The 2nd Workshop on Promotion of Energy Science Education for Sustainable Development in Cambodia

Current Energy Situation and Needs to Transform Toward Sustainable System

Assoc. Prof. Dr. Nguyen Manh Khai, HUS-VNU

Assoc. Prof. Dr. Nguyen Thi Ha, HUS-VNU

Chanthea KHUN, Lecturer

Institute of Technology of Cambodia

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Part 1: Current Status and Future Energy Scenarios

1. Introduction
2. World Energy Resources and Demand
3. Future Energy Scenarios

1.1 Introduction

- Energy is a resource coming from two main sources: solar energy and geothermal energy”
  - Solar energy exists in main types: solar radiation, bioenergy (biomass), energy occupied in the movement of atmosphere and hydrosphere (wind, wave, sea current, tide, and river)
  - Geothermal Energy includes: thermal energy in volcanoes, hot springs, geysers and radioactive energy.

Units of Energy

- Joule (James Prescott Joule):
  $E = mc^2$ ($kg.m^2.s^{-2}$)

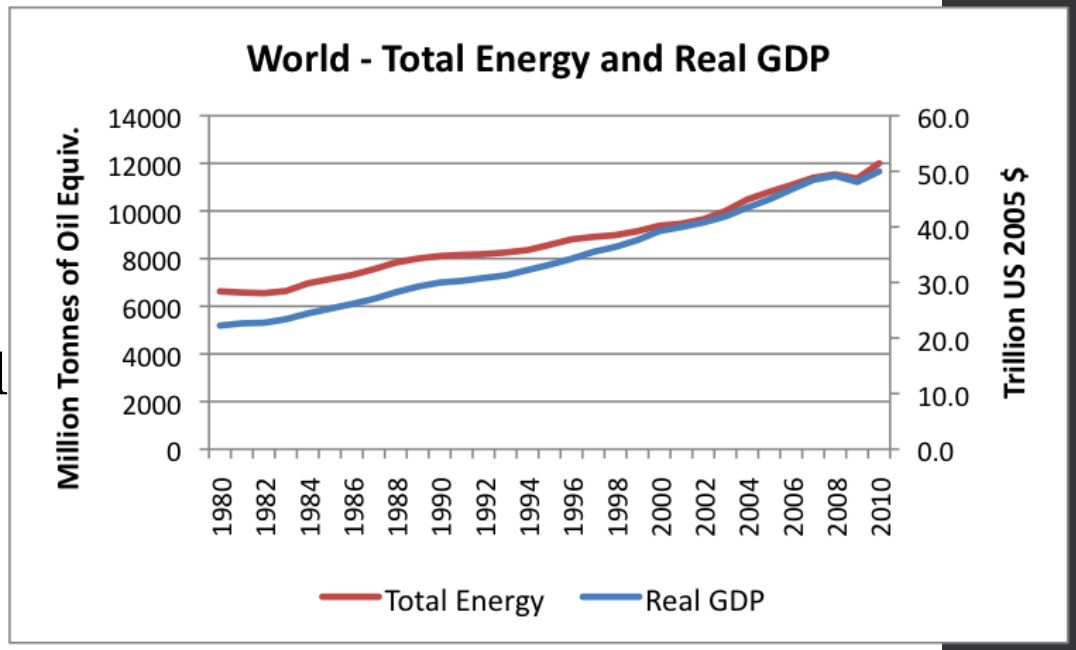
By CGS system (centimeter-gram-second):
$1\ g.cm^2/s^2 = 1.0*10^{-7}$ Joule

- 1 BTU = 1054 Joule
- 1 kWh = $3.6*10^6$ J

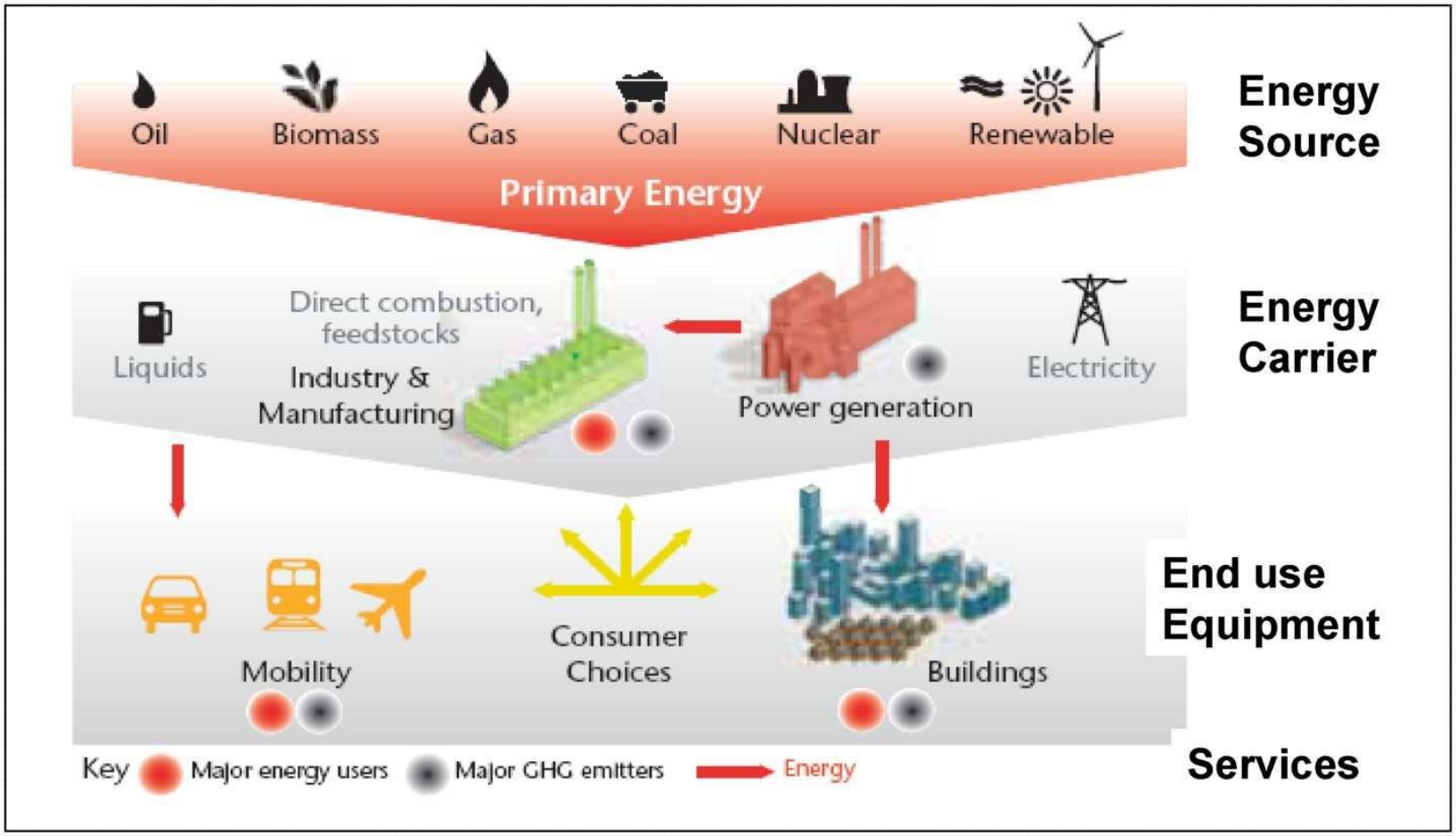
- Work and Calorie are Energy
  1 cal = 4.186 Joules
  1 kcal = 4,186 Joules

Energy Use

- Economic development and energy consumption
- Energy resource and its utilization
  - Last 250 years, powered by fossil fuels
  - Current status
    - Resources availability
    - Global warming



Energy System

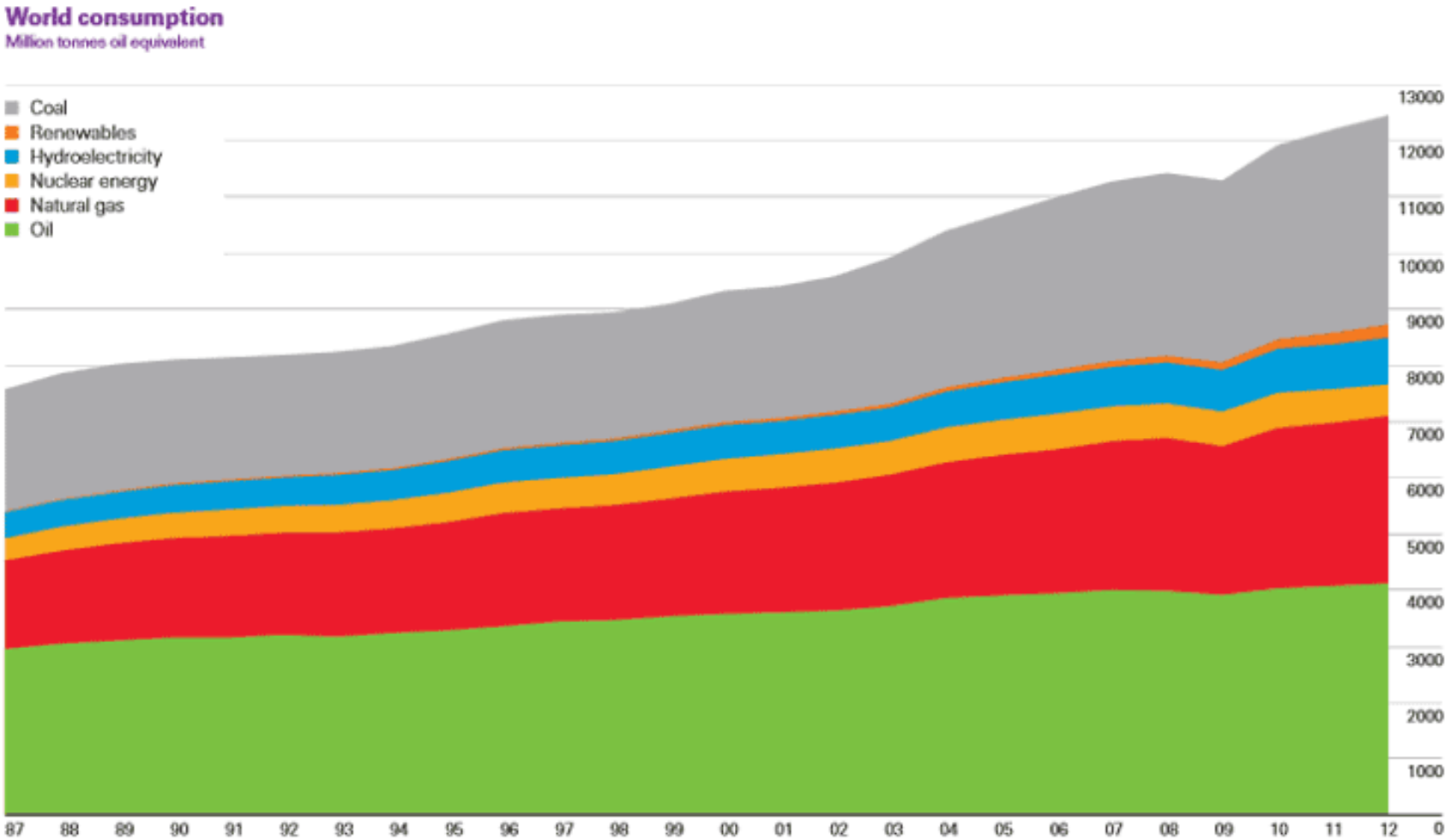


1.2 World Energy Resources and Demand

World Energy Resources

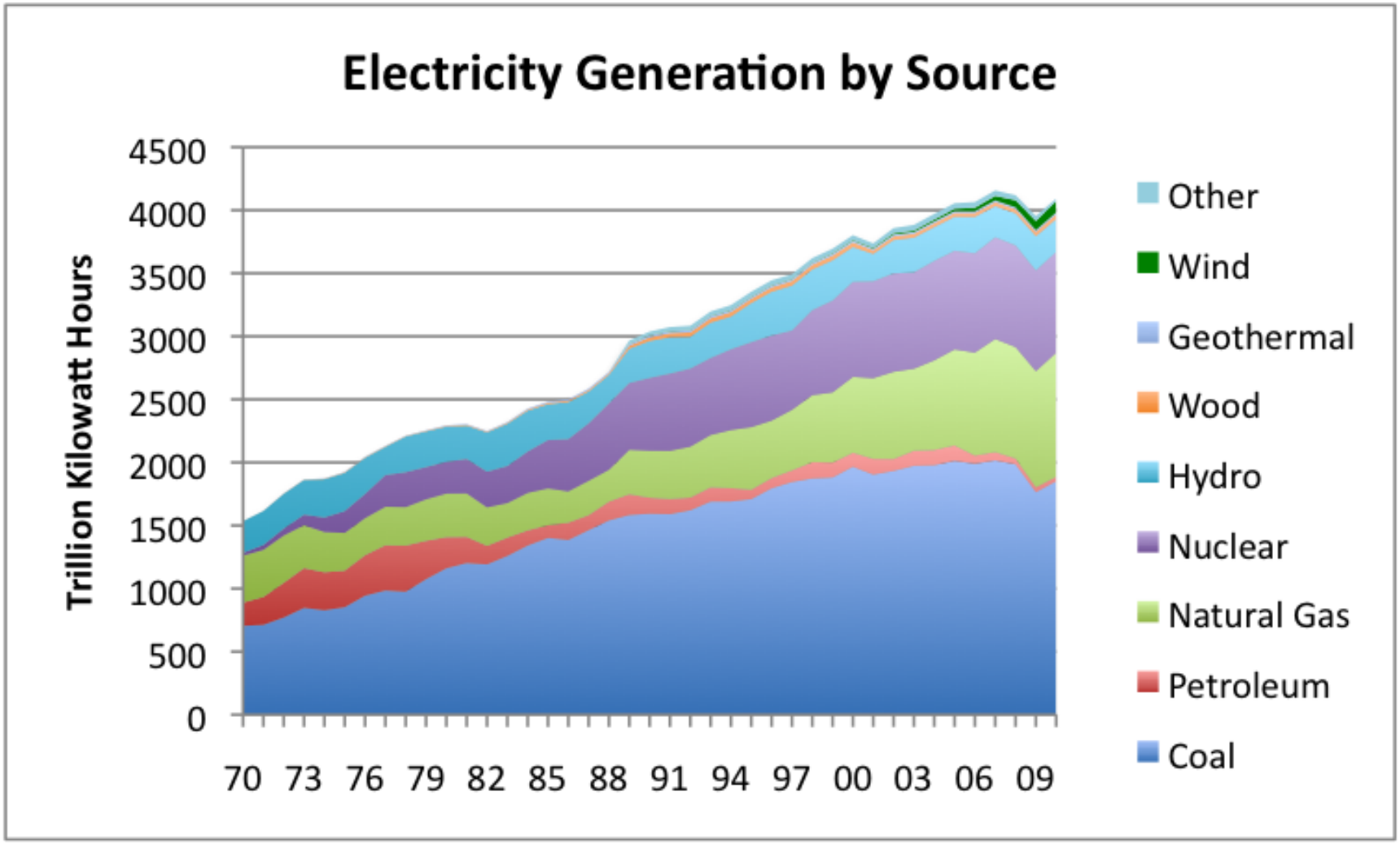
Source	Annual energy supply	Ratio of annual energy supply/energy use	Total reserve
Solar	3,900,000 EJ/y*	8,700	---
Wind	6,000 EJ/y*	13	---
Hydro	149 EJ/y*	0.33	---
Bioenergy	2,900 EJ/y*	6.5	---
Ocean	7,400 EJ/y*	17	---
Geothermal	140,000,000 EJ/y*	31,000	---
Total conventional fossil fuel reserve	396 EJ/y*	104	46,700 EJ
Total unconventional fossil fuel reserve	0.06 EJ/y**	42	18,800 EJ
Total Uranium reserve	31 EJ/y***	6.7 - 23	3,000- 10,500 EJ
Current global energy use	448 EJ/y (2004)* Conv. Biofuels adds - 45 EJ/y	1	

