the treatment facility. A small payment to the deliverer, which would cover transport costs (for example, 100 baht per ton) plus a small profit (for example, 100 baht/ton), could be made to encourage delivery. The cost of treatment should be absorbed by the fund if there is a surplus; otherwise, it should be covered by a special contribution from the government. At the same time, efforts should be made to bring as many of small, unregistered producers as possible into a legal framework where they could be licensed to operate and subject to the same charges and bonds as the larger factories. Accepting hazardous waste from unregistered sources is in the public interest, and payment by the government is consistent with the "polluter pays principle": the polluter cannot be identified at reasonable cost, and the social benefits from collection and treatment are presumed to exceed the collection and treatment costs. The fears that hazardous waste from registered firms would be sold to the treatment facility for profit are unfounded since no company would forego a 1,000 baht bond to earn a 100 baht profit.

Controlling Industrial Water Pollution (BOD)

The environmental fund for hazardous waste control and treatment could be expanded into an environmental fund for industrial pollution control that encompassed biochemical oxygen demand (BOD) discharged in industrial wastewater. However, because biodegradable waste is less hazardous and more voluminous, it cannot be economically collected and treated by a central treatment facility. It would be best controlled and treated at its source. It is proposed that a pollution charge based on the type of industry and level of output be collected in advance by the fund as a precondition of the annual licensing of factory operation by the DIW. As in the case of hazardous waste, the presumptive rate would be set at the maximum for the industry type and output level. Factories that produced lower levels of BOD could request rebates with interest. The Environmental Fund would conduct its own auditing and random inspection to verify the firm's claim. If the latter was verified, any excess charge would be refunded, with interest. A firm could, in fact, treat its own waste discharge, and claim zero BOD discharge into the public water body. In that case, all the pollution charge would be refunded following a verification of the claim. However, even in cases of treatment at source, a residual BOD is still discharged for which the factory would have to pay a reduced rate.

Under this system, factories would have a wide range of options for minimizing waste and, hence, they could reduce the pollution charge that they ultimately pay. They could reduce output, change their inputs, improve their technology, treat wastes, and relocate to areas where charges were lower. For this relocating purpose, they would be eligible to obtain a low-interest loan from the Fund. A group of factories would also be able to borrow collectively from the fund to build a joint or central treatment facility if this was the lowest cost option available to them. The fund could also be used for research on water pollution, on technical assistance to industry in pollution control methods, on technologies, monitoring, auditing, and inspection. A part of the fund could also be used to finance the central treatment of household waste, if this would permit attainment of the river's ambient standard with substantially lower charges for industrial waste (that is, if this was a profitable investment from the point of view of the industry which pays these charges).

The charge should be set at the average cost of treatment of wastewater of a given concentration of BOD corresponding to each industrial group. The average treatment cost in 1991 is estimated at 1,000 baht per ton of BOD for the industry as a whole. This assumes a 70 percent level treatment. At the projected 1991 BOD loading of 525,442 tons from nine industries which the major sources of BOD such as sugar, pulp and paper, rubber, beverages, etc., (see Table 2.11), a 1000 baht per ton of BOD charge would raise a fund of 368 million baht, or about 1 percent of the GDP of these industries (see Table

6.3). While this amount as a percentage of the relevant GDP figure is five times higher than that of hazardous waste treatment and disposal, it is still affordable. If we assume a 20 percent profit rate it would not exceed 5 percent of the generating industry's profits. Moreover, wastewater can be more easily treated than hazardous waste. A major contributing factor in the large quantities of wastewater generated by the Thai food industry is the very low cost of groundwater (1 baht to 2 baht per ton), and the absence of any charge for wastewater discharge, with the exception of few cases such as sugar mills. It is expected that the implementation of the proposed pollution charge for both wastewater and its BOD concentration can be reduced significantly and at a modest cost. Furthermore, the industry can recover a part of these payments in the form of low-interest loan and other assistance for waste treatment.

In all other aspects, the fund for biodegradable waste and water pollution would work exactly in the same manner as the fund for hazardous waste. In fact, the two funds could, and possibly should, be administratively joined to form one fund that would cover all forms of industrial pollution and be financed by appropriate charges for each type of waste. Environmental auditing is as central to biodegradable waste control as it is to hazardous waste control. Therefore, a significant new competitive and profitable industry, the environmental auditing industry, would thus be created in response to market demand, and would be accredited by the fund.

Industrial Air Pollution

The conversion of industrial boilers to lignite from other sources of energy is potentially the single major source of industrial air pollution in the foreseeable future. Lignite, a newly developed domestic source of energy, has a great cost advantage over all other energy sources: the three closer substitutes to lignite—coal, natural gas, and fuel oil—sell at 2 to 2.5 times the price of lignite per kilo ton of oil equivalent (KTOE). In terms of emissions of pollutants, however, lignite is by far the "dirtiest" source of energy. It produces 4.5 times as much SO_2, 1.5 times as much NO_x, and 2 times as much SPM as coal does. It pollutes substantially more than even heavy fuel oil, especially in terms of NO_x and SPM (see Table 6.5). In comparison, natural gas, which also a domestic energy source, produces no SO_2, only 12 percent of lignite's NO_X output, and virtually no SPM. Natural gas is also lowest in terms of CO_2, and, therefore, its potential impact on the accumulation of greenhouse gases in the atmosphere is reduced. (see Table 6.5). Lignite is preferred to natural gas by the manufacturing industry, however, because its cost advantage is directly beneficial to a firm, while its pollution disadvantage is a social cost that is not paid by the users, but by society.

Lignite is clearly underpriced for several reasons. First, the royalties paid to the government are minimal (18 baht per ton) and do not reflect its cost advantage over other fuels. Since the resource is state owned, and not private property, and minimum exploration is required, virtually all the rents should go to the government. Second, lignite mining results in considerable environmental damage to the landscape that may preclude future land use. While the Electricity Generating Authority of Thailand (EGAT) pays 4 baht per ton for reclamation costs, it is not clear that the private mines which supply industrial boilers make any reclamation cost payments. The key element in the argument against lignite is that it is just about the dirtiest source of energy possible at the consumption point. Its price should reflect this fact.

The burning of lignite and the resulting pollution and the damage to human health, property, visibility, and aesthetics is not discussed here, but if we judge from the experience of other countries that have used coal (a cleaner fuel) in large quantities, the environmental cost of lignite use could be substantial. These costs are likely to be particularly high in the case of the Thai industry which is concentrated in Bangkok and profoundly affects its environment. The potential impact of lignite burning on the quality of life and the tourist industry could very well exceed lignite's cost advantage.

In principle, it is possible for industrial boilers to use scrubbers, but because of substantial economies of scale, these and other pollution control technologies can only be afforded by very large industries. It is therefore socially preferable for lignite to be restricted to: (1) power generation by EGAT, which has both the scale and remote location to manage air pollution, (2) large industries, such as Siam Cement, which have the necessary scale for the installation of scrubbers and (3) large industries located away from major population centers.

In the absence of a more targeted instrument, it is proposed that the price of lignite be raised to a parity with natural gas to discourage the conversion of industrial boilers: a very costly process that would be difficult to reverse in the future. As a result of the current Gulf Crisis, the increase in fuel oil price is making the conversion of boilers to lignite increasingly attractive. It is, therefore, urgent that the users of industrial boilers are discouraged from shifting to lignite by at least doubling its lignite price, and by requiring that all industrial boilers using lignite have scrubbers installed. The use of natural gas, however, should be encouraged. Very large lignite or coal users, such as Siam Cement, may still find it profitable to install pollution control equipment and to continue to use lignite rather than natural gas. To the extent that these plants are located away from high-density pollution areas and employ pollution control equipment, their impact on the environment is limited to their contribution to acid rain. The fuel shift from heavy fuel oil and lignite to natural gas could be encouraged by a combination of a price increase of heavily polluting fuels (especially lignite) and price and tax incentives for conversion to natural gas.

Two supplementary measures for controlling air pollution from industrial sources should be: (1) a reduction of the maximum sulfur content in fuel oil from 3.5 percent to 2 percent initially, and to 1 percent in the long-run, (2) a reduction by a similar percentage for diesel oil, and (3) the establishment of emissions standards for new and replacement boilers, especially for industries in Bangkok and other urban areas. (For details see "Energy and Environment: Choosing the Right Mix").

Chapter 7

Summary, Conclusion and Policy Recommendations

SUMMARY

The main findings of this study can be summarized as follows:

- Industrial pollution is expected to quadruple within the next 15 years to 20 years and to have an increasing impact on human health, property, and the quality of life.
- Industrial pollution is currently concentrated in the Bangkok Metropolitan Region (BMR) and will continue to be in the foreseeable future. There are indications, however, that some of the worse polluters are moving outside Bangkok and into the satellite provinces of the BMR.
- The 1980s were characterized by an increase in output from the industries including textiles, leather, chemicals, basic metals, and petrochemicals. The economic forecast for these industries in the 1990s shows high growth potential.
- The structural changes in industry and in production materials are leading to the emergence of new types of pollution problems in Thailand. A shift is occurring from traditional pollutants such as wastewater pollution in the form of biochemical oxygen demand (BOD) to more complex toxic pollutants including heavy metals, toxic air and water pollutants, and hazardous wastes. With pollutants accumulating at a exponential rate and becoming increasingly hazardous, no piecemeal patching up of existing regulations will reverse the trend.
- Industrial promotion policies have accelerated the introduction of new, technology-based industries into Thailand. The Board of Investment (BOI) has provided investors with privileges and incentive packages in order to draw foreign investment, but has not used environmental impact assessments (EIAs) or pollution intensity per unit of the GDP among its selection criteria for these target industries. By neglecting this, it has accelerated the production of hazardous industrial waste. An analysis of BOI-promoted industries indicated that the proportion of investment approved for hazardous-waste-generating industries increased from 25 percent in 1987 to 55 percent in 1989.
- Industrial estates have an unrealized potential in industrial pollution control. While all 23 industrial estates have wastewater treatment facilities, none are

known to operate a hazardous waste treatment facility or to have a formal environmental unit.

CONCLUSION

Industrialization creates innumerable benefits ranging from employment and income growth to export earnings and technological development, which ultimately result in improved quality of life. There is a price to be paid, however, in terms of industrial pollution which either lowers the quality of life or costs time and money to clean up. If there is a price to be paid, it should be kept at the minimum cost possible and be paid by those who benefit most from industrialization (producers and consumers) who can best afford it and can, by their own decisions, lower the price by shifting to other less polluting products and technologies. Whatever payment principle is applied to the allocation of the environmental cost of industrialization—the beneficiary pays principle or the polluter principle—the burden would, and should, fall on the industry.

Until the present, society has been called upon to bear the environmental costs of industrialization by foregoing traditional uses of surface water, breathing foul air, and risking injury from hazardous waste. When the industrial sector was in its infancy, and the urban population was small and Thailand was struggling to industrialize this may not have been a bad arrangement. Today, however, the Thai industry is among the most dynamic and rapidly growing industrial sectors in the world; Thailand will soon become a newly industrialized country. Exposing the general public to the risks of industrial waste, or relying on the taxpayer pay for the clean-up of pollution does not befit a modern industrial sector attuned to its social responsibilities. It is also inefficient and is not cost effective. The public has no choice but to suffer or to pay to clean up whatever waste the industry chooses to leave behind, in whatever amounts. The public can do nothing to reduce the quantity of waste generated while the industry, which can, has no incentive to reduce waste since it costs nothing to dump it.

The government has tried to regulate the industry and to control and treat its industrial waste—environmental regulations, effluent and ambient standards, requirements for environmental impact assessments, and waste treatment facilities abound—but either these standards are not consistently enforced or, when they are enforced, the actions are not necessarily effective. Thai culture, perhaps more than other cultures, does not lend itself to command and control environmental mechanisms, and even if it did, the costs of attaining the desired levels of environmental quality (ambient standards) through command and control would be onerous. Moreover, the introduction and amendment of regulations is a very slow process that cannot meet the dramatic change and dynamic growth of Thai industry.

It is somewhat of a paradox that economic incentives have not been used more extensively in Thailand to deal with industrial pollution; they have definitely been used to attract foreign investment and the promoted industries generate a large portion of the overwhelming amount of industrial pollution which now constitutes a problem for the country.

One would expect that industry would take a more active role in protecting its own interests against inflexible effluent standards and waste treatment requirements imposed from outside. By promoting more flexible arrangements among its members, industry could accomplish the ambient standards at considerably lower cost. It is not in industry's interest for Thailand to acquire the reputation of a "pollution haven" that attracts polluting industries that other countries discard or reject. It is not unlikely that such a reputation might lead to calls for retaliatory tariffs against the imports of Thai industrial products into countries with higher effective environmental standards on account of unfair trading.

However, it is easy to understand why the industry has not taken an active role in industrial pollution control until recently. The largest industrial growth spurt has taken place over the past three years to four years, and the industry has only recently acquired its own collective voice through the Federation of Thai Industries (FTI), which has made improved environmental quality one of its primary objectives. At the same time the Department of Industrial Works (DIW) has been experimenting with the privatization of industrial waste management (Bang Khuntien Treatment Center) with some success. The concept of industrial estates under the Industrial Estate Authority of Thailand (IEAT) offers another vehicle for the industry to act collectively to deal with industrial pollution. Some progress has been made here (for example, all industrial estates have wastewater treatment facilities, although hazardous waste goes untreated). Moreover, it is not clear that the industries have any flexibility to minimize the costs of their compliance for whatever ambient standards have been set.

PROPOSED POLICY MEASURES

A Proposed Public-Private Sector Initiative

While both the industry and the government appear prepared to experiment with more innovative approaches to industrial pollution control that employ economic incentives and private sector initiatives, a comprehensive scheme or mechanism to implement such an approach is lacking. The present study building on the Bang Khuntien experience, the industrial estate concept, and the FTI interest in a more active role in industrial pollution control proposes such a mechanism: The Industrial Environment Fund (IEF). The fund, would provide a vehicle for managing industrial pollution and its future growth at a minimum cost (less than 0.5 percent of the GDP) and with the maximum freedom of choice and participation by the industry. The critical elements of the fund, which are described in detail in Chapter 6 are (1) a waste charge, (2) a refundable bond, and an (3) environmental audit system. In the case of hazardous waste, a central treatment facility (CTF) and a central disposal facility (CDF) are also involved, but they are run as businesses by the private sector. An annual factory operation licensing system would be a helpful element (except for the CTF and CDF) and would be equally applicable to both hazardous and biodegradable waste. This system could be implemented in six steps:

Step 1 The DIW, the FTI, the IEAT, and the National Environmental Board (NEB) (and possibly the BOI) would meet to establish the IEF as an autonomous foundation or nonprofit company or corporation. The IEF would have a charter; a board of directors with participation from all the above agencies; a managing director; and departments or divisions for hazardous waste, biodegradable waste, bond management, and environmental auditing.

Step 2 With the fund in place, the DIW, the FTI, and the IEAT would set a matrix of maximum waste/output ratios by type of industry and technology (based on engineering parameters or monitoring data) which would serve as the initial presumptive rates for setting the waste charges and bonds. Most firms would have lower waste/output ratios and thus would be eligible for rebates with interest following environmental auditing. The NEB would set ambient standards which would form the target level of environmental quality and the needed level of pollution control.

Step 3 Once the legal aspects had been settled, the Ministry of Industry (MOI) would announce that factories whose annual operation license had expired must submit, along with their application to the DIW for renewal and other documentation, a certificate from the IEF that they had deposited their presumptive waste charge and bond (or bank guarantee) with the fund. The presumptive rate figures would be available to the company in advance. The MOI would announce and publish these rates in a manner analogous to the posted prices for minerals by the DMR. The presumptive rates would not be negotiable at the licensing stage, but would be verifiable and adjustable following an environmental audit.

Step 4 The MOI and the FTI would promote the establishment of environmental audit firms which would be accredited by the MOI and bonded with the fund. Each company would be required to submit its own environmental auditor's report at the end of the year to the fund as a condition for the release of its bond with interest. Claims of lower waste/output coefficients than the presumptive rates would be verified by the fund's auditors and if upheld, the balances would be fully refund with interest by the fund. It is expected that environmental auditing would develop into a competitive private industry with its own code of ethics.

Step 5 The fund, with a government loan guarantee, would obtain credit from domestic for example, the Industrial Finance Corporation of Thailand (IFCT) or external, for example, the International Finance Corporation (IFC) sources to finance the construction of hazardous waste treatment and disposal facilities. The operation of these facilities would be awarded to a private firm through annual competitive annualcompetitive bidding among accredited/bonded waste management firms. The waste would be collected from the factory by the treatment facility (as in Bang Khuntien procudures), recorded, treated, and disposed at the disposal of facility. Once the waste was delivered, the corresponding part of the bond could be released.

