สมาคมการกัดกร่อนโลหะและวัสดุไทย
Thai Corrosion of Metals and Materials Association

MTEC
a member of NSTDA

Aspects of Corrosion Cost in Thailand

TCPC 2015 October 2015

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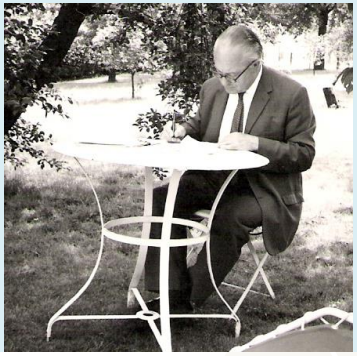
Corrosion Cost is.....

- The “direct initial cost” is for corrosion prevention.....

  .....Herbert Uhlig

- The corrosion prevention cost consumed by major industrial & government sectors...

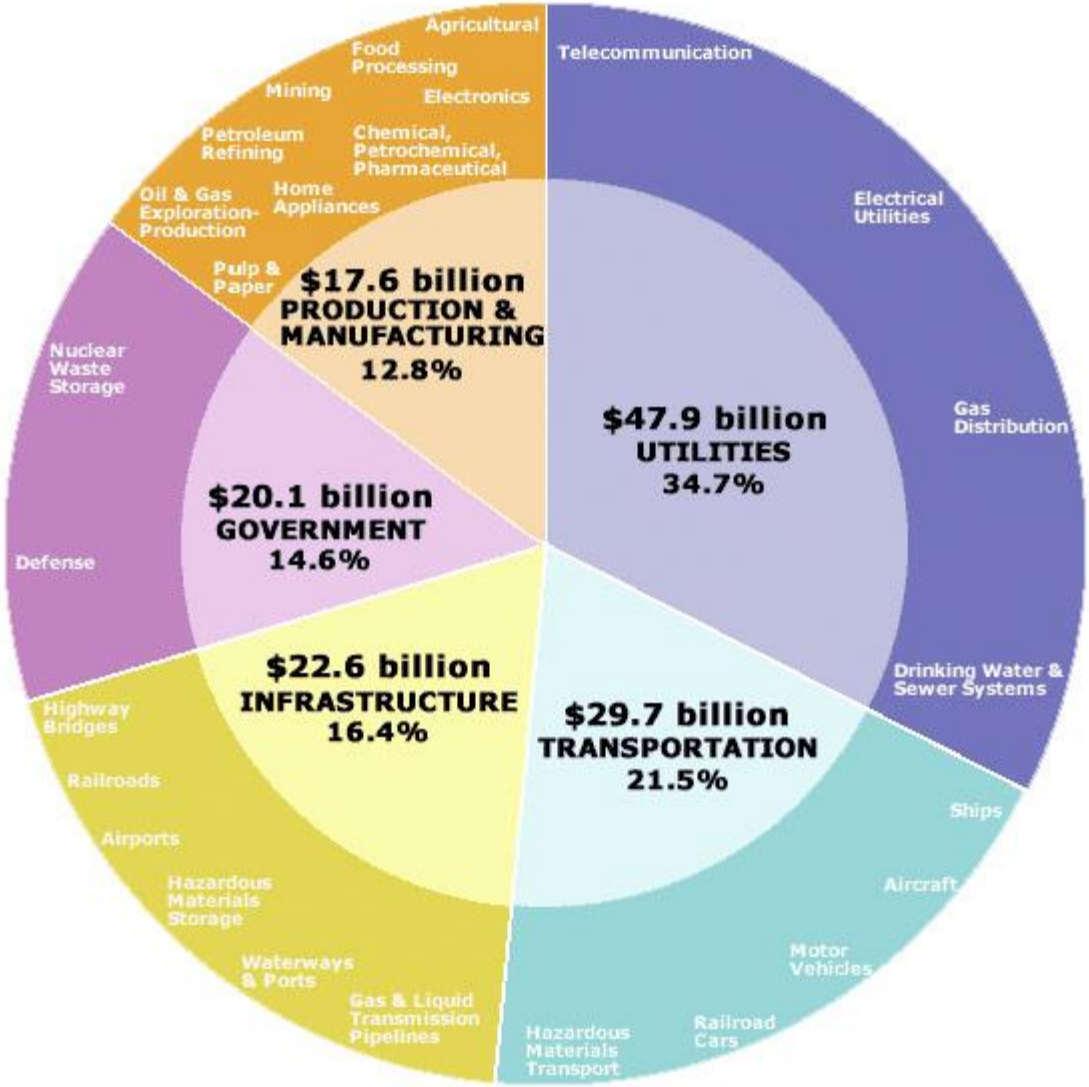
  .... Thomas Percy Hoar



Methodology

Method	Principles	Thailand Configuration
Uhlig Method	Calculate from direct initial corrosion protection cost	• Organic coating • Metallic coating • Inhibitors • Cathodic protection system • Corrosion resistant materials • R &D / Inspection
Hoar Method	Calculate from direct losses and direct corrosion protection cost in the survey industries and estimation to cover unsurvey industries.	• Construction sector • Machinery sector • Chemicals industry sector • Transportation sector • Energy & Utilities sector • Metal industry sector