Consumption of Energy Sources

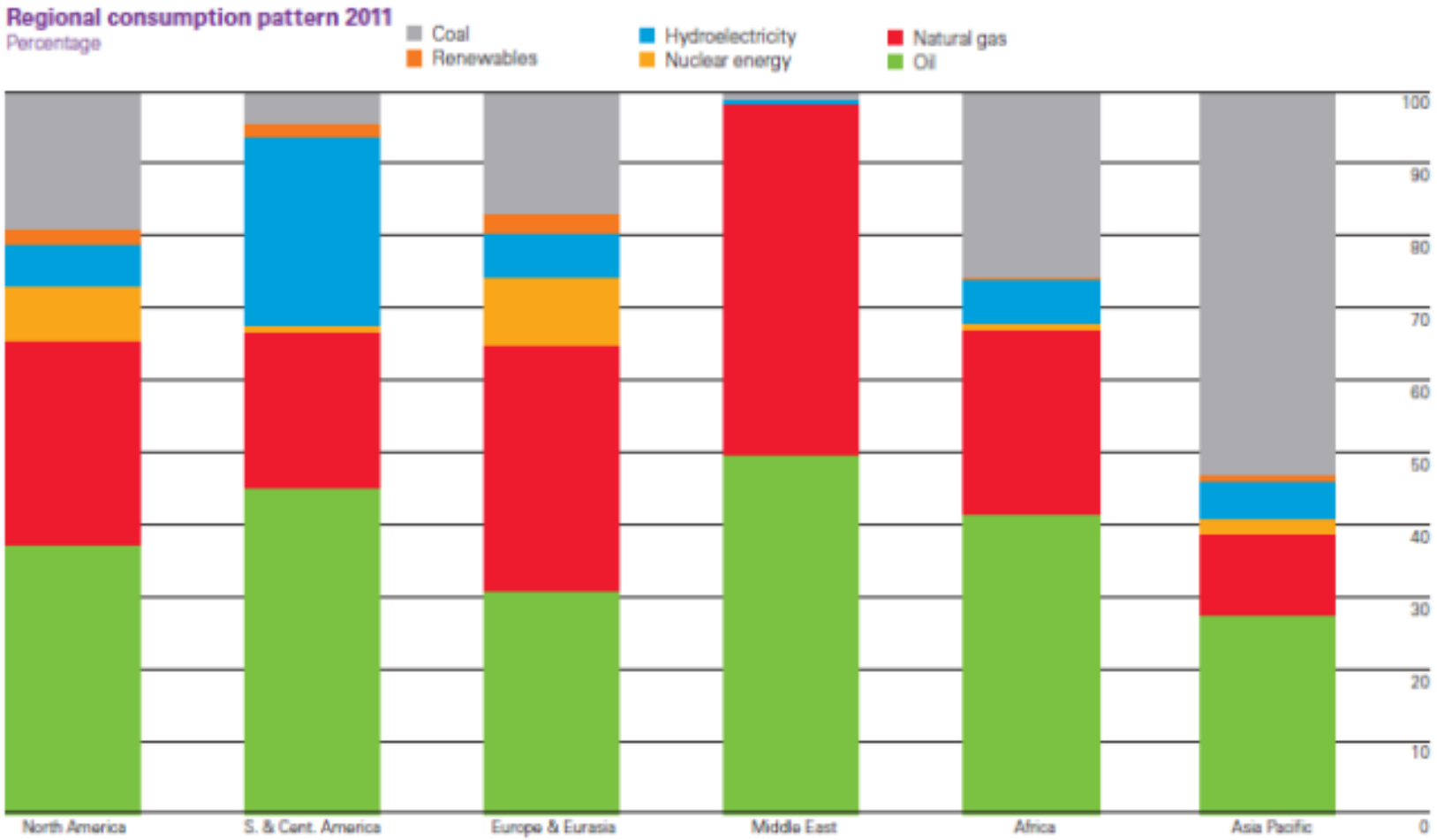


World primary energy consumption grew by a below-average 1.8% in 2012. Growth was below average in all regions except Africa. Oil remains the world's leading fuel, accounting for 33.1% of global energy consumption, but this figure is the lowest share on record and oil has lost market share for 13 years in a row. Hydroelectric output and other renewables in power generation both reached record shares of global primary energy consumption (6.7% and 1.9%, respectively).