Step 6 To facilitate the smooth operation of the system, the MOI would announce that the licensing of factory operation would be simplified and required annually.

At present, operation licenses are required every three years, but in the rapidly growing economy of Thailand, many things change in three years. To adjust to the more dynamic character of the Thai industry in the 1990s, annual, but simplified, licensing is warranted for other reasons as well increased flexibility, collection of better statistics, etc. The old system was introduced when the Thai industry was small and changed slowly.

No doubt many more details need to be worked out and modifications need to be made based on prior DIW, IEAT, and FTI experience. There may be legal or other difficulties which have not been anticipated that call for changes of one or more elements in the plan. It is the concept rather than the details that are emphasized here. The central concept is that pollution control does not cost much if the incentives are right; the industry would be willing to pay if it is certain that every company pays its share and that the policy and costs are known ahead of time, or are at least predictable.

The concept of the IEF as described or appropriately modified, could be tried on a pilot basis with the 500 largest companies in Thailand and/or the group of industries in Pathum Thani that have already began taking their own initiative to control industrial pollution.

ADDITIONAL POLICY MEASURES

1. A major source of air pollution, sulfur dioxide, comes form industrial boilers which are increasingly being converted to lignite under the incentive of a low lignite price and high and rising oil prices. The price of lignite should be raised to include environmental costs at the mining stage, land reclamation, and full user costs in the form of royalties to the government. In the absence of sufficient information to estimate these costs, the price of lignite should be raised to a parity with the price of natural gas (in kilotons of oil equivalent) to forestall a massive conversion of industrial boilers to lignite, which cannot be easily reversed. In addition, the reduction of the sulfur content of heavy fuel oil used in industrial boilers (from 3.5 percent to 2.0 percent in the medium run, and to 1.0 percent in the long run).
2. The Government investment promotion policies that inadvertently conflict with environmental protection, such as the BOI's promotional privileges given to the hazardous-waste-generating industries, should be reviewed and changed. The great demand for BOI promotion privileges by foreign and domestic investors and the need to be more selective suggest environmental criteria (for example, quantity of hazardous waste per unit of the GDP) should play a more decisive role in investment project selection. It is critical that the government restructure the BOI promotional policies to favor environmentally sound investments and to promote industries that minimize pollutants per unit of value added.
3. Industrial estates should be encouraged (or required) to take more active role in pollution control within their territory, taking advantage of proximity; homogeneity; and economies of scale in treatment, monitoring, and enforcement. The concept of the industrial estate can be used to consolidate new, small-scale industries, to minimize the cost of monitoring and coordination, and to attain economies of scale in pollution control and infrastructure. While there are several backward and forward linkages between firms in an industrial zone, a loose demarcation of zones for "polluting" and "nonpolluting" industries, with the latter encouraged to locate at a specified distance from densely populated areas, might be an effective means of reducing the environmental risk factor.
4. The government's policy to decentralize industry into the rural areas, to reduce congestion in Bangkok, and to spread the benefits of industrialization should also take into account the environmental pros and cons. A preferable alternative might be to promote a limited number of clusters of industry outside the BMR rather than to institute comprehensive rural industrialization program. Taiwan is now experiencing a backlash because it has spread industrial pollution throughout the countryside.

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Appendix 2.1

Industrial Classification

Appendix 2.1

Industrial Classification

There are various systems of industrial classification being used at present including (1) the Ministry of Industry (MOI) category numbering system which the DIW uses to license factories; (2) the Thailand Standard Industrial Classification (TSIC) system, which is employed for purposes including the National Economic and Social Development Board (NESDB) national income accounting process; (3) the Board of Investment (BOI) code used for granting privileges to industry. (See Table 1)

GROUPING OF INDUSTRY IN ENVIRONMENTAL CONTEXT

From an environmental standpoint, industries can be clustered based upon types of wastes produced. The term wastes is also classified by varying aspects including the following:

- o By the medium to which they are released (e.g. air contaminants, wastewater, and solid wastes)
- o By their origins (e.g. construction debris, mine tailings, or municipal wastes)
- o By their physical characteristics (whether they are gaseous, liquid, or solid)
- o By type of risk or problem they create (e.g. hazardous wastes and radioactive wastes)

These different ways of classifying wastes reflect the complexity in managing wastes, and a single waste stream may be managed under different programs. For instance, liquid wastes released by a zinc mine may be simultaneously classified as water pollutants, mining wastes, hazardous wastes, and wastes released to land.

This report, however, organizes industries into two main groups. The first group is categorized based on which environmental compartments are affected by its waste. The second group divides industries into hazardous and nonhazardous-waste-producing industries. Several environmental management programs conducted by the ONEB and the DIW are based on these two classifications, which are the basic context for this report.

GROUPING BASED ON AFFECTED ENVIRONMENTAL COMPARTMENTS

The environment is comprised of three major areas--air, water and land. These compartments receive analogous forms of industrial wastes. For example, the atmosphere receives air pollutants from fossil fuel burning and chemical industries, and streams and land receive wastewater and solid wastes from various kinds of industries. Since these environmental areas and the corresponding wastes have absolutely different physicochemical natures, effective technologies and management schemes are also varied. Based on this understanding, Table 2 categorizes industries as air-polluting industries (e.g. cement, iron and steel foundries, textiles and petroleum, and water-polluting industries (e.g. food, pulp and paper, tannery, and textile). The classification in Table 3 does not address the land-polluting industry because most of the waste treatment plants convert their original wastewater and air pollutants to solid waste as a final product. Thus it can be stated that all industries unload solid wastes, in one way or another, to the land resource.

In fact, pollutants can be removed from a wastewater stream and either dumped on the ground--creating solid wastes--or incinerated--creating both air wastes and, with the remaining ash, solid wastes. Similarly, air pollution control devices can create solid wastes or wastewater. In some cases, waste may be chemically or physically converted to a form that is not considered waste, even though it may still cause problems. For example, both air and water pollution control devices frequently convert organic (carbon-containing) wastes to carbon dioxide (CO_2) and water which they release to the atmosphere. This CO_2 disappears from the environmental accounting system, yet it is still a waste product, because it contributes to the atmospheric CO_2 overload. Given this factor, although the waste cycle after treatment is not taken into account, this classification is still meaningful in controlling the emission of waste at the source which is normally the first step of pollution control.

Table 1 Industrial Classification

TSIC Code	DIW Club	FTI	BOI Code	Type of Industry
311,312	2,4,5,6,7,8 10,11,12,9 (exclude 9.1) 13,14,15	F1	1.2,1.3,1.4 1.5,1.6,1.7,1.10 1.14,1.17,1.18 1.19,1.20,5.27 5.38,5.52,5.53	Food
313	16,17,18 19,20	F1		Beverage
314	1,21	-		Tobacco
321	22,23,24	F25	5.15,5.17,5.30 5.37,5.47,5.54 5.55	Textile
322	28	F25	5.8,5.21,5.29 5.36,5.50	Wearing Apparel
323,324	29,30,31 32,33	F17	5.39	Leather & Footwear
331	34,35,36	F23	1.15,5.9	Wood & Cork
332	37	F4		Furniture & Fixure
341	38,39,40	F14,F19	3.8,3.10,5.26 5.31,5.35	Paper & Paper Products
342	41	F11		Printing Publishing
355,356	51,52	F8,F24 F5	1.8,5.6,5.22 5.34,5.51	Rubber & Plastic Product
351,356	42,43,44 45,46,47,48	F3 F15	3.1,3.2,3.3 3.5,3.6,3.7 3.9,3.11,5.14,5.24	Chemical Products
353,354	49,50	F18	3.4,3.12	Petroleum Products
361,362 369	53,54,55 56,57,58	F12,F21 F22	2.5,5.43	Non-Metallic
371,372	59	F6	2.4	Basic Metal Industries
381	60,61,62 63,64	F20	5.44,5.45	Fabricated Products
382	65,66,67 68,69,70	F7,F10	4.1,4.2,4.3,4.7	Machinery & Parts

Table 1 (Continued)

TSIC Code	DIW Club	FTI	BOI Code	Type of Industry
383	71,72,73 74,81,82,83	F2,F9	4.4,4.6,5.40	Electrical Machinery
384	75,76,77,78 79,80(95)	F13	4.5,5.12,5.13 5.28,5.46,5.48	Transport Equipment
385-390	3,84,85,86,87 88,89,90,91,92 93,94,97,98,99	-	5.1,5.2,5.3,5.4 5.5,5.7,5.10,5.11 5.18,5.19,5.20,5.24 5.32,5.33,5.41,5.49	Other

Note: TSIC = Thailand Standard Industrial Classification
DIW = Department of Industrial Words
FTI = Federation of Thai Industry
BOI = Board of Investment

Table 2 Grouping of Industries Based on Affected Environmental Compartment

Pollution	TSIC	DIW Code	Industry
I. Air Pollution			
1. Dust and Soot	31163	2(1,2,5)	Grain floor mills
	31169	9(3)	Other grain mill products
	31182	11(2,3,4)	Sugar refineries
	31219	11(1)	Syrup
	31220	15(2)	Manufacture of animal feeds
	33113	34(1,2)	Builder's woodwork
	35591	51	Rubber sheets & block rubber
	36921	57	Cement
	37120	59	Iron and steel foundries
	37200	60	Non-ferrous metals
	39090	3(1,3)	
2. Oder and Smell	31151	8(2)	Manufacture of oils & fats
	31219	12(2)	Instant coffee
	31220	15(2)	Manufacture of animal feeds
	35591	52(1)	Rubber Sheets & block rubber
	35599	52(2)	Other rubber products
3. Vapour and Particulate of Chemicals and Heavy Metals	32117	22(4)	Textile printing
	32118	22(3)	Textiles finishing
	32190	27(6)	Textiles not elsewhere classified
	35120	43	Fertilizers and Pesticides
	35210	45(1,2)	Paints, varnishes & lacquers
	35231	47(1)	Soap & cleaning preparations
	35200	42	Chemicals (not fertilizer)
	35300	49	Petrolium refineries
	35400	50(3,5)	products of petroleum & coal
	38198	64(10)	Coating, engraving
	38199	60	Other fabricated metal products
	38393	74(1)	Electric lamps
	39090	27(1)	Other industrial products (oil carpet)
II. Water Pollution	31111	4(1)	Slaughtering
	31119	4(2)	Other meat products
	31151	4(3),8(1,3,4)	Manufacture of oils & fats

Table 2 (Continued)

Pollution	TSIC	DIW Code	Industry
	31112	4(4)	Meat canning
	31122	5(1,2,3)	Milk factories
	31123	5(6)	Ice-cream
	31152	5(4,5),8(5)	Manufacture of margarine
	31131	6(1)	Canning of fruit & veg.
	31139	6(2)	Preserving of fruit & veg.
	31219	7(1),12(1-7) 11(1),13(4,6)	Other food products
	31149	7(2)	Preserving of fish
	31161	9(1)	Rice mills
	31211	9(2)	Manufacture of starches
	31169	9(3)	Other grain mill products
	31171	10(1)	Bakeries
	31172	10(2)	Manufacture of biscuits
	31173	10(3)	Noodles & similar products
	31182	11(2,3,4,6)	Sugar refineries
	31190	12(8)	Confectionery
	31220	15(2)	Manufacture of animal feeds
	31310	16	Distilling & rectifying
	35111	17	Basic industrial chemicals
	31320	18	Wine industries
	31330	19(2)	Breweries
	31340	20(1,2)	Soft drinks & carbonated water
	32190	22(1)	Textiles not elsewhere classified
	32118	22(2)	Textile finishing
	32117	22(3)	Textile printing
	32130	24	Knitting mills
	32140	25	Carpets & rugs
	32150	26	Cordage, rope & twine industry
	32330	29,30	Products of leather
	32310	31	Tanneries, leather finishing
	33201	37	Furniture & fixtures
	34111	38(1)	Pulp, paper & paperboard
	34112	38(2),40(1)	Manufacture of fiberboard
	34120	39	Containers & boxes of paper

Table 2 (Continued)

Pollution	TSIC	DIW Code	Industry
	34190	40(2)	Items of pulp, paper & paperboard
	35299	42	Other chemical products
	35120	43	Fertilizers & pesticides
	35210	45	Paints, varnishes & lacquers
	35220	46	Drugs & medicine
	35231	47(1,2)	Soap & cleaning preparations
	35300	49	Petroleum refineries
	35400	50(4)	Products of petroleum & coal
	35609	53	Other plastic
	36100	54	Manufacture of pottery
	36200	55	Glass and glass products
	36910	56	Structural clay products
	37200	63(1,2),64(4) 60	Non-ferrous metals
	38298	62,63(4),81 63(4),65,66,67	Machinery repair shops
	38413	63(3)	Building of other boats
	38292	63(5)	Air conditioning
	38199	64(1,2,3 6,7,9)	Other fabricated metal products
	38391	64(5)	Insulated wire & cable
	38198	64(8,10)	Coating, engraving
	38330	72,73	Electrical appliances
	38393	74(1)	Electric lamps
	38310	74(5)	Industrial electrical products
	38414	75(3)	Breaking up of ships
	38431	77	Assembly of automobiles
	38440	78	Motorcycles, tricycles & bicycles
	38450	79	Manufacture of aircraft
	38490	80	Other transport equipment
	38240	81(3),83	Special industrial
	39030	86	Sporting and athletic goods
	39090	27(2,3) 87(4) 44,92,98	Other industrial products

Note: TSIC = Thailand Standard Industries Classicfication
DIW = Department of Industries Works

Source: DIW Ordinance No.147/1989 dated September 5, 1989

CLASSIFICATION BASED ON THE HAZARDOUS NATURE OF WASTE

The term "hazardous" implies harm to human health or to the environment and is broader than the term "toxic." For example, wastes that are hazardous because of their corrosivity, flammability, explosiveness, or infectiousness are not normally considered toxic (Office of Technology Assessment 1986)[1].

Hazardous waste is waste that has physical, chemical, or biological characteristics which require special handling and disposal procedures to avoid risk to health and/or other adverse environmental effects (World Health Organization 1983)[2]. According to the MOI's classification, the following three categories of waste have been identified to acquire special handling and disposal; 1) wastes or unwanted products which have one of the following characteristics: flammability, corrosivity, explosiveness, and toxicity; 2) twenty types of solvents as listed; 3) wastes or unwanted products from the listed industries, for example, wastewater sludge from battery factories and paint residues from repair shops (Ministry of Industry 1988).[3]

Recently a more systematic approach for ahazardous-waste-generating potential ranking system was conducted by Engineering Science, Inc. et al. (1989)[4]. In their study, idustry was grouped into four ranks following the criteria shown in Table 3.3. The results of the ranking system shown in Table 4 indicate that industries which should receive serious attention (Rank 3) include the chemical, fertilizers and pesticides, synthetic resins, plastics and fibers, paints, varnishes and lacquers, soaps, cleansers, cosmetics, toiletries, petroleum and explosives, and ammunition and weapons.

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1 Office of Technology Assessment. 1986. *Serious Reduction of Hazardous Waste: Summary*, OTA-ITE-318, Washington, D.C., 63pp.

2 World Health Organization. 1983. *Management of Hazardous Waste: Policy Guidelines and Code of Practice,* Edited by Michael J. Suess and Jan W. Huismans, WHO Regional Publications, European Series No. 14, England, 100pp.

3 Ministry of Industry. 1988. Notification of Ministry of Industry No. 25 dated August 3, 1988.

4 Engineering Science, Inc., Thai DCT and Systems Engineering. 1989. *National Hazardous Waste Management Plan: Volume 2-Main Report*, a study commissioned by the ONEB.

The classification system based on the hazardous nature of waste is of important in that it indicates industries which require special regulations in handling their wastes. When determining industrial promotion policy, this classification system would provide a guideline for the concerned organizations to direct industrial growth so that the number of hazardous-waste-producing industries would not be increased to a level that exceeds the safety limit of the environment.

Table 3 Hazardous-Waste-Generating Potential Ranking System

Rank	Description
0	Little or no potential for generation of hazardous wastes, such as food processing industries.
1	Potential for generating only small quantities of hazardous waste, such as repair shops.
2	Potential to generate moderate quantities of hazardous waste with low levels of hazardous constituents, such as electroplating and heavy equipment manufacture.
3	Potential to generate large quantities of hazardous waste or small quantities of wastes containing very high levels of hazardous constituents, such as organic manufacturings.

Source: Engineering Science, Inc. (1989).