Global Corrosion Cost

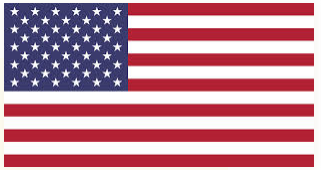


USA
1998
$137.9 billion

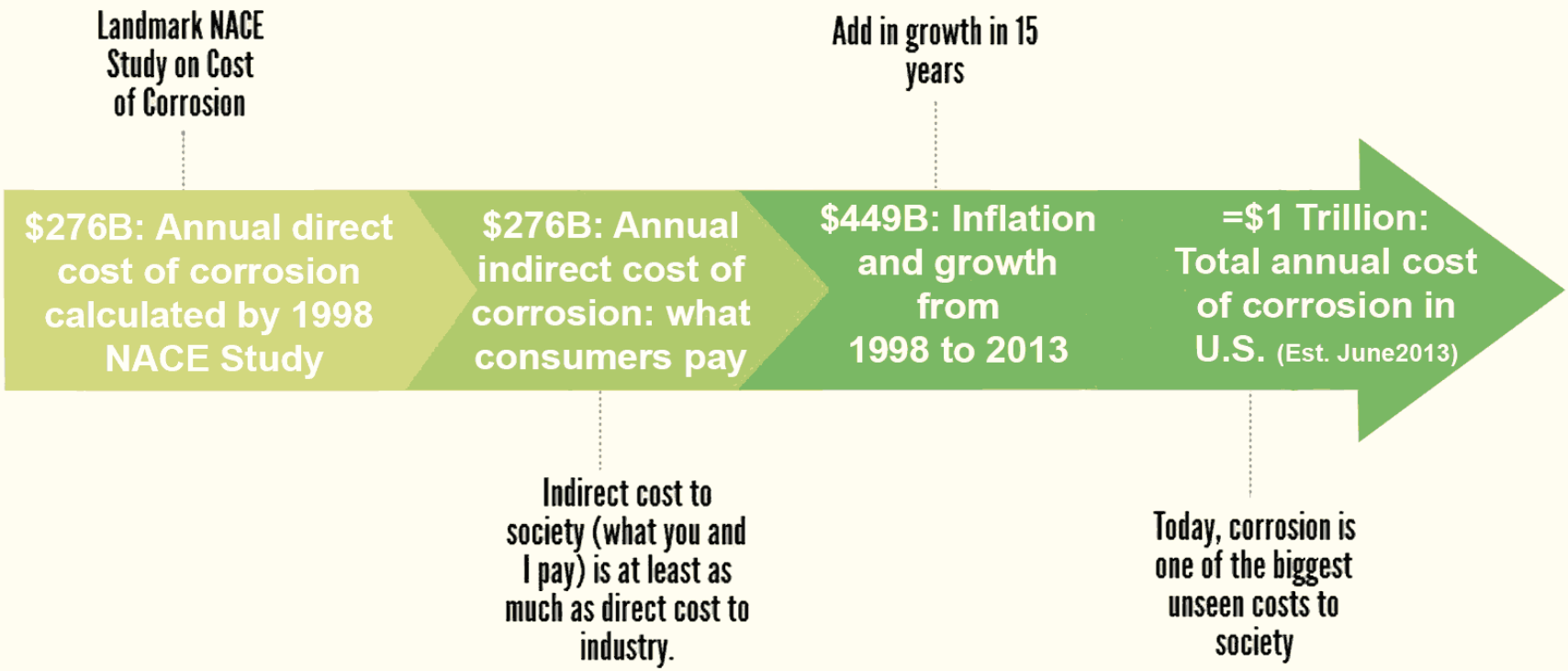
Extrapolated
$276 billion
3.1% GDP

G. H. Koch et al., Report FHWA-RD-01-156, September 2001

Global Corrosion Cost



$1 TRILLION:
Annual Cost of Corrosion in U.S. 2013



http://www.g2mtlabs.com/2011/06/nace-cost-of-corrosion-study-update/

Global Corrosion Cost

Industrial sector	Million US dollar			
Country	**Japan**	**China**	**Korea**	**Thailand**
Year	**1997**	**2000**	**2005**	**2009**
Chemical	10,272	4,800	9	?
Construction	15,337	16,000	2,879	
Energy & Utilities	4,385	2,753	1,728	
Machinary	14,990	8,198	772	1st study &survey 2009 -2011
Metals & Alloy	265	-	29	
Transportation	5,229	4,862	2,223	
Total	**50,479**	**36,613**	**7,640**	
	1.1% GDP	3.0% GDP	0.94% GDP	

T.Shibata, NACE EAP, 2013

Ke Wei, *Corrosion and Protection*, Vol.25, No.1, pp1-8, 2004.

Committee on Cost of Corrosion in Japan, "Cost of Corrosion in Japan", *Zairyo-to-Kankyo (Corrosion Engineering)*, 50, 490-512 (2001).

Y. S. Kim, H. K. Lim, J. J. Kim, W. S. Hwang, and Y. S. Park, *Corrosion Science and Technology*, Vol.10, No.2(2011), pp.52-59.

