The Abdus Salam
International Centre
for Theoretical Physics

2372-14

Joint ICTP-IAEA Workshop on Sustainable Energy Development: Pathways and Strategies after Rio+20

1 - 5 October 2012

From natural resource utilizations to an ambitious green energy: Thailand

Waraporn Rattanongphisat

Naresuan University, Phitsanulok - Thailand
& Politecnico di Milano
Italy

From natural resource utilizations to an ambitious green energy: Thailand

Waraporn Rattanongphisat[1,2]

[1]Dep. of Physics, Energy Technology Division, Fac. of Science, Naresuan University, Phitsanulok 65000, Thailand

[2]Dip. Scienza e Tecnologie dell'Ambiente Costruito (BEST), Politecnico di Milano, Milano 20133, Italia

Topic

Dynamics of natural resource utilization, environmental impacts and technologies in increasing the sustainability of energy systems

The Rio+20 Outcome

128. increasing the share of renewable energy and cleaner and energy-efficient technologies are important for sustainable development

Outline

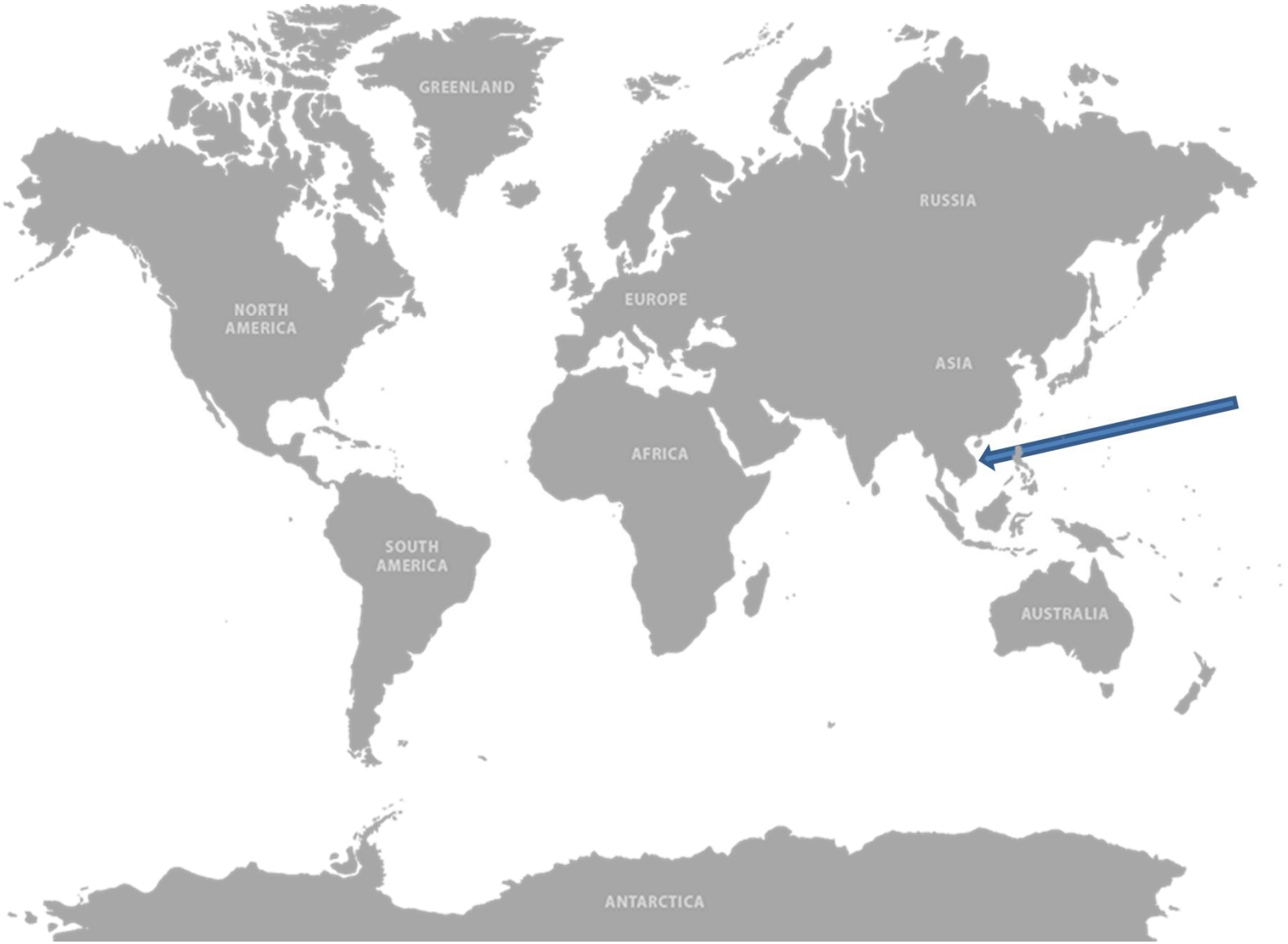
Thailand: Energy consumption and production situation

Potential of alternative energy and current status

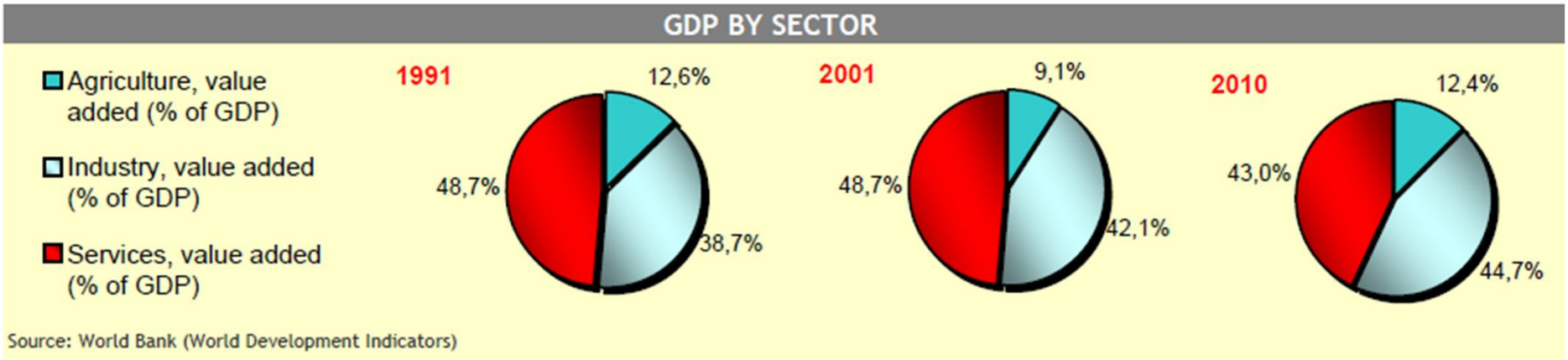
- Renewable energy resource map: solar, wind
- Current status of RE and Nuclear Energy

Towards Green Energy

- Alternative Energy Development Plan (2008-2020)
- Power Development Plan 2010 (2010-2030)



http://www.southernseaventures.com/choose-your-trip/world-map/



http://trade.ec.europa.eu/doclib/docs/2006/september/tradoc_113454.pdf

2

1

Service industry: The country's tourism, hospitality, health care, film, broadcasting and entertainment sectors are growing

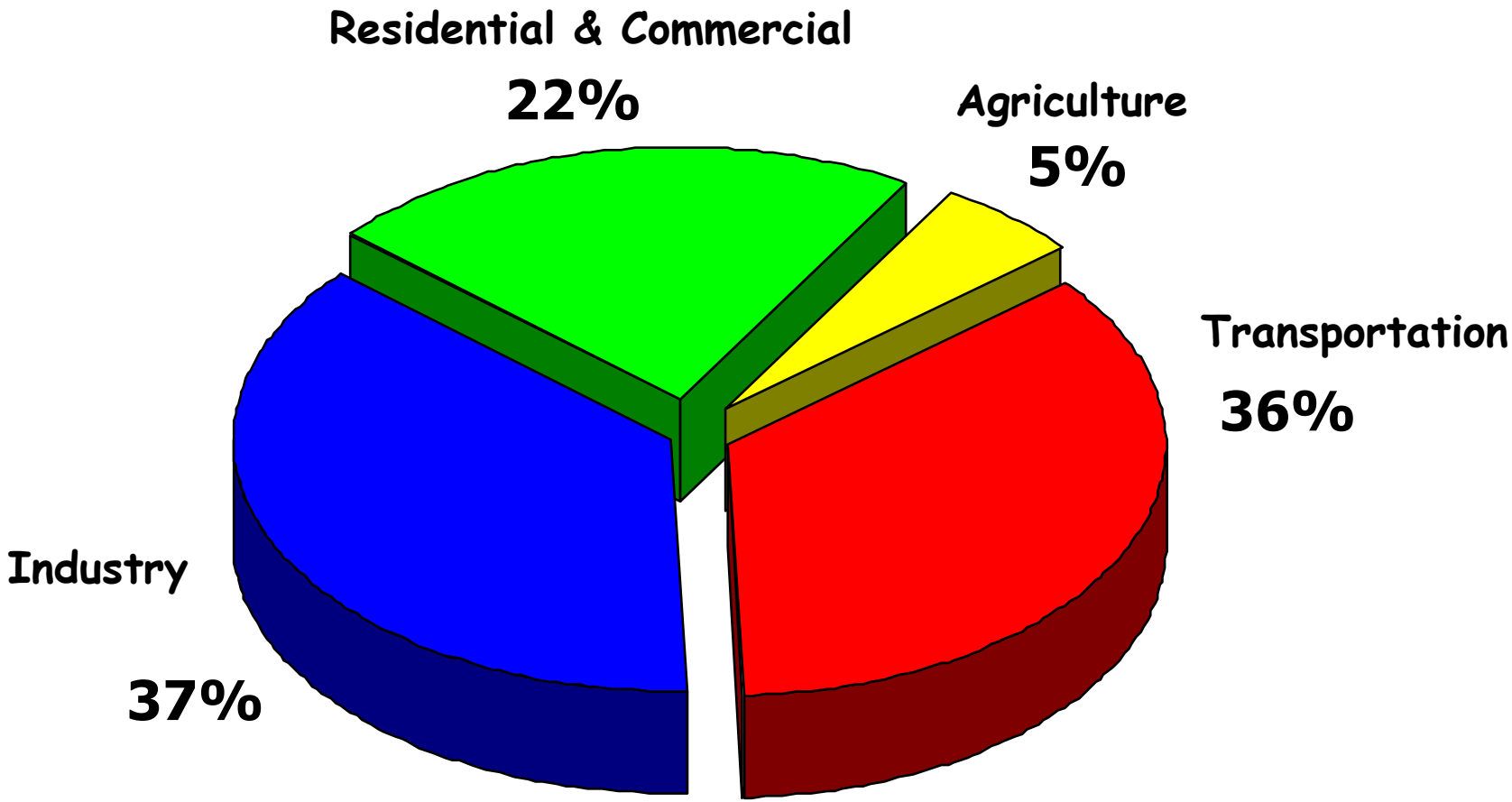
http://www.ethailand.com/news/thai-industrial-sector-gdp-grows-considerably-in-2010-92737.html