Table 4 Grouping of Industries Based on Hazardous Nature of Waste

Industry		TSIC
1. Non-Hazardous Waste Producing Industry	Rank 0	31110,31120,31130,31140,31150 31160,31170,31180,31190,32112 31220,31310,31320,31330,31340 31400,32120,32140,32150,32200 32310,32330,32400,33110,36100 36200,36910,36920,39010
2. Hazardous Waste Producing Industry	Rank 1	32190,33120,33190,33200,34120 34190,34200,35510,35590,35600 36990,38130,38410,38420,38450 38490,38500,39020,39030,39090 41010,95130,95190,95200
	Rank 2	32110,32130,34110,35400,37100 37200,38110,38120,38190,38210 38220,38230,38240,38250,38290 38310,38320,38330,38390,38430 38440
	Rank 3	35110,35120,35130,35220,35230 35290,35300,35291

Note: TSIC = Thailand Standard Industries Classification

Source: Modified from Engineering Science, Inc. et. al. (1989).

Appendix 2.2

Hazardous Waste Quantity,1986

Appendix 2.2 Hazardous Waste Quantity , 1986

Unit : Tons

TSIC	Industry	Oils	Liquid Organic	Organic Sludge	Inorganic Sludge	Heavy met. Sludge	Solvent	Acid Waste	Allkaline Waste	Off Spec. Prod.	PCB	Aqueous Organic Residues	Photo Waste	Total
371-372	Basic metal industry	0	0	0	0	732,508	0	0	0	0	0	0	0	732,508
381	Fabricated products	1,303	0	0	4,116	55,854	760	56,272	14,563	0	0	0	0	132,868
384	Transport equipment	58,509	0	0	1,078	3,521	501	384	0	0	0	0	0	63,993
383	Electrical machinery	701	0	0	1,491	20,096	591	20,407	5,246	0	2,458	0	0	50,990
351-352	Chemical products	15,455	187	2,751	1,003	10,034	3,250	3,266	1,843	12	0	116	0	37,916
382	Machinery	25,150	0	0	132	0	4,715	3	158	0	0	0	0	30,158
321	Textiles	17,362	0	0	0	0	0	0	0	0	0	0	0	17,362
342	Printing,publishing,allited	0	0	642	0	0	5,405	0	0		0	0	8,820	14,867
356	Rubber-rubber products	3,923	0	0	0	0	4,350	0	0	0	0	0	0	8,273
341	Paper and paper products	1,325	0	42	1,370	0	0	0	0	0	0	0	0	2,737
353-354	Petroleum products	454	0	302	509	508	205	0	0	0	0	0	0	1,978
385-390	Miscellaneous nec.	12	0	0	393	549	7	719	142	0	0	0	0	1,821
332	Furniture - fixtures	0	0	0	1,092	0	0	0	0	0	0	0	0	1,092
331	Wood - cork	0	0	0	515	0	0	0	0	0	0	0	0	515
361-369	Non metallic mineral	0	0	0	0	0	0	0	0	0	0	0	0	0
314	Tobacco	0	0	0	0	0	0	0	0	0	0	0	0	0
323-324	Leather prod. - footware	0	0	0	0	0	0	0	0	0	0	0	0	0
313	Beverage	0	0	0	0	0	0	0	0	0	0	0	0	0
311-312	Food	0	0	0	0	0	0	0	0	0	0	0	0	0
322	Wearing apparel	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	124,194	187	3,737	11,698	823,070	19,783	81,051	21,952	12	2,458	116	8,820	1,097,078

Source : Engineering Scince et.al. (1989)

Appendix 2.3

Projection of Industrial

Biochemical Oxygen Demand (BOD)

Appendix 2.3 Projection of Industrial Biochemical Oxygen Demand (BOD)

INDUSTRY	BOD LOAD (thousand tons)																				
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sugar	140.7	153.7	168.2	183.3	199.2	215.6	232.4	249.5	266.7	284.2	302.2	321.1	341.1	362.4	385.2	409.9	436.4	465.2	496.2	529.7	565.8
Pulp & Paper	93.2	102.7	113.3	124.6	136.5	149.0	162.0	175.4	189.1	203.2	217.9	233.5	250.1	268.0	287.3	308.3	331.1	355.9	382.8	412.1	444.0
Rubber [1]	89.7	96.5	104.4	112.5	120.8	129.2	137.5	145.7	153.8	161.6	169.6	177.7	186.1	195.0	204.4	214.5	225.2	236.7	248.9	262.0	276.0
Beverages [2]	84.0	91.3	99.0	106.7	114.7	122.8	130.9	139.0	147.0	155.0	163.0	171.3	180.0	189.2	198.9	209.4	220.5	232.5	245.3	259.0	273.7
Tapioca	36.7	40.2	44.2	48.3	52.6	57.1	61.8	66.5	71.3	76.2	81.3	86.7	92.3	98.4	104.9	112.0	119.6	127.9	136.8	146.5	157.0
Slaughter [3]	14.9	15.5	16.1	16.7	17.3	17.8	18.2	18.6	18.9	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.7	21.0	21.3	21.6	22.0
Canned Fish & Crustaceans [4]	10.1	10.9	11.8	12.7	13.7	14.6	15.6	16.6	17.5	18.5	19.4	20.4	21.5	22.6	23.7	25.0	26.3	27.7	29.3	30.9	32.6
Tannery	9.6	10.6	12.0	13.8	15.8	18.2	20.9	23.9	27.3	31.1	35.4	40.3	46.0	52.4	59.9	68.4	78.4	89.8	103.1	118.5	136.3
Canned Pineapple [5]	3.5	3.7	3.9	4.1	4.3	4.5	4.6	4.8	4.9	5.1	5.2	5.3	5.4	5.5	5.7	5.8	6.0	6.1	6.3	6.4	6.6
SUM	482.5	525.2	573.0	622.7	674.8	728.8	784.0	840.0	896.6	954.0	1,013.4	1,075.8	1,142.3	1,213.5	1,290.2	1,373.7	1,464.1	1,562.8	1,670.1	1,786.8	1,913.9

Note: [1] Accounting for BOD from rubber sheet processing only.
[2] Accounting for BOD from beer, distillery & soft drinks processing.
[3] Accounting for BOD from beef & swine slaughtering only.
[4] Accounting for BOD from exported products only.
[5] Accounting for BOD from exported products only.

Appendix 3.1

Number and Distribution of

Registered Factories Classified by TSIC

Appendix 3.1 Number and Distribution of Registerd Factories Classified by TSIC

Number of Registerd Factoreies Classified by TSIC,1987

TSIC	Sector	Greater Bangkok	Central	North	Northeast	South	Whole Kingdom
311,312	Food	1708	2602	767	2418	584	8079
313	Beverage	93	38	43	28	21	223
314	Tobacco	10	1	90	0	0	101
321	Textile	1288	81	13	60	12	1454
322	Wearing apparel	1419	6	11	3	0	1439
323,324	Leather & footwear	556	5	2	0	0	563
331	Wood & cork	1360	710	401	231	418	3120
332	Furniture & fixture	746	104	156	171	143	1320
341	Paper & paper products	399	11	9	3	5	427
342	Printing, publishing	1420	36	14	13	17	1500
355,356	Rubber, plastic product	352	71	20	32	147	622
351,352	Chemical products	801	51	62	21	23	958
353,354	Petroleum products	21	5	4	0	1	31
361,362,369	Non-metalic	1704	579	410	487	306	3486
371,372	Basic metal	175	5	2	8	12	202
381	Fabricated products	4448	241	216	260	157	5322
382	Machinery & parts	2062	996	845	603	600	5106
383	Electrical machinery	844	61	38	31	13	987
384	Transport equipment	2613	831	606	738	473	5261
385-390	Other	795	464	163	204	178	1804
	Total	22814	6898	3872	5311	3110	42005

Distribution of Registered Factories Classified by TSIC,1987

		Greater Bangkok	Central	North	North-east	South	Whole Kingdom
311,312	Food	7.49	37.72	19.81	45.53	18.78	19.23
313	Beverage	0.41	0.55	1.11	0.53	0.68	0.53
314	Tobacco	0.04	0.01	2.32	0.00	0.00	0.24
321	Textile	5.65	1.17	0.34	1.13	0.39	3.46
322	Wearing apparel	6.22	0.09	0.28	0.06	0.00	3.43
323,324	Leather & footwear	2.44	0.07	0.05	0.00	0.00	1.34
331	Wood & cork	5.96	10.29	10.36	4.35	13.44	7.43
332	Furniture & fixture	3.27	1.51	4.03	3.22	4.60	3.14
341	Paper & paper products	1.75	0.16	0.23	0.06	0.16	1.02
342	Printing, publishing	6.22	0.52	0.36	0.24	0.55	3.57
355,356	Rubber, plastic product	1.54	1.03	0.52	0.60	4.73	1.48
351,352	Chemical products	3.51	0.74	1.60	0.40	0.74	2.28
353,354	Petroleum products	0.09	0.07	0.10	0.00	0.03	0.07
361,-2,-9	Non-metalic	7.47	8.39	10.59	9.17	9.84	8.30
371,372	Basic metal	0.77	0.07	0.05	0.15	0.39	0.48
381	Fabricated products	19.50	3.49	5.58	4.90	5.05	12.67
382	Machinery & parts	9.04	14.44	21.82	11.35	19.29	12.16
383	Electrical machinery	3.70	0.88	0.98	0.58	0.42	2.35
384	Transport equipment	11.45	12.05	15.65	13.90	15.21	12.52
385-390	Other	3.48	6.73	4.21	3.84	5.72	4.29
	Total	100.00	100.00	100.00	100.00	100.00	100.00

Note : Excluding rice mills.

Source: Computed from data of Industry Work Department.

Number of Registerd Factoreies Classified by TSIC,1988

TSIC	Sector	Greater Bangkok	Central	North	Northeast	South	Whole Kingdom
311,312	Food	1809	3225	1112	3486	622	10254
313	Beverage	100	42	45	30	24	241
314	Tobacco	10	2	95	0	0	107
321	Textile	1427	89	13	63	12	1604
322	Wearing apparel	1603	9	13	4	0	1629
323,324	Leather & footwear	632	9	2	1	0	644
331	Wood & cork	1443	750	425	237	472	3327
332	Furniture & fixture	809	118	162	186	157	1432
341	Paper & paper products	436	13	9	3	5	466
342	Printing, publishing	1492	36	14	13	17	1572
355,356	Rubber, plastic product	382	78	20	32	165	677
351,352	Chemical products	843	59	65	23	24	1014
353,354	Petroleum products	23	5	4	0	1	33
361,362,369	Non-metalic	1901	659	471	540	335	3906
371,372	Basic metal	183	5	2	8	14	212
381	Fabricated products	4773	272	237	290	173	5745
382	Machinery & parts	2170	1084	917	663	624	5458
383	Electrical machinery	921	66	43	35	15	1080
384	Transport equipment	2757	927	677	842	508	5711
385-390	Other	894	493	179	225	201	1992
	Total	24608	7941	4505	6681	3369	47104

Distribution of Registered Factories Classified by TSIC,1988

		Greater Bangkok	Central	North	Northeast	South	Whole Kingdom
311,312	Food	7.35	40.61	24.68	52.18	18.46	21.77
313	Beverage	0.41	0.53	1.00	0.45	0.71	0.51
314	Tobacco	0.04	0.03	2.11	0.00	0.00	0.23
321	Textile	5.80	1.12	0.29	0.94	0.36	3.41
322	Wearing apparel	6.51	0.11	0.29	0.06	0.00	3.46
23,324	Leather & footwear	2.57	0.11	0.04	0.01	0.00	1.37
331	Wood & cork	5.86	9.44	9.43	3.55	14.01	7.06
332	Furniture & fixture	3.29	1.49	3.60	2.78	4.66	3.04
341	Paper & paper products	1.77	0.16	0.20	0.04	0.15	0.99
342	Printing, publishing	6.06	0.45	0.31	0.19	0.50	3.34
355,356	Rubber, plastic product	1.55	0.98	0.44	0.48	4.90	1.44
351,352	Chemical products	3.43	0.74	1.44	0.34	0.71	2.15
353,354	Petroleum products	0.09	0.06	0.09	0.00	0.03	0.07
361,362,369	Non-metalic	7.73	8.30	10.46	8.08	9.94	8.29
371,372	Basic metal	0.74	0.06	0.04	0.12	0.42	0.45
381	Fabricated products	19.40	3.43	5.26	4.34	5.14	12.20
382	Machinery & parts	8.82	13.65	20.36	9.92	18.52	11.59
383	Electrical machinery	3.74	0.83	0.95	0.52	0.45	2.29
384	Transport equipment	11.20	11.67	15.03	12.60	15.08	12.12
385-390	Other	3.63	6.21	3.97	3.37	5.97	4.23
	Total	100.00	100.00	100.00	100.00	100.00	100.00

Note : Excluding rice mills.

Source: Computed from data of Industry Work Department.

Number of Registerd Factoreies Classified by TSIC,1989

TSIC	Sector	Greater Bangkok	Central	North	Northeast	South	Whole Kingdom
311,312	Food	1902	3353	1204	3629	672	10759
313	Beverage	101	11	48	31	28	255
314	Tobacco	10	2	96	0	0	108
321	Textile	1619	94	20	83	13	1829
322	Wearing apparel	[illegible]	13	18	7	0	1862
323,324	Leather & footwear	719	16	2	3	0	740
331	Wood & cork	1517	787	453	246	537	3540
332	Furniture & fixture	872	130	170	193	172	1537
341	Paper & paper products	486	16	13	4	6	525
342	Printing, publishing	1576	36	14	13	18	1657
355,356	Rubber, plastic product	403	96	22	34	185	740
351,352	Chemical products	893	70	70	28	29	1090
353,354	Petroleum products	26	5	4	0	1	36
361,362,369	Non-metalic	2146	768	560	605	397	4476
371,372	Basic metal	192	7	2	8	14	223
381	Fabricated products	5126	300	284	339	186	6235
382	Machinery & parts	2326	1213	1068	737	649	5993
383	Electrical machinery	1023	77	49	39	16	1204
384	Transport equipment	2918	1071	839	1006	540	6374
385-390	Other	1022	553	208	248	227	2258
	Total	26704	8651	5144	7252	3690	51441

Distribution of Registered Factories Classified by TSIC,1989

		Greater Bangkok	Central	North	Northeast	South	Whole Kingdom
311,312	Food	7.12	38.76	23.41	50.03	18.21	20.92
313	Beverage	0.39	0.51	0.93	0.43	0.76	0.50
314	Tobacco	0.04	0.02	1.87	0.00	0.00	0.21
321	Textile	6.06	1.09	0.39	1.14	0.35	3.56
322	Wearing apparel	6.83	0.15	0.35	0.10	0.00	3.62
323,324	Leather & footwear	2.69	0.18	0.04	0.04	0.00	1.44
331	Wood & cork	5.68	9.10	8.81	3.39	14.55	6.88
332	Furniture & fixture	3.27	1.50	3.30	2.66	4.66	2.99
341	Paper & paper products	1.82	0.18	0.25	0.06	0.16	1.02
342	Printing, publishing	5.90	0.42	0.27	0.18	0.49	3.22
355,356	Rubber, plastic product	1.51	1.11	0.43	0.47	5.01	1.44
351,352	Chemical products	3.34	0.81	1.36	0.39	0.79	2.12
353,354	Petroleum products	0.10	0.06	0.08	0.00	0.03	0.07
361,-2,-9	Non-metalic	8.04	8.88	10.89	8.34	10.76	8.70
371,372	Basic metal	0.72	0.08	0.04	0.11	0.38	0.43
381	Fabricated products	19.20	3.47	5.52	4.67	5.04	12.12
382	Machinery & parts	8.71	14.02	20.76	10.16	17.59	11.65
383	Electrical machinery	3.83	0.89	0.95	0.54	0.43	2.34
384	Transport equipment	10.93	12.38	16.31	13.87	14.63	12.39
385-390	Other	3.83	6.39	4.04	3.42	6.15	4.39
	Total	100.00	100.00	100.00	100.00	100.00	100.00

Note : Excluding rice mills.

Source: Computed from data of Industry Work Department.