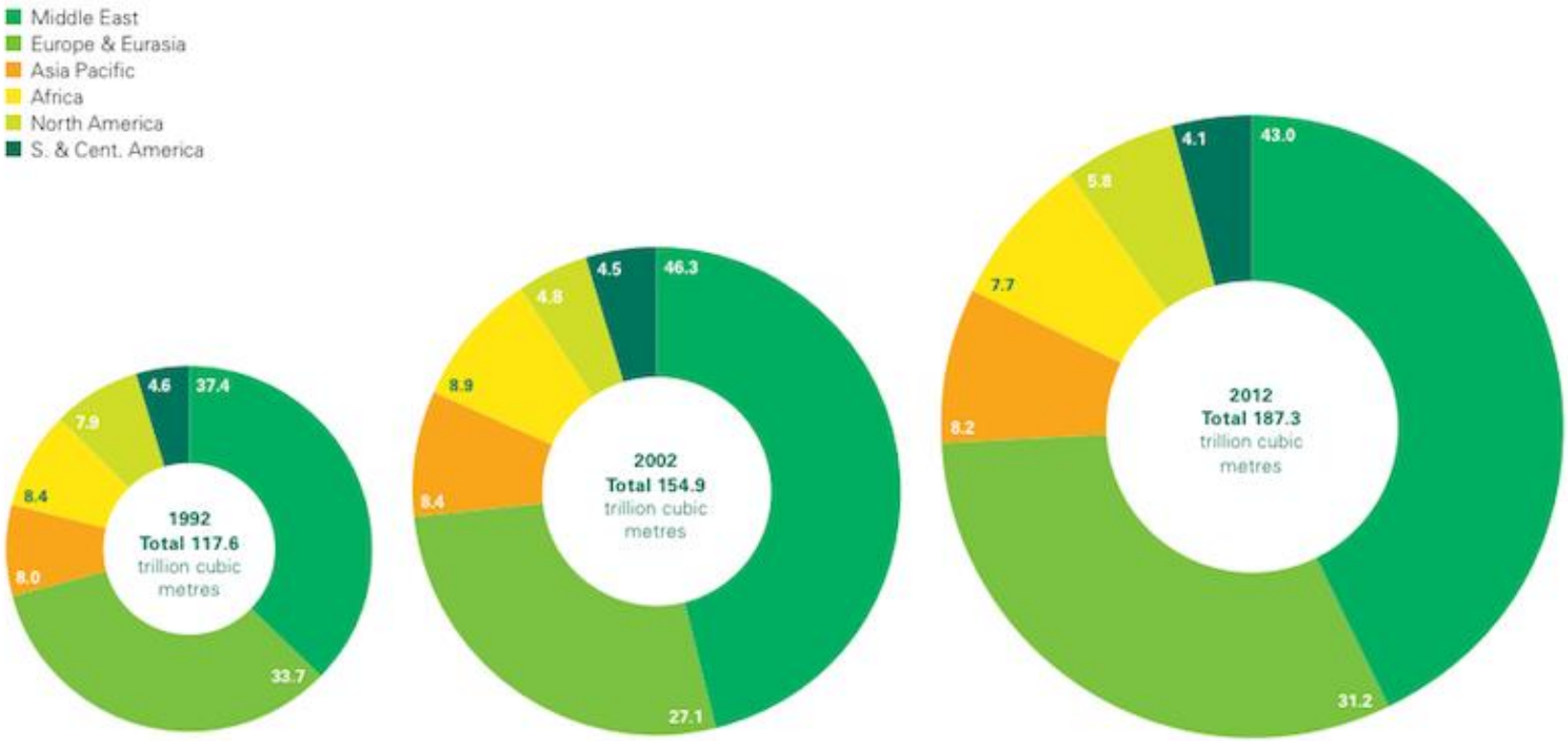
World Electricity Generation by Source



Energy Use – By Region, 2011

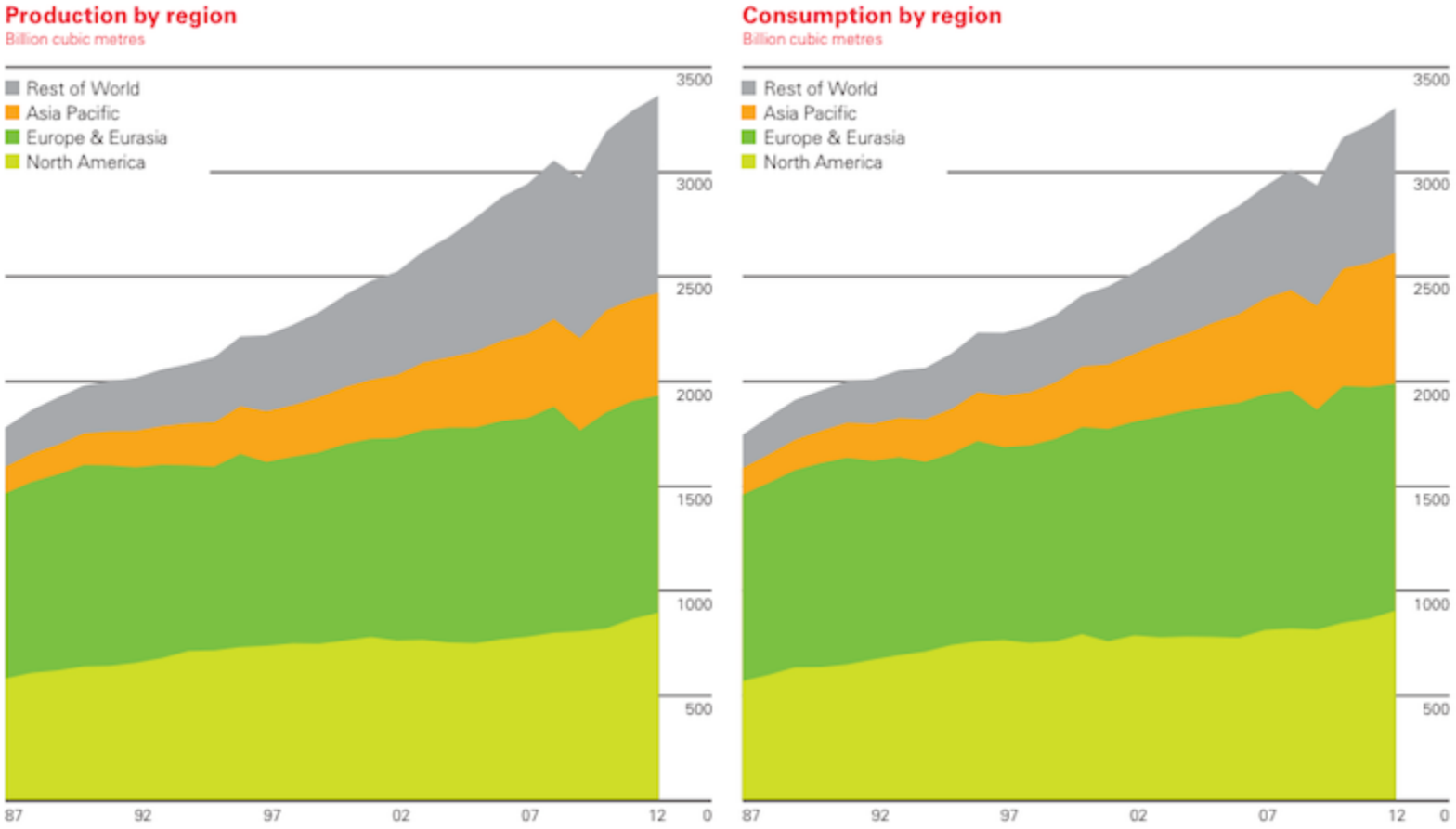


World Oil Reserves 2012

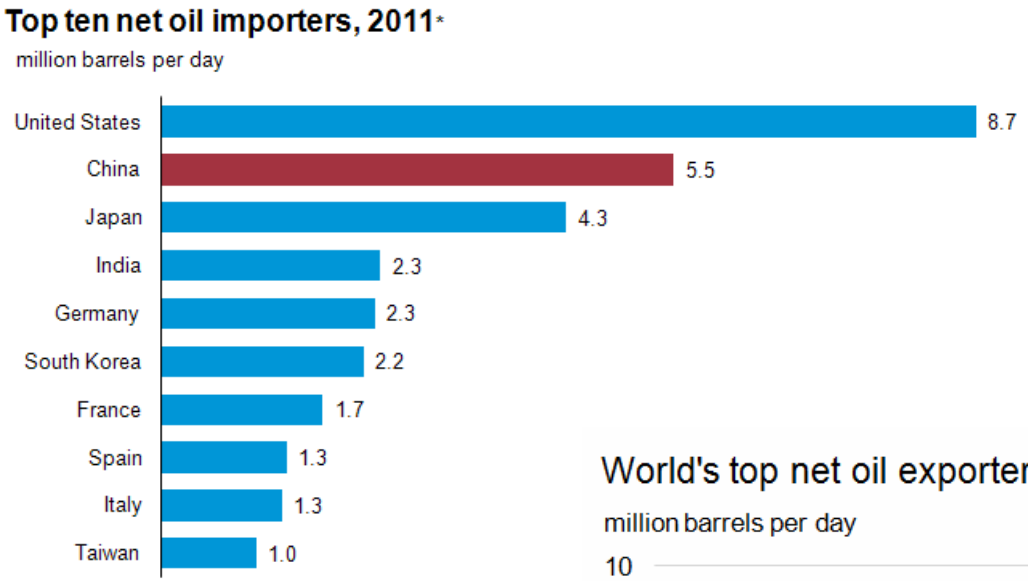


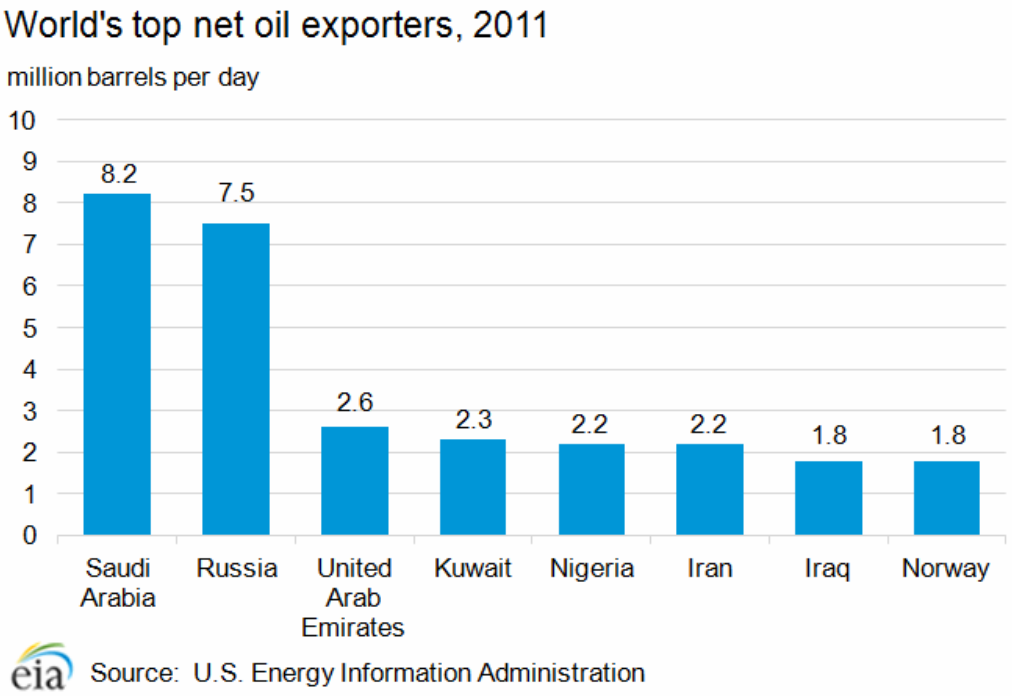
World Oil Production and Consumption, 2012