http://farmlandgrab.org/6738

http://www.nationsencyclopedia.com/Asia-and-Oceania/Thailand-AGRICULTURE.html

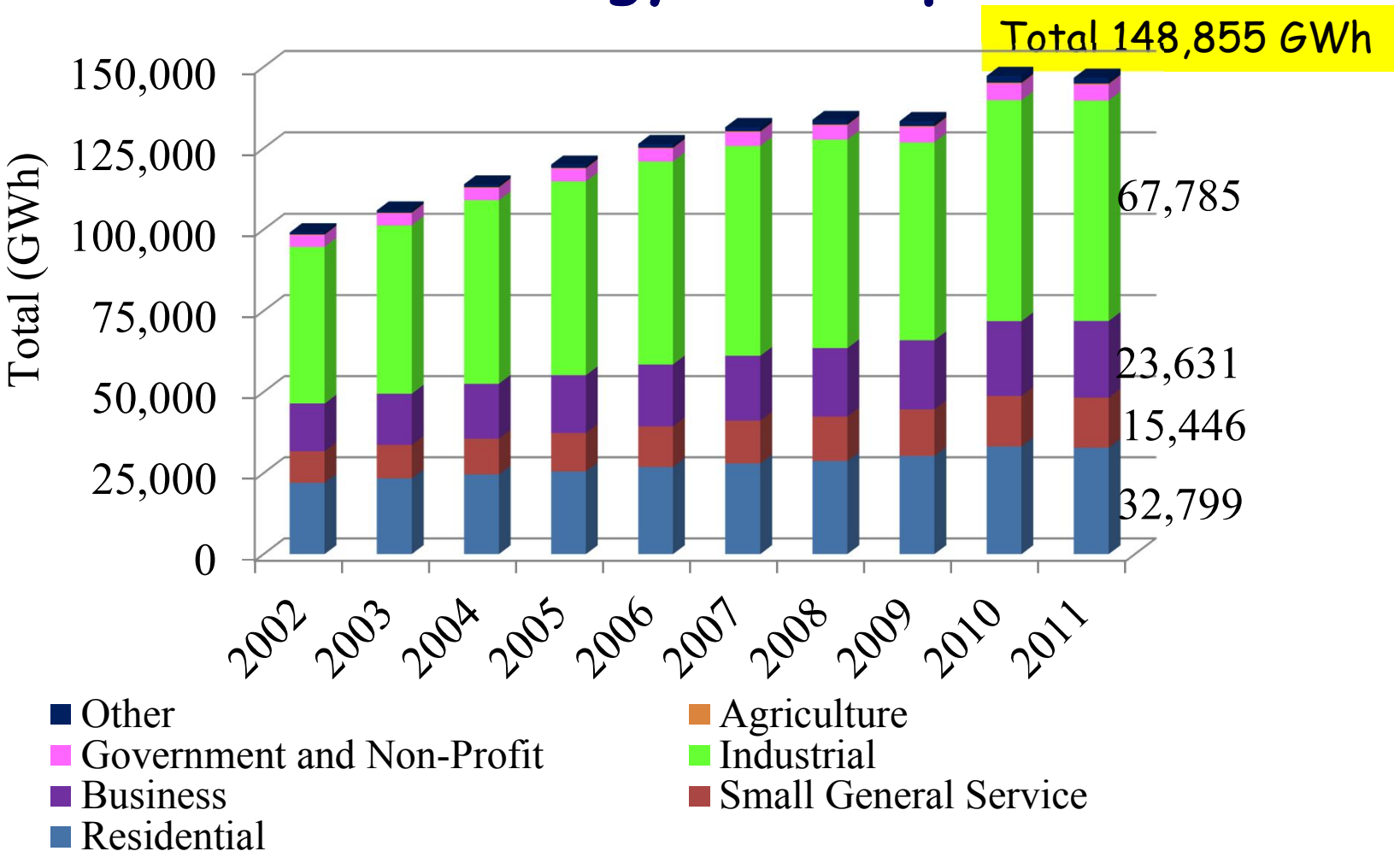
Current situation Energy consumption and production in Thailand

Final energy consumption classified by sector in 2011



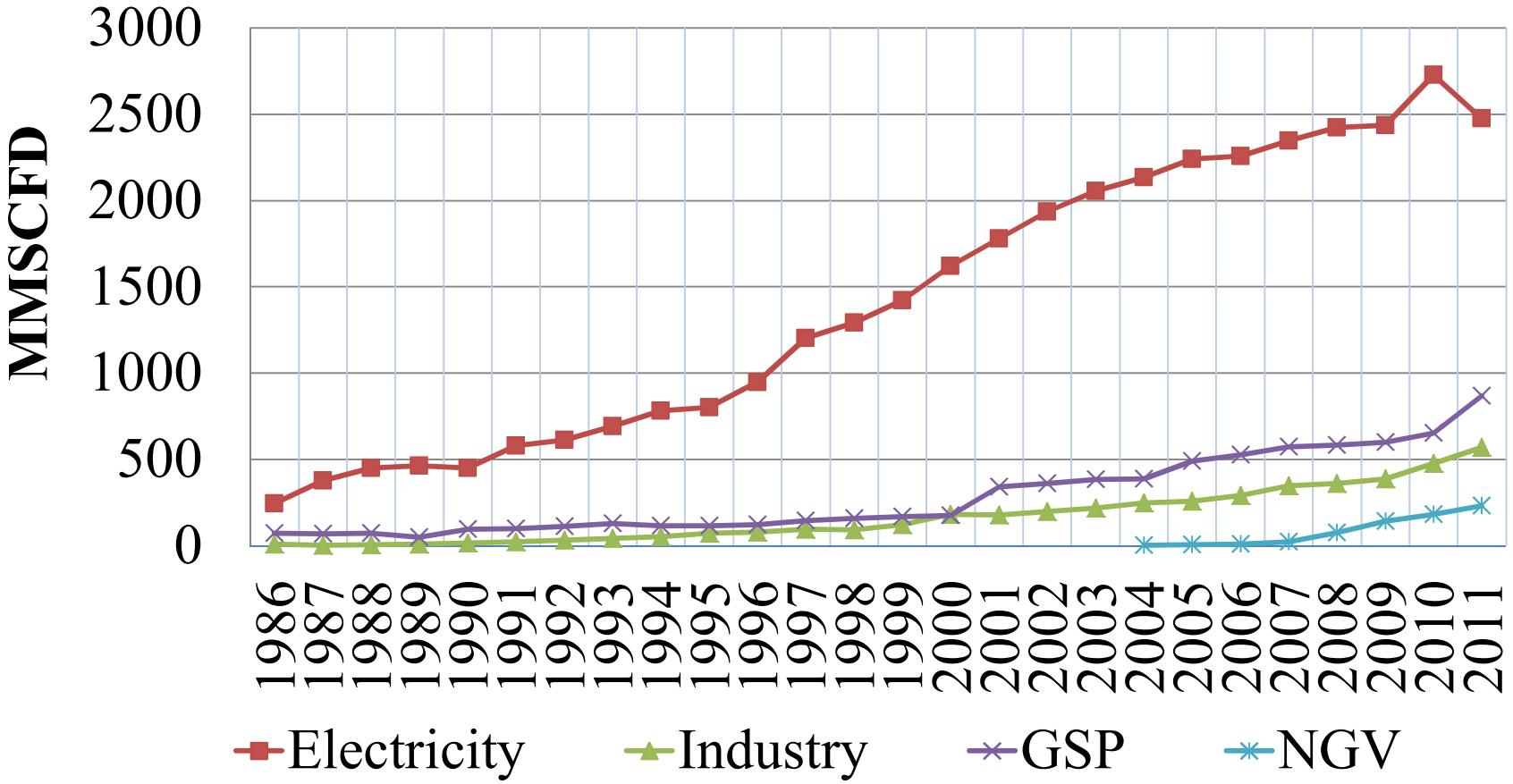
Source: Department of Alternative Energy Development and Efficiency (DEDE)