Appendix 3.2

Gaseous Emission

Appendix 3.2 Gaseous Emission

Total SO2 Emission (by Region and Year)

(Unit : Ton/Year)

	1986	1988	1991	1996	2001	2006	2011
Whole Region	433303	541025	957203	1265638	2164376	2538483	3155010
BMR	163890	200677	384429	387311	525353	582057	805092
Central	35485	46930	75935	279753	358835	514784	826462
North	173326	223844	398723	532090	1055312	1087985	1141058
Northeast	21906	25039	34089	30990	38087	47550	60181
South	38689	44450	64022	35732	187173	306825	323331
Total	433296	540939	957198	1265876	2164761	2539202	3156124

Share of SO2 Emission (by Region and Year)

(Unit : Percent)

	1986	1988	1991	1996	2001	2006	2011
Whole Region	100.00	100.02	100.00	99.98	99.98	99.97	99.96
BMR	37.82	37.10	40.16	30.60	24.27	22.92	25.51
Central	8.19	8.68	7.93	22.10	16.58	20.27	26.19
North	40.00	41.38	41.66	42.03	48.75	42.85	36.15
Northeast	5.06	4.63	3.56	2.45	1.76	1.87	1.91
South	8.93	8.22	6.69	2.82	8.65	12.08	10.24
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total NOx Emission (by Region and Year)

(Unit : Ton/Year)

	1986	1988	1991	1996	2001	2006	2011
Whole Region	309333	399822	536835	793307	1097564	1502263	2072608
BMR	164806	217083	288063	421205	563301	728983	981598
Central	39319	53770	77197	129921	181534	356342	593087
North	44218	55142	78558	107284	169072	179821	201712
Northeast	26781	32196	39514	55358	66405	79570	96704
South	34207	41607	53455	79719	117790	158692	201630
Total	309331	399798	536786	793486	1098102	1503408	2074731

Share of NOx Emission (by Region and Year)

(Unit : Percent)

	1986	1988	1991	1996	2001	2006	2011
Whole Region	100.00	100.01	100.01	99.98	99.95	99.92	99.90
BMR	53.28	54.30	53.66	53.08	51.30	48.49	47.31
Central	12.71	13.45	14.38	16.37	16.53	23.70	28.59
North	14.29	13.79	14.63	13.52	15.40	11.96	9.72
Northeast	8.66	8.05	7.36	6.98	6.05	5.29	4.66
South	11.06	10.41	9.96	10.05	10.73	10.56	9.72
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total CO2 Emission (by Region and Year)

(Unit : Ton/Year)

	1986	1988	1991	1996	2001	2006	2011
Whole Region	71750422	85243668	109807113	149123985	201850427	276855518	385505812
BMR	35699346	43097047	53297900	67728900	86705909	104701283	137812734
Central	11457263	14742266	20789168	34922583	46729692	93867810	158590022
North	10823994	12589536	17699773	22479598	36902563	39157718	42865015
Northeast	6564791	6919851	8461612	10890230	12204546	13882608	16215684
South	7202686	7889857	9546282	13106291	19322812	25276185	30082437
Total	71748080	85238557	109794736	149127602	201865521	276885603	385565891

Share of CO2 Emission (by Region and Year)

(Unit : Percent)

	1986	1988	1991	1996	2001	2006	2011
Whole Region	100.00	1.00	1.00	1.00	1.00	1.00	1.00
BMR	49.76	50.56	48.54	45.42	42.95	37.81	35.74
Central	15.97	17.30	18.93	23.42	23.15	33.90	41.13
North	15.09	14.77	16.12	15.07	18.28	14.14	11.12
Northeast	9.15	8.12	7.71	7.30	6.05	5.01	4.21
South	10.04	9.26	8.69	8.79	9.57	9.13	7.80
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SPM Emission (by Region and Year)

(Unit : Ton/Year)

	1986	1988	1991	1996	2001	2006	2011
Whole Region	448437	513843	619790	780937	951042	1195852	1594634
BMR	218868	255106	312420	371240	452862	578733	756700
Central	80902	105507	150480	200664	247113	340502	465306
North	41896	44237	63222	112484	147203	162165	242024
Northeast	42213	42710	38813	40221	42208	45744	52556
South	64566	66168	54562	57671	65827	77643	94703
Total	448445	513729	619497	782279	955213	1204786	1611289

Share of SPM Emission (by Region and Year)

(Unit : Percent)

	1986	1988	1991	1996	2001	2006	2011
Whole Region	100.00	100.02	100.05	99.83	99.56	99.26	98.97
BMR	48.81	49.66	50.43	47.46	47.41	48.04	46.96
Central	18.04	20.54	24.29	25.65	25.87	28.26	28.88
North	9.34	8.61	10.21	14.38	15.41	13.46	15.02
Northeast	9.41	8.31	6.27	5.14	4.42	3.80	3.26
South	14.40	12.88	8.81	7.37	6.89	6.44	5.88
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SO2 Emission in BMR Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	111390	99901	58255	83845	108689	146622	208303	314620	475638
Agriculture	19143	18379	1385	1358	2761	1602	1850	2138	2474
Res. & Comm.	6652	7007	3816	3946	3006	2966	3245	3647	4485
Transportation	10023	14475	58774	78888	103819	95348	129225	171959	232443
Power Generation	177763	212205	41660	32640	166058	140573	182370	89103	89103
Refineries	11042	9894	2537	2957	4113	6350	6350	6350	6350
Total	336013	361861	166427	203634	388446	393462	531343	587817	810494

Share SO2 Emission in BMR Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	33.15	27.61	35.00	41.17	27.98	37.26	39.20	53.52	58.68
Agriculture	5.70	5.08	0.83	0.67	0.71	0.41	0.35	0.36	0.31
Res. & Comm.	1.98	1.94	2.29	1.94	0.77	0.75	0.61	0.62	0.55
Transportation	2.98	4.00	35.32	38.74	26.73	24.23	24.32	29.25	28.68
Power Generation	52.90	58.64	25.03	16.03	42.75	35.73	34.32	15.16	10.99
Refineries	3.29	2.73	1.52	1.45	1.06	1.61	1.20	1.08	0.78
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total NOx Emission in BMR Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26359	25463	14872	20003	31111	41406	54210	77008	107418
Agriculture	5153	5028	388	383	779	893	1030	1191	1378
Res. & Comm.	36470	36250	19684	20436	14590	13185	13321	13705	15650
Transportation	115726	118135	121965	165392	218196	345722	468557	623504	842814
Power Generation	23689	29704	7898	10869	23319	19721	25584	12500	12500
Refineries	1640	1470	377	439	611	943	943	943	943
Total	209037	216050	165183	217522	288606	421869	563646	728852	980704

Share NOx Emission in BMR Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	12.61	11.79	9.00	9.20	10.78	9.81	9.62	10.57	10.95
Agriculture	2.47	2.33	0.23	0.18	0.27	0.21	0.18	0.16	0.14
Res. & Comm.	17.45	16.78	11.92	9.39	5.06	3.13	2.36	1.88	1.60
Transportation	55.36	54.68	73.84	76.03	75.60	81.95	83.13	85.55	85.94
Power Generation	11.33	13.75	4.78	5.00	8.08	4.67	4.54	1.72	1.27
Refineries	0.78	0.68	0.23	0.20	0.21	0.22	0.17	0.13	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total CO2 Emission in BMR Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	14261820	13457878	9035322	10217341	13769999	18508412	22756533	29244407	38850861
Agriculture	3096083	2982959	218665	216531	440440	504857	582824	673812	779641
Res. & Comm.	19200377	19183464	10737180	11368505	8571661	8422940	9151035	10180432	12384294
Transportation	12520736	12705423	12773815	16984493	22320802	33372718	45230063	60187114	81357234
Power Generation	7925248	9922554	2934365	4310201	8193387	6911466	8966484	4380898	4380898
Refineries	1085402	972596	249396	290715	404266	624234	624234	624234	624234
Total	58089666	59224874	35948742	43387787	53700556	68344628	87311173	105290896	138377163

Share CO2 Emission in BMR Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	24.55	22.72	25.13	23.55	25.64	27.08	26.06	27.77	28.08
Agriculture	5.33	5.04	0.61	0.50	0.82	0.74	0.67	0.64	0.56
Res. & Comm.	33.05	32.39	29.87	26.20	15.96	12.32	10.48	9.67	8.95
Transportation	21.55	21.45	35.53	39.15	41.57	48.83	51.80	57.16	58.79
Power Generation	13.64	16.75	8.16	9.93	15.26	10.11	10.27	4.16	3.17
Refineries	1.87	1.64	0.69	0.67	0.75	0.91	0.71	0.59	0.45
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SPM Emission in BMR Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	90550	90624	68798	89174	152603	188316	230555	315575	417799
Agriculture	1526	1577	147	144	293	336	387	448	518
Res. & Comm.	190767	189717	104371	106435	70842	56374	49718	42506	39972
Transportation	52081	49029	42513	56918	76153	113869	154327	205361	277594
Power Generation	9952	11578	3040	2436	12019	10185	13213	6456	6456
Refineries	594	532	136	159	221	342	342	342	342
Total	345470	343057	219004	255265	312131	369421	448543	570688	742681

Share SPM Emission in BMR Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26.21	26.42	31.41	34.93	48.89	50.98	51.40	55.30	56.26
Agriculture	0.44	0.46	0.07	0.06	0.09	0.09	0.09	0.08	0.07
Res. & Comm.	55.22	55.30	47.66	41.70	22.70	15.26	11.08	7.45	5.38
Transportation	15.08	14.29	19.41	22.30	24.40	30.82	34.41	35.98	37.38
Power Generation	2.88	3.37	1.39	0.95	3.85	2.76	2.95	1.13	0.87
Refineries	0.17	0.16	0.06	0.06	0.07	0.09	0.08	0.06	0.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SO2 Emission in Central Region(by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	111390	99901	23727	32779	55417	70166	91151	132912	194363
Agriculture	19143	18379	2786	2732	5556	3224	3722	4303	4978
Res. & Comm.	6652	7007	821	849	647	638	698	784	965
Transportation	10023	14475	7863	10554	13890	12756	17289	23006	31098
Power Generation	177763	212205	289	17	425	192969	245976	353780	595057
Refineries	11042	9894	7965	8177	9678	25133	25133	25133	25133
Total	336013	361861	43450	55107	85613	304886	383968	539917	851594

Share SO2 Emission in Central Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	33.15	27.61	54.61	59.48	64.73	23.01	23.74	24.62	22.82
Agriculture	5.70	5.08	6.41	4.96	6.49	1.06	0.97	0.80	0.58
Res. & Comm.	1.98	1.94	1.89	1.54	0.76	0.21	0.18	0.15	0.11
Transportation	2.98	4.00	18.10	19.15	16.22	4.18	4.50	4.26	3.65
Power Generation	52.90	58.64	0.66	0.03	0.50	63.29	64.06	65.52	69.88
Refineries	3.29	2.73	18.33	14.84	11.30	8.24	6.55	4.65	2.95
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total NOx Emission in Central region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26359	25463	9408	13215	22336	29503	37630	53904	74962
Agriculture	5153	5028	780	770	1567	1796	2073	2397	2773
Res. & Comm.	36470	36250	4233	4395	3138	2836	2865	2948	3366
Transportation	115726	118135	16317	22127	29192	46253	62687	83417	112757
Power Generation	23689	29704	8580	13262	20965	49533	76279	213677	399228
Refineries	1640	1470	1183	1214	1437	3733	3733	3733	3733
Total	209037	216050	40502	54984	78634	133653	185266	360075	596819

Share NOx Emission in Central Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	12.61	11.79	23.23	24.04	28.40	22.07	20.31	14.97	12.56
Agriculture	2.47	2.33	1.93	1.40	1.99	1.34	1.12	0.67	0.46
Res. & Comm.	17.45	16.78	10.45	7.99	3.99	2.12	1.55	0.82	0.56
Transportation	55.36	54.68	40.29	40.24	37.12	34.61	33.84	23.17	18.89
Power Generation	11.33	13.75	21.19	24.12	26.66	37.06	41.17	59.34	66.89
Refineries	0.78	0.68	2.92	2.21	1.83	2.79	2.01	1.04	0.63
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total CO2 Emission in Central Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	14261820	13457878	3322692	3902476	6087533	8510385	10285749	13224034	17372479
Agriculture	3096083	2982959	439964	435672	886187	1015797	1172669	1355742	1568676
Res. & Comm.	19200377	19183464	2309211	2444988	1843480	1811495	1968084	2189473	2663451
Transportation	12520736	12705423	1708968	2272302	2986230	4464831	6051188	8052244	10884528
Power Generation	7925248	9922554	3676428	5686828	8985739	19120075	27252002	69046316	126100887
Refineries	1085402	972596	782943	803776	951392	2470540	2470540	2470540	2470540
Total	58089666	59224874	12240207	15546041	21740560	37393123	49200232	96338350	161060562

Share CO2 Emission in Central Region(by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	24.55	22.72	27.15	25.10	28.00	22.76	20.91	13.73	10.79
Agriculture	5.33	5.04	3.59	2.80	4.08	2.72	2.38	1.41	0.97
Res. & Comm.	33.05	32.39	18.87	15.73	8.48	4.84	4.00	2.27	1.65
Transportation	21.55	21.45	13.96	14.62	13.74	11.94	12.30	8.36	6.76
Power Generation	13.64	16.75	30.04	36.58	41.33	51.13	55.39	71.67	78.29
Refineries	1.87	1.64	6.40	5.17	4.38	6.61	5.02	2.56	1.53
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SPM Emission in Central Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	90550	90624	52349	74551	124184	158377	198145	285398	392281
Agriculture	1526	1577	295	290	589	675	780	901	1043
Res. & Comm.	190767	189717	22447	22891	15236	12124	10693	9142	8597
Transportation	52081	49029	5688	7615	10188	15234	20647	27475	37138
Power Generation	9952	11578	124	161	283	14253	16849	17587	26248
Refineries	594	532	428	440	521	1352	1352	1352	1352
Total	345470	343057	81330	105947	151001	202016	248465	341854	466658

Share SPM Emission in Central Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26.21	26.42	64.37	70.37	82.24	78.40	79.75	83.49	84.06
Agriculture	0.44	0.46	0.36	0.27	0.39	0.33	0.31	0.26	0.22
Res. & Comm.	55.22	55.30	27.60	21.61	10.09	6.00	4.30	2.67	1.84
Transportation	15.08	14.29	6.99	7.19	6.75	7.54	8.31	8.04	7.96
Power Generation	2.88	3.37	0.15	0.15	0.19	7.06	6.78	5.14	5.62
Refineries	0.17	0.16	0.53	0.42	0.34	0.67	0.54	0.40	0.29
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SO2 Emission in North Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	111390	99901	9691	12068	23084	38298	55624	84641	135389
Agriculture	19143	18379	4419	3984	7921	4458	5027	5676	6414
Res. & Comm.	6652	7007	862	814	586	524	521	532	595
Transportation	10023	14475	9435	12227	13398	9805	11055	12239	13764
Power Generation	177763	212205	148919	194751	353734	479006	983086	984897	984897
Refineries	11042	9894	0	0	0	0	0	0	0
Total	336013	361861	173326	223844	398723	532090	1055312	1087985	1141058

Share SO2 Emission in North Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	33.15	27.61	5.59	5.39	5.79	7.20	5.27	7.78	11.87
Agriculture	5.70	5.08	2.55	1.78	1.99	0.84	0.48	0.52	0.56
Res. & Comm.	1.98	1.94	0.50	0.36	0.15	0.10	0.05	0.05	0.05
Transportation	2.98	4.00	5.44	5.46	3.36	1.84	1.05	1.12	1.21
Power Generation	52.90	58.64	85.92	87.00	88.72	90.02	93.16	90.52	86.31
Refineries	3.29	2.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total NOx Emission in North Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26359	25463	2793	3185	8110	16995	23223	29270	45146
Agriculture	5153	5028	1237	1124	2234	2484	2800	3162	3573
Res. & Comm.	36470	36250	4445	4217	2842	2327	2138	2000	2076
Transportation	115726	118135	19580	25634	28159	35551	40085	44377	49906
Power Generation	23689	29704	16163	20983	37213	49928	100826	101011	101011
Refineries	1640	1470	0	0	0	0	0	0	0
Total	209037	216050	44218	55142	78558	107284	169072	179821	201712

Share NOx Emission in North Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	12.61	11.79	6.32	5.78	10.32	15.84	13.74	16.28	22.38
Agriculture	2.47	2.33	2.80	2.04	2.84	2.31	1.66	1.76	1.77
Res. & Comm.	17.45	16.78	10.05	7.65	3.62	2.17	1.26	1.11	1.03
Transportation	55.36	54.68	44.28	46.49	35.84	33.14	23.71	24.68	24.74
Power Generation	11.33	13.75	36.55	38.05	47.37	46.54	59.63	56.17	50.08
Refineries	0.78	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total CO2 Emission in North Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	14261820	13457878	1360867	1431851	2201686	3241718	4179912	5751795	8535255
Agriculture	3096083	2982959	697808	635461	1263338	1404736	1583870	1788452	2021108
Res. & Comm.	19200377	19183464	2424846	2345695	1670008	1486732	1468593	1485455	1642959
Transportation	12520736	12705423	2050653	2632365	2880535	3431727	3869430	4283728	4817405
Power Generation	7925248	9922554	4289820	5544164	9684206	12914686	25800759	25848288	25848288
Refineries	1085402	972596	0	0	0	0	0	0	0
Total	58089666	59224874	10823994	12589536	17699773	22479598	36902563	39157718	42865015