Oil production grow up every year in every region

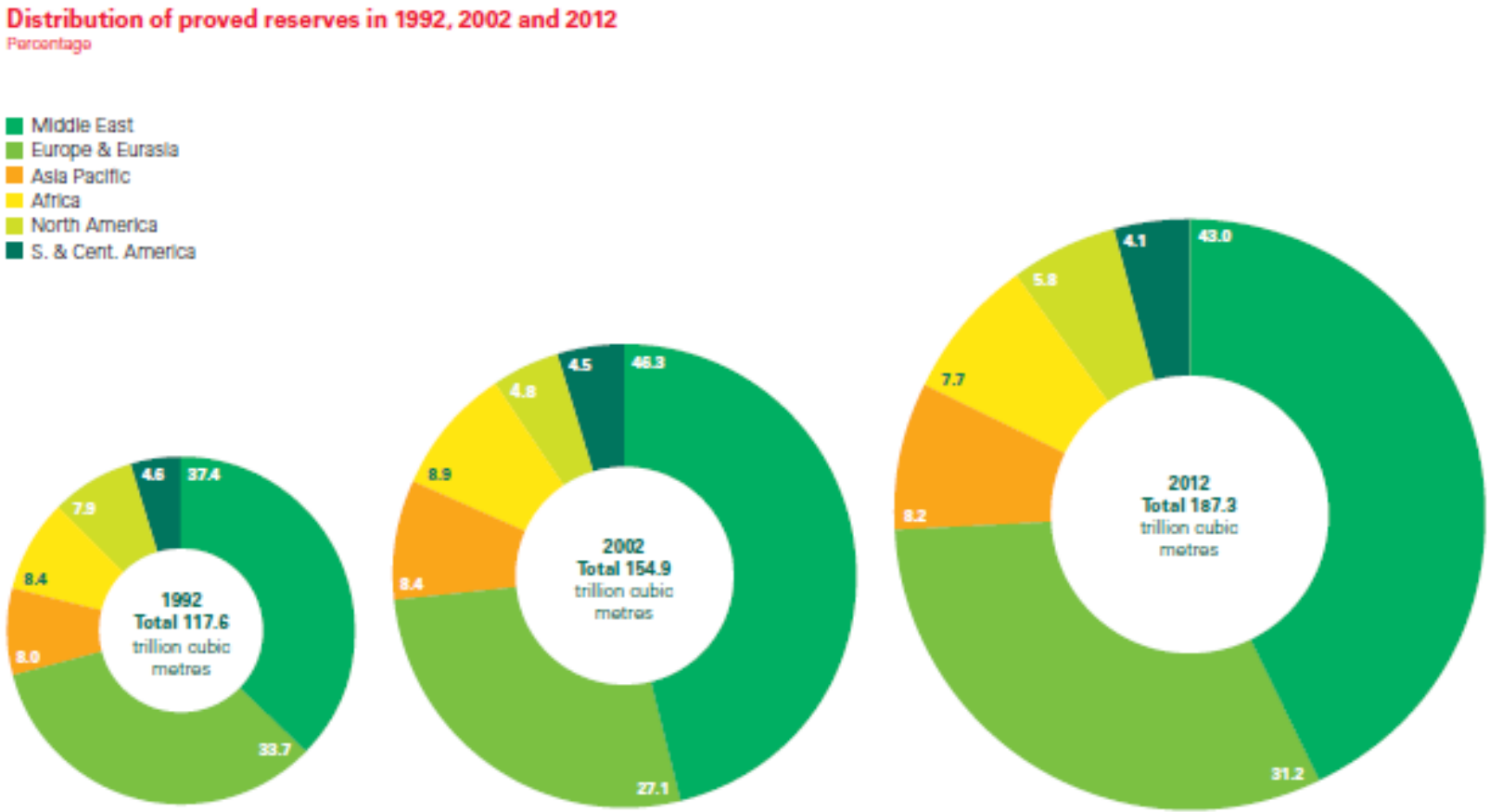


World Oil Production and Trade, 2011

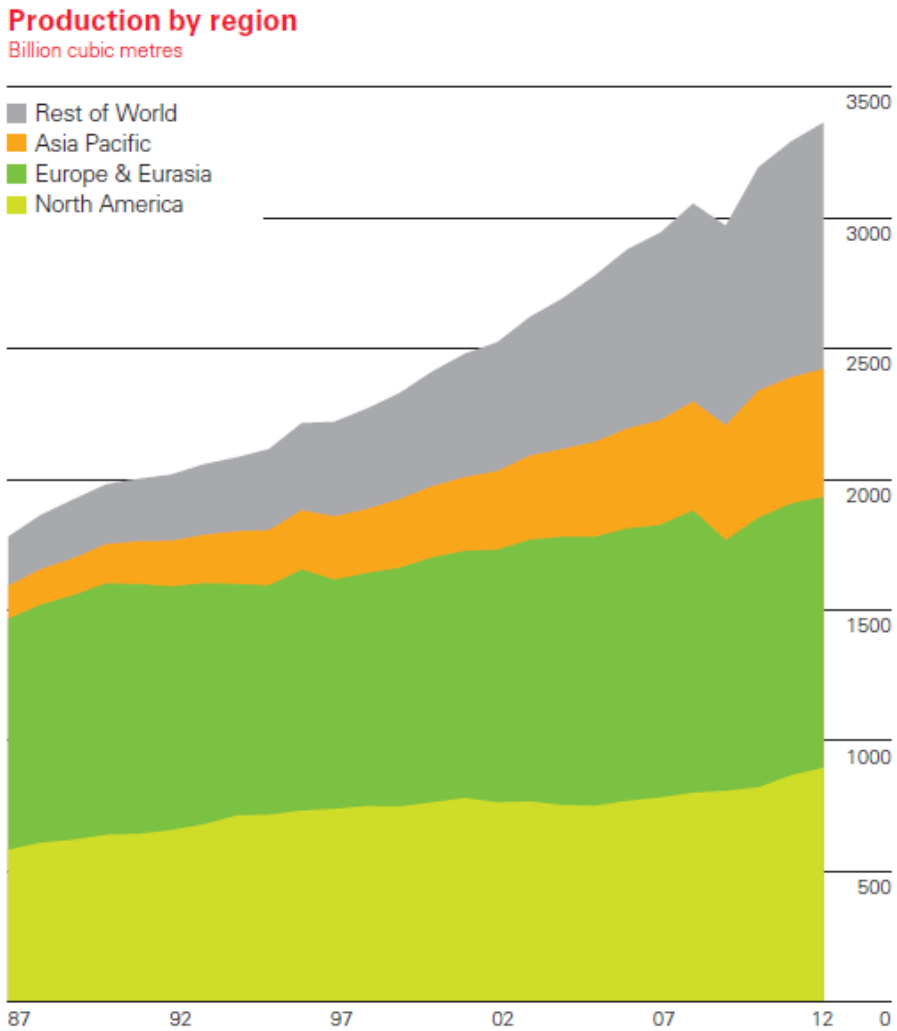


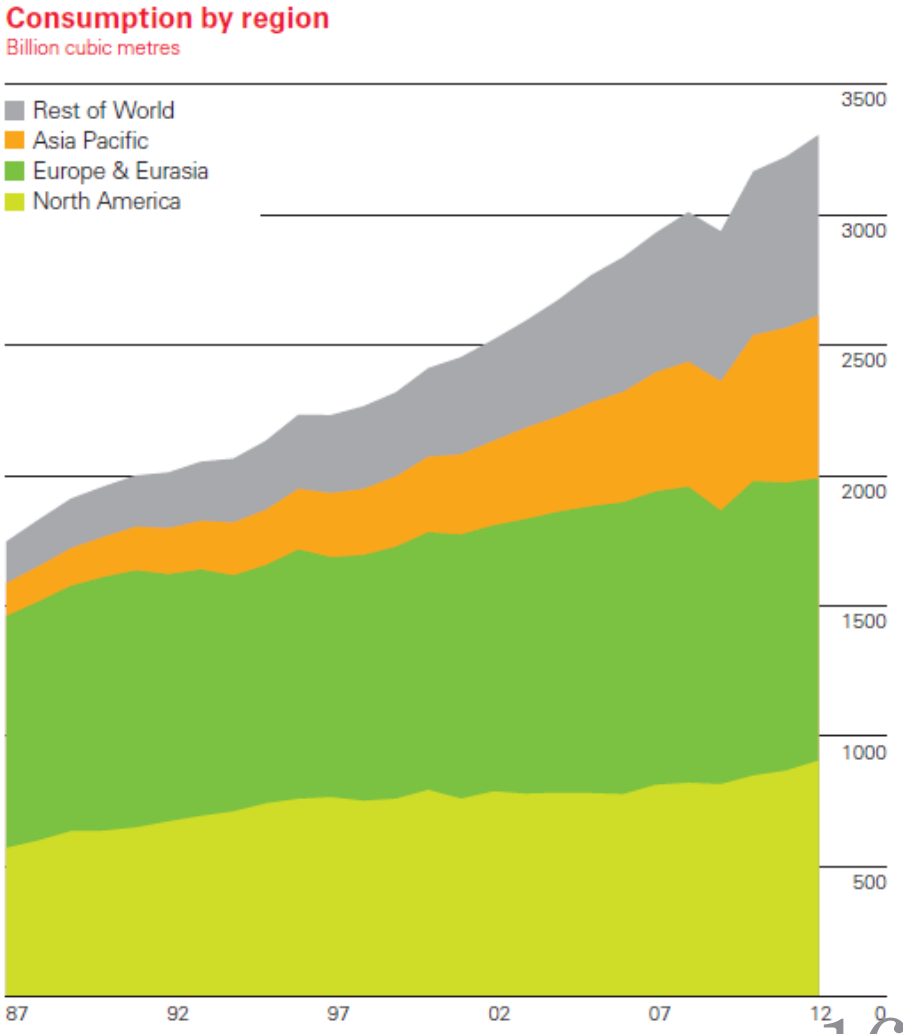


World Natural Gas Reserves, 2012

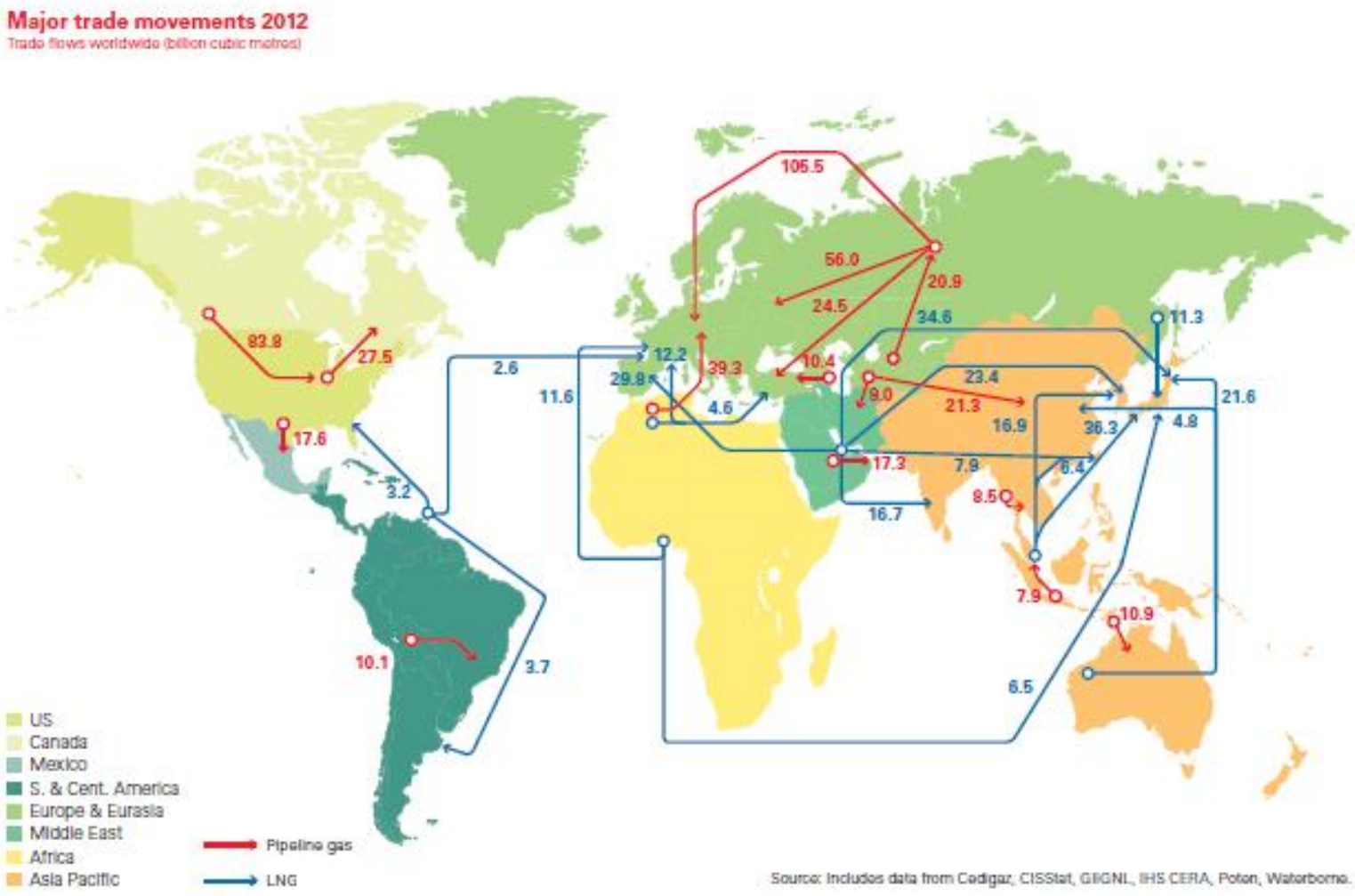


World Natural Gas Production / Consumption, 2012

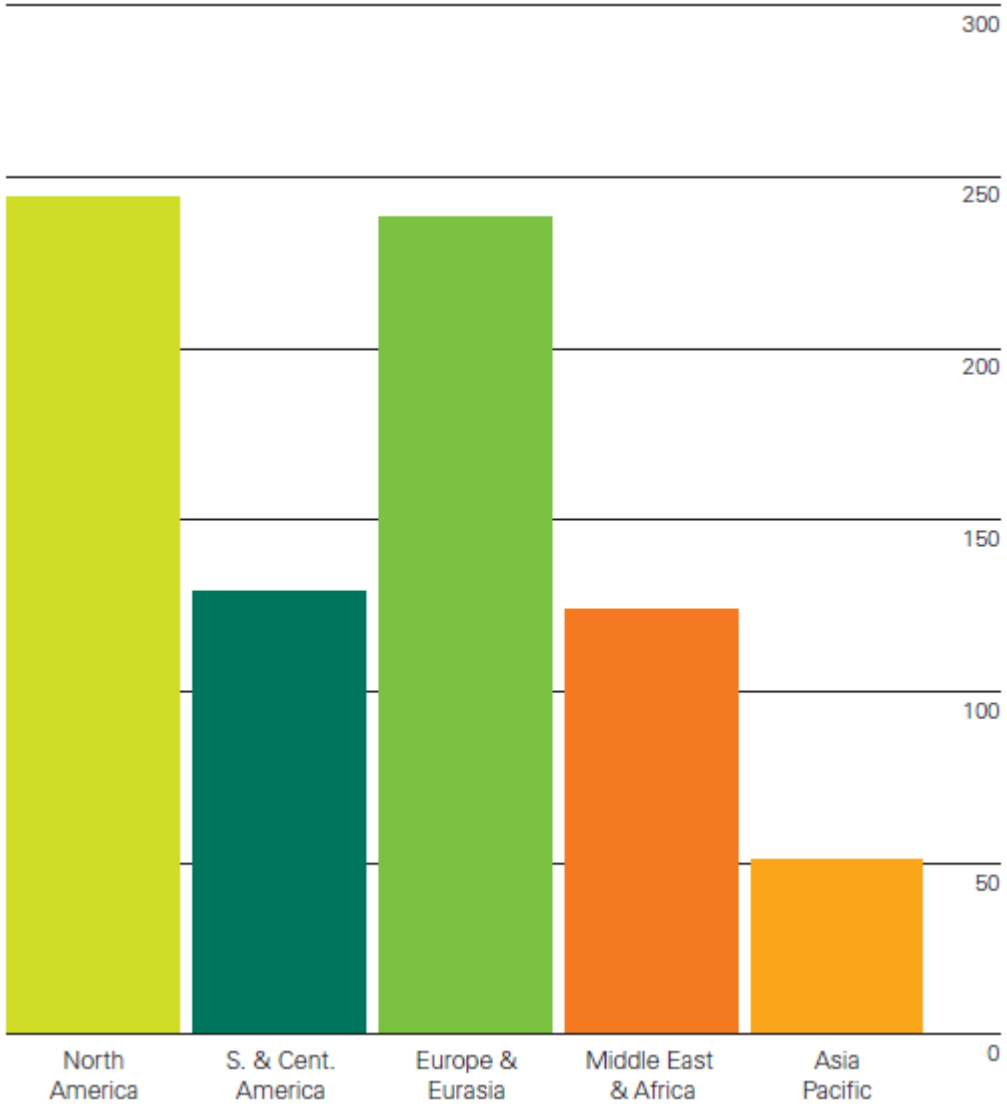




World Natural Gas Trade 2012

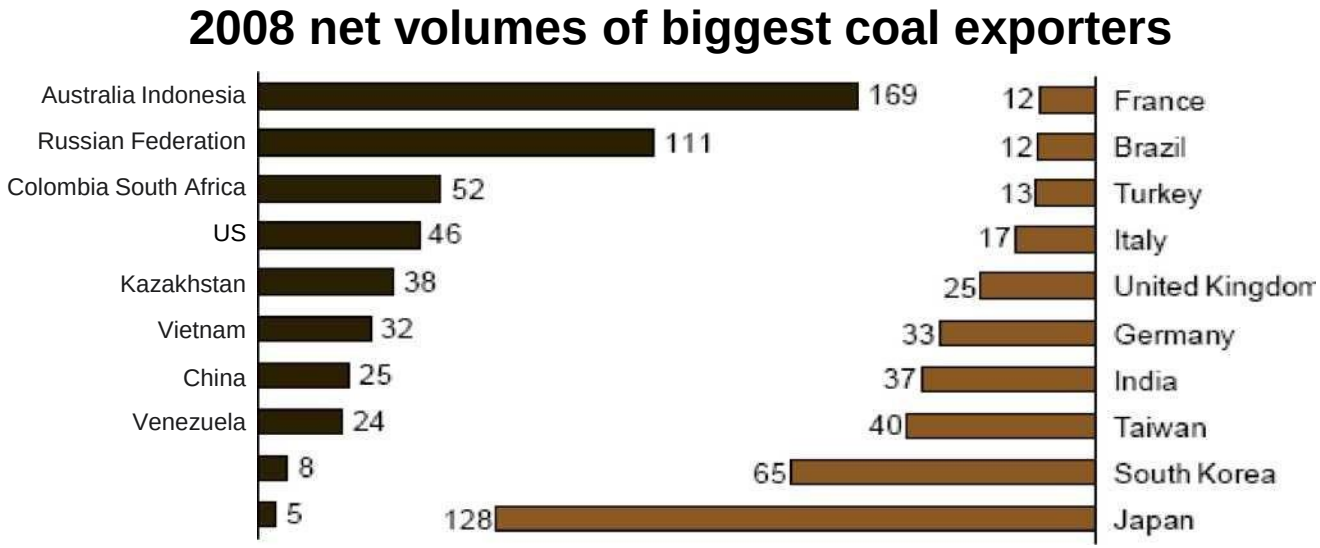


World Coal Reserves-to-Production Ratios by Region, 2012



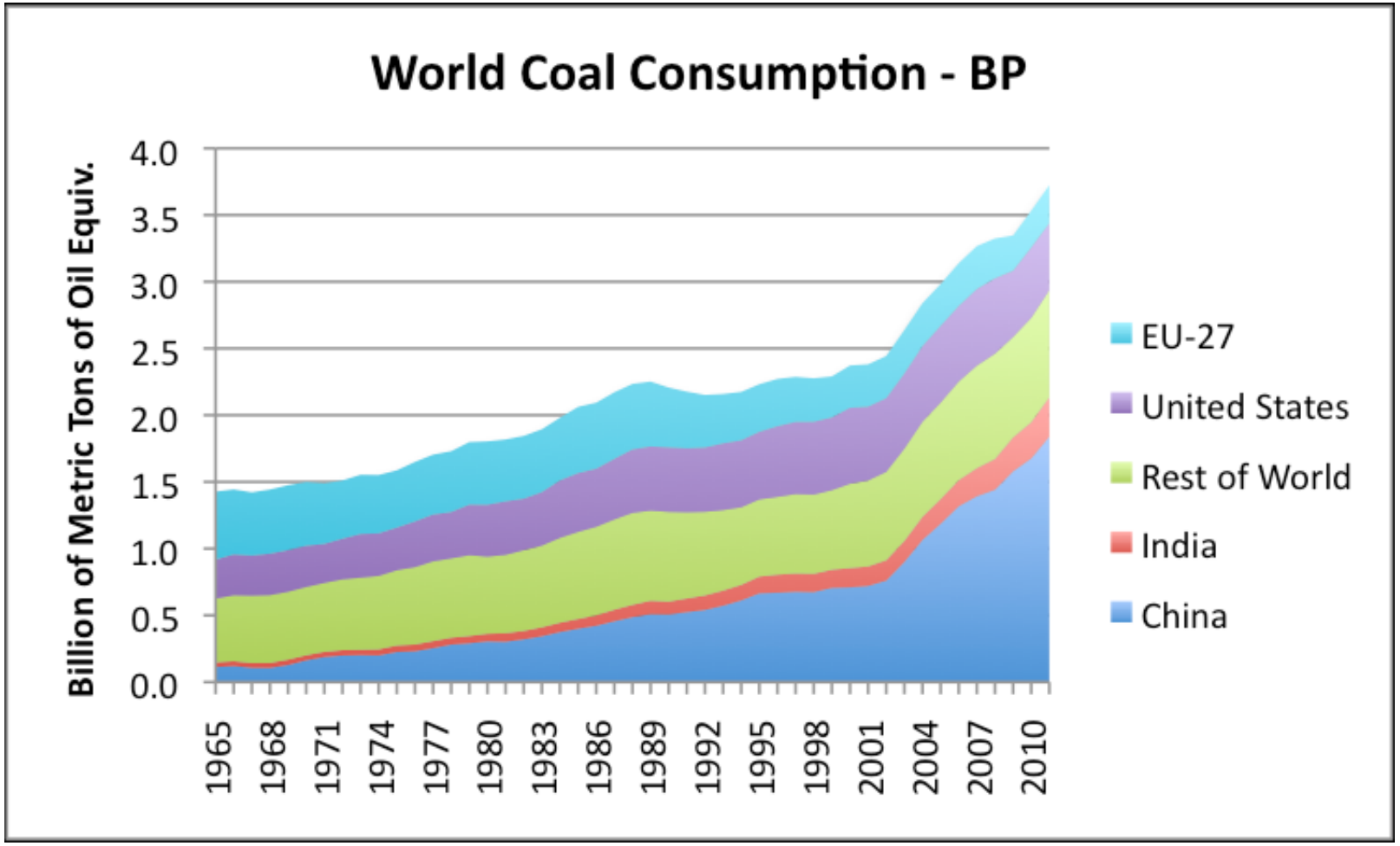
Coal Exporter/Importer

Top 10 coal net-exporters and importers, 2008



2008 nettrade volumes of biggestcoal importers

World Coal Consumption, 2010



- Coal production and consumption by region, 2010 (million tons of oil equivalent)
- ~ 50% of global coal consumption was in China.