Electric energy consumption



Source : MEA, PEA and EGAT

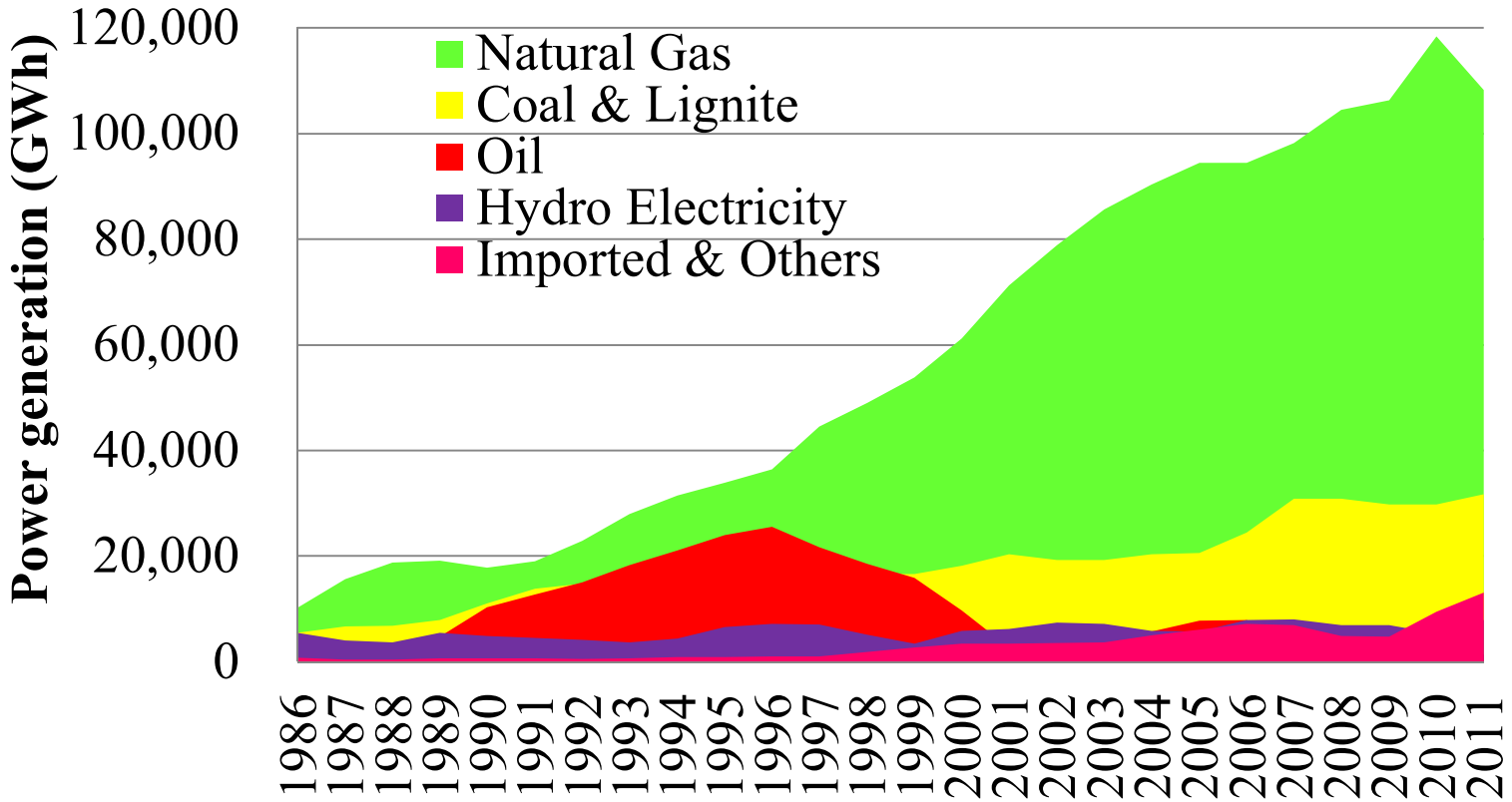
Natural gas consumption



Sources: EPPO, 2012

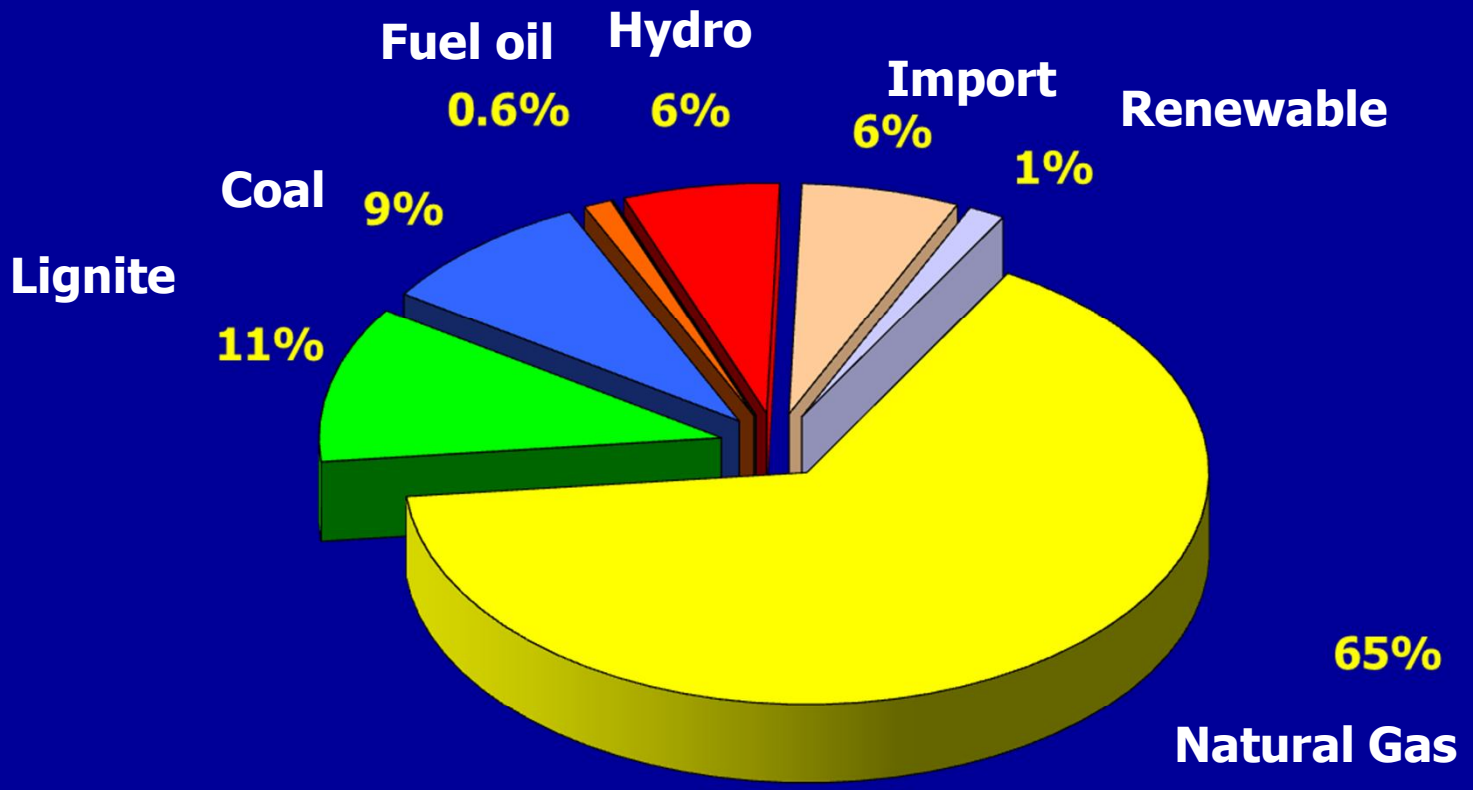
Noted: GSP =Gas Separation Plant

Power generation categorized by fuel type



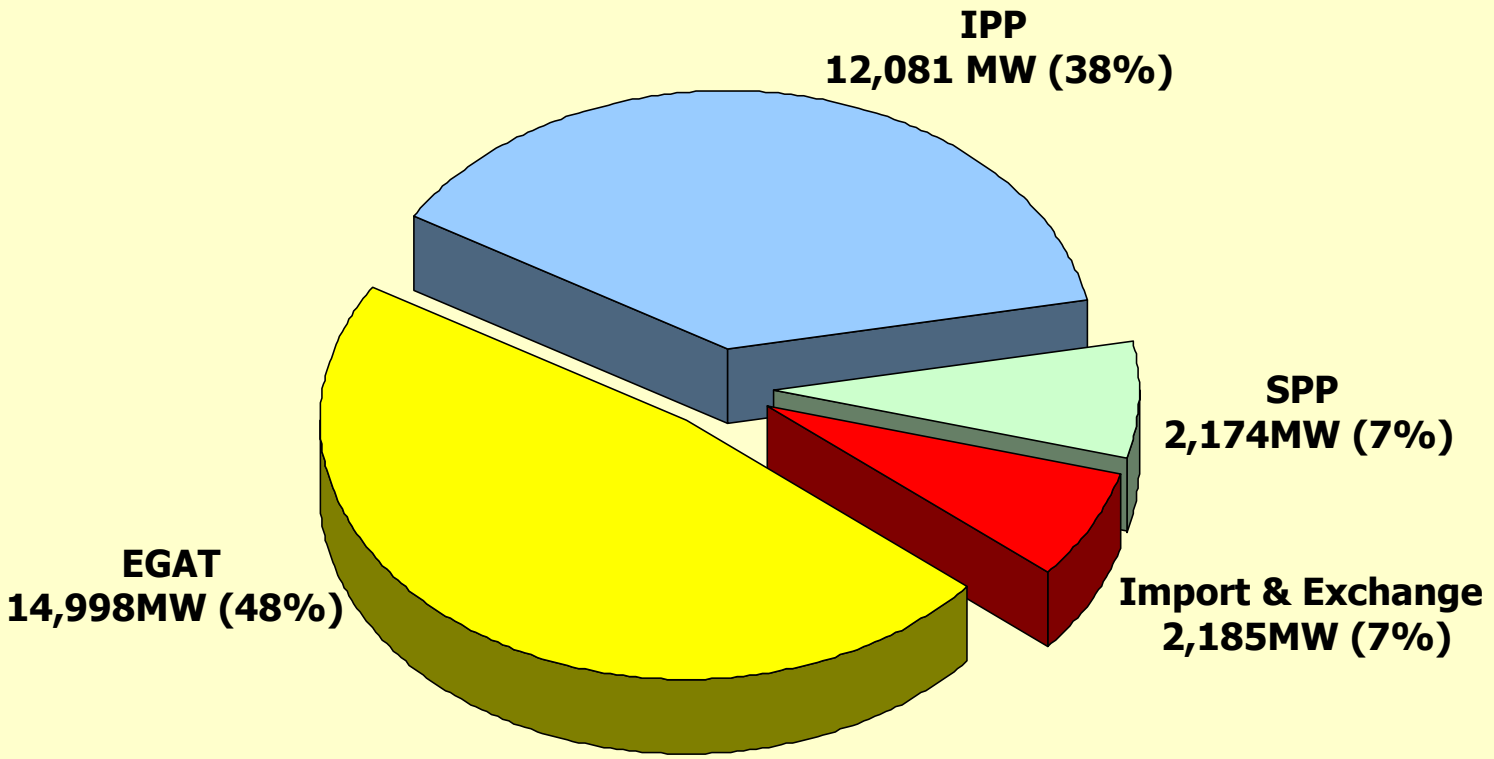
SOURCE : EGAT

Share of Power Generation by Fuel Type June 2012



Sources: EPPO (Energy Policy and Planning Office), Ministry of Energy, Thailand, 2012

Installed Generating Capacity June 2012



Sources: EPPO (Energy Policy and Planning Office), Ministry of Energy, Thailand, 2012

The private power producer selling electricity to EGAT divided into three categories;

1. VSPP=Very Small Power Producer
   The generating capacity is less than 10 MW
2. SPP =Small Power Producer
   The generating capacity is between 10 and 90 MW
3. IPP =Independent Power Producer
   The generating capacity is more than 90 MW

EGAT = Electricity Generating Authority of Thailand

DEDE = Department of Alternative Energy Development and Efficiency

Residential and transportation sectors

Building

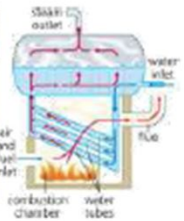
- The implementation of the energy conservation strategies e.g. building energy code and high efficient appliances

กระทรวงพลังงาน
MINISTRY OF ENERGY

Energy Efficiency Measures

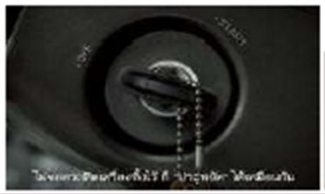
Mandate & Regulation	Financial Schemes	Social Events
❑ Building Energy Code	❑ Energy Finance	❑ Standards and Labeling
❑ Energy ISO	❑ Revolving Fund	❑ AC Cleaning
	❑ ESCO FUND	❑ Light Bulbs