Uhlig Method

Uhlig Method

- Organic Coating
- Metallic Coating
- Corrosion Resistant Materials
- Inhibitors
- Cathodic Protection
- Research & Development

Exisiting Data

- Metallic Coating
- Corrosion Resistant Materials

Survey

- Organic Coating
- Research & Development

Estimation

- Inhibitors
- Cathodic Protection

Uhlig Method

Organic Coating

Survey

PROTECTIVE COATING

- Power plant
- Petro chemical plant
- Chemical plant
- Jetty and harbor
- Tank farm
- Steel structure
- Bridges
- Rails
- Pipe Lines
- Oil/Gas Rigs (off shore)

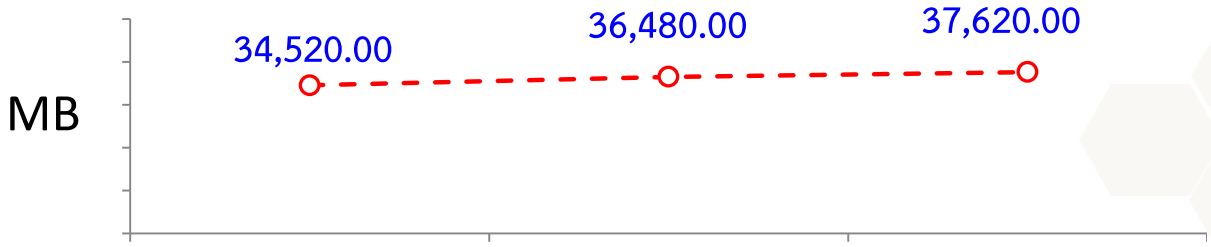
Total product sales + the cost of the coating process

(10 x protective coating & 15 x marine coating sale values)

Organic Coatings Cost (in Million Bahts)	2009 MB	2010 MB	2011 MB
Protective coatings	19,800	21,120	21,780
Marine coatings	14,720	15,360	15,840

MARINE COATING

- Tanker
- Cargo vessel
- Ferry
- Yatch (Aluminium/Steel)



Uhlig Method

Metallic Coating

Exisiting Data

Zn plated
Zn-Al /Zn-Ni

Steel Consumption x Price different compared with steel

(Metallic coating)	2009 MB	2010 MB	2011 MB
Zinc coated steel	8,147.86	13,577.83	14,965.45
Tin plated & Tin free	6,692.54	8,818.14	8,813.00

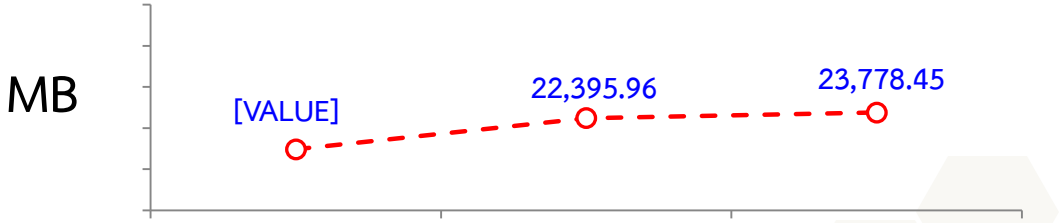
Tin plated

http://www.ehow.com

Tin free

http://ww66.com/Cans.asp

http://www.recyclethis.co.uk



Uhlig Method

Corrosion Resistant Materials

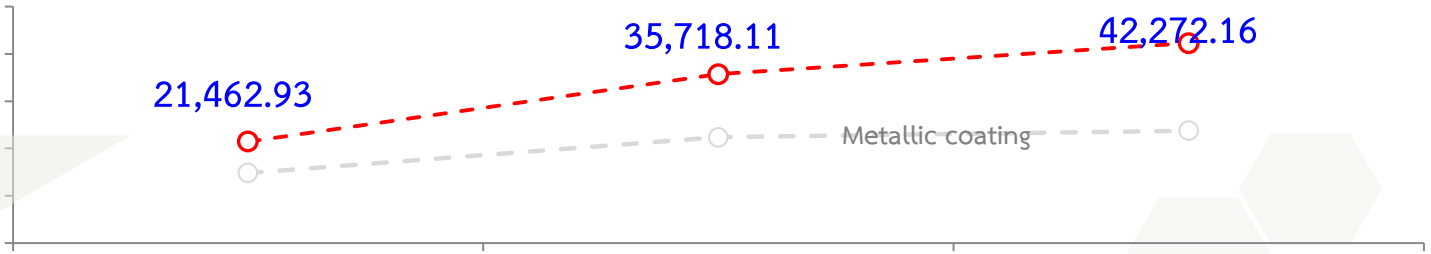
Exisiting Data

Stainless Steels

Consumption x price difference compared to steel.

bakeryequipment.com

Anti-corrosion materials	2009 MB	2010 MB	2011 MB
Stainless Steel	21,462.93	35,718.11	42,272.16



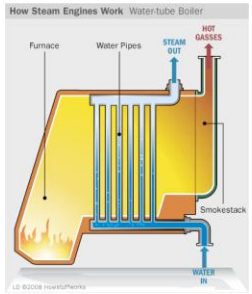
Uhlig Method

Inhibitors

A chemical added in a small amount to prevent interaction between metal surface and environment.