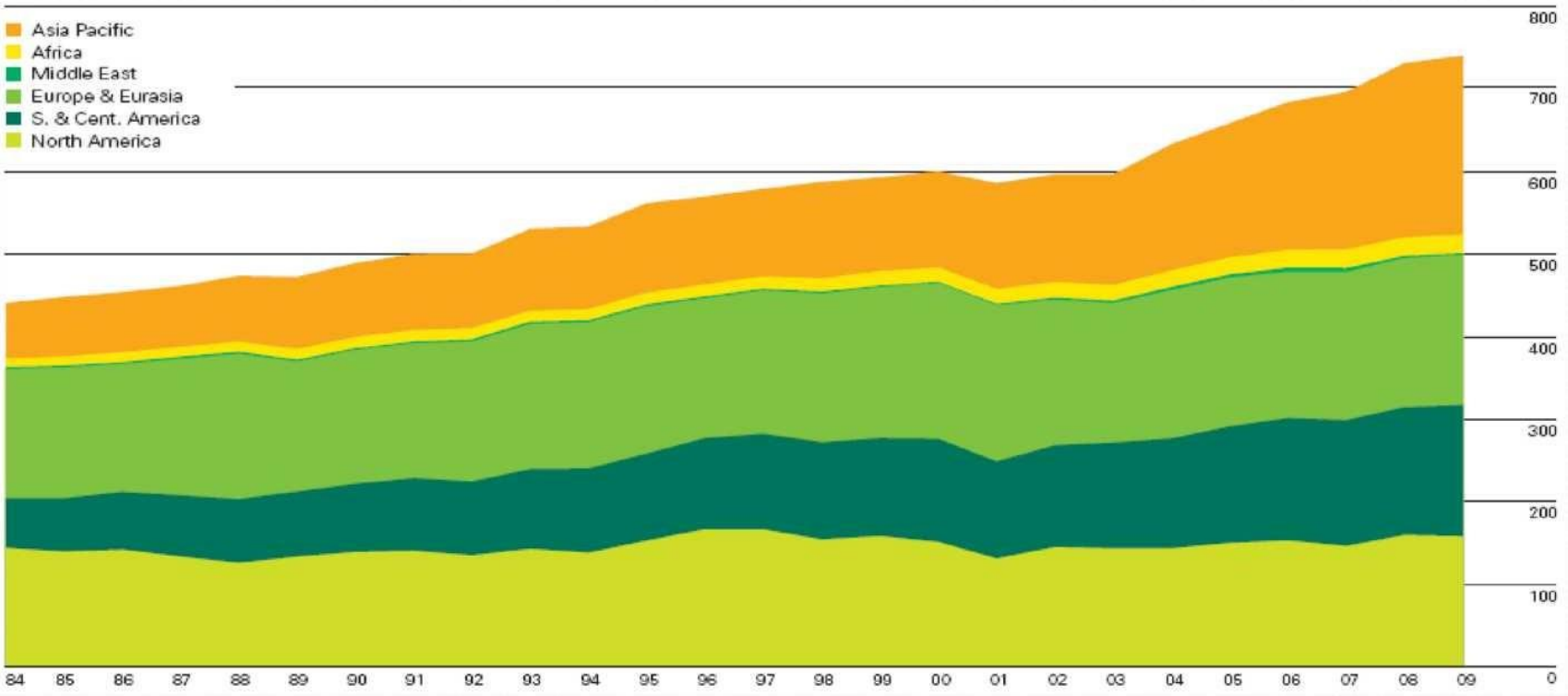
Cambodia: Thermal Power Plant, Coal

- Install Capacity: 2 x 50 MW
- Location: Sihanouk Province
- Operation Date: 2013

Sihanouk Ville Coal Power Plant N.1

2nd SHV coal (1st stage) ≈ 400 MW (2014-2017)

World Hydropower



- Hydroelectricity was the main rapidly growing major fuel in 2009.
- The growth was led by China, Brazil and US.

Hydropower in Cambodia

- Install Capacity: 18 MW
  (2 x 9 MW)
- Reservoir

- Location: Koh Kong Province
- Operating Date: 27-Sept-2012

Kirirom III Hydro Power Plant

Hydropower in Cambodia

- Install Capacity: 194.1 MW (3 x 60 MW, 3 x 3.1 MW, 0.8 MW, 4 MW)
- Reservoir
- Location: Kampot Province
- Operating Date: 30-Dec-2012

Kamchay Hydro Power Plant

Hydropower in Cambodia

- Install Capacity: 120 MW
  (4 x 25 MW, 2 x10 MW)
- Reservoir
- Location: Pursat Province
- Under Commissioning

Hydro PP: Atay Hydro Power Plant

Hydropower in Cambodia

- Install Capacity: 246 MW (3 x 82 MW)
- Reservoir
- Location: Koh Kong Province
- Operation Date: 2014

Tatay Hydro Power Plant

Hydropower in Cambodia

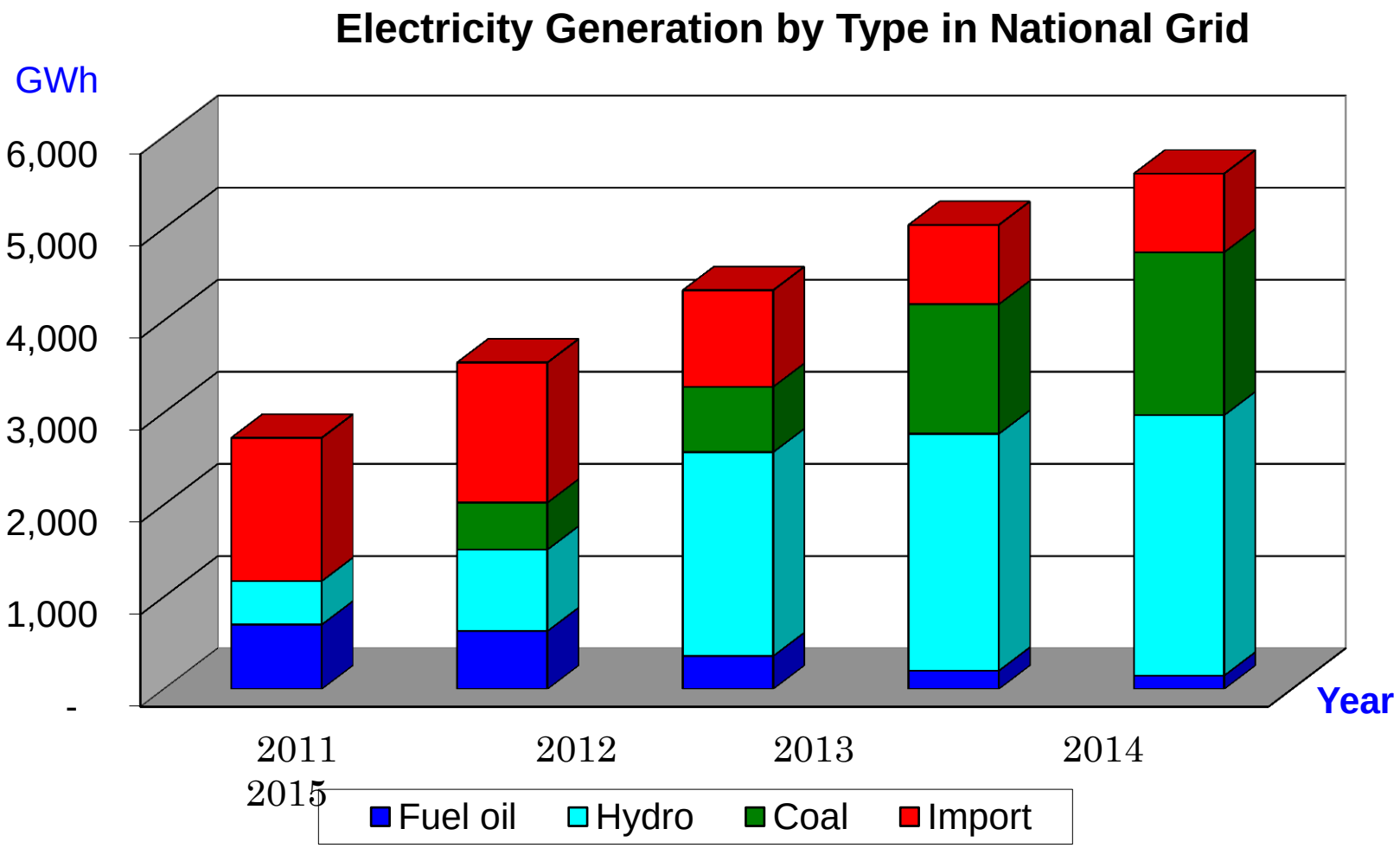
- Install Capacity: 338 MW
  (2 x 103 MW, 2 x 66 MW)
- 103 MW is under commissioning
- Reservoir

- Location: Koh Kong Province

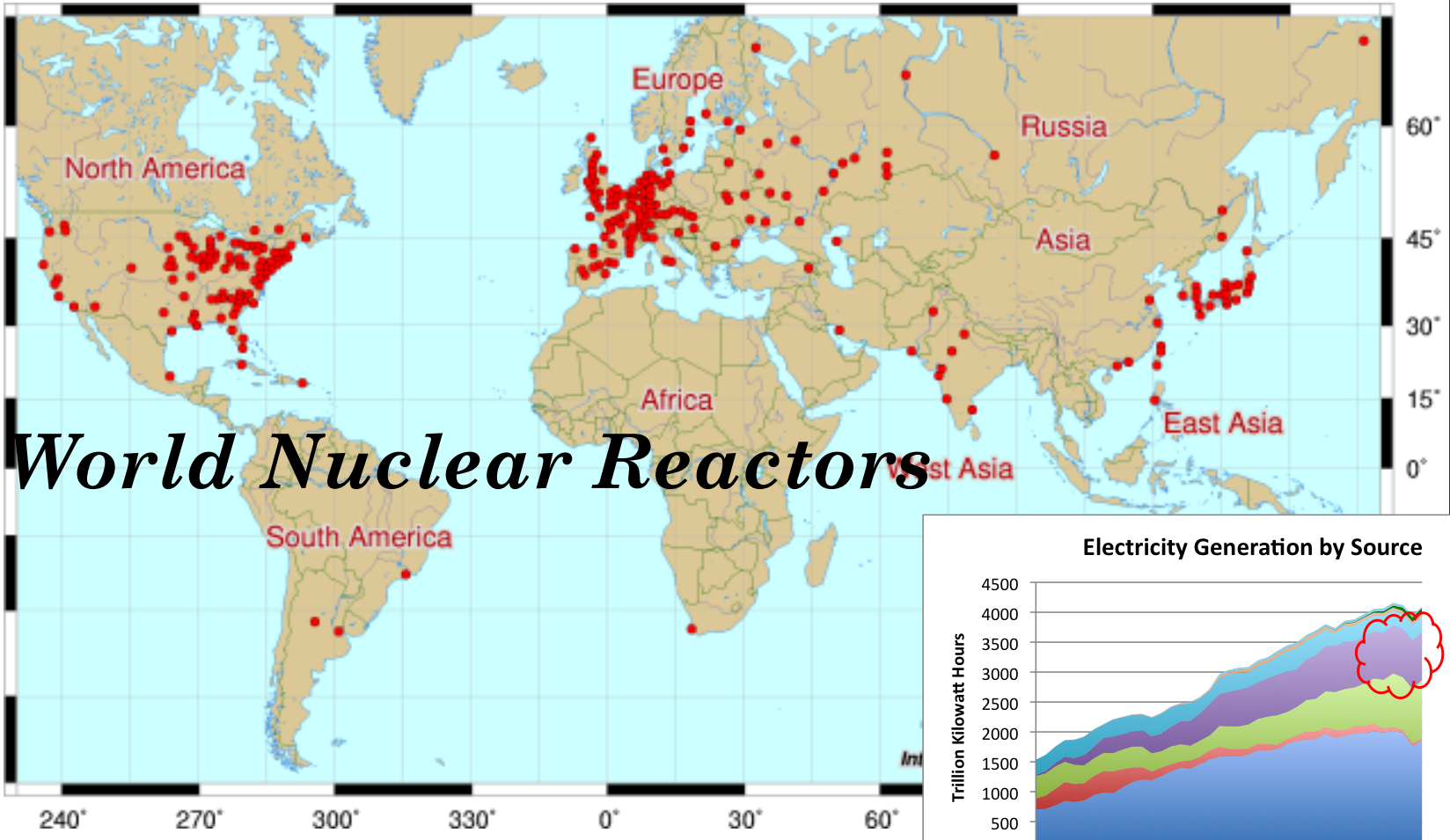
- Operation Date: 2014

Lower Reussey Chroum Hydro Power Plant

Energy Generation by Fuel Type 2011-15



World Nuclear, 2009

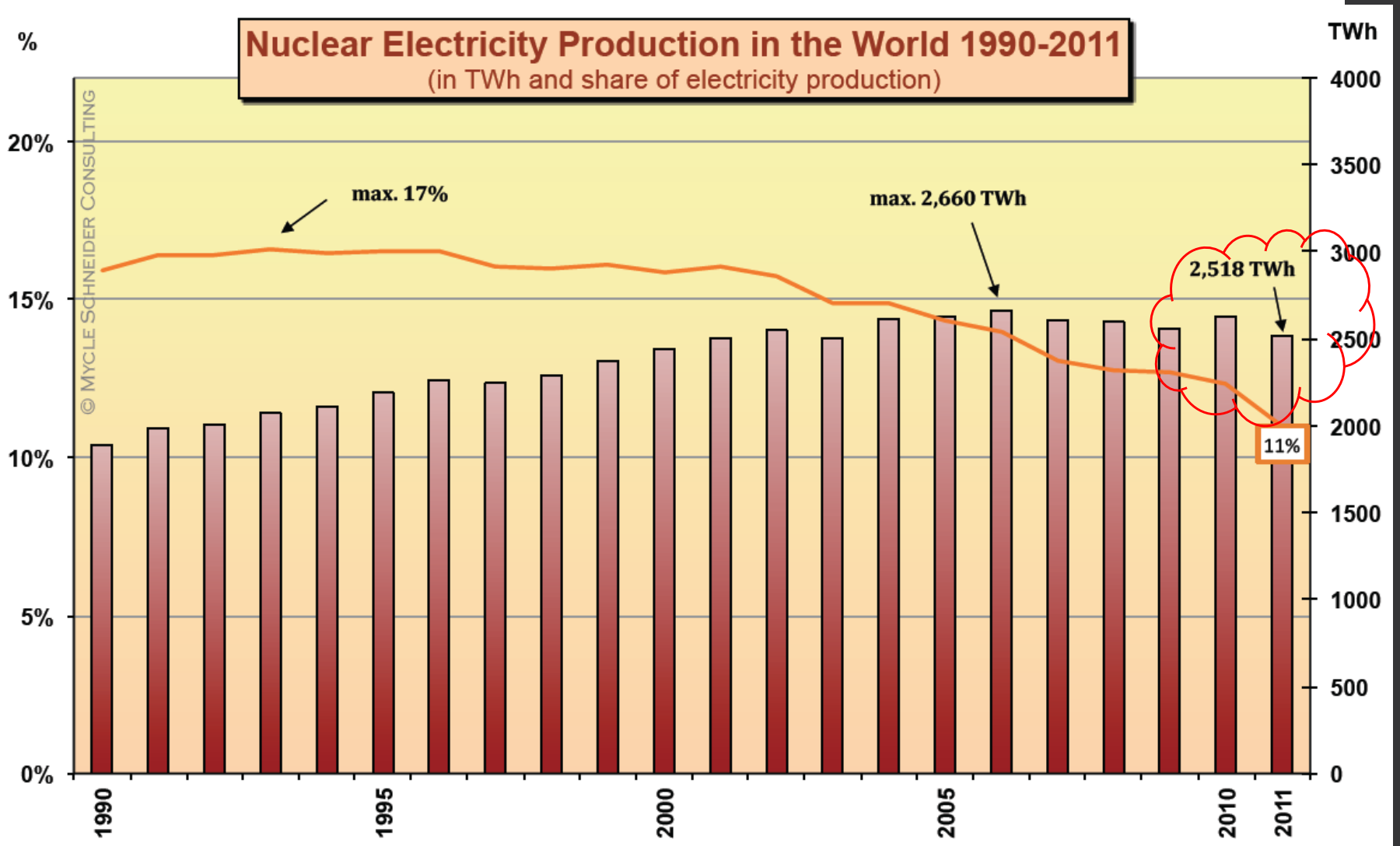


World Nuclear Reactors

In 2009, Nuclear Power supplied approximately 15% of the World Generation Source.