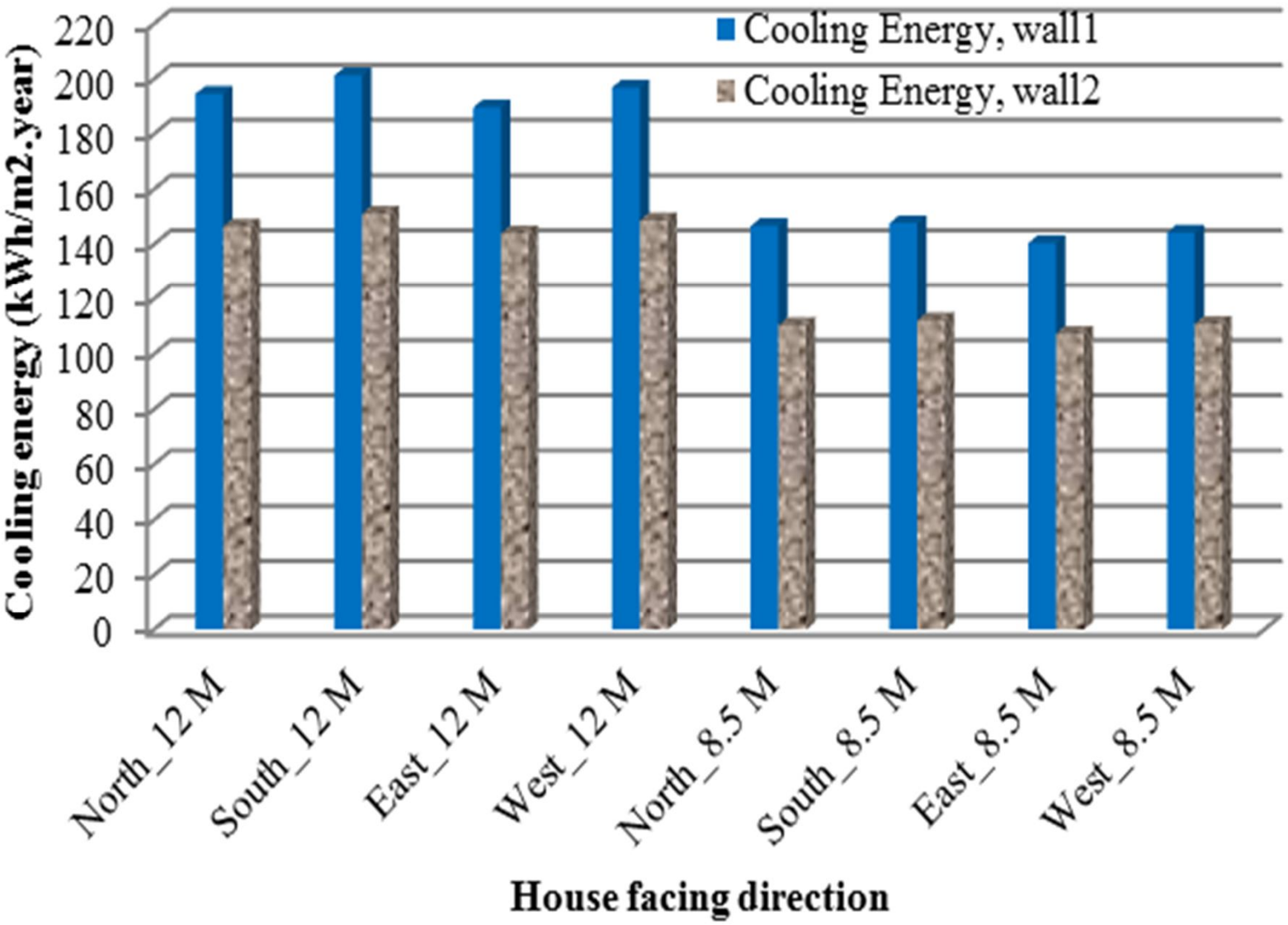




Dr.W Channukul (Minister of Energy), Thailand's Renewable Energy and Energy Efficiency, 5th Feb 2010

A case study on low cost house

- Building energy code began in 1992: The Energy Conservation Promotion Act (ECP Act)
- Energy conservation for designed buildings started since 1995
- Space cooling, electrical appliances and lighting are the main end use
- Number of houses started installing air conditioning systems increase rapidly

Rattanongphisat et al, 2012



Rattanongphisat et al, 2012

- The influential parameters on the cooling energy demand: operation period of air conditioning unit and building envelope

Rattanongphisat et al, 2012

Mechanical equipment

HVAC and Renewable energy

e.g. evaporative cooler, fan, PV etc.

lighting etc.

Passive system

Thermal comfort

e.g. natural ventilation, day lighting etc.

Building design

Cut down building heat gain

e.g. insulation, construction material, efficient appliances etc.

N. Lechner, Heating, Cooling, Lighting: Sustainable Design Methods for Architects, 3rd edition, John Wiley&Sons Inc., USA., 2009

Transportation solution

- Public transportation systems must be implemented since it provide high potential of reducing both energy requirements and CO_2 emissions

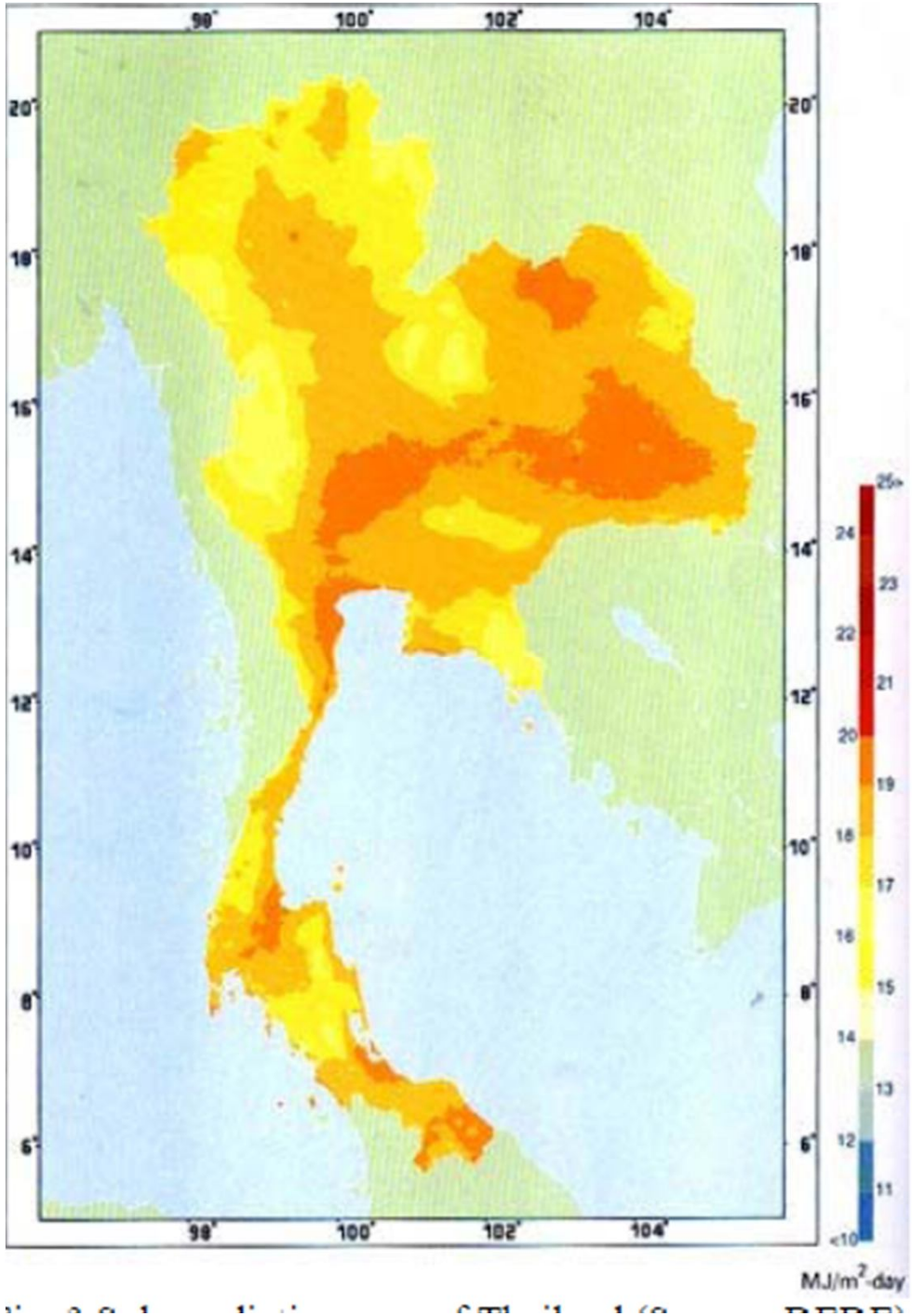
- Need good policy to control the number of cars run in the city and the tax

Alternative energy and Current status

Electricity Adder

Renewable Energy Technology/Fuel	2007-2008 Adder Rate (THB/kWh)	2009 Adder Rate (THB/kWh)	2010 Adder Rate (THB/kWh)	Special Adder for Diesel Replacement (THB/kWh)	Special Adder for Three Southernmost Provinces (THB/kWh)	Support Duration (Years from COD)
1. Biomass						
- Installed Capacity ≤ 1 MW	0.30	0.50	0.50	1.00	1.00	7
- Installed Capacity > 1 MW	0.30	0.30	0.30	1.00	1.00	7
2. Biogas						
- Installed Capacity ≤ 1 MW	0.30	0.50	0.50	1.00	1.00	7
- Installed Capacity > 1 MW	0.30	0.30	0.30	1.00	1.00	7
3. Waste (MSW and Industrial Waste, excluding Hazardous Waste and Organic Waste)						
- Landfill or Digestion Process	2.50	2.50	2.50	1.00	1.00	7
- Thermal Process	2.50	3.50	3.50	1.00	1.00	7
4. Wind						
- Installed Capacity ≤ 50 kW	3.50	4.50	4.50	1.50	1.50	10
- Installed Capacity > 50 kW	3.50	3.50	3.50	1.50	1.50	10
5. Small/Microhydro						
- Installed Capacity 50 - ≤ 200 kW	0.40	0.80	0.80	1.00	1.00	7
- Installed Capacity < 50 kW	0.80	1.50	1.50	1.00	1.00	7
6. Solar	8.00	8.00	6.50	1.50	1.50	10

Thailand PV status report 2011. http://www.dede.go.th/dede/images/stories/pdf/t_pv_11.pdf