Estimation

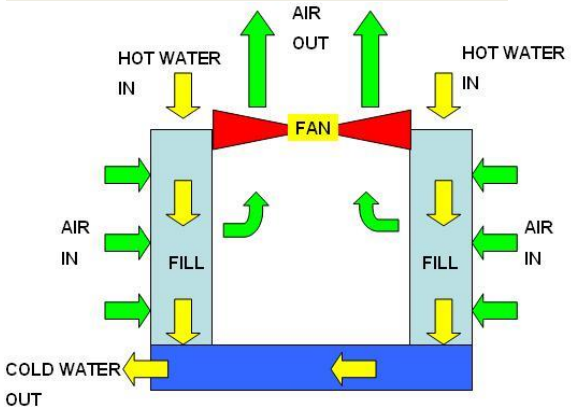
BOILER



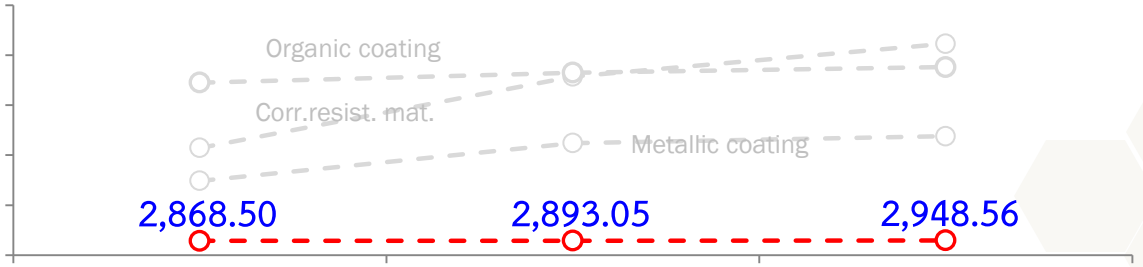
The number of registered factories x 2 (syst) x cap10,000 kg/hr. X 3,100 baht/1,000 kg.(avg cost) x 5 ppm inhibitor(avg. conc.)

www.coolingtowercentral.com.au

COOLING TOWER



Inhibitor (in Million Bahts)	2009 MB	2010 MB	2011 MB
Boiler and cooling water treatment	2,868.50	2,893.05	2,948.56



Uhlig Method

Cathodic Protection

Estimation

1.Sacrificial anode

No.of steel ship x avg surface area / ship x wt of Zn anode consumption /area x Zn price /weight + Installation (3 xZn cost)

2. Impress Current

The length of buried pipesx Installation cost/km+ maintenance costs

Cathodic Protection (MB)	2009(MB)	2010(MB)	2011(MB)
Marine Transportation	562.68	578.65	596.10
Underground-subsea pipelines	34.83	27.52	69.45
Total	597.52	606.17	665.55

- No. of of iron ships from the Marine Department.
- No.of Zn anode "Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS)," published in April 1999. The reference number is EPA-842-R-99-001.
- Average installation cost from http://www.stoprust.com/4offshorecp.htm
- The length of buried pipe from PTT gas and MWA.
- Installation and maintenance cost for CP system from N.G.Thompson, Appendix E: Gas and liquid transmission pipeline 2001

Uhlig Method

R&D and Inspection

Surveys from professors, researchers, and private companies in corrosion technology

R&D and failure analysis

Survey

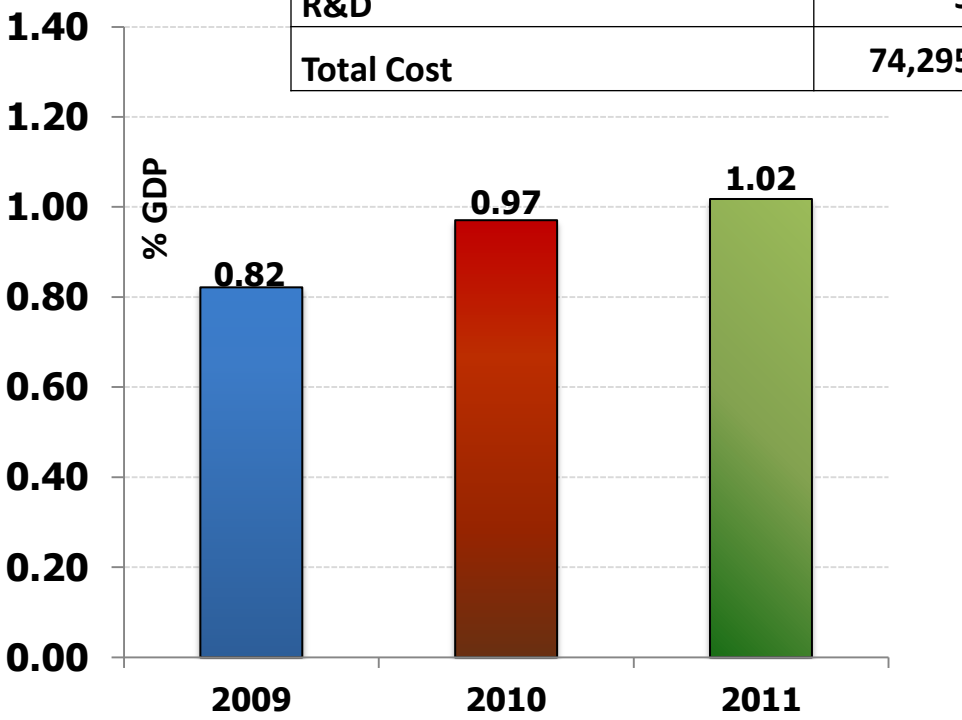
R&D	2009 MB	2010 MB	2011 MB
Total	5.72	7.65	4.03

Investment on R&D in corrosion science in Thailand is less than 10 MB per year.