- Vietnam will construct nuclear power plant in near future

World Nuclear Energy, 2012



Nuclear Power Generation have been decreased by 11% in 2011

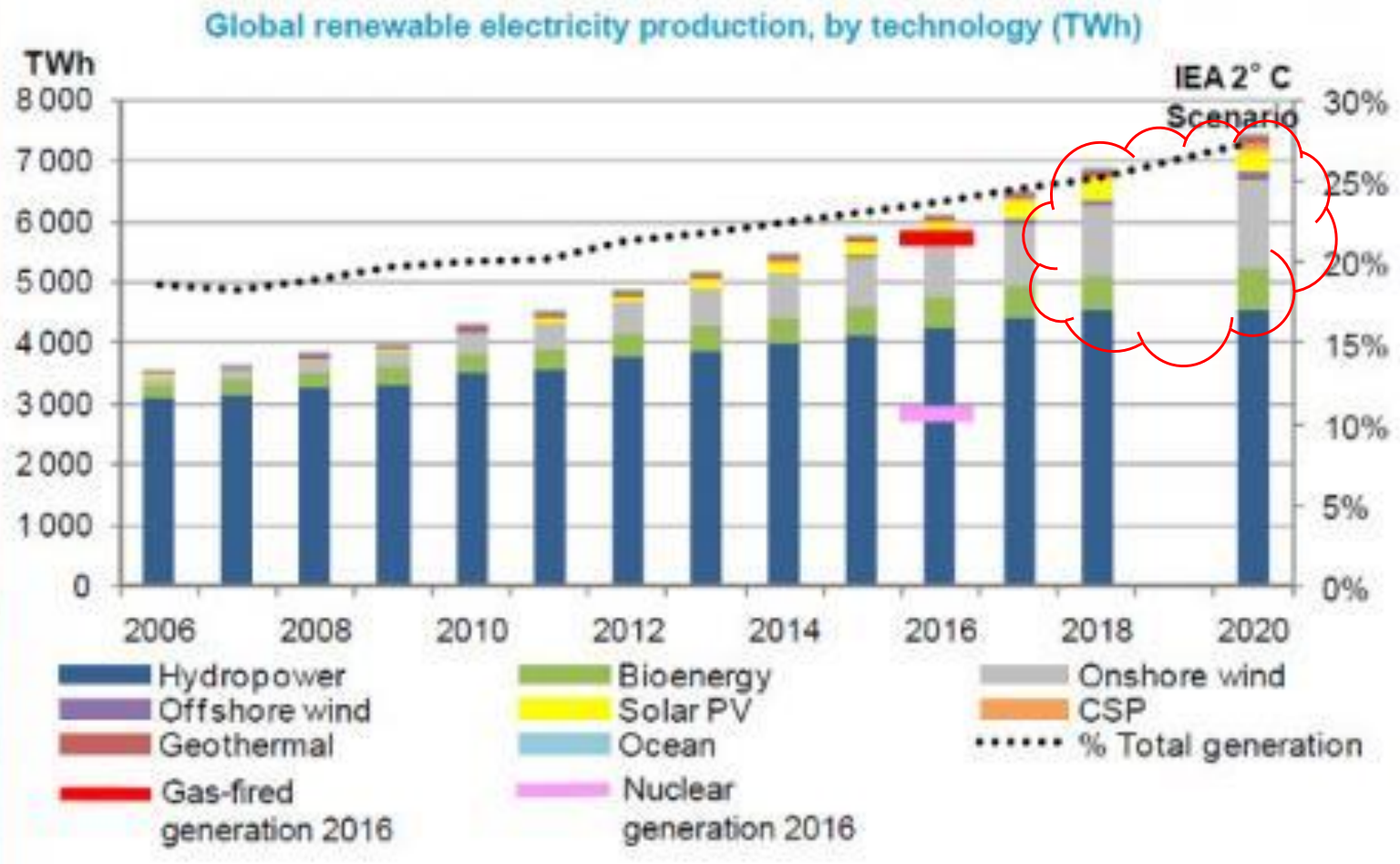
Renewable Energy Potential

2008 world primary energy consumption = 11,500 mtoe = 0.54x 10^{18}Joule

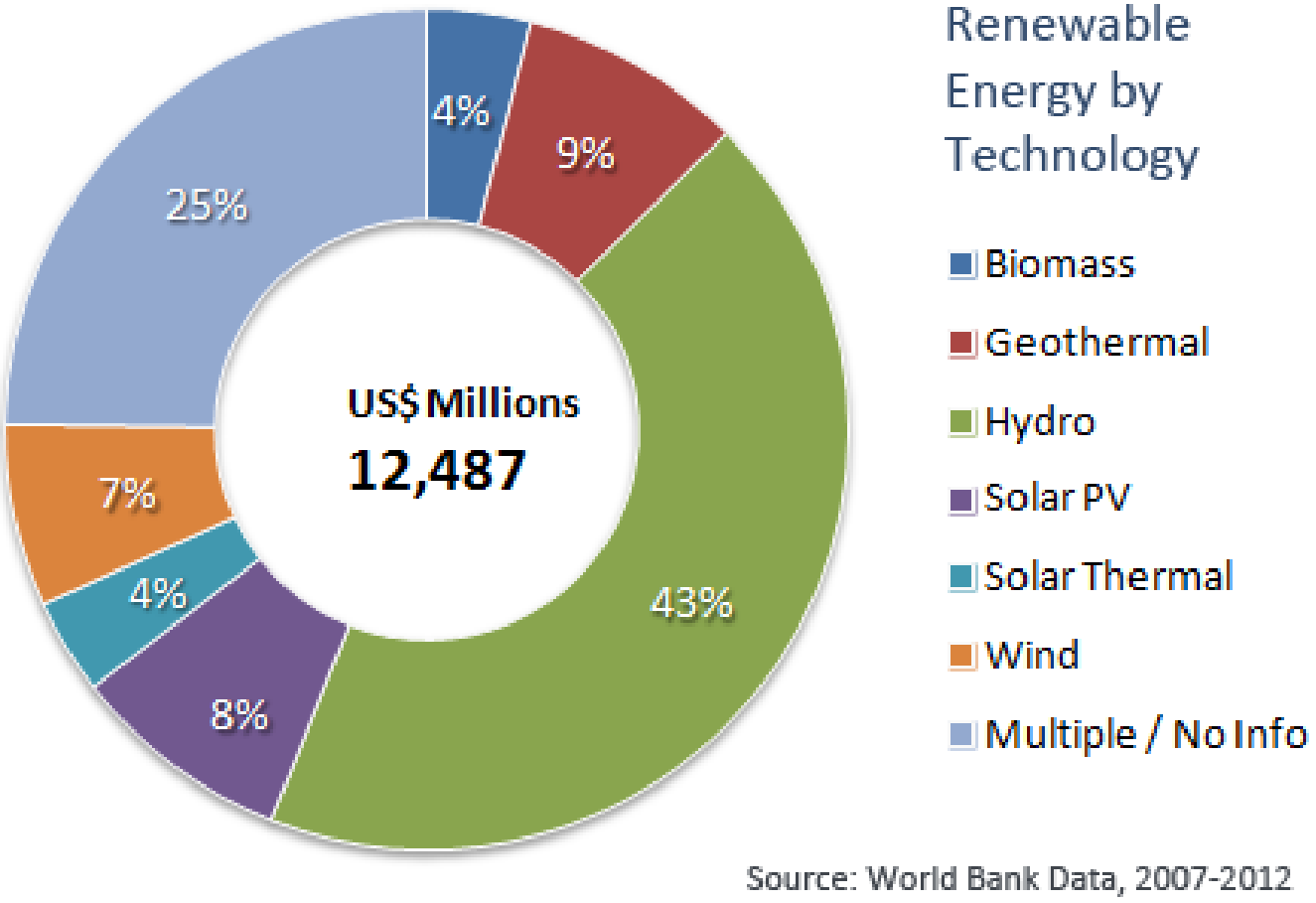
Resource	Technical potential (exa joule per year)	Theoretical potential (exa joule per year)
Hydropower	50	150
Biomass Energy	>250	2,900
Solar Energy	>1,600	3,900,000
Wind Energy	600	6,000
Geothermal Energy	5,000	140,000,000
Ocean Energy	-	7,400
Total	>7,500	>143,000,000

1 exa joule= 10^{18} Joule
1 toe = 42 GJ

Renewable Energy Potential



Renewable Energy Potential

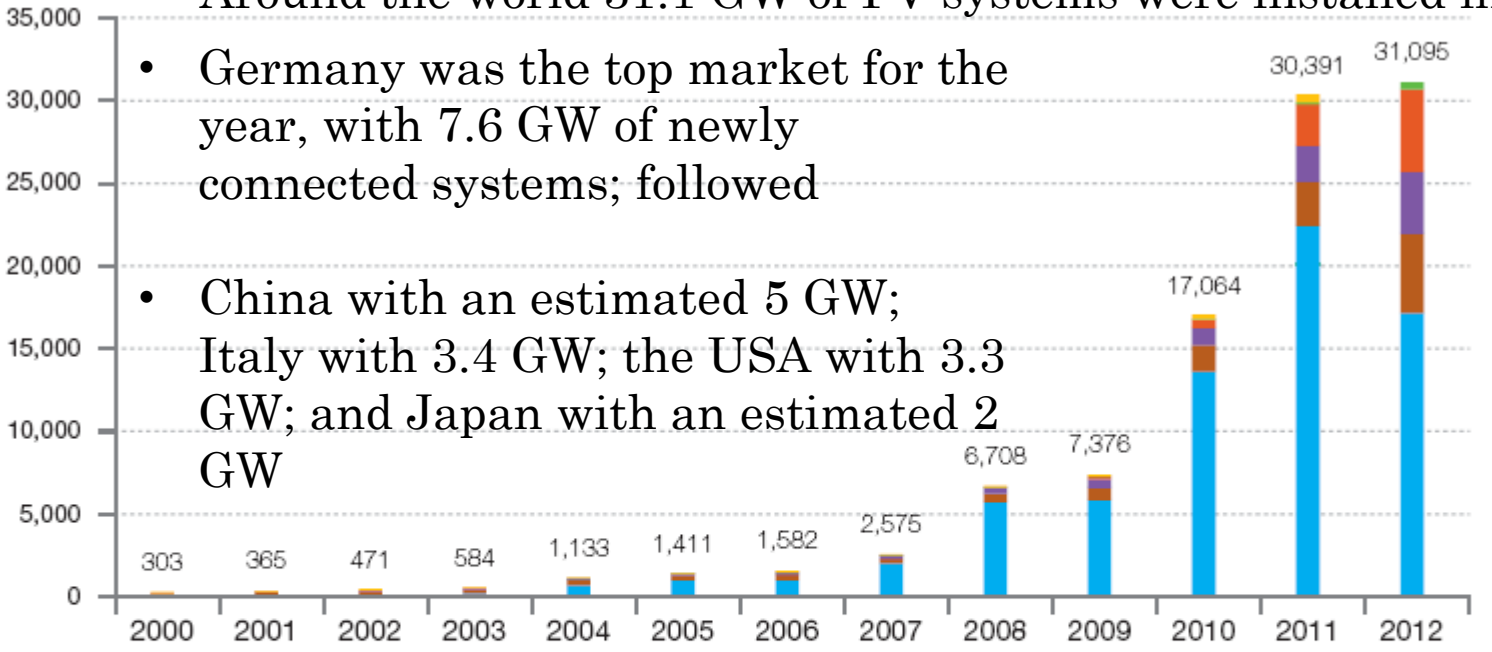


Source: World Bank Data, 2007-2012

Solar Photovoltaic

Global PV Annual Installations 2000-2012 (MW)