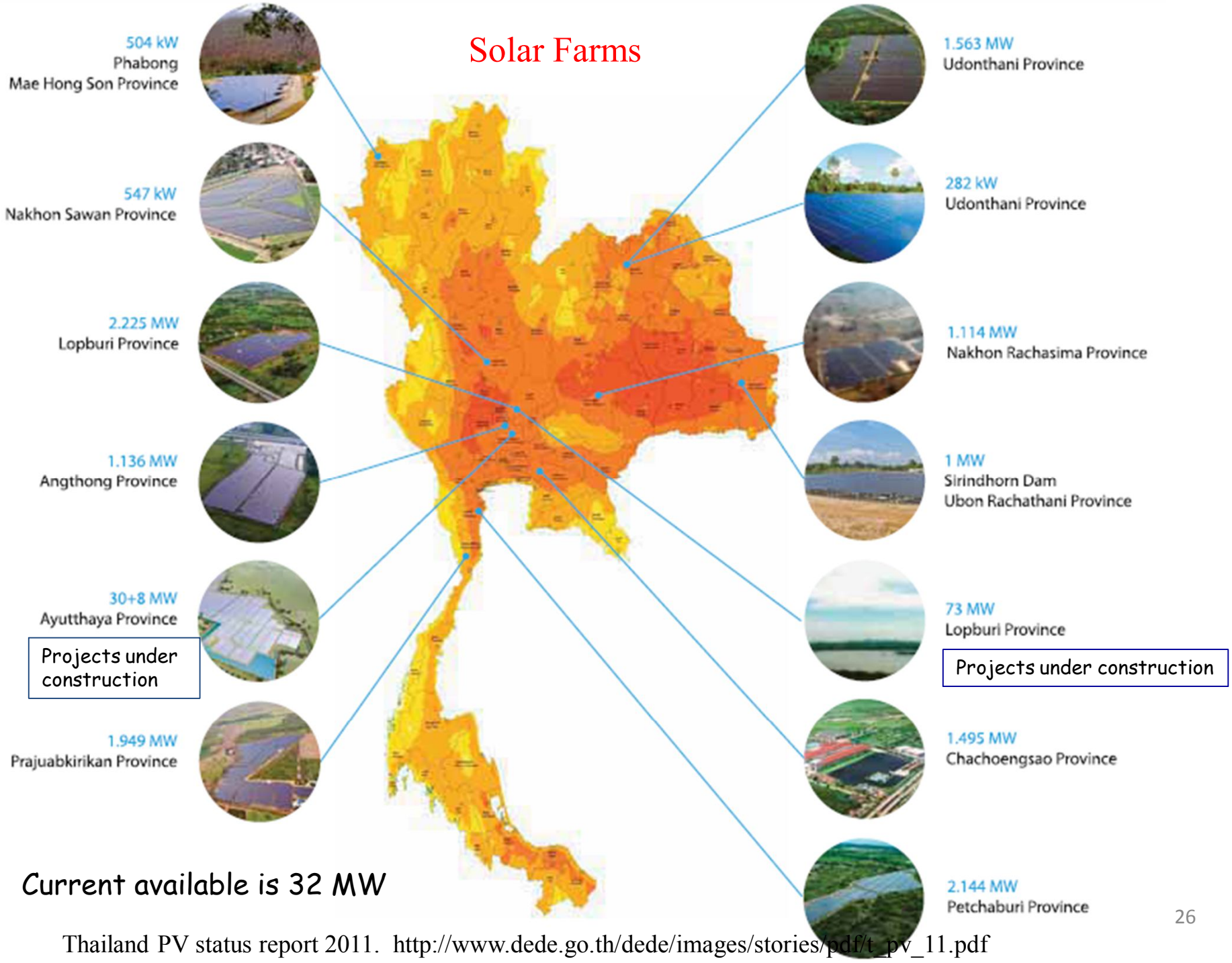


Solar Electricity

- High solar intensity range between 15 and 20 MJ/m^2.day
- Solar electricity use in rural health station since 1976
- Current capacity 32 MW
- 15 years AEDP targets 500 MW in 2022

Solar radiation map (DEDE)

Solar Farms



Current available is 32 MW

Thailand PV status report 2011. http://www.dede.go.th/dede/images/stories/pdf/t_pv_11.pdf

The challenge of PV power plant

The PV industry in Thailand greatly relies on imported components such as modules and supportive materials which is about 70% - 80% of the total investment.

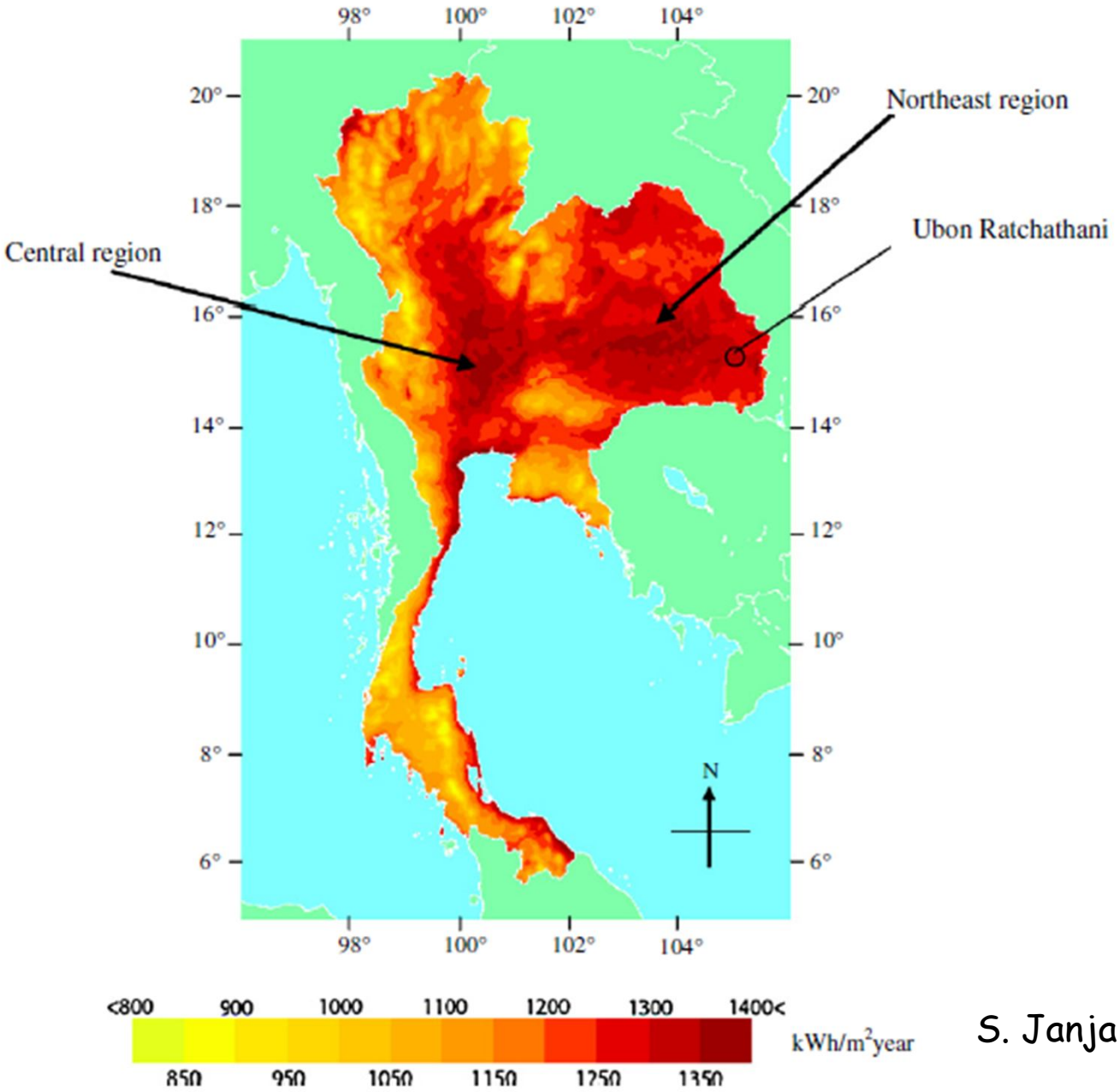
What can be done to improve the situation?

Would having own PV factory speed up the PV power production?

Solar thermal energy

- Main applications: Solar hot water system and Food drying
- Potential to solar thermal power generation e.g. CSP (Concentrating Solar Power) system on going research projects
- Currently, thermal energy capacity is 0.5 ktoe
- 15 years AEDP targets 38 ktoe in 2022

Source: Sawangphol and Pharino, 2011

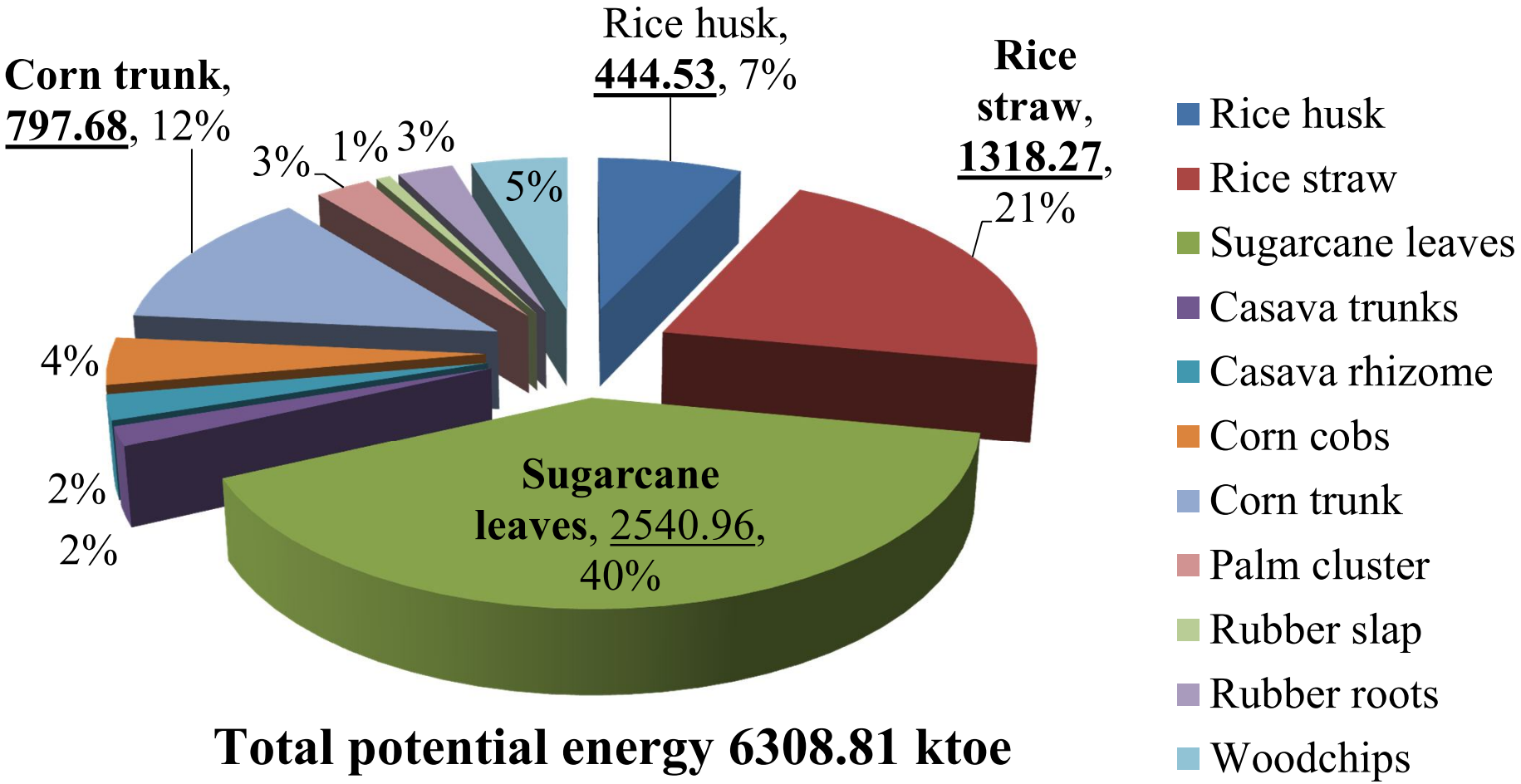


S. Janjai et al (2011)

A map of Thailand showing geographical distribution of year sum of direct normal irradiation.

Biomass

- Agricultural residues 61 Mton/year but only about one-third is used



Total potential energy 6308.81 ktoe

Source: Sawangphol and Pharino, 2011

Biomass (Cont.)

- The other two main sources of biomass: forest industry and residential sector
- Power generation capacity 1751 MW: 632 MW (rice husk), 106 MW (bagasse), 32 MW (wood residue) [OERC, 2010]
- 15 years AEDP targets of 3700 MW in 2022

Biomass (Cont.)