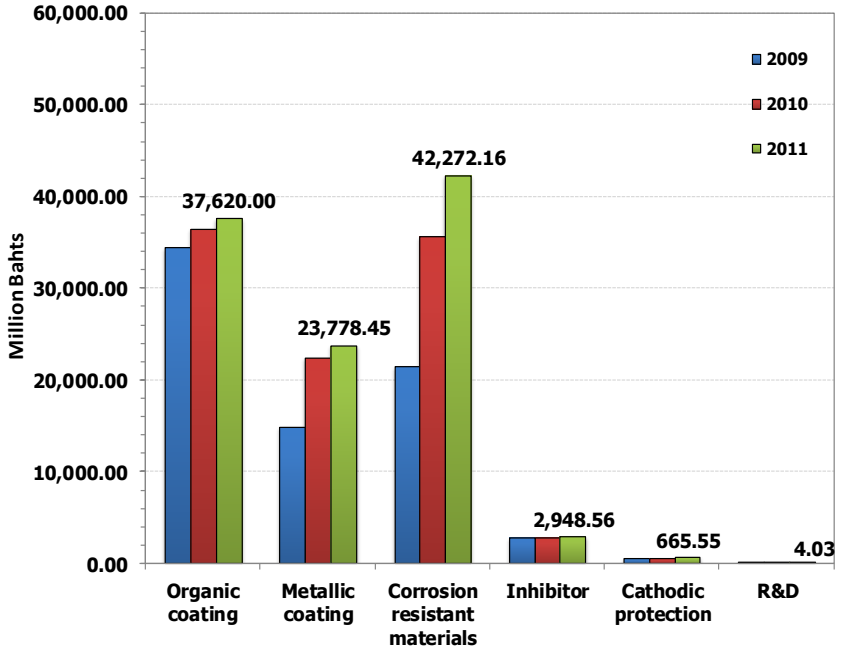
This no. is underestimated since it does not include the internal R&D funding and inspection cost in the company.

Summary : Uhlig Method

Cost in Millions Baht	2009	2010	2011
Organic coating	34,520.00	36,480.00	37,620.00
Metallic coating	14,840.41	22,395.96	23,778.45
Corrosion resistant materials	21,462.93	35,718.11	42,272.16
Inhibitor	2,868.50	2,893.05	2,948.56
Cathodic protection	597.52	606.17	665.55
R&D	5.72	7.65	4.03
Total Cost	74,295.08	98,100.95	107,288.75



2009	2010	2011
74,295.08	98,100.95	107,288.75



Hoar Method

Hoar Method

- Transportation
- Energy & Utility
- Chemical Industry
- Construction
- Machinery

Corrosion cost of the organization

Annual Cost	Proportion Cost for Corrosion Protection
Production	• From Survey • Estimation by Experts • from raw data
Construction of new facilities	
Maintenance of the old facilities	

Direct Cost

- Organic coating
- Corrosion resistant materials
- Inhibitor
- R&D-Training
- Inspection
- Metallic coating
- Cathodic protection

Hoar Method

Transportation

1.Railway : No. of locomotive trains that need to be repaired/ year x corrosion protection cost / train (**Repair Information ,railway company)**

2. Ship: Cathodic protection cost (Uhlig)+ 25% of Marine coating cost (Uhlig)

Transportation	Corrosion Cost (in Million Baht)		
	2009	2010	2011
Railway	9.10	6.60	12.40
Ships	4242.68	4,418.65	4,556.10
Cars-Pickup-Motorcycles	15,790.45	18,153.52	17,143.32
Total	20,042.24	22,578.78	21,711.82

3.Cars-Pickup-Motorcycles :

No. of car sales x 1.8 %

(Japan survey 1997) **Committee on Cost of Corrosion in Japan, Zairyo-to-Kankyo, 58, 402-428(2009)**

Energy & Utilities

1.Electricity Generation : Thermal power plant 57%) ,Combined cycle (28%) ,Cogeneration plant (10%) and Hydro Plant(5%)

Corrosion cost = Construction cost (x) % + Maintenance cost (y%)

2.Water Service : Corrosion cost = Coating cost (30%maintenance cost + CP system cost (10% maintenance cost)

3.Natural Gas for Transportation :

Corrosion cost = cost of CP system (from Uhlig) + coating cost (20 xCP cost)

Energy & Utilities	Corrosion Cost (Million Baht)		
	2009	2010	2011
Electrical generation	5,063.24	4,496.93	4,938.82
Water service	93.02	88.05	97.12
Natural gas	166.54	147.28	275.03
Total	5,322.80	4,732.26	5,310.97

[1] The report of NG pipeline company PTT (2010) . Information from inquiry directly
[2] N.G.Thompson, Appendix E: Gas and liquid transmission pipeline 1998
[3] G. H. Koch, M.l P.H.Brongers, N.l G. Thompson, Y. P. Virmani, J. H. Payer, Report FHWA-RD-01-156, September 2001

Hoar Method

Chemical Industry

Production cost [1] x The proportion of the corrosion cost [2]

Chemical	Corrosion Cost (Million Baht)		
	2009	2010	2011
Petrochemical	3,095.18	3,019.16	3,555.01
Food-Drinks-Medicine	9,084.15	9,928.49	11,396.08
Pulp&Paper	1,516.92	1,718.19	1,715.33
Oil Refinery	10,286.27	12,610.75	13,808.76
Plastic	1,761.51	2,054.18	2,400.02
Rubber	1,739.09	2,678.96	3,383.38
Total	27,483.11	32,009.73	36,258.58

[1] Office of Industrial Economics[2] Committee on Cost of Corrosion in Japan, Zairyo-to-Kankyo, 58, 402-428(2009)

Hoar Method

Machinery sector

Production cost [1] x The proportion of the corrosion cost [2]