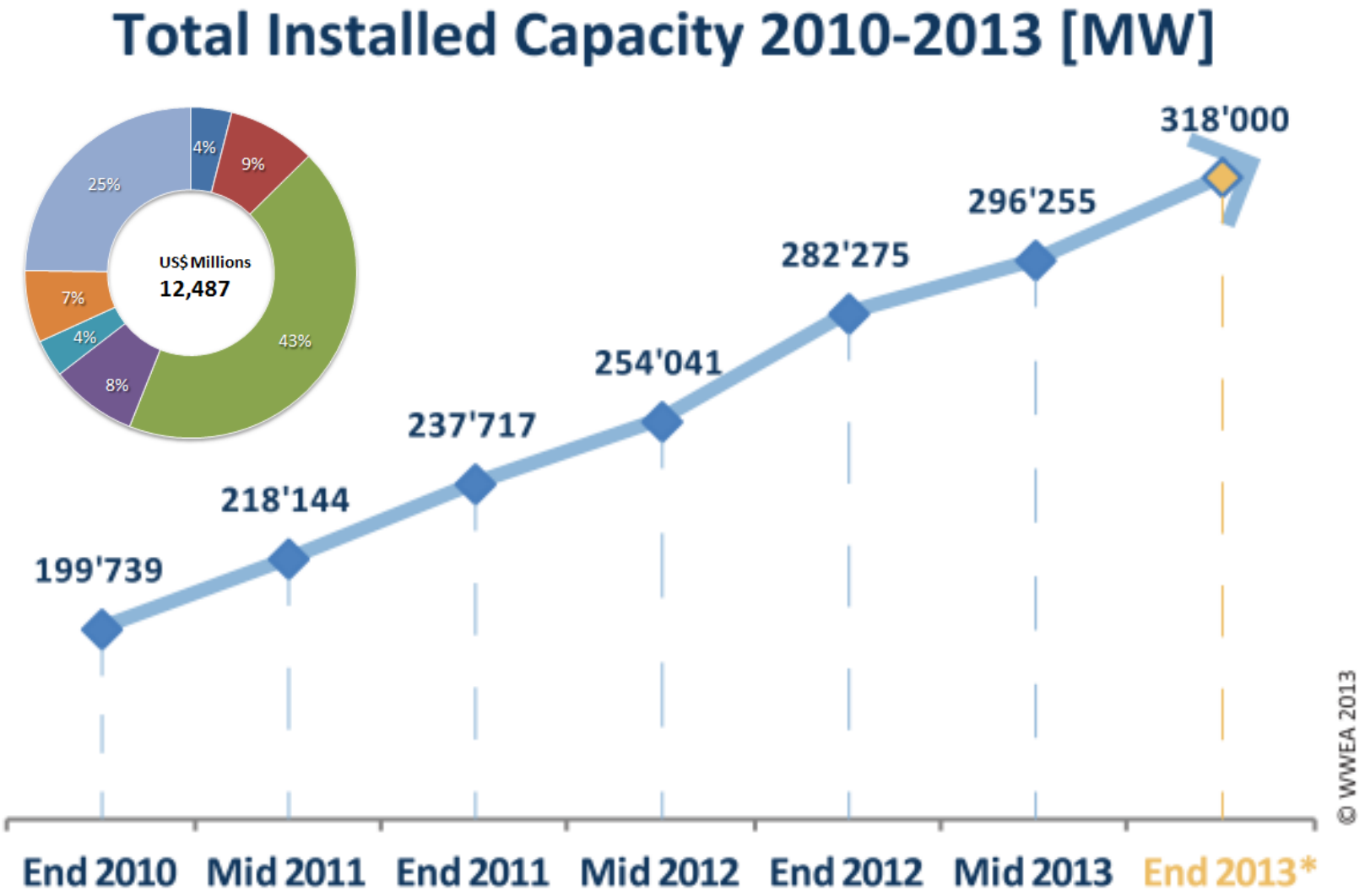
- Around the world 31.1 GW of PV systems were installed in 2012
- Germany was the top market for the year, with 7.6 GW of newly connected systems; followed
- China with an estimated 5 GW; Italy with 3.4 GW; the USA with 3.3 GW; and Japan with an estimated 2 GW



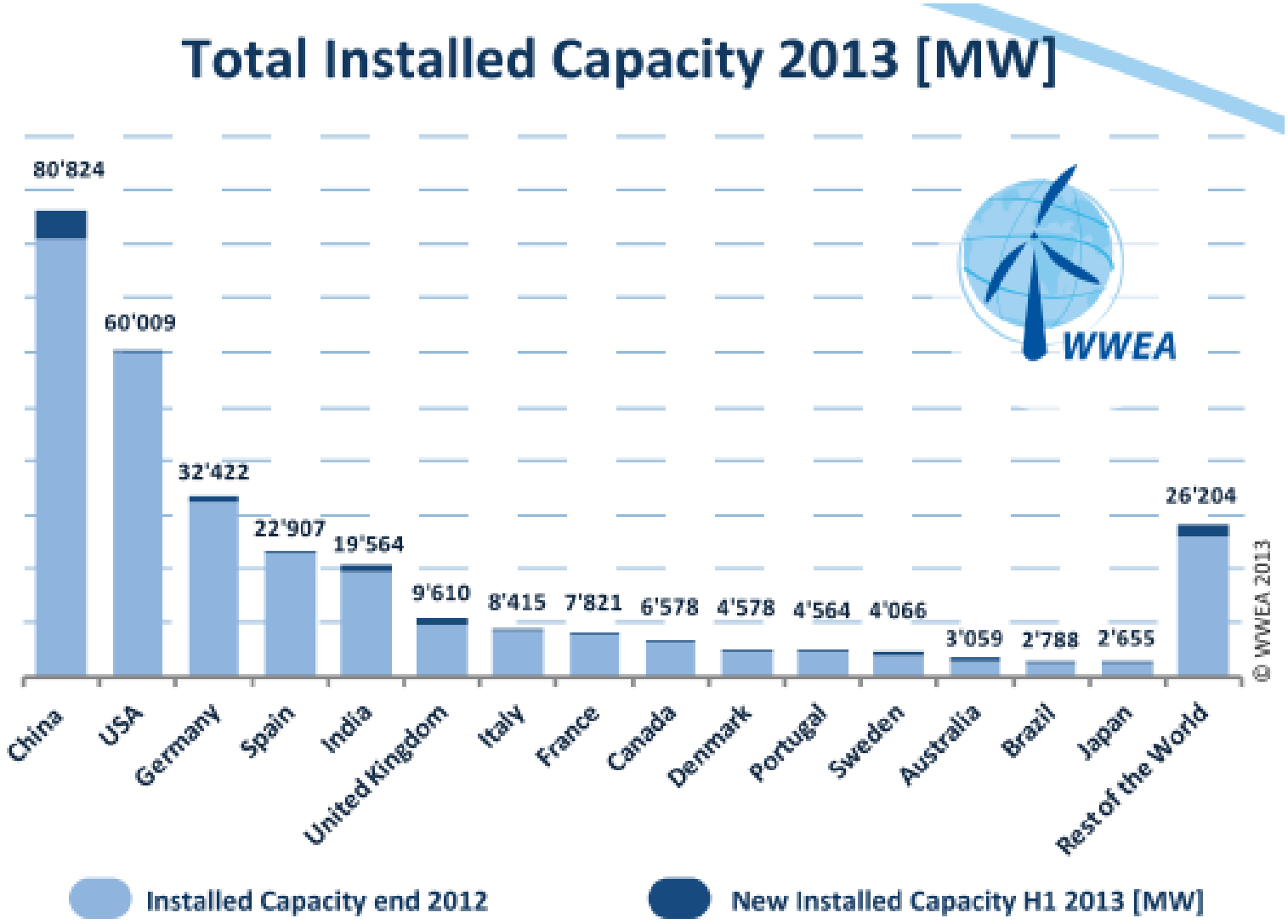
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ROW	88	56	80	77	29	10	105	42	76	80	284	508	-*
MEA	n/a	n/a	n/a	n/a	1	n/a	n/a	1	1	22	46	121	410
China	19	5	19	10	10	8	10	20	40	160	500	2,500	5,000
Americas	24	32	47	66	104	106	150	213	346	543	1,029	2,179	3,758
APAC	117	140	191	230	282	303	324	271	535	742	1,583	2,672	4,769
Europe	56	133	135	202	707	984	992	2,028	5,710	5,830	13,622	22,411	17,159
Total	**303**	**365**	**471**	**584**	**1,133**	**1,411**	**1,582**	**2,575**	**6,708**	**7,376**	**17,064**	**30,391**	**31,095**

Source: EPIA, 2012

World Wind Energy Status

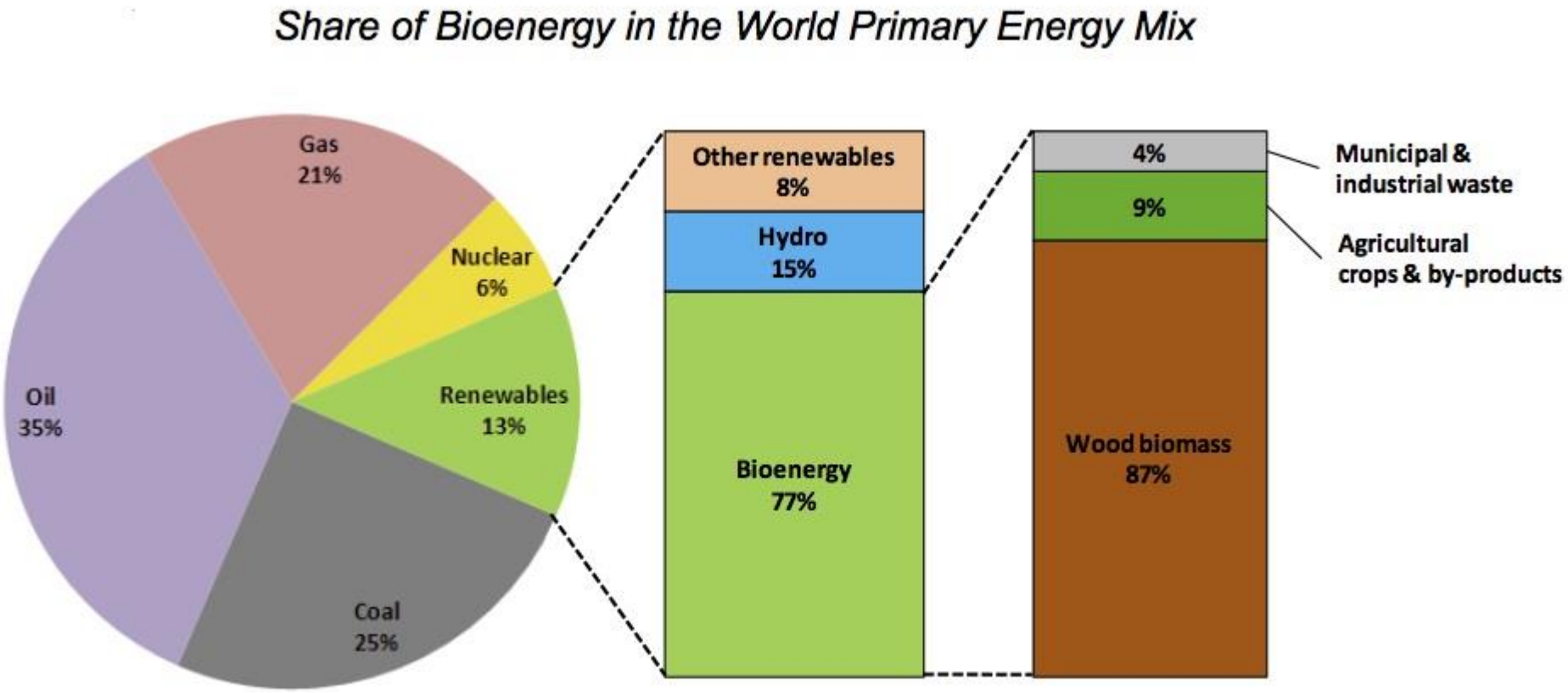


Wind Energy by OECD Countries



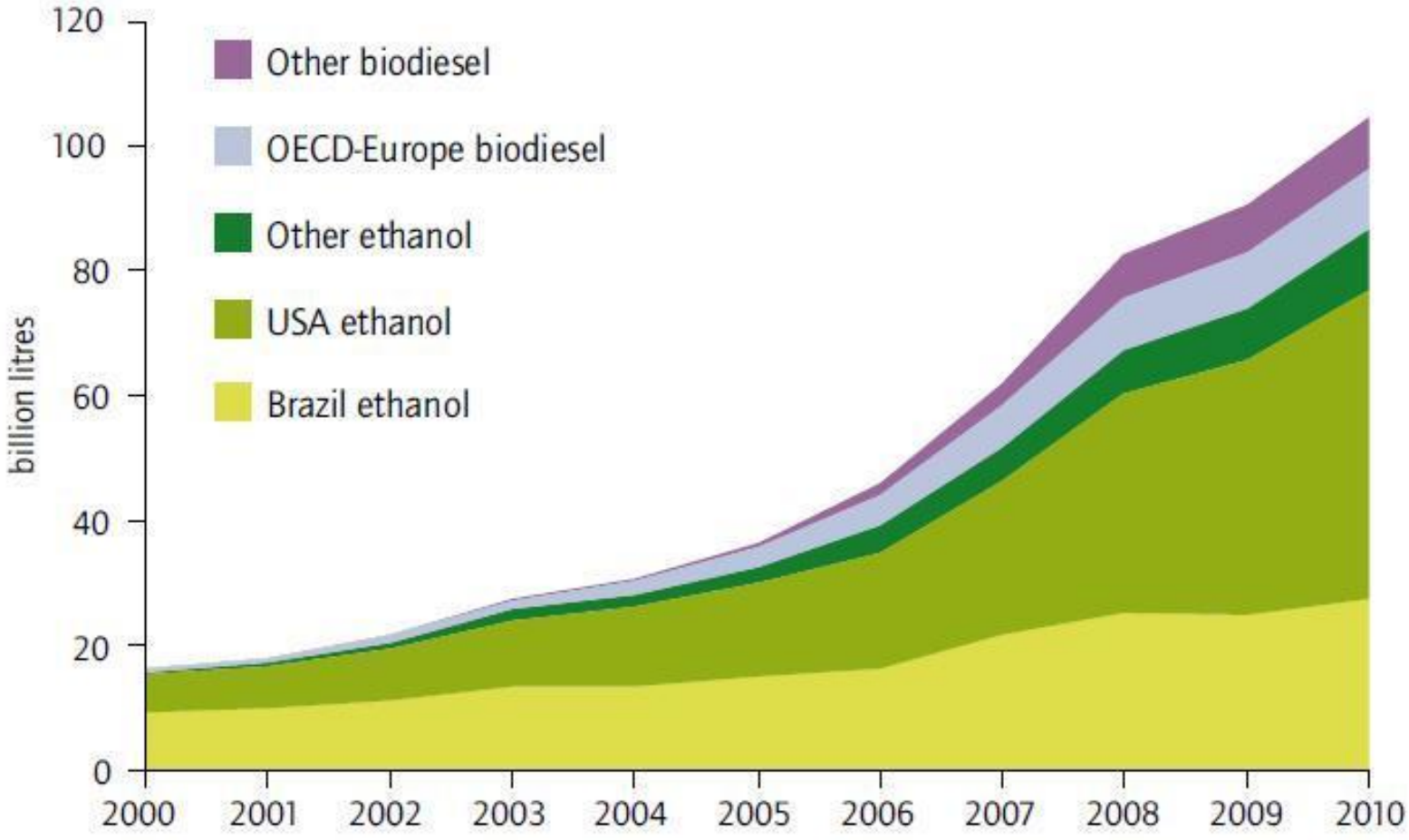
In ASEAN: Thailand and Vietnam is developing their Wind Energy