- Current biomass thermal is 3017 ktoe and 15 years AEDP targets 6760 ktoe in 2022

Source: Sawangphol and Pharino, 2011

Biomass challenges

- Post-harvest management is required for high moisture content agricultural residues
- Distribution of residues area concern with collecting and fuel for transportation
- **Biomass fuel should be in short distance to the power plant**

Bio gas

- Bio gas produced from anaerobic digestion or fermentation process
- Materials: biomass, manure, sewage, municipal waste and energy crops
- Power capacity of industrial waste water and pig manure are 74.96 MW and 97 MW, respectively [OERC, 2010]
- 15 years AEDP targets of 120 MW in 2022

Municipal Solid Waste

- MSW comprises of food waste (41-61 %), paper (4-25%) and plastic (3.6-28%) [Chiemchaisri et.al., 2007]

- Current power generation from of MSW is 5.6 MW

  15 years AEDP targets of 160 MW in 2022

- Current MSW thermal is 1.09 ktoe and

  15 years AEDP targets 35 ktoe in 2022

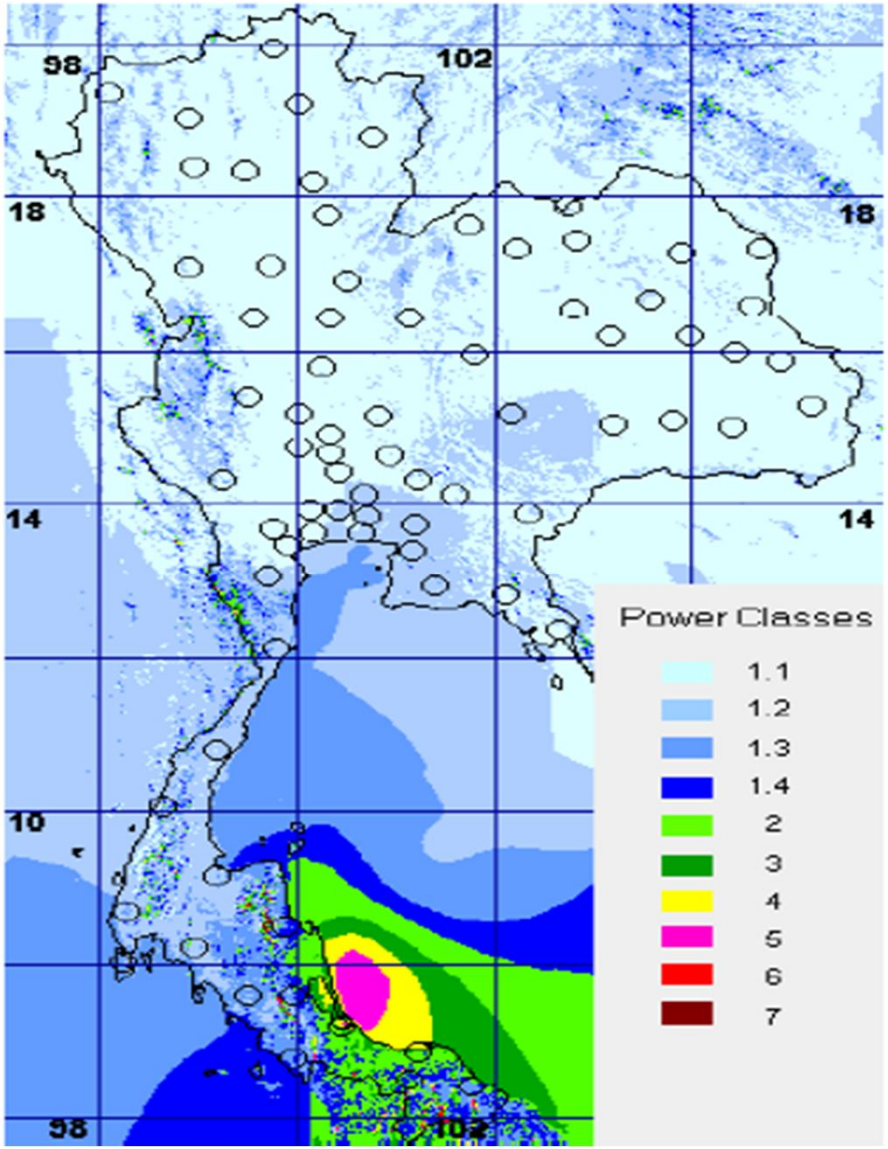
Source: Sawangphol and Pharino, 2011

Hydro power

- Potential hydro power: 700 MW, existing: 56 MW [EPPO, 2010]
- 15 years AEDP targets of 324 MW in 2022

Challenge: Hydro power

- Only small hydro power plant could be built because of less impact on land use and living style of community
- Limited number of plant in the future



Wind energy

- An average wind speed is rather low and normally less than 4 m/s
- High potential of wind along the coastlines in the Southern region
- Wind power capacity is 0.38 MW [OERC, 2010]
- 15 years AEDP targets of 800 MW in 2022

Wind map (DEDE)

Table 1-1 Classes of wind power density at 10 m and 50 m[(a)].

Wind Power Class*	10 m (33 ft)		50 m (164 ft)	
	Wind Power Density (W/m^2)	Speed[(b)] m/s (mph)	Wind Power Density (W/m^2)	Speed[(b)] m/s (mph)
1	0	0	0	0
2	100	4.4 (9.8)	200	5.6 (12.5)
3	150	5.1 (11.5)	300	6.4 (14.3)
4	200	5.6 (12.5)	400	7.0 (15.7)
5	250	6.0 (13.4)	500	7.5 (16.8)
6	300	6.4 (14.3)	600	8.0 (17.9)
7	400	7.0 (15.7)	800	8.8 (19.7)
	1000	9.4 (21.1)	2000	11.9 (26.6)

http://rredc.nrel.gov/wind/pubs/atlas/tables/1-1T.html

(a) Vertical extrapolation of wind speed based on the 1/7 power law
(b) Mean wind speed is based on Rayleigh speed distribution of equivalent mean wind power density

Ex. Wind Power Class = 3: range between 150 W/m^2 and 200 W/m^2

Challenge: Wind power

- Wind power technology in domestic require development to achieve higher efficiency
- Imported technologies are costly and must be modified for tropical weather and low wind speed.

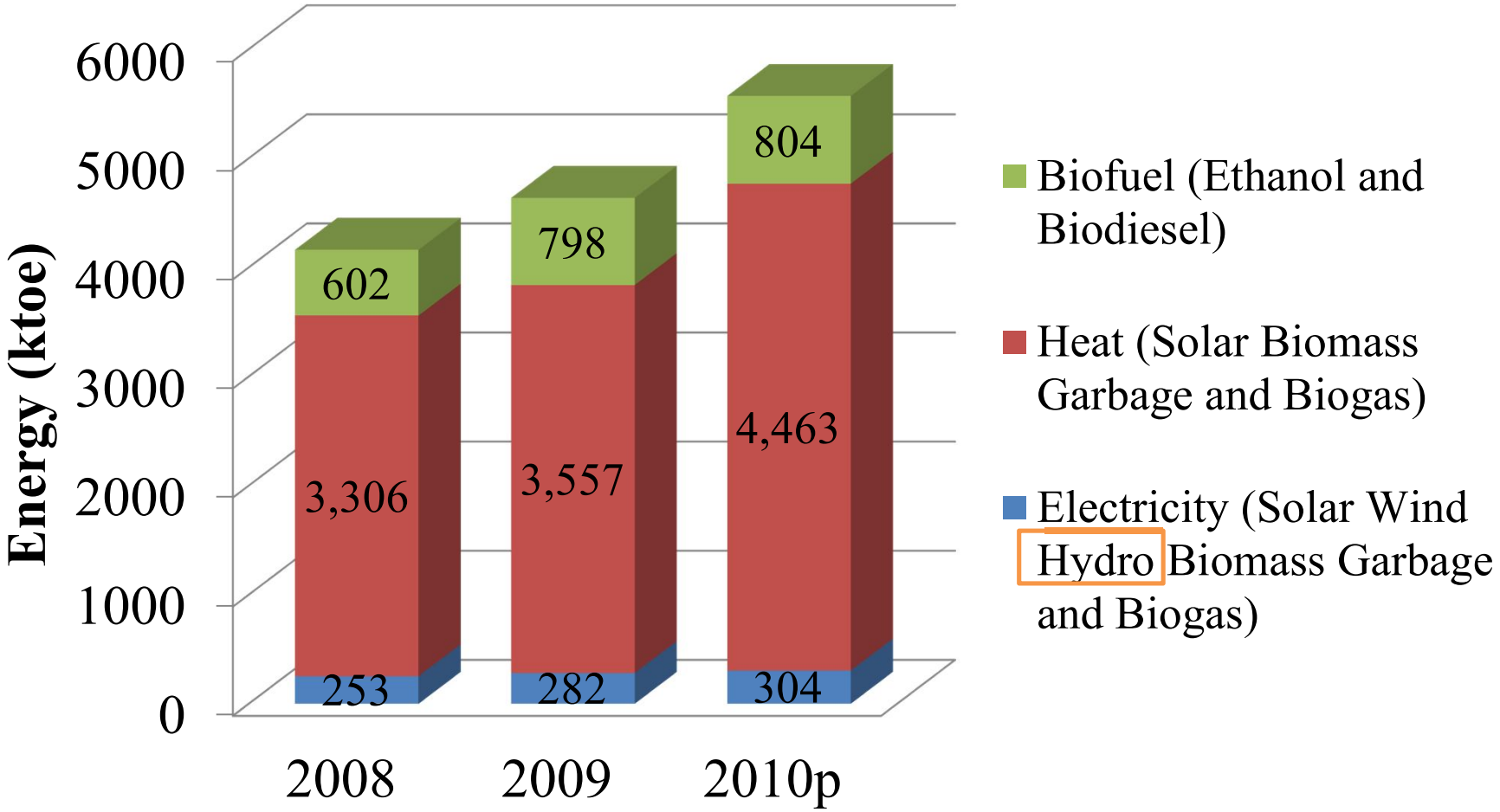
- ❖ Substantial investment on the research in wind turbine, component parts and an establishment of wind farm is a key to achieve the goal.
- ❖ Good driving policy from the government

Geo thermal

- A 300 kW binary cycle geothermal power plant at Fang district (EGAT)
- Waste hot water is used for drying agricultural products
- Only one geothermal site in Northern part of Thailand considered significant
- This type of energy has limited potential in Thailand

Source: Sawangphol and Pharino, 2011

Current status of Renewable energy utilization



Percentage of alternative energy consumption is 6.3% (2008), 7% (2009), 7.8% (2010)

http://ee.dede.go.th/energystat/renewusage.html

Nuclear energy

History of nuclear power project in Thailand (Patchimpattapong, 2010)

1966 EGAT proposed Nuclear Power Plant (NPP) project
1967 Government appointed the Nuclear Sub-Committee to conduct feasibility study and site selection
1970 Government approved Ao Phai in Chonburi Province as NPP site
1972 Government approved a 600 MWe BWR reactor for the project
1974 EGAT reserved nuclear fuel with Energy Research and Development Administration (ERDA), U.S.
1976 EGAT proposed to call for bidding
1978 Government postponed the project indefinitely
1982-1991 EGAT carried out site survey and selection
1993-1994 Parliament Energy Commission studied nuclear power generation
1992-1995 EGAT and NEWJEC Inc., Japan coperformed initial environmental exam and site evaluation
1996 Cabinet appointed Committee to conduct study on economic and infrastructure for NPP project

2010 Government approved PDP-2010 plan, 5 nuclear power plants with capacity of 1000MW each. The first one shall be start operate in 2020

2011 Government postpone the construction plan for the first nuclear power plant to the next three years

Nuclear Power Development Schedule

Year	Phase
2007	Preliminary
2008-2010	Pre-Project Activities
2011-2013	Project Implementation
2014-2019	Construction
2020	Operation

Postpone

The tsunami in Japan in 2011 has caused the global public concern on the safety of the nuclear power plant.