Machinery in	Corrosion Cost (Million Baht)		
	2009	2010	2011
Agricultural	346.31	2,526.84	2,948.30
Industrial	6,316.13	7,580.51	8,844.90
AC	4,356.61	5,657.42	6,096.62
House hold appliance	777.25	829.01	954.38
Refrigerators	1,760.93	2,011.77	2,202.01
House hold electronic goods	4,735.54	3,393.27	3,718.68
Total	20,023.58	24,117.69	26,587.68

[1] Office of Industrial Economics [2] Committee on Cost of Corrosion in Japan, Zairyo-to-Kankyo, 58, 402-428(2009)

Hoar Method

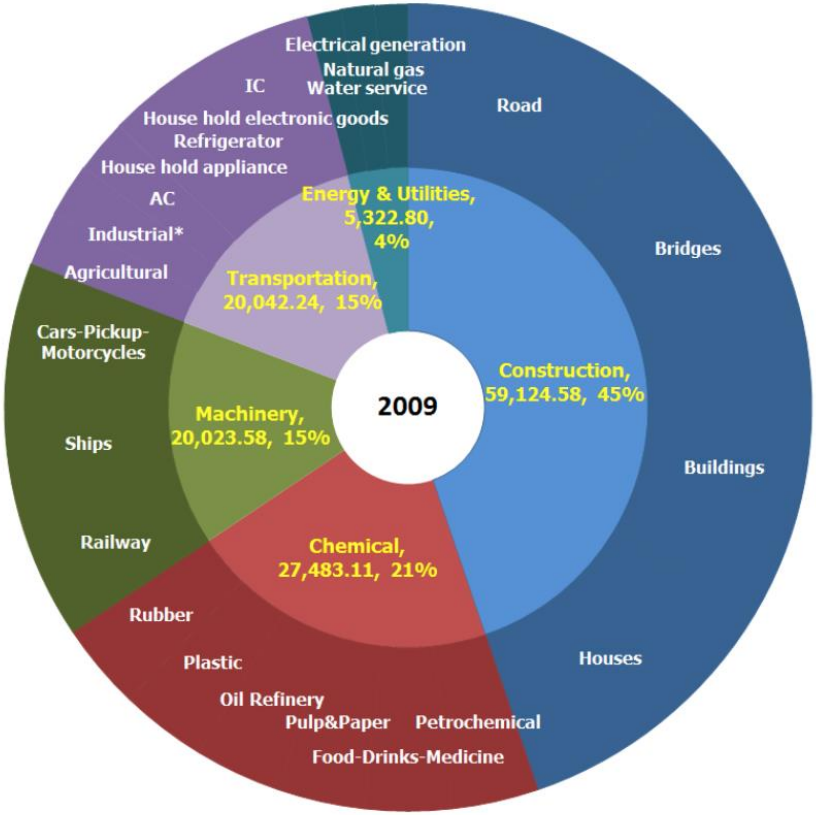
Construction sector

Corrosion cost estimation from construction sector

	2009	2010	2011
Numbers of contractors	29,360	31,079	32,798
Average construction cost /contractor (MB)	13.43	12.58 (extrapolated)	12.14 (extrapolated)
% investment growth		6.8	2.7
Total construction cost (MB)	394,163.87	417,722.41	408,929.47
Corrosion cost (15% of total construction cost) (MB)	59,124.58	62,658.36	61,339.42

Summary : Hoar Method

Total	2009	2010	2011
GDP (MB)	9,041,551.00	10,104,821.00	10,540,134.00
Estimated corrosion cost (MB)	131,996.30	146,096.82	151,208.47
Corrosion Cost (% GDP)	1.45	1.45	1.43