World Bio Energy Status



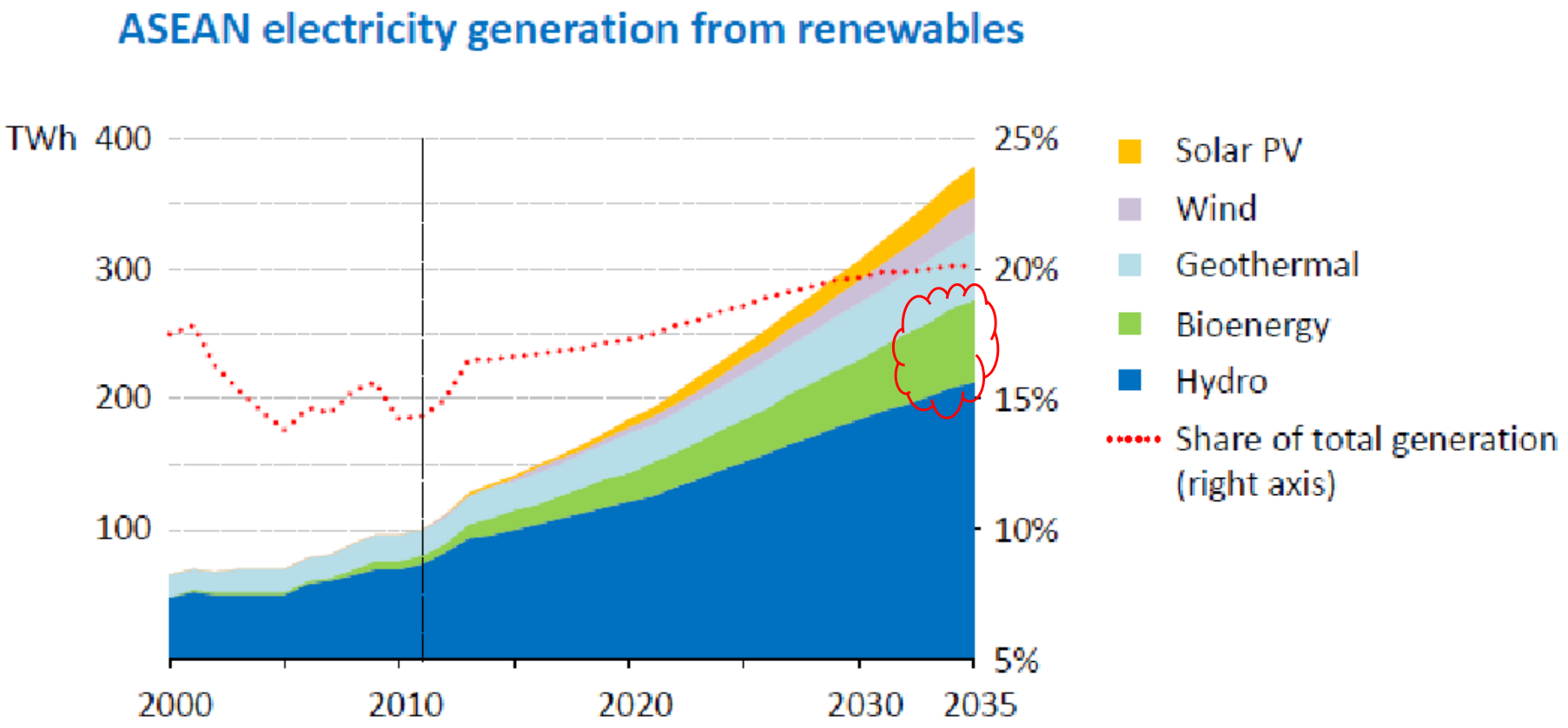
Source: Bioenergy – a Sustainable and Reliable Energy Source. IEA Bioenergy ExCo:2009:05

Bio Energy Status by Regions



Global Biofuel Production (billion liters) from 2000-2010 [1].

Bio Energy Status in ASEAN



Future Energy Scenarios

IEO 2010 Reference case, IEA Reference Scenario – 2008

IEA New Policies Scenario – 2010

WEC Energy Policy Scenario for – 2050

Group Discussions

1. Sustainable Energy Development Plans

2. Gender in Sustainable Development

3. Renewable Energy Issue and Environmental Impacts. Etc.

Contents

Part 2: Environmental Cost and Social Cost

1. Review Concepts
2. Environmental Cost
3. Social Cost
4. Environmental Impacts

Review Concepts

The **Environment**, which has many components:

- Physical: geology, topography, soils, water resources, air quality, forest, etc.
- Biological: fauna, flora, biodiversity, ecosystems…
- Social: including culture, religion and local values.

The Impacts:

- **Conceptual motivation**: Development cannot be sustainable unless it considers environmental impacts
- **Other tangible benefits**: Avoid problems before they occur- lower project costs in the long-term
- Provides decision-makers with alternatives
- Provides benefits to public such as opportunity to learn, express concerns, and influence decision-making process

Environmental Cost

- Direct cost to prevent or reduce environmental pollution.
- Or indirect cost of using resources, damage ecosystem.
- In some cases, the environmental treatment cost can be taken back through recycle, reuse, i.e. wastewater…, by reducing medical treatment, healthcare cost, etc.

Social Cost

- Social Cost is the cost to society as a whole from an event, action or change policy.
- Including negative externalities and does not count costs that are transfers to others, in contrast to private cost.
- Marginal Social Cost : MSC

$$MSC = MPC + MEC$$

MPC : Marginal Private Cost

MEC : Marginal External Cost

Social Cost Evaluation Criteria (1)

Kind of Impact	Criteria	Goals
Emigration	• Number of emigrants • % ethnic minority	Proper resettlement social equity
Culture and Social Impacts	• Impact culture and religion • Lose of important culture monuments • Impact culture organizations • Change the mean to access the outside world. • Lack of community participant in planning. • Increase social crimes	Properly compensation

Social Cost Evaluation Criteria (2)

Kind of Impact	Criteria	Goals
Impact on job	• Change the mean to access the natural resources • Lose agriculture lands • Job opportunity • Limit the area for resettlement and cultivation	- Properly compensation - Create jobs & support small enterprises - Area for resettlement
Loss of biodiversity	• A large area with high biodiversity is influenced • Reservation zone is affected • Rivers, water base	- Biodiversity Program - Follow regulation of reservation zone - Reduce

Social Cost Evaluation Criteria (3)

Kind of Impact	Criteria	Goals
Loss of biodiversity	• Rivers, water base • Loss of wetland • Impact cold-water ecosystems • Impact Immigrant bird, fish and wildlife	- Reduce - Reduce - Reduce - Design electric line, dam and wind turbine properly
Loss of access to natural resources	• Loss of forest • Fishing • Increase in soil erosion • Influence landscape	- Replanting program - Properly compensation

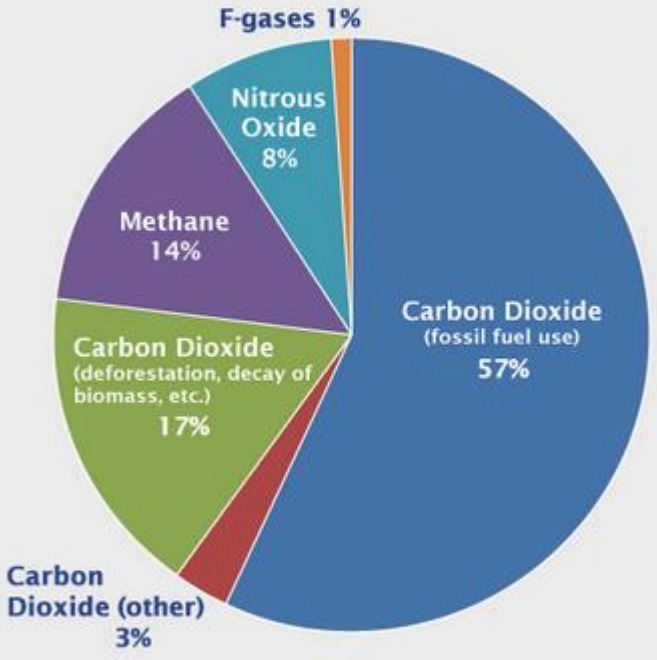
Social Cost Evaluation Criteria –An operational Risks Reduction Model for Population Resettlement (IRR) -1

Risks	Mitigation Activities	Proposed Methods
Landless	▪ Land-based resettlement	- Land compensation
Jobless	▪ Re-employment	- More investment needed
Homeless	▪ House reconstruction	- House compensation - Subsidy
Marginalization	▪ Social Inclusion	- Financial support for resettlement - Directly support impacted people
Increase morbidity and mortality	▪ Improve health care service	- Construct clean water and sanitation system - Training on health care - Village health care center

Social Cost Evaluation Criteria –An operational Risks Reduction Model for Population Resettlement (IRR) -2

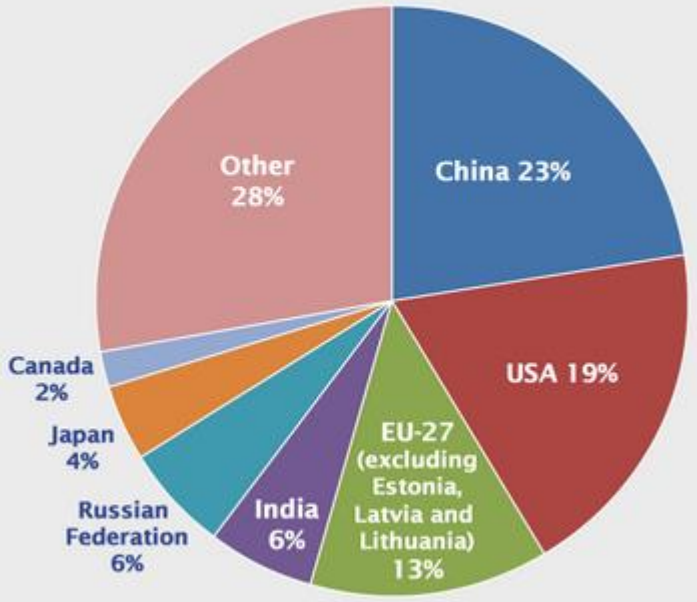
	n Activities	Proposed Methods
	e nutrition	
	ion of ity assets ar	
	ng networks munities	

Global Greenhouse Gas Emissions by Gas



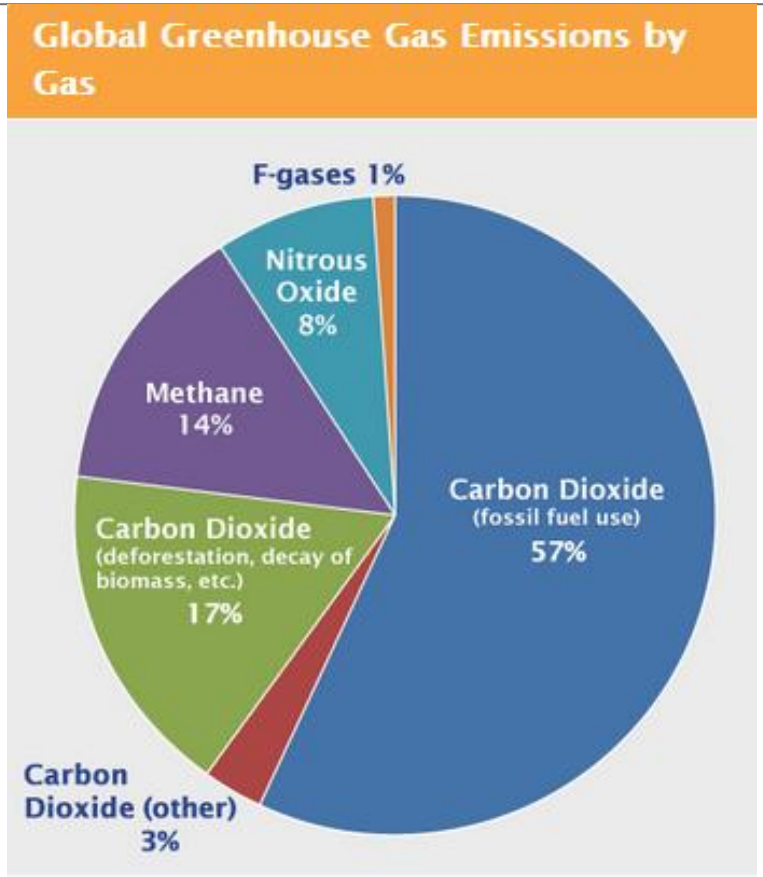
Source: IPCC (2007); EXIT Disclaimer based on global emissions from 2004. Details about the sources included in these estimates can be found in the *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.

2008 Global CO_2 Emissions from Fossil Fuel Combustion and some Industrial Processes (million metric tons of CO_2)



Source: National CO_2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751–2008.

Social and Environmental Cost : Greenhouse Gas Emission



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