Recently, Germany has planed to replace nuclear power plant by using renewable energy resource within 2022 (according to the news).

"Germany introduced a plan in 2011 to phase-out nuclear energy gradually, following the Fukushima Daiichi nuclear disaster in Japan. Around eight nuclear reactors were closed immediately, reducing nuclear generation in Germany from 133.01 Terawatt-hours (TWh) in 2010 to 102.31 TWh. In 2011, the country's installed capacities for wind and solar technologies were 29,264.8 Megawatts (MW) and 24,870 MW respectively, accounting for an impressive cumulative share of 32% of the energy mix. However, the anticipated loss of more nuclear power has prompted Germany to focus on increasing their renewable energy technologies further."

http://www.utilityproducts.com/news/2012/08/21/germany-s-nuclear-free-smart-grid-future.html

Towards Green Growth

The Alternative Energy Development Plan, Ministry of Energy

- To increase the role of renewable energy to 20.3 % of the final energy consumption in 2022.
- The share of renewable energy in power generation is expecting at 5,608 MW or 2.4 % by the year 2022

SUMMARY OF THAILAND POWER DEVELOPMENT PLAN 2010-2030, Electricity Generating Authority of Thailand, *April 2010*

Renewable Energy Targets (2008-2022)

Type of Energy	Potential	existing	2008 - 2011		2012 - 2016		2017 - 2022	
Electricity	**MW**	**MW**	**MW**	**ktoe**	**MW**	**ktoe**	**MW**	**ktoe**
Solar	50,000	**32**	**55**	6	**95**	11	**500**	56
Wind Energy	1,600	**1**	**115**	13	**375**	42	**800**	89
Hydro Power	700	**56**	**165**	43	**281**	73	**324**	85
Biomass	4,400	**1,610**	**2,800**	1,463	**3,220**	1,682	**3,700**	1,933
Biogas	190	**46**	**60**	27	**90**	40	**120**	54
Municipal Solid Waste	400	**5**	**78**	35	**130**	58	**160**	96
Hydrogen			**0**	0	**0**	0	**4**	1
Total		**1,750**	**3,273**	1,587	**4,191**	1,907	**5,608**	2,313
Thermal	**ktoe**	**ktoe**		**ktoe**				**ktoe**
Solar Thermal	154	**1**		**5**				**38**
Biomass	7,400	**2,781**		**3,660**		**5,000**		**6,760**
Biogas	600	**224**		**470**		**540**		**600**
Municipal Solid Waste		**1**		**15**		**24**		**35**
Total		**3,007**		**4,150**		**5,582**		**7,433**
Biofuel	**m lt/d**	**m lt/d**	**m lt/d**	**ktoe**	**m lt/d**	**ktoe**	**m lt/d**	**ktoe**
Ethanol	3.00	**1.24**	**3.00**	805	**6.20**	1,686	**9.00**	2,447
Biodiesel	4.20	**1.56**	**3.00**	950	**3.64**	1,145	**4.50**	1,415
Hydrogen			**0**	0	**0**	0	0.1 mill kg/d	124
Total			**6.00**	1,755	**9.84**	2,831	**13.50**	3,986
Total Energy Consumption		66,248		70,300		81,500		97,300
Total Energy from R E (ktoe)		4,237		7,492		10,319		13,709
Renewable Energy Ratio		**6.4%**		**10.6%**		**12.7%**		**14.1%**
NGV (mmscfd - ktoe)		108.1	393.0	3,469	596	5,260	690	6,090
Total Energy from RE + NGV (ktoe)				10,961		15,579		19,799
Alternative Energy Raio				**15.6%**		**19.1%**		**20.3%**

The cumulative target

SUMMARY OF THAILAND POWER DEVELOPMENT PLAN 2010-2030, Electricity Generating Authority of Thailand, *April 2010*

Power Development Plan 2010
EGAT

PDP 2010

1. System Reliability

   - Reserve Margin

     Talking about > 20% of total generating capacity

   - Power Purchase from Neighbouring Countries

     Max. 38% from 4 countries

PDP 2010 (cont.)

2. Clean Energy and Efficient Utilization

- Demand Side Management (DSM)

  Energy conservation, market mechanism and consumer behavior e,g efficiency "No.5 Label"

- Electricity Generation from Renewable Energy

  Follow AEDP to 2022, not less than 5% for VSPP after 2020
  2009: 753 MW
  2022: 4803 MW
  2030: 6101 MW

- Electricity Generation with Cogeneration System

  2009: 1962 MW
  2030: 9139 MW

- Greenhouse Gas Emission Reduction

  2010: 0.482 kg CO_2 / kWh ; 2030 : 0.368 kg CO_2 / kWh

Note for Clean Coal Power Plant

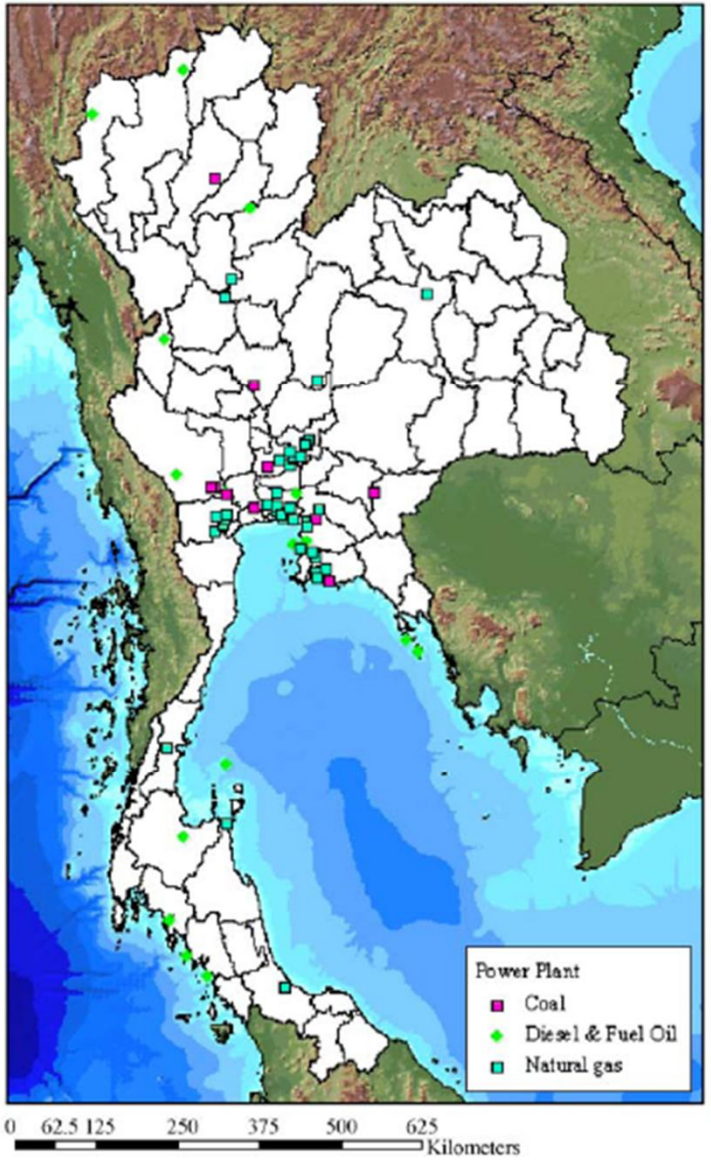
Similarly to nuclear power plant, coal-fired power plants are low production cost.

With difficulties on location, greenhouse gas emission and public acceptance

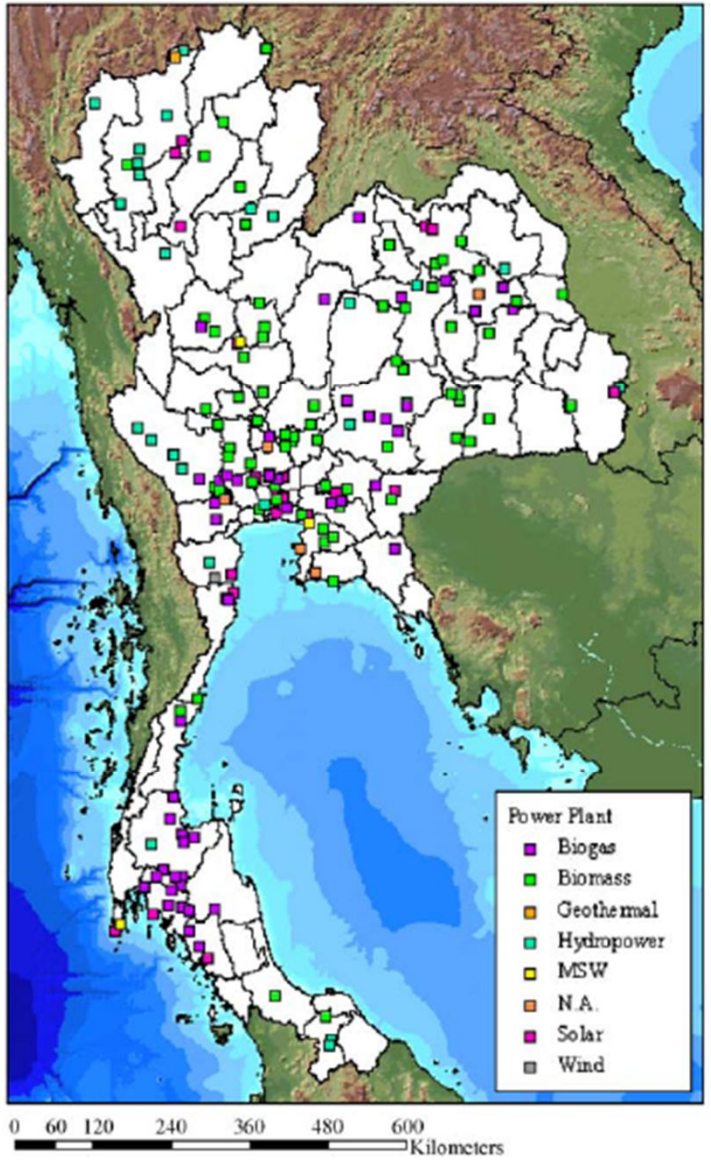
Despite Supercritical or Ultra-supercritical technologies with bituminous fuel and FGD equipment

Clean coal power plants were the last priority in new planting for PDP 2010

Source: Sawangphol and Pharino, 2011



(a) Conventional Fuel Source: OERC

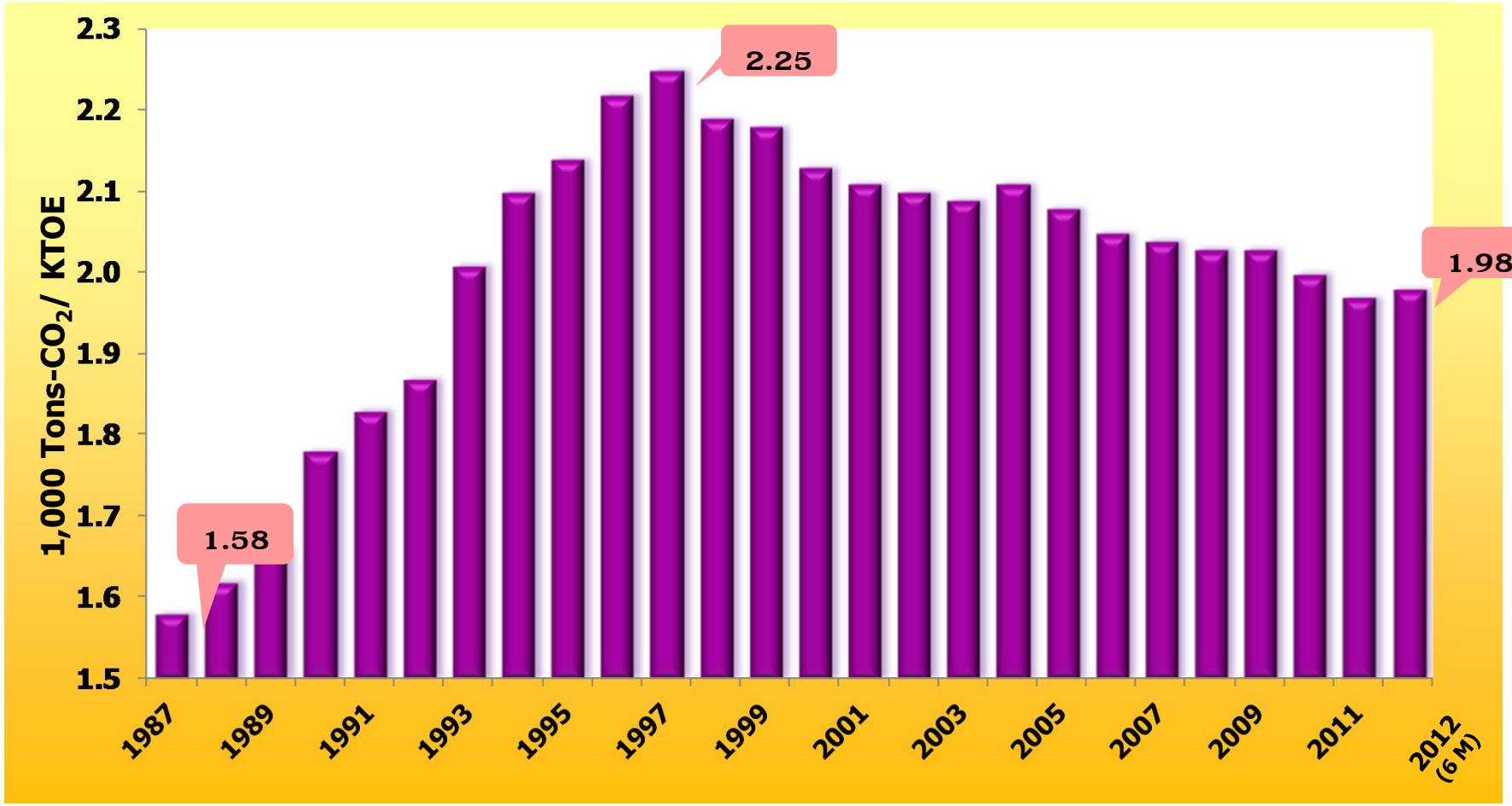


(b) Non-conventional Fue Source: EPPO

Distribution of power plant in Thailand: (Sawangphol and Pharino,2011)

Carbon emission

CO_2 Emission per Primary Energy Consumption



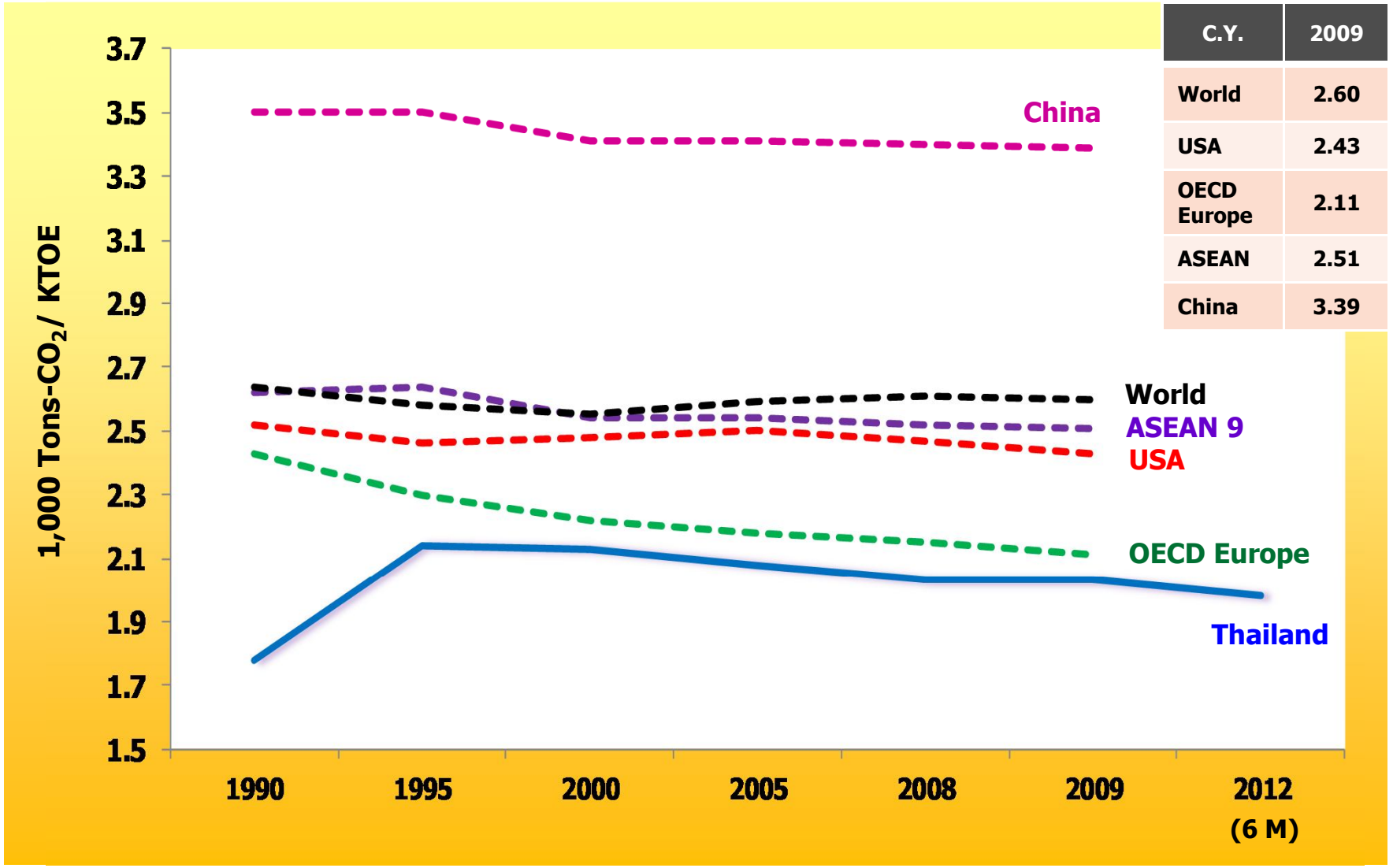
NRE Included in Primary Energy Consumption

Unit : 1,000 Tons-CO_2/KTOE

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	1.58	1.62	1.66	1.78	1.83	1.87	2.01	2.1	2.14	2.22	2.25	2.19	2.18
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012 (6 M)**
CO_2	2.13	2.11	2.10	2.09	2.11	2.08	2.05	2.04	2.03	2.03	2.00	1.97	1.98

Source : Thailand data from EPPO-Emission Database System ; International data from EDMC, Japan 2012

International CO_2 Emission per Consumption



C.Y.	2009
World	2.60
USA	2.43
OECD Europe	2.11
ASEAN	2.51
China	3.39

Source : Thailand data from EPPO-Emission Database System ; International data from EDMC, Japan 2012

Keys to succeed Sustainability Energy Development

- The collaboration with R&D organization, the technologies transformation from Developed countries highly benefit to enhance institution on energy efficiency and sustainability

Keys to succeed Sustainability Energy Development (cont.)

- Investment, cost of establishing on renewable energy production is high; hence, the subsidy from government is essential
- As equally important the encouragement to private sector to take an investment on renewable power plant

summary

- Natural gas is the main natural resource utilization in power generation.
- Great potential for renewable resources: solar energy and biomass

- The government of Thailand has an ambitious on green energy as the Alternative Development Energy Plan (ADEP) targets 20.3% of the final energy consumption in 2022

Keys to sustainable energy development

Policy, government subsidy, investment from private sectors, internationally collaboration to enhance the strength of institution and transform technologies

References

1. N. Sawangphol, C. Pharino, Status and outlook for Thailand's low carbon electricity development, Renewable and Sustainable Energy Reviews 15 (2011) 564–573
2. Energy Policy and Planning Office. Energy statistic. Bangkok: Energy Policy and Planning Office. Ministry of Energy
3. The Office of the Energy Regulatory Commissioner. License status of energy industry operation. Statistics. Bangkok: The Office of the Energy Regulatory Commissioner; 2010
4. P. Sarikprueck, S.K. Korkua, W.J Lee, P. Lumyong, Developing Important Renewable Energies in Thailand, 978-1-4577-1002-5/11/,2011, IEEE
5. SUMMARY OF THAILAND POWER DEVELOPMENT PLAN 2010-2030, Electricity Generating Authority of Thailand, *April 2010*
6. Suramaythangkoor T, Gheewala SH. Potential alternatives of heat and power technology application using rice straw in Thailand. Applied Energy 2010;87: 128–33.
7. http://www.ocf.berkeley.edu/~doonyapo/Section_7.pdf (โครงการโรงไฟฟ้านิวเคลียร์ของประเทศไทย)

References (Cont.)

8. Patchimpattapong A., Development of Thailand's First Nuclear Power Plant, *PEA-AIT International Conference on Energy and Sustainable Development: Issues and Strategies (ESD 2010), Chiang Mai, Thailand. 2-4 June 2010.*
9. S.N Uddin, R. Taplin, X. Yua, Towards a sustainable energy future—exploring current barriers and potential solutions in Thailand, Environ Dev Sustain (2010) 12:63–87.
10. S. Tanatvanit, B. Limmeechokchai, S. Chungpaibulpatana, Sustainable energy development strategies:implications of energy demand management and renewable energy in Thailand, Renewable and Sustainable Energy Reviews, 7 (2003) 367–395

Acknowledgment

The fellowship supported by ICTP Programme for Training and Research in Italian Laboratories (TRIL), Trieste, Italy is greatly appreciated.

Thank you for your kind attention