Share CO2 Emission in North Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	24.55	22.72	12.57	11.37	12.44	14.42	11.33	14.69	19.91
Agriculture	5.33	5.04	6.45	5.05	7.14	6.25	4.29	4.57	4.72
Res. & Comm.	33.05	32.39	22.40	18.63	9.44	6.61	3.98	3.79	3.83
Transportation	21.55	21.45	18.95	20.91	16.27	15.27	10.49	10.94	11.24
Power Generation	13.64	16.75	39.63	44.04	54.71	57.45	69.92	66.01	60.30
Refineries	1.87	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SPM Emission in North Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	90550	90624	9762	11373	35748	85828	116651	131825	210608
Agriculture	1526	1577	468	422	840	934	1053	1189	1344
Res. & Comm.	190767	189717	23571	21961	13802	9951	7979	6202	5303
Transportation	52081	49029	6825	8821	9828	11709	13203	14616	16437
Power Generation	9952	11578	1271	1660	3004	4062	8317	8332	8332
Refineries	594	532	0	0	0	0	0	0	0
Total	345470	343057	41896	44237	63222	112484	147203	162165	242024

Share SPM Emission in North Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26.21	26.42	23.30	25.71	56.54	76.30	79.25	81.29	87.02
Agriculture	0.44	0.46	1.12	0.95	1.33	0.83	0.72	0.73	0.56
Res. & Comm.	55.22	55.30	56.26	49.64	21.83	8.85	5.42	3.82	2.19
Transportation	15.08	14.29	16.29	19.94	15.54	10.41	8.97	9.01	6.79
Power Generation	2.88	3.37	3.03	3.75	4.75	3.61	5.65	5.14	3.44
Refineries	0.17	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SO2 Emission In Northeast Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	111390	99901	7767	8785	11549	14355	17859	23186	30398
Agriculture	19143	18379	4392	3931	8236	4809	5573	6467	7511
Res. & Comm.	6652	7007	937	877	639	572	562	568	628
Transportation	10023	14475	8809	11445	13665	11253	14092	17327	21642
Power Generation	177763	212205	0	0	1	2	2	2	2
Refineries	11042	9894	0	0	0	0	0	0	0
Total	336013	361861	21906	25039	34089	30990	38087	47550	60181

Share SO2 Emission in Northeast Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	33.15	27.61	35.46	35.09	33.88	46.32	46.89	48.76	50.51
Agriculture	5.70	5.08	20.05	15.70	24.16	15.52	14.63	13.60	12.48
Res. & Comm.	1.98	1.94	4.28	3.50	1.87	1.84	1.48	1.19	1.04
Transportation	2.98	4.00	40.21	45.71	40.09	36.31	37.00	36.44	35.96
Power Generation	52.90	58.64	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Refineries	3.29	2.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total NOx Emission in Northeast Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26359	25463	2436	2548	3592	4884	5444	6554	7405
Agriculture	5153	5028	1230	1108	2322	2679	3105	3603	4184
Res. & Comm.	36470	36250	4836	4544	3100	2541	2308	2135	2192
Transportation	115726	118135	18280	23996	28720	40801	51095	62825	78470
Power Generation	23689	29704	0	0	1779	4453	4453	4453	4453
Refineries	1640	1470	0	0	0	0	0	0	0
Total	209037	216050	26781	32196	39514	55358	66405	79570	96704

Share NOx Emission in Northeast Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	12.61	11.79	9.09	7.91	9.09	8.82	8.20	8.24	7.66
Agriculture	2.47	2.33	4.59	3.44	5.88	4.84	4.68	4.53	4.33
Res. & Comm.	17.45	16.78	18.06	14.11	7.85	4.59	3.48	2.68	2.27
Transportation	55.36	54.68	68.26	74.53	72.68	73.70	76.95	78.96	81.14
Power Generation	11.33	13.75	0.00	0.00	4.50	8.04	6.71	5.60	4.60
Refineries	0.78	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total CO2 Emission in Northeast Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	14261820	13457878	1318873	1301154	1625722	1903480	2021255	2285034	2630525
Agriculture	3096083	2982959	693668	626899	1313520	1515372	1755993	2037789	2366739
Res. & Comm.	19200377	19183464	2637710	2527602	1821386	1623427	1585617	1585819	1734274
Transportation	12520736	12705423	1914540	2464197	2937982	3938539	4932268	6064554	7574734
Power Generation	7925248	9922554	0	0	763002	1909412	1909412	1909412	1909412
Refineries	1085402	972596	0	0	0	0	0	0	0
Total	58089666	59224874	6564791	6919851	8461612	10890230	12204546	13882608	16215684

Share CO2 Emission in Northeast Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	24.55	22.72	20.09	18.80	19.21	17.48	16.56	16.46	16.22
Agriculture	5.33	5.04	10.57	9.06	15.52	13.91	14.39	14.68	14.60
Res. & Comm.	33.05	32.39	40.18	36.53	21.53	14.91	12.99	11.42	10.70
Transportation	21.55	21.45	29.16	35.61	34.72	36.17	40.41	43.68	46.71
Power Generation	13.64	16.75	0.00	0.00	9.02	17.53	15.65	13.75	11.78
Refineries	1.87	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SPM Emission in Northeast Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	90550	90624	9736	10372	12842	14855	15543	17022	19486
Agriculture	1526	1577	465	417	873	1007	1167	1355	1573
Res. & Comm.	190767	189717	25640	23664	15053	10866	8615	6621	5598
Transportation	52081	49029	6372	8258	10024	13438	16829	20692	25845
Power Generation	9952	11578	0	0	22	54	54	54	54
Refineries	594	532	0	0	0	0	0	0	0
Total	345470	343057	42213	42710	38813	40221	42208	45744	52556

Share SPM Emission in Northeast Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26.21	26.42	23.06	24.28	33.09	36.93	36.82	37.21	37.08
Agriculture	0.44	0.46	1.10	0.98	2.25	2.50	2.77	2.96	2.99
Res. & Comm.	55.22	55.30	60.74	55.41	38.78	27.01	20.41	14.47	10.65
Transportation	15.08	14.29	15.09	19.33	25.83	33.41	39.87	45.24	49.18
Power Generation	2.88	3.37	0.00	0.00	0.06	0.13	0.13	0.12	0.10
Refineries	0.17	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SO2 Emission in South Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	111390	99901	7198	7907	9709	10335	12126	14918	18808
Agriculture	19143	18379	3532	3451	7035	4184	4955	5877	6975
Res. & Comm.	6652	7007	820	764	557	514	527	556	641
Transportation	10023	14475	11191	14397	19062	17612	23964	32015	43447
Power Generation	177763	212205	15948	17932	27659	3087	145601	253459	253459
Refineries	11042	9894	0	0	0	0	0	0	0
Total	336013	361861	38689	44450	64022	35732	187173	306825	323331

Share SO2 Emission in South Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	33.15	27.61	18.60	17.79	15.16	28.92	6.48	4.86	5.82
Agriculture	5.70	5.08	9.13	7.76	10.99	11.71	2.65	1.92	2.16
Res. & Comm.	1.98	1.94	2.12	1.72	0.87	1.44	0.28	0.18	0.20
Transportation	2.98	4.00	28.93	32.39	29.77	49.29	12.80	10.43	13.44
Power Generation	52.90	58.64	41.22	40.34	43.20	8.64	77.79	82.61	78.39
Refineries	3.29	2.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total NOx Emission in South Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26359	25463	3862	4261	5163	5484	5762	6501	7226
Agriculture	5153	5028	989	973	1984	2331	2760	3274	3886
Res. & Comm.	36470	36250	4230	3954	2705	2283	2164	2088	2237
Transportation	115726	118135	23223	30185	40061	63859	86892	116084	157536
Power Generation	23689	29704	1903	2234	3541	5762	20213	30745	30745
Refineries	1640	1470	0	0	0	0	0	0	0
Total	209037	216050	34207	41607	53455	79719	117790	158692	201630

Share NOx Emission in South Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	12.61	11.79	11.29	10.24	9.66	6.88	4.89	4.10	3.58
Agriculture	2.47	2.33	2.89	2.34	3.71	2.92	2.34	2.06	1.93
Res. & Comm.	17.45	16.78	12.37	9.50	5.06	2.86	1.84	1.32	1.11
Transportation	55.36	54.68	67.89	72.55	74.94	80.11	73.77	73.15	78.13
Power Generation	11.33	13.75	5.56	5.37	6.63	7.23	17.16	19.37	15.25
Refineries	0.78	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total CO2 Emission in South Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	14261820	13457878	1324708	1329467	1582810	1728228	1801994	1978467	2218061
Agriculture	3096083	2982959	557759	550397	1122087	1318394	1561291	1851636	2197768
Res. & Comm.	19200377	19183464	2307235	2199623	1589191	1458407	1486455	1551366	1770459
Transportation	12520736	12705423	2432280	3099752	4098164	6164379	8387678	11205594	15207028
Power Generation	7925248	9922554	580703	710618	1154030	2436884	6085394	8689121	8689121
Refineries	1085402	972596	0	0	0	0	0	0	0
Total	58089666	59224874	7202686	7889857	9546282	13106291	19322812	25276185	30082437

Share CO2 Emission in South Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	24.55	22.72	18.39	16.85	16.58	13.19	9.33	7.83	7.37
Agriculture	5.33	5.04	7.74	6.98	11.75	10.06	8.08	7.33	7.31
Res. & Comm.	33.05	32.39	32.03	27.88	16.65	11.13	7.69	6.14	5.89
Transportation	21.55	21.45	33.77	39.29	42.93	47.03	43.41	44.33	50.55
Power Generation	13.64	16.75	8.06	9.01	12.09	18.59	31.49	34.38	28.88
Refineries	1.87	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Total SPM Emission in South Region (by Sector and Year)

(Unit : Ton/Year)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	90550	90624	18143	21438	25271	25713	26798	29499	33438
Agriculture	1526	1577	374	366	746	876	1038	1231	1461
Res. & Comm.	190767	189717	22427	20593	13134	9761	8076	6477	5714
Transportation	52081	49029	8095	10388	13982	21033	28619	38234	51887
Power Generation	9952	11578	15527	13383	1429	288	1296	2202	2202
Refineries	594	532	0	0	0	0	0	0	0
Total	345470	343057	64566	66168	54562	57671	65827	77643	94703

Share SPM Emission in South Region (by Sector and Year)

(Unit : Percent)

	1979	1981	1986	1988	1991	1996	2001	2006	2011
Industry	26.21	26.42	28.10	32.40	46.32	44.59	40.71	37.99	35.31
Agriculture	0.44	0.46	0.58	0.55	1.37	1.52	1.58	1.59	1.54
Res. & Comm.	55.22	55.30	34.74	31.12	24.07	16.93	12.27	8.34	6.03
Transportation	15.08	14.29	12.54	15.70	25.63	36.47	43.48	49.24	54.79
Power Generation	2.88	3.37	24.05	20.23	2.62	0.50	1.97	2.84	2.32
Refineries	0.17	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Appendix 3.3

Top Five Hazardous Waste

Producing Industries,1989

Appendix 3.3 Top Five Hazardous - Waste - Producing Industries,1989

NO.	PROVINCE	BASIC METAL	FABRICATED PRODUCTS	TRANSPORT PRODUCTS	ELECTRICAL MACHINERY	CHEMICAL PRODUCTS	TOTAL
1	BANGKOK	67	4252	2300	811	555	7985
2	NAKORNPATO	9	48	84	11	37	189
3	NONTHABURI	1	84	100	23	34	242
4	PATHUM	8	51	43	33	47	182
5	SAMUTPRAKA	89	537	302	125	174	1227
6	SAMUTSAKOR	18	154	89	20	46	327
*	GREATER BK	192	5126	2918	1023	893	10152
7	KANCHANAB	0	29	168	24	9	230
8	CHANTABURI	1	21	99	2	0	123
9	CHACHEANGS	1	15	25	9	6	56
10	CHONBURI	0	34	100	7	13	154
11	CHAINAT	0	3	16	0	0	19
12	TRAD	0	10	104	1	0	115
13	NAKORNNAY	0	5	21	1	2	29
14	PRACHEUB	1	20	66	2	3	92
15	PRACHIN	0	9	35	4	4	52
16	AYUDHAYA	0	21	24	4	3	52
17	PETBURI	0	18	60	3	2	83
18	RAYONG	0	13	37	1	1	52
19	RATBURI	0	33	134	2	4	173
20	LOPBURI	0	20	53	2	3	78
21	SAMUTSONG	1	4	21	0	2	28
22	SARABURI	3	14	33	0	11	61
23	SINGBURI	0	2	18	0	0	20
24	SUPHAN	0	26	52	14	5	97
25	ANGTHONG	0	3	5	1	2	11
*	CENTRAL	7	300	1071	77	70	1525

Appendix 3.3 Top Five Hazardous - Waste - Producing Industries,1989

NO.	PROVINCE	BASIC METAL	FABRICATED PRODUCTS	TRANSPORT PRODUCTS	ELECTRICAL MACHINERY	CHEMICAL PRODUCTS	TOTAL
26	KAMPANGPET	0	11	30	1	2	44
27	CHIENGMAI	1	14	50	4	19	88
28	CHIENGRAI	0	22	47	3	3	75
29	TAK	0	4	10	0	1	15
30	NAKORNSAW	0	41	85	5	7	138
31	NAN	0	22	56	2	0	80
32	PAYAO	0	6	31	0	0	37
33	PICHIT	0	21	53	0	6	80
34	PISANULOK	1	36	111	13	2	163
35	PETCHABOON	0	22	146	16	0	184
36	PHARE	0	14	39	2	4	59
37	MAEHONGSO	0	3	6	0	8	17
38	LAMPANG	0	26	42	1	11	80
39	LAMPHUN	0	13	15	2	1	31
40	SUKOTHAI	0	13	50	0	3	66
41	UTRALADIT	0	16	65	0	3	84
42	UTHAI	0	0	3	0	0	3
*	NORTH	2	284	839	49	70	1244
44	KHONKAN	1	48	149	8	10	216
45	CHAIPHUM	0	6	14	1	0	21
46	NAKOAMPAN	0	20	67	0	2	89
47	NAKORNRATS	2	54	180	8	5	249
48	BURIRUM	0	7	24	0	0	31
49	MAHASARAK	0	7	37	1	0	45
50	MUGDAHAN	0	2	23	0	0	25
51	YASOTHON	0	4	11	0	0	15
52	ROIET	0	22	54	5	6	87
53	LEOI	0	0	3	0	0	3
54	SISAKET	0	0	2	0	1	3
55	SAKON	1	18	66	0	1	86
56	SURIN	1	14	45	0	0	60
57	NONGKAI	0	23	40	0	1	64
58	UDON	3	60	181	11	2	257
59	UBON	0	45	91	5	0	141
*	NORTHEAST	8	339	1006	39	28	1420
60	KRABI	0	0	10	0	0	10
61	CHUMPON	0	3	38	1	2	44
62	TRANG	1	10	16	0	2	29
63	NAKORNSRIT	0	17	95	2	3	117
64	NRATIVAT	0	19	73	1	0	93
65	PATTANI	0	13	36	1	1	51
66	PANGA	2	6	31	1	0	40
67	PATALUNG	0	2	25	0	2	29
68	PHUKET	2	15	56	4	1	78
69	YALA	4	10	20	1	0	35
70	RANONG	1	2	18	0	1	22
71	SONGKLHA	4	69	69	2	13	157
72	SATUN	0	3	4	0	0	7
73	SURATANI	0	17	49	3	4	73
*	SOUTH	14	186	540	16	29	785

Appendix 4.1

Toxic Metal

Effects and Sources

Appendix 4.1 Toxic Metal : Effects and Sources

Metal	Major health effects	Major ecological effects	Major atmospheric emission sources
Arsenic as Arsenic Trioxide (AS_2O_3)	Carcinogen (also shown for man), possible teratogen neurotoxin		Smelting of non-ferrous ores, pesticides, catalyst and reagent for inorganic chemical production, additive to glass and non-ferrous alloys
Beryllium (Be)	Contact dermatitis, ulcers, inflammation of mucous membranes chronic berylliosis and (animal) carcinogen		Combustion of coal and oil, mining, production of beryllium metal, cement plants, alloys, ceramics and rocket propellants
Cadmium (Cd)	(Animal) carcinogen, teratogen, damage to liver, kidneys, lungs and blood (anaemia)	Has a long biological half-life and bioaccumulates	By-product of zinc processing, used in electroplating, plastics pigments and batteries; waste disposal by incineration, fertilizer processing and application, combustion of fossil fuels
Lead (Pb)	Impairment of haem synthesis in children, and possible subclinical neurological problems		Lead-acid batteries manufacture, lead-based paint, gasoline combustion, non-ferrous smelters
Mercury (Hg)	Central nervous system and kidney disorders (toxicity depends on chemical form)	Transformed into alkyl mercury compounds with long biological half-life and bioaccumulative	Electrical apparatus, electrolytic preparation of caustic soda and chlorine, antifouling paint, pharmaceutical products and coal combustion

Note. Arsenic is a metalloid with semimetallic properties; it is placed in this Table, however, because it is usually associated with the metal industry and metal emissions

Source: OECD

Appendix 4.2

Known or Potential Toxic Organic Compounds

(Sources and Environmental Presence)

Appendix 4.2 Known or Potentially Toxic Organic Compounds (Sources and Environmental Presence)

Organic compound	Major emission sources	Remarks on environmental presence
Acetaldehyde (Ethanal)	Coffee roasting, manufacture of acrylic acid, acetic acid and vinyl acetate, car exhaust	Atmospheric half-life: 1-2 days
Acrylonitrile (2-Propenenitrile)	Intermediate in the production of polymers and other chemicals	
Allyl chloride (3-Chloro-1-propene)	Synthetic intermediate chemical	
Benzene (C_6H_6)	Petrol-fuelled internal combustion engines, raw material in production of other chemicals, petroleum refineries, gasoline storage and handling and coke ovens	
Benzidine ($C_{12}H_{12}N_2$) [(1,1-Biphenyl)-4,4-diamine]	Manufacture of dye, paper, textiles and leather	Atmospheric half-life: 1-4 days
Benzo(a)pyrene ($C_{20}H_{12}$) Indicator pollutant for Polycyclic organic matter	By-product of incomplete combustion of coal (coke ovens), wood, charcoal and diesel fuel	
Benzyl chloride (Chloromethylbenzene)	Manufacture of polychlorinated biphenyls, n-butylbenzyl phthalate, benzyl alcohol, quaternary ammonium compounds and benzyl acetate	
Bis (Chloro-methyl) ether	Manufacture of polymethylene and polyphenyl isocyanate	
Carbon tetrachloride (CCl_4)	Dichlorodifluoromethane and trichlorofluoromethane production, fire extinguishers, dry cleaning agents, cleaning agents for machinery and electrical parts	Atmospheric half-life: 10 years; half-life in water: 70 000 years
Chlorofluorocarbons	Aerosol propellant, refrigerant and foaming agents in plastics industry	Potential effect on stratospheric ozone layer with possible increase of UV radiation and possible climatic changes
Chloroform ($CHCl_3$)	Production of chlorodifluoromethane, miscellaneous (industrial solvent, fumigant, pharmaceuticals, solvent, rubber industry)	Atmospheric half-life: 1-2 years
Chloroprene (2-Chloro-1,3-butadiene)	Production of neoprene	Atmospheric half-life: 10 hours
Dioxins such as TCDD (Polychlorinated dibenzo-p-dioxins)	Waste incinerators, herbicides	Half-life in soil: 10 to 12 years
Epichlorohydrin (1-Chloro-2,3-epoxypropane)	Production of synthetic glycerinepoxy resins and elastomers	
Ethylene dibromide ($C_2H_4Br_2$) (1,2-Dibromoethane)	Scavenger in leaded gasoline, soil and seed fumigant, dye production, pharmaceuticals and solvent	Atmospheric half-life: 20 hours
Ethylene dichloride, ($C_2H_4Cl_2$) (1,2-Dichloroethane)	Production of vinyl chloride	Atmospheric half-life: 1 000 days
Ethylene oxide (C_2H_4O) (Oxirane)	Intermediate in production of ethylene glycol, production of polyester fibre and film and non-ionic surface active agents	Atmospheric half-life: 3 hours - 1.6 days
Formaldehyde (CH_2O) (Methanal)	Charcoal manufacturing, catalytic cracking in petroleum refining, internal combustion engine exhausts, resin production, formaldehyde production and storage	
Hexachlorobenzene (C_6Cl_6)	Origin partly unknown	Atmospheric half-life: 2 days
Methyl chloroform (1,1,1-Trichloroethane)	Metal cleaning and cleaning plastic molds	
Methylene chloride (CH_2Cl_2)	Major component in paint-strippers	Atmospheric half-life 1-2 years
2-Naphtylamines ($C_{10}H_9H$)	Research purposes	

Appendix 4.2 Known or Potentially Toxic Organic Compounds (Sources and Environmental Presence)

Organic compound	Major emission sources	Remarks on environmental presence
Nitrobenzene ($C_6H_5NO_2$)	Production of aniline	
Nitrosamines (R-RN-N=O)	Limited commercial production but formed in air, water and food from precursors, amines, nitrogen oxides and nitrates	
Perchloroethylene (C_2Cl_4) (1,1,2,2-Tetrachloroethene)	Chlorination of acetylene, dry cleaning solvent and degreasing metals	
Phenol (C_6H_6O)	Manufacture of explosives, fertilizer, coke, illuminating gas, lampblack, paints, paint removers, rubber, asbestos goods, wood preservatives, synthetic resins, textiles, drugs, pharmaceutical preparations, perfumes, bakelite and other plastics (phenoloformaldehyde resins); disinfectant in petroleum, leather, paper, soap, toy, tanning, dye and agricultural industries	
Phosgene ($COCl_2$) (Carbonic dichloride)	Manufacture of dyestuffs based on triphenylmethane, coal tar and urea, used in the organic synthesis of isocyanates and their derivatives, carbonic acid esters (polycarbonates) and in the manufacture of some insecticides and pharmaceuticals	
Polychlorinated biphenyls ($C_{12}Cl_xH_{10-x}$)	Production, storage and transport of PCBs, incineration of waste PCBs (electrical transformers and capacitors), solid waste disposal, evaporative losses of plasticisers, volatilisation of PCB containing paints and coatings	Atmospheric half-life: 26 days; a widespread pollutant of fish and wildlife
Propylene oxide (C_3H_6O) (Methyl oxirane)		Atmospheric half-life: 23 hours
Trichloroethylene (C_2HCl_3) (1,1,2,Trichloroethene)	Solvent in degreasing operations, PVC production, inks, surface coatings, adhesives, dry cleaning and pharmaceuticals	
Vinyl chloride (C_2H_3Cl) (1-chloroethene)	Production of polyvinyl chloride	Atmospheric half-life: 12 hours
Vinylidene chloride ($C_2H_2Cl_2$) (1,1-dichloroethene)	Monomer and polymer synthesis (latex coatings, extrusion resins), fabrication and polymer processing	

Source: OECD (17)

Appendix 4.3

Characteristics and Effects of Major Air Pollutant

Appendix 4.3 Characteristics and Effect of Major Air Pollutant

Pollutant	Characteristics	Principal sources	Principal effects	Controls	National ambient standards [1,2] (in micrograms per cubic meter)
Total suspended particulates (TSP)	Any solid or liquid particles dispersed in the atmosphere, such as dust, pollen, ash, soot, metals, and various chemicals; the particles are often classified according to size as settleable particles: larger than 50 microns· aerosols: smaller than 50 microns; and fine particulates: smaller than 3 microns	Natural events such as forest fires, wind erosion, volcanic eruptions; stationary combustion, especially of solid fuels; construction activities; industrial processes; atmospheric chemical reactions	Health: Directly toxic effects or aggravation of the effects of gaseous pollutants; aggravation of asthma or other respiratory or cardiorespiratory symptoms; increased cough and chest discomfort; increased mortality Other: Soiling and deterioration of building materials and other surfaces, impairment of visibility, cloud formation, interference with plant photosynthesis	Cleaning of flue gases with inertial separators, fabric filters, scrubbers, or electrostatic precipitators; alternative means for solid waste reduction; improved control procedures for construction and industrial processes	Primary: Annual=75 24-hour=260 Secondary: Annual=60 24-hour=150 Alert: 24-hour=375
Sulfur dioxide (SO_2)	A colorless gas with a pungent odor, SO_2 can oxidize to form sulfur trioxide (SO_3), which forms sulfuric acid with water	Combustion of sulfur-containing fossil fuels, smelting of sulfur-bearing metal ores, industrial processes, natural events such as volcanic eruptions	Health: Aggravation of respiratory diseases, including asthma, chronic bronchitis, and emphysema; reduced lung function; irritation of eyes and respiratory tract; increased mortality Other: Corrosion of metals; deterioration of electrical contacts, paper, textiles, leather, finishes and coatings, and building stone; formation of acid rain; leaf injury and reduced growth in plants	Use of low-sulfur fuels; removal of sulfur from fuels before use; scrubbing of flue gases with lime or catalytic conversion	Primary: Annual=80 24-hour=365 Alert: 24-hour=800
Carbon monoxide (CO)	A colorless, odorless gas with a strong chemical affinity for hemoglobin in blood	Incomplete combustion of fuels and other carbon-containing substances, such as in motor vehicle exhausts; natural events such as forest fires or decomposition of organic matter	Health: Reduced tolerance for exercise, impairment of mental function, impairment of fetal development, aggravation of cardiovascular diseases Other: Unknown	Automobile engine modifications (proper tuning, exhaust gas recirculation, redesign of combustion chamber); control of automobile exhaust gases (catalytic or thermal devices); improved design, operation, and maintenance of stationary furnaces (use of finely dispersed fuels, proper mixing with air, high combustion temperature)	Primary: 8-hour=10,000 1-hour=40,000 Alert: 8-hour=17,000

See footnotes at end of table.

Appendix 4.3 Characteristics and Effect of Major Air Pollutant

Pollutant	Characteristics	Principal sources	Principal effects	Controls	National ambient standards [1,2] (in micrograms per cubic meter)
Photochemical oxidants (O_X)	Colorless, gaseous compounds which can comprise photochemical smog, e.g., ozone (O_3), peroxyacetyl nitrate (PAN), aldehydes, and other compounds	Atmospheric reactions of chemical precursors under the influence of sunlight	Health: Aggravation of respiratory and cardiovascular illnesses, irritation of eyes and respiratory tract, impairment of cardiopulmonary function Other: Deterioration of rubber, textiles, and paints; impairment of visibility; leaf injury, reduced growth, and premature fruit and leaf drop in plants	Reduced emissions of nitrogen oxides, hydrocarbons, possibly sulfur oxides	Primary: 1-hour=160 Alert: 1-hour=200
Nitrogen dioxide (NO_2)	A brownish-red gas with a pungent odor, often formed from oxidation of nitric oxide (NO)	Motor vehicle exhausts, high-temperature stationary combustion, atmospheric reactions	Health: Aggravation of respiratory and cardiovascular illnessas and chronic nephritis Other: *Fading of paints* and dyes, impairment of visibility, reduced growth and premature leaf drop in plants	Catalytic control of automobile exhaust gases, modification of automobile engines to reduce combustion temperature, scrubbing flue gases with caustic substances or urea	Primary: Annual=100 Alert: 24-hour=282 1-hour=1,130
Hydrocarbons (HC)	Organic compounds in gaseous or particulate form, e.g., methane, ethylene, and acetylene	Incomplete combustion of fuels and other carbon-containing substances, such as in motorvehicle exhausts; *processing, distribution*, and use of petroleum compounds such as gasoline and organic solvents; natural events such as forest fires and plant metabolism; atmospheric reactions	Health: Suspected contribution to cancer Other: Major precursors in the formation of photochemical oxidants *through* atmospheric reactions	Automobile engine modifications (proper tuning, crankcase ventilation, exhaust gas recirculation, redesign of combustion chamber); control of automobile exhaust gases (catalytic or thermal devices); improved design, *operation, and* maintenance of stationary furnaces (use of finely dispersed fuels, proper mixing with air, high combustion temperature); improved control procedures in processing and handling petroleum compounds	Primary: 3-hour=160

[1] Pollutants for which national ambient air quality standards have been established.

[2] Primary standards are intended to protect against adverse effects on human health. Secondary standards are intended to protect against adverse effects on materials, vegetation, and other environmental values.

[3] The federal episode *criteria specify that meteorological conditions are such that* pollutant concentrations may be expected to remain at these levels for 12 or more hours or to increase; in the case of oxidants, the situation is likely to reoccur within the next 24 hours unless control actions are taken.

Source: Based on information compiled by Enviro Control, Inc.

Appendix 5.1

Agencies of Environmental Policy

Appendix 5.1

Agencies of Environmental Policy

PLANNING AND POLICY FORMULATION AGENCIES

The Office of National Economic and Social Development Board (NESDB) -- The NESDB is a planning agency directly under the Prime Minister's Office which overlooks both macro and sectoral plans. Under the National Economic and Social Development Act of 1978, the NESDB is chartered with carrying out the following functions:

1. To formulate policies and draw up master plans for the country's economic and social development.
2. To translate the policies and plans into consistent operational plans for the related ministries, bureaus, and departments in the government so that they can be implemented.
3. To monitor and follow up on various plans and projects of the implementing agencies.
4. To evaluate the actual implementation of the plans and projects of the various government agencies.

For environmental policies and plans, the Technology Planning and Environment Division is the unit directly charged with these responsibilities in the NESDB. The Government-Private Cooperation Division is the unit directly in charge of industrial policies and plans.

In the planning and formulation of industrial and environment plan, it can be said that the NESDB is the core agency which provides the studies and analysis to back up such activities. It also screens developmental projects and offers advice in solving problems to various governmental agencies. The approach that the NESDB uses while carrying out its duties is to consult and coordinate with the various government agencies together with domestic and expatriate academics and experts in various fields. Also, the NESDB quotes through various working groups and subcommittees.

The Office of the National Environment Board (ONEB) -- The ONEB was established in 1975 under the Ministry of Science, Technology, Energy. (MSTE).

The ONEB has the following principle duties:

1. To perform works that are entrusted by the National Environment Board (NEB)
2. To study and analyze the environmental conditions and quality to be used for planning purposes, to determine standards of national environmental quality, and to formulate guidelines for its enhancement
3. To recommend measures to the NEB for improvement and enhancement of national environmental quality
4. To check and evaluate the results of compliance with, or enforcement of laws, rules, and regulations concerning the prevention and the conservation of environmental quality by government agencies, state enterprises, and private organizations, and to report to the NEB
5. To receive for consideration and remedy a petition from any person concerning aggressive or damaging acts having an adverse effect on environmental quality
6. To act as the center for coordination and public relations environmental quality matters within the country and for contacts with foreign countries on environmental matters
7. To promote or carry out studies, research, and dissemination of information on problems of environmental quality in coordination with educational establishments and other agencies
8. To promote and encourage the study of environmental quality at every level of education
9. To perform other functions as may be designated by law to be the responsibility of the ONEB

The National Environmental Quality Act (NEQA) does not give direct enforcement capability to the NEB. However, it empowers the ONEB to issue ministerial regulations for certain designated projects requiring them to submit an Environmental Impact Assesment (EIA) to be approved by the NEB for industries of a certain size. The ONEB can make recommendations to responsible agencies such as the Ministry of Industry (MOI) concerning pollution problems requesting them to use their enforcement function.

POLICY-IMPLEMENTING AGENCIES

The Department of Industrial Work (DIW) -- The DIW is under the MOI and is in charge of administering the Factory Act and other acts relating to the operation of factories. In conjunction with its provincial offices, the DIW is responsible for all activities concerning industrial environmental services and controlling and enforcing the Factory Act throughout the country. In the area of regulation, the DIW has instituted a number of programs to license industrial discharges, enforce effluent standards, monitor work, provide central treatment facilities for hazardous waste, and provide training programs for waste treatment operators. The DIW licensing program covers all aspects of industrial activity such as boiler safety, building code requirements, worker sanitation and health, wastewater discharge, air emissions, odors, community health and safety, and industrial solid wastes. The DIW activities in industrial pollution control industries consist of the following:

1. Licensing System Prior to Construction - Review of treatment system design and/or measure in control pollution (water, air, hazardous waste, and industrial solid waste) prior to construction.
2. Licensing System Prior to Operation - Inspection of treatment facilities according to the design previously submitted to the DIW.
3. Factory Monitoring - Pollution monitoring work is performed by the DIW at end of pipe (for both water and air) for efficiency inspection. The DIW is empowered by the Factory Act to enforce the following orders.
4. License Renewal - Every three years, factory licenses must be renewed, and the DIW will inspect a factory when necessary -- especially those with violation records.
5. Industrial Complaint - In case of a complaint related to industrial pollution, the DIW will inspect the treatment system and follow the procedure in step 3.
6. Factory Expansion License - For every factory expansion, the DIW will review the existing treatment system in relation to the proposed expansion capacity for its viability.
7. Treatment Design Service - The DIW gives treatment design service free of charge to a factory with a small production capacity.
8. Central Treatment Facility - The DIW has constructed central treatment systems to facilitate waste from sugar refineries in Ratchaburi Province and Kanchanaburi Province and from a hazardous waste treatment factory at Bangkhuntien.
9. Training for Treatment Operation - The DIW conducts training courses for industry wastewater operators and for technical staff employed by industry.

Within the DIW, the One Stop Service Center is responsible for issuing a factory license for industrial activity that was not by the promoted BOI as well as for managing to obtain further permits needed for the following industries and activities: food processing, drug, cosmetic, toxic materials, furniture, animal feed, building building construction building, storing fuel oil, and operating artesian well water.

The Industrial Estate Authority of Thailand (IEAT) -- The IEAT, founded in 1972, is a public enterprise under the MOI. A primary objective of the government is to accelerate industrialization and urban development planning through implementation of well-equipped industrial locations as a way to help solving the problem of urban deterioration. The IEAT's responsibility encompasses the planning, developing, and management of industrial estates and export-processing zones throughout the country. The projects are managed either separately by the IEAT or in cooperation with private enterprise.

The industrial estate is divided into two zones:

General Industrial Zone (GIZ) - This area is designated for industrial activities or other activities beneficial to or connected with industrial activities.

Export-Processing Zone (EPZ) - This area is designated for industrial activities or other activities beneficial to, or connected with, industrial activities for the purpose of export products.

The following were laid down as objectives of IEAT:

1. To procure suitable land for the establishment or expansion of industrial estates or for other business beneficial to or connected with IEAT
2. To improve land under the first objective in order to provide services as well as other facilities for the operation of industrial operators such as providing roads, drainage systems, wastewater treatment plants, electricity and water works
3. To let sale by hire-purchase and sale of immovable or movable properties in an industrial estate or for direct benefit of the activities of an industrial estate
4. To carry out other businesses beneficial to, or connected with, the activities which are within the scope of the IEAT's objectives
5. To cooperate with other persons in carrying out the objectives under (1), (2) or (3) including being a partner with limited liability in a limited partnership or a shareholder in any juristic person whose objectives are beneficial to or connected with the activities which are within the scope of the IEAT's objectives
6. To promote and regulate industrial estates for both private and state agencies

To achieve its tasks the IEAT is carrying out the following activities:

1. Surveying, planning, designing, construction, and maintenance of facilities and provision of services to industrial operators and persons engaged in activities beneficial to or connected with industrial operators
2. Designation of categories and size of industrial activities permissible in an industrial estate
3. Supervision of living conditions of workers in an industrial estate
4. Control of the operations of industrial operators, of persons engaged in activities beneficial to or connected with industrial operators, and of persons utilizing land in an industrial estate in accordance with rules, regulations, and laws including the carrying out of works in connection with public health and affecting environmental quality
5. Investment
6. Borrowing of money for financing activities of the IEAT
7. Issuance of bonds or other instruments for investment
8. Inspecting and certifying of kinds and quantity of raw materials or products or the kinds and number of machinery in the case where it is necessary to issue certificates or in the case where they are brought into or taken out of an industrial estate
9. Renting of immovable or movable property and maintenance fees for facilities as well as service charges in an industrial estate
10. Providing necessary services and facilities to industrial operators in industrial estates

Although the activities list does mention environmental quality, the IEAT does not have a formal environmental unit to handle work at either the feasibility stage or the operational stage.

Department of Health (DOH) -- The DOH is under the Ministry of Public Health (MOPH) and is in charge of the Public Health Act (PHA). Besides implementing the government's health program, it is also responsible for environmental protection pertaining to waste disposal environmental monitoring, and environmental conditions in the work place. The work is being undertaken by two units, namely the Occupational Health Division and the Environmental Health Division. The Occupational Health Division is concerned with environmental conditions in the work place. The Environmental Health Division is responsible for environmental protection pertaining to the disposal of wastes from communities and hospitals and for environmental monitoring.

The Board of Investment (BOI) -- The BOI was set up in 1960 and is Thailand's central investment planning authority, with wide discretionary powers to promote both foreign and domestic investment, especially in the industrial sector. The activities of the BOI have been concentrated in the provision of investment incentives to targeted industries. In 1972 the BOI began to provide extra incentives to particular areas outside Bangkok. The main functions of the BOI include the following:

1. To disseminate information regarding the investment climate together with attracting investment in target industries.
2. To establish an investment center to provide services to investors including the obtaining of various permits, project preparation assistance, and identification of project partners
3. To analyze project applications for investment promotion and to verify, control, and evaluate projects which received promotion privileges
4. To identify investment opportunities and promote new industries

Under the BOI, the Investment Service Center (ISC) was established to facilitate investors' obtaining all permits and registrations to operate a factory. There are two centers established to provide full service to investor: (1) The Center Office of the Board of Investment is responsible for issuing factory licences for BOI-promoted activity, as well as managing to obtain further permits; and (2) The Center in the Department of Industrial Works is responsible for issuing factory licenses for nonpromoted activity as well as for managing to obtain further permits.

The ISC is empowered to issue permits for the establishment or expansion of factories, or for factories operation, and will coordinate with the related agencies to obtain other permits within 90 days of the date of application. In relation to environmental requirements, certain industrial projects have to conform with all the requirements stipulated by the ONEB and the MSTE prior to BOI promotion.

PRIVATE SECTOR INSTITUTIONS RELATED TO INDUSTRY/ENVIRONMENT

The Industrial Finance Corporation of Thailand (IFCT) -- The IFCT was established by the government under the Industrial Finance Corporation of Thailand Act in 1958 (2502) during the same period when the BOI was set up. The principal purpose of the IFCT is to provide investment capital for the establishment, expansion, and modernization of industries in Thailand. The IFCT appraisal process includes marketing, financing, and engineering analyses. (The Industrial Management Co. Ltd., an affiliated company of the IFCT, was established in 1977 to provide consultancy services in the area of industrial management, and research services on economic and industrial issues to both the public and private sectors as well as international institutions. The consultancy services include feasibility studies, marketing research, accountıng and production systems designs, and staff training). The key criteria are debt-equity ratio -- long-term debt should not exceed 60 percent of total equity -- cash flow adequacy, and an interest rate of return (IRR) at least equal to the opportunity cost of capital. The IFCT does provide investment capital needed by industries to implement in-plant waste treatment as part of the loan package.

The Federation of Thai Industries (FTI) -- The FTI, originally founded in 1967 as the Association of Thai Industries (ATI), is a legally representative body of the industrial private sector in Thailand. It plays a key role in bringing about cohesion between the private and the government sectors based on mutual benefit through the Joint Public/Private Sector Consultative Committee (JPPSCC). At present, FTI consists of more than 1,800 members. These are grouped into 24 industrial clubs and six provincial subcommittees. Each club has its own representative to the FTI. Through coordination with the MOI, the FTI plays an important role in promoting industrial development which falls under the responsibility of the MOI, namely, plant establishments, applications for promotion privileges, production, increases in technological input, etc.

In accordance with FTI Act of 1987 (2530), the main functions of the FTI include the following:

1. To act as a spokesman for manufacturers who form a major part of the private sector in coordinating with the government in matters relating to industrial policies and production
2. To promote activities to benefit the manufacturing sector
3. To seek remedial action for any problems arising in the industrial sector
4. To promote and improvise services to members, such as feasibility studies, research, training, dissemination of information on technology, and technical knowledge related to manufacturing (these may be organized to serve the need of the general public as well
5. To assist in conducting tests on products and to issue certificates of origins and product quality certificates
6. To advise the government on raising the country's industrial input for economic development
7. To give encouragement to manufacturers and, at the same, time serve as a forum for industrialists in various fields to exchange views which would be beneficial to the industry
8. To ensure that members comply with industrial standards and regulations laid down by the government
9. To engage in other activities as governed by other laws concerning the FTI or assigned by the government agencies

The Industrial Environmental Management Subproject IEM, under the management of the Natural Resources and Environment for Sustainable Development Project (MANRES) funded by USAID, is operated by the FTI to promote greater awareness among Thai industrialists of fundamental environmental problems. The FTI is charged with maintaining an effective liaison with the MOI, the ONEB, and other relevant RTG agencies using FTI channels and mechanisms with in the public sector. The activities of the FTI on IEM consist of the following:

1.Establish constructive dialogue between various interest groups on specific policy issues

2.Introduce and disseminate information on experience and technology available

3.Discuss relevant international experience with the application of incentives/disincentives to bring about behavioral modification by industrial users

4.Support the development of action plans for eventual implementation by participating Thai industries

5.Support technical assistance to the Thai industrial sector in cooperation with lending organizations and industries from the United States, focusing in the areas of industrial pollution control, toxic and hazardous waste management, and work health and safety

Appendix 5.2

Foreign Investment

Appendix 5.2 Foreign Investment

Foreign Investment Pattern by Country of Origin

(Percentage)

Country	Percentage Share b/						Annual Growth Rate b/				
	1980	1985	1986	1987	1988	1989p c/	1980-85	1985-86	1986-87	1987-88	1989p c
United States	18.9	54.2	18.7	20.1	11.3	14.2	26.7	(65.5)	7.2	(44.0)	77.9
Japan	23.3	34.6	44.1	36.1	51.7	50.2	11.2	26.7	(18.1)	42.9	42.1
EEC.	20.0	9.7	7.4	10.4	8.0	9.3	(7.7)	(23.8)	41.1	(23.4)	112.4
United Kingdom	2.1	2.0	3.6	3.6	3.1	3.6	8.1	31.9	0.0	(14.0)	390.0
W.Germany	6.8	3.8	2.3	5.0	2.2	1.5	(6.4)	(30.9)	113.8	(55.6)	9.1
France	0.3	3.3	1.3	1.5	1.0	3.0	61.7	(59.4)	11.4	(32.0)	140.2
Netherlands	0.6	(1.0)	(0.8)	0.6	1.0	0.3	(23.8)	(14.6)	(200.0)	24.4	(2.5)
Italy	4.0	0.3	1.1	0.1	0.1	0.4	(14.0)	360.0	(93.0)	25.0	335.4
Australia	1.0	(1.8)	2.1	0.3	0.1	0.4	(24.7)	(217.8)	(86.8)	(140.4)	169.1
Canada	(1.1)	0.6	0.5	0.1	0.2	0.1	13.1	(38.1)	(76.9)	75.0	(15.6)
Switzerland	1.9	1.8	4.0	0.7	2.0	3.5	1.3	121.7	117.8	(77.1)	177.0
Asian NIEs	36.2	(6.9)	21.7	22.6	28.4	20.2	(12.3)	(412.1)	4.2	26.1	(0.1)
Hong Kong	28.7	14.7	13.8	8.8	10.9	10.1	(7.2)	(6.2)	(36.4)	22.8	23.4
Korea	0.3	(0.1)	0.1	0.2	1.1	0.5	(10.5)	(187.5)	257.1	324.0	(23.6)
Singapore	7.2	(25.5)	5.8	5.9	5.4	(0.9)	(38.2)	(122.9)	1.4	(9.1)	(118.7)
Taiwan	0.0	3.9	1.9	7.6	11.2	10.5	145.1	(50.5)	295.6	47.2	45.4
Asean-4	4.0	0.9	(0.6)	(0.0)	0.3	0.0	(11.7)	(165.9)	(100.0)	9.0	(39.3)
Brunei	0.0	0.1	0.1	0.0	0.0	0.0	999.9	(37.5)	(60.0)	(100.0)	(28.6)
Indonesia	0.1	0.2	0.1	0.1	0.1		11.8	(37.5)	(30.0)	14.3	255.0
Malaysia	3.9	0.4	0.1	(0.1)	0.2	0.0	(13.4)	(74.4)	(190.9)	(270.0)	(296.2)
Philippines	(0.0)	0.2	(0.9)	0.0	0.0	(0.1)	52.8	(473.9)	(100.0)	0.0	28.1
Other	2.1	6.5	2.1	1.7	1.9	2.2	28.5	(67.8)	(17.3)	(213.4)	(20.1)
Total	100.0	100.0	100.0	100.0	100.0	100.0					
Total amount (Million baht)	3,078.2	4,402.2	6,908.1	9,043.7	28,243.8	17,132.0	2.6	56.9	30.6	212.3	36.5

Notes: a/ Equity and loans from parent or related companies including capital funds of foreign commercial banks.

b/ The calculations are based on the net inflow of foreign direct investment, and do not include net capital outflow of Thai investors (equity investment).

c/ Data refer to January-June.

Source: Bank of Thailand

Distribution of Foreign Investment by Sector

(Percentage)

Type of Business	Percentage Share b/						Annual Growth Rate b/				
	1980	1985	1986	1987	1988	1989p c/	1980-85	1985-86	1986-87	1987-88	1989p c/
1 Financial institutions	(4.5)	(29.1)	7.4	4.9	9.5	11.5	(49.2)	139.9	(13.2)	515.1	166.3
2 Trade	19.4	24.6	25.8	9.4	13.9	17.7	7.6	64.9	(52.2)	380.9	102.5
3 Construction	20.2	36.0	17.9	14.9	6.9	9.2	15.2	(22.1)	9.2	43.7	109.2
4 Mining & quarrying	15.4	11.7	3.5	2.1	1.7	1.8	(2.6)	55.4	(20.1)	146.1	19.7
4.1 Oil exploration	11.4	9.8	3.4	2.8	1.4	1.7	(0.5)	(45.0)	6.3	58.8	23.9
4.2 Other	4.0	2.0	0.1	(0.7)	0.3	0.1	(7.7)	(95.6)	(1,660.5)	(224.1)	(23.4)
5 Agriculture	5.4	1.6	2.9	3.2	1.1	(0.1)	(10.3)	162.9	41.4	7.5	(111.5)
6 Industry	26.2	30.9	30.7	52.5	57.9	47.1	6.0	56.4	123.6	244.2	2.7
6.1 Food	2.4	9.0	4.2	4.8	4.4	3.5	34.1	27.3	52.2	101.6	45.2
6.2 Textiles	(0.0)	1.4	1.2	11.0	6.0	(1.1)	109.0	43.1	1,061.8	12.4	(166.3)
6.3 Metal based and non-metallic	1.2	(2.9)	(0.3)	4.0	6.9	7.0	(29.3)	82.0	(1,715.5)	436.9	13.9
6.4 Electrical appliances	11.6	6.4	8.9	12.6	22.3	18.9	(6.6)	120.4	84.2	455.1	(15.8)
6.5 Machinery & transport equipment	2.4	0.7	(0.2)	1.8	2.6	2.2	(10.6)	(146.6)	973.2	354.8	(9.0)
6.6 Chemicals	5.5	11.1	7.0	9.6	6.9	6.7	18.0	(0.8)	79.4	124.3	59.7
6.7 Petroleum products	0.1	0.0	0.1	(0.2)	3.0	0.0	(14.8)	999.9	(292.7)	(5,375.9)	100.0
6.8 Construction materials	0.1	0.9	0.1	0.1	0.1	0.3	93.8	(85.9)	16.7	325.4	1,166.9
6.9 Other	3.1	4.3	9.8	8.8	7.8	9.8	9.7	254.0	18.2	175.1	40.1
7 Services	18.0	24.2	11.8	13.0	8.9	12.7	8.8	(23.5)	44.0	115.5	110.6
7.1 Transportation & travel	5.5	4.5	3.7	2.4	1.4	1.0	(1.5)	29.2	(13.7)	85.0	7.1
7.2 Housing & real estate	3.9	6.9	0.8	3.6	3.2	4.8	15.2	14.0	888.8	171.4	287.7
7.3 Hotels & restaurants	2.3	5.1	1.5	1.1	2.0	4.9	20.5	55.0	(5.6)	490.0	243.8
7.4 Other	6.3	7.7	6.0	5.8	2.4	2.1	6.7	23.0	27.3	26.3	(14.4)
Total	100.0	100.0	100.0	100.0	100.0	100.00					
Total amount (Million baht)	3,878.2	4,402.2	6,908.1	9,043.7	28,243.8	17,132.8	2.6	56.9	30.9	212.3	36 5

Notes: a/ Equity and loans from parent or related companies including capital funds of foreign commercial banks.
b/ Calculations are based on net inflow of foreign direct investment; and do not include net capital outflow of Thai investors (equity investment).
c/ = Data refer to January-June.
p = Preliminary

Source : Bank of Thailand.

Appendix 5.3

BOI - Promoted Industries,1986 - 1989

Appendix 5.3 Board of Investment - Promoted Industries,1986 - 1989

BOI - Promoted Industries ,1986

PRODUCT	CODE	NUMBER OF FIRMS	INVESTMENT FUNDS (M. Baht)	REGISTERED CAPITAL (M. Baht)	THAI (Million Bahts)	FOREIGN (Million Bahts)	NUMBER OF LABOR (Persons)
Preserving of fish	31149	5	182	63	63	0	2426
Canning food	311	11	825	243	189	54	5441
Textile finishing	32118	2	48	15	3	13	716
Non-rubber footwear	32400	8	321	91	69	22	4566
Electrical appliance	38330	4	715	466	23	443	595
Electronic product	38330	14	1351	608	174	513	3088
Jewelry	39012	7	474	119	28	91	1006
Toy	39090	8	172	58	49	9	1749
Furniture	332	7	261	89	81	8	1656
Plastic bag	35601	3	64	15	8	7	297
Artificial flower	32120	4	86	25	22	3	1343
Spining,weaving,printing	321	6	769	189	119	70	2306
Machinery & Engine	38210	20	9295	1534	1045	488	3541
Glass and ceramic	36200	2	210	20	20	0	211
Artificial food product	31219	3	43	15	14	1	203
leather product (except footwear)	32330	8	241	60	42	18	1709
rubber product (except rubber-hand)	35599	17	720	275	195	80	1525
Chemical product	351-352	16	5094	704	326	377	1398
Plastic product (except plastic bag)	35609	7	141	57	41	16	1102
Para rubber wooden product	33190	6	660	202	172	30	897
Animal & other product	31219	5	839	133	89	44	541
Vegetable & fruit product	31219	37	2065	790	666	124	5914
Watch and equipment	39090	1	177	20	0	20	874
Glasses and equipment	39090	2	84	10	0	10	154
Metal transformation	37120	15	1787	533	395	138	1585
Mineral	39090	9	577	249	199	49	1501
Paper	34111	3	798	286	215	71	270
TOTAL		230	27999	6869	4247	2699	46614

Source : Board of Investment

BOI - Promoted Industries,1987

PRODUCT	CODE	NUMBER OF FIRMS	INVESTMENT FUNDS (M. Bahts)	REGISTERED CAPITAL (M. Bahts)	THAI (Million Bahts)	FOREIGN (Million Bahts)	NUMBER OF LABOR (persons)
Preserving of fish	31149	19	702	204	198	6	4797
Canning food	311	21	1074	442	364	79	13007
Textile finishing	32118	1	10	8	0	8	200
Non-rubber footwear	32400	28	1375	449	205	244	18522
Electrical appliance	38330	22	2473	845	174	671	4559
Electronic product	38330	38	9234	2107	657	1450	29541
Jewelry	39012	21	360	150	58	92	3453
Toy	39090	24	1200	581	233	348	11467
Furniture	332	14	600	329	215	113	3504
Plastic bag	35601	4	129	35	33	2	626
Artificial flower	32120	9	229	59	32	27	3777
Spining,weaving,printing	321	63	22310	5281	3839	1442	43548
Machinery & Engine	38210	41	3067	889	401	488	7952
Glass and ceramic	36200	6	426	81	57	24	1801
Artificial food product	31219	6	194	82	57	25	791
leather product (except footwear)	32330	15	270	100	40	60	2963
rubber product (except rubber-hand)	35599	28	1639	437	276	161	3572
Chemical product	351-352	32	4000	1364	696	669	2659
Plastic product (except plastic bag)	35609	27	1054	368	210	150	4251
Para rubber wooden product	33190	12	568	146	146	0	1471
Animal & other product	31219	10	2456	1033	334	699	8874
Vegetable & fruit product	31219	20	1436	326	178	147	2745
Watch and equipment	39090	2	30	6	0	6	133
Glasses and equipment	39090	5	211	49	11	30	874
Metal transformation	37120	39	4317	1203	563	719	4613
Mineral	39090	5	157	52	44	7	574
Paper	34111	4	145	47	41	6	350
Rubber-hand	35599	6	605	36	19	17	1205
Bamboo wooden product	33190	2	17	5	4	1	172
Color electric product	38393	14	579	168	32	136	8574
Rice product	31169	6	488	162	127	34	717
Sport goods	39030	6	508	289	30	259	2489
TOTAL		550	61863	17333	9274	8120	193781

Source : Board of Invesment

BOI - Promoted Industries,1988

PRODUCT	CODE	NUMB OF FIRMS	INVESTMENT FUNDS (M. Baht)	REGISTERED CAPITAL (M. Baht)	THAI (Million Bahts)	FOREIGN (Million Bahts)	NUMBER OF LABOR (Persons)
Preserving of fish	31149	6	279	92	46	46	2307
Canning food	311	25	1085	395	315	80	11430
Textile finishing	32118	2	132	60	27	34	610
Non-rubber footwear	32400	43	3363	959	561	398	30064
Electrical appliance	38330	41	11317	3126	475	2651	12322
Electronic product	38330	112	23541	8311	957	7354	53082
Jewelry	39012	32	1097	300	114	186	8185
Toy	39090	29	1865	611	159	452	18239
Furniture	332	44	1620	518	403	115	10148
Plastic bag	35601	8	180	82	32	50	1348
Artificial flower	32120	11	209	94	58	36	4165
Spining,weaving,printing	321	66	14733	3650	2756	894	17052
Machinery & Engine	38210	92	13822	4886	1347	3539	17359
Glass and ceramic	36200	25	14417	3611	1244	2367	6914
Artificial food product	31219	6	271	91	84	6	1295
leather product (except footwear)	32330	15	584	201	107	93	7096
rubber product (except rubber-hand)	35599	209	9579	2767	2302	465	22211
Chemical product	351-352	58	35516	9560	5156	4404	4793
Plastic product (except plastic bag)	35609	91	9029	3115	1540	1575	19164
Para rubber wooden product	33190	17	3667	1188	777	412	3297
Animal & other product	31219	20	1623	632	404	228	4350
Vegetable & fruit product	31219	65	3694	1210	840	370	8236
Watch and equipment	39090	13	1912	1185	53	1131	4459
Glasses and equipment	39090	4	85	13	6	7	426
Metal transformation	37120	61	8096	2045	1042	1003	9163
Mineral	39090	17	945	402	344	58	2727
Paper	34111	23	14794	4019	2512	1506	6063
Rubber-hand	35599	113	8151	2488	1488	1000	25026
Bamboo wooden product	33190	21	148	71	47	24	2022
Color electric product	38393	12	314	178	24	154	5507
Rice product	31169	7	442	229	176	53	686
Sport goods	39030	26	847	331	78	253	5898
Preserving of chicken	31219	2	537	661	637	24	4530
TOTAL		1316	187894	57081	26111	30968	330174

Source : Board of Investment

BOI - Promoted Industry,1989

PRODUCT	CODE	NUMBER OF FIRMS	INVESTMENT FUNDS (M. Baht)	REGISTERED CAPITAL (M. Baht)	THAI (Million Bahts)	FOREIGN (Million Bahts)	NUMBER OF LABOR (Persons)
Preserving of fish	31149	28	3662	645	553	93	18129
Canning food *	311	14	1083	303	196	107	5812
Textile finishing	32118	16	1827	550	319	231	11102
Non-rubber footwear	32400	26	1780	598	236	362	17116
Electrical appliance	38330	23	6729	1714	331	1383	11954
Electronic product	38330	100	18633	4702	734	3968	44140
Jewelry	39012	38	1363	539	196	343	11639
Toy	39090	27	805	281	128	152	10180
Furniture	332	11	588	176	107	69	3077
Plastic bag	35601	6	276	185	145	40	1066
Artificial flower	32120	14	375	162	119	43	4547
Spining,weaving,printing	321	52	10312	2257	1619	638	8306
Machinery & Engine	38210	76	8277	2870	1163	1707	12694
Glass and ceramic	36200	19	2027	664	295	369	4114
Artificial food product	31219	3	164	50	43	7	1205
leather product (except footwear)	32330	20	1311	342	200	142	4470
rubber product (except rubber-hand)	35599	43	1816	878	303	575	4800
Chemical product	351-352	39	19935	4857	3049	1808	4600
Plastic product (except plastic bag)	35609	70	6186	1853	1066	786	12621
Para rubber wooden product	33190	3	845	260	143	118	926
Animal & other product	31219	13	1796	421	275	146	6610
Vegetable & fruit product	31219	69	6271	1482	1073	409	12908
Watch and equipment	39090	8	464	92	18	74	2248
Glasses and equipment	39090	7	1236	382	14	367	1400
Metal transformation	37120	80	27060	6594	3459	3136	16539
Mineral	39090	13	1322	438	272	166	1296
Paper	34111	48	30867	5619	4401	1217	10212
Rubber-hand	35599	20	1503	467	278	189	5849
Bamboo wooden product	33190	10	85	45	32	13	1199
Color electric product	38393	10	545	182	26	157	4691
Rice product	31169	2	132	30	12	18	236
Sport goods	39030	20	1084	315	124	190	5698
Preserving of chicken	31219	3	263	64	48	16	1355
TOTAL		931	160622	40017	20977	19039	262739

Source : Board of Investment

Appendix 6.1

Sample Case : Final/Auditing System Operation

Appendix 6.1

Sample Case : Fund/Auditing System Operation

Hazardous-waste-producing firm H wishes to obtain a license to operate a plant in 1991 to produce 5,000 tons of fabricated aluminum frames using technology X. According to the technical coefficients of this technology, a ton of output generates 0.2 tons of heavy metals. Based on current estimates of transport, treatment, and disposal costs, one ton of heavy metals costs 1,200 baht to collect, treat, and safely dispose of (including management costs). Therefore, company H would deposit a payment of 1.2 million baht (5,000x0.2x1,200) with the fund as a waste charge, and a bond or bank guarantee of 1.2 million baht, and would obtain the necessary documentation for securing an operation license from the Department of Industrial Works (DIW).

Company H would then tell Treatment Facility T to collect 83 tons of hazardous waste (heavy metals) on a monthly basis from its production plant. Once the waste was collected, the corresponding part of the bond could be released by the fund to Company H without interest. If Company H preferred to obtain interest, it should not demand return of its bond until the end of the year.

Treatment Facility T would treat the waste as contracted with the fund and would dispose of it at Disposal Facility D, which would then verify the disposal of the specified quantity and type of hazardous waste. Copies of the receipts issued by both Treatment Facility T to Company H and by Disposal Facility D to the treatment facility would be sent to the fund. At the end of the year, company H and the treatment and disposal facilities would have to submit an environmental auditors report to secure the release of their bonds with interest. If Company H had produced and delivered waste in the range of 950 tons to 1,050 tons, the full bond would be returned or applied to the following year of operation. Production of waste above 1,050 tons would be unlikely since the presumptive rate of 1,000 tons for Company H had been set at the maximum for the type of industry and technology and the level of output. Production of waste lower than 950 tons, would be both likely and desirable.

In the event that Company H's environmental auditors report that only 850 tons of waste were produced and delivered, Company H would have the choice of either accepting a return of 5 percent of the bond or claiming a rebate on the grounds that it is a more efficient operation who generated less waste. In the latter case, the fund would conduct it own audit and random inspections during the following year to verify Company H's claim. If verified, Company H would receive both a rebate and the balance of the bond with interest, and its presumptive rate would be lowered to 850 tons for the following year. This lower waste/output coefficient (presumptive rate) could be retained as long as it was upheld by subsequent audits and random inspections. Company H would have an incentive to try to minimize waste by improving its efficiency and technology, or by doing part of the treatment itself to reduce the volume of waste sent for central treatment, as long as these efforts cost less than the cost of the central treatment. The same process as that outlined above would be used by the fund to verify new reduction in waste/output ratios reported in the company's annual environmental auditing report.

Appendix 6.2

An Example of Polluter Pays Principle

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AN EXAMPLE OF POLLUTER PAYS PRINCIPLE

It seems to be a new thing when one talks about application of polluter pays principle and pollution charges in Thailand. Actually, it has been in practice for years in most industrial estates and central waste treatment plants. The central treatment facilities for sugar industries at Ta Maka, Kanchanaburi Province, is a typical example of an application of polluter pays principle in Thailand. Although its application in Thailand has not exactly corresponded to the theoretical concept, the review of its evolution is worth understanding of how the principle works in the Thai context.

BACKGROUND

During the last 20- 25 years, sugar industry have developed very rapidly along the Mae Klong River especially in the Ta Maka areas, Kanchanaburi Province. In 1972-1973, industries along the Mae Klong River which most are sugar factories has discharged their wastewaters into the river so large in volume and organic load that the river could no longer naturally reaerate and treat herself fast enough to maintain aerobic condition. Consequently, the Mae Klong River became heavily polluted. The river environment beginning from Ta Maka down to Samut Songkram Province was so polluted that many tons of fish and other aquatic lives had been killed.

Outcomes of the severe pollution in the Mae Klong River in 1972 - 1973 drew markedly public attention and also many complaints from various sources. This event push forward the Thai Government to realize the significance of the environmental protection. The crux of the situation was that the companies were required by DIW to participate in order to stop discharging heavy pollution loadings into the river by constructing a 400-rai (158 acre) waste stabilization pond system to treat their wastewaters. DIW financed the development costs and operated the facility for the first seven years.

DESIGN AND DEVELOPMENT

The plant was built in two stages, the second following closely after completion of the first. The first stage cost B 14 million and the second B 7 million. Land acquisition prices were B 10,000 per rai in 1972 which would indicate that about 20 percent of development costs were for land acquisition. The collection system consists of about 12 km of 12 inches diameter steel pipeline. The pipe was fabricated from seam-welded steel plate and was without internal or external lining. There is another five km of pipeline which distributes treated wastewater to various rice and sugar cane farms. All wastewater delivered to the treatment plant is pumped and all effluent discharges are by gravity.

OPERATION AND MAINTENANCE

The sugar harvest period during which the mills are in operation runs from about December through March. Each company is assigned a period of time on specified days when it may deliver wastewater to the plant; only one plant delivers wastewater at any given time. A series of check valves directs the flow to the treatment plant, preventing it from backing up in the collection system. Thus all factories must have adequate storage to cover the periods between their scheduled delivery times.

After the initial seven year period during which operations were directly under DIW control, the system has been operated under the direction of two committees set up by the participating companies. These are the Engineers Committee which handles all technical matters, and the Managers Group which handles all financial and planning matters. The management approach has been to hire and operating contractor to take care of all operating and maintence functions; the contract is rebid annually, but the present contracotr has been awarded the contract for the past seven years.

The Managers Group has 15 members including an official from DIW. During the operating season, DIW's official is present at the site on a full time nasis for overall supervision and control of plant operations and contractor performance.

There are a total of 14 full time employees, furnished by the participating companies, but paid through the contractor. Staff are basically laborers except for a laboratory technician and an assistant laboratory technician.

FINANCE

The original funding for development of the CTF was obtained from the Sugar Fund which is a fund created from a tax on sugar sales and is used to stabilize sugar prices. Each factory was required to pay a share of capital costs, based on the quantity of raw material processed, as though it had borrowed its share of the costs of development through a three year loan at 7 percent interest. In effect, the approach permitted the participating firms to make their contributions to initial capital over a three year period.

Major replacements are finaced on a cash basis through direct charges to the participating firms. For example, the B 8 million for pipeline replacement was chared to the participating firms as part of the annual costs of operations and maintenance for that year.

The basis for sharing operating and maintenance cost has evolved over the years form one that originally considered only the quantity of sugar cane processed, to one that gives increasing weight to the qualtity and waste loading characteristics of the wastewater. After the initial period of sharing costs based only on raw material processing quantities, costs were shared with 50 percent weight being given to raw material quantities and the remanining 50 percent to waste flow quantites and strengths. From the 1987 onward, the ratios have been changed to 40 percent weighting on raw material processed, and 30 percent each on wastewater volume and waste loading. This evolutionary proces has been promoted by several firms which have the most efficient and effective houskeeping in their factories. the Managers group meers each three months to determine each company's share of consts for the quarter. Until the raw material processing records are domplete ofr the current year, the previous year's records are used. Adjustments are made during subsequent billing periods as appropriate.

The system employed for cost sharing is not oriented to producing a unit charge for wastewater delivered. However, it is possible to derive such figures based on the total share of costs allocated to a particular factory and the volume of wastes delivered for treatment. These unit figures vary from firm to firm and from year to year. They are estimated to range between B 1 and B 2 per cubic meter. For the billing period examined, the average for all firms was B 1.8 per cubic meter. The exact unit cost does not seem to be of critical importance. The treatment facility and its operation are simple and low cost and represent good value to the participaitng companies. Total costs for 1986 were B1.02 million. This represents only about 0.1 percent of estimated gross revenue, after deducting revenue shared with the farmers for raw materials. Additional costs are incurred in-plant by each company for pumping and pH control, but these are not major items.

REFERENCE

Watson Hawksley (1987), *Samutprakarn Industrial Pollution Control and Management*, Volume 3 : Appendixes.