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Summary –Hoar method

Hoar Method

- Transportation
- Energy & Utility
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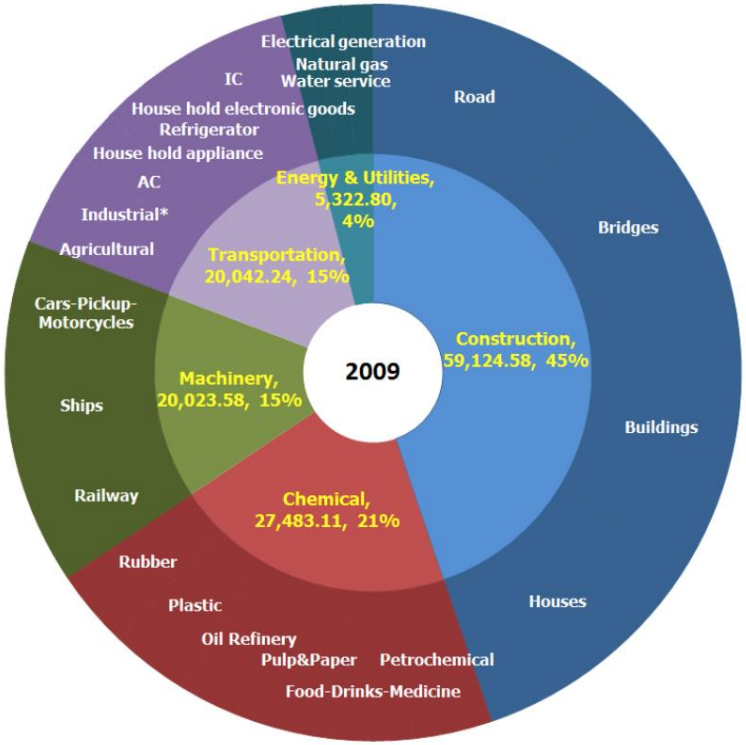
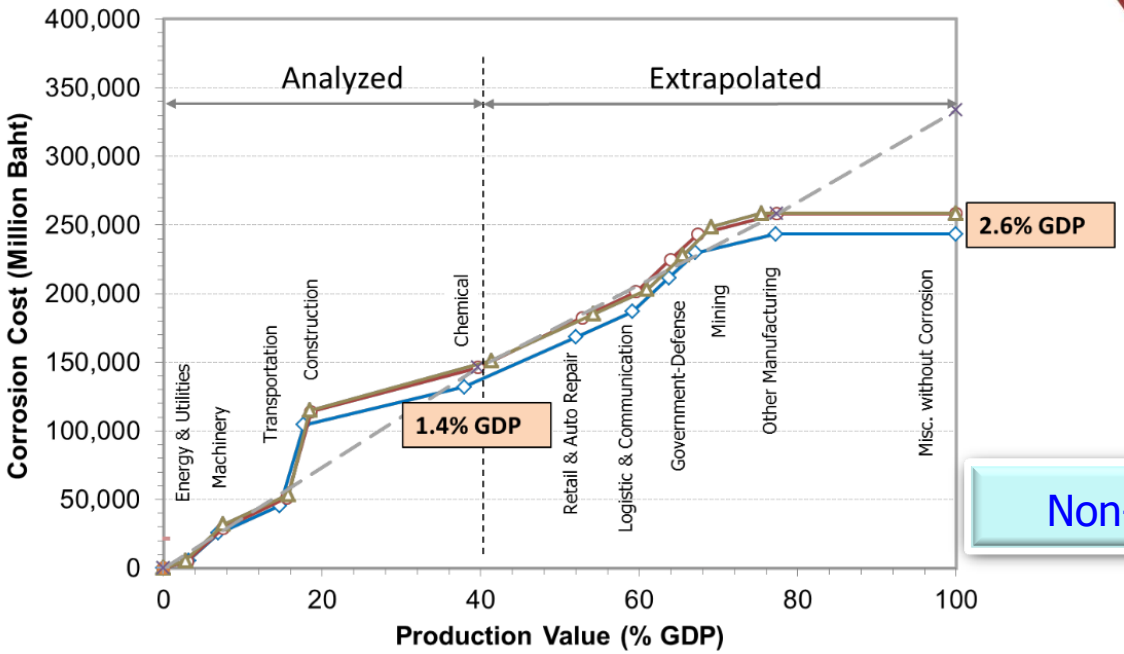
- Construction
- Machinery

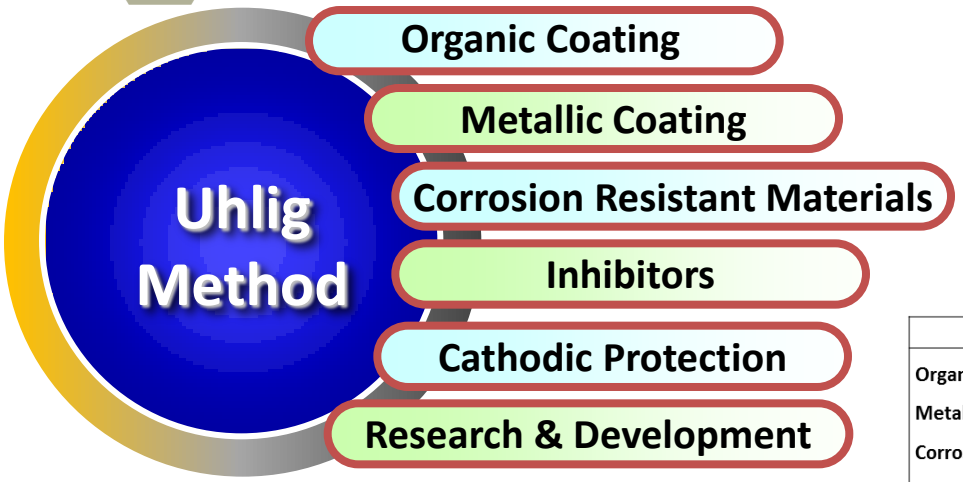




250,000 MB

Non-Linear Extrapolation

Summary –Uhlig method



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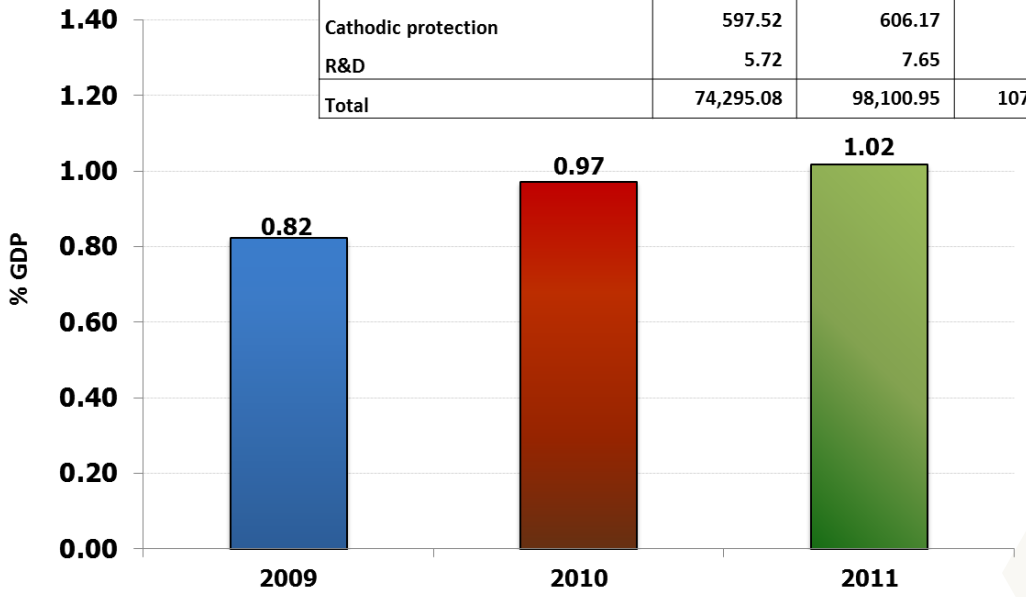
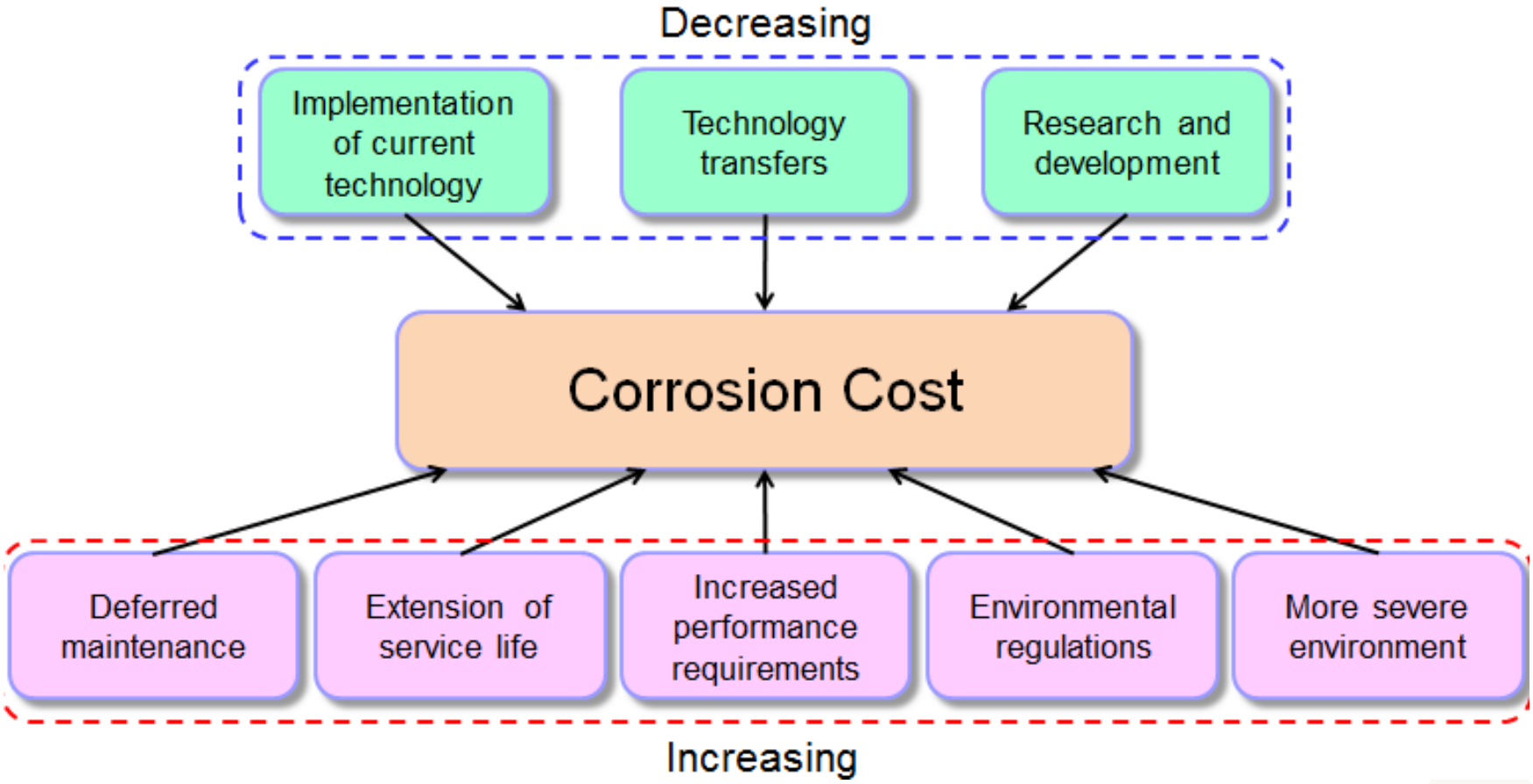


How is the corrosion cost ..?



Acknowledgement

- National Metal and Materials Technology Center (MTEC)
- National Science and Technology Development Agency (NSTDA) , MOST
- Office of Industrial Economics
- Iron and Steel Institute of Thailand
- Metropolitan Electricity Authority
- Tinplate MFG Co., Ltd.
- Sime Darby LCP Power Co., Ltd.
- Rayong Olefins Co., Ltd.
- Thai Oil Public Co., Ltd.
- Suranaree University of Technology
- Chulalongkorn University
- Metallurgy and Materials Science Research Institute, CU

and Other anonymous companies.

Khob Khun Kha

Thank you for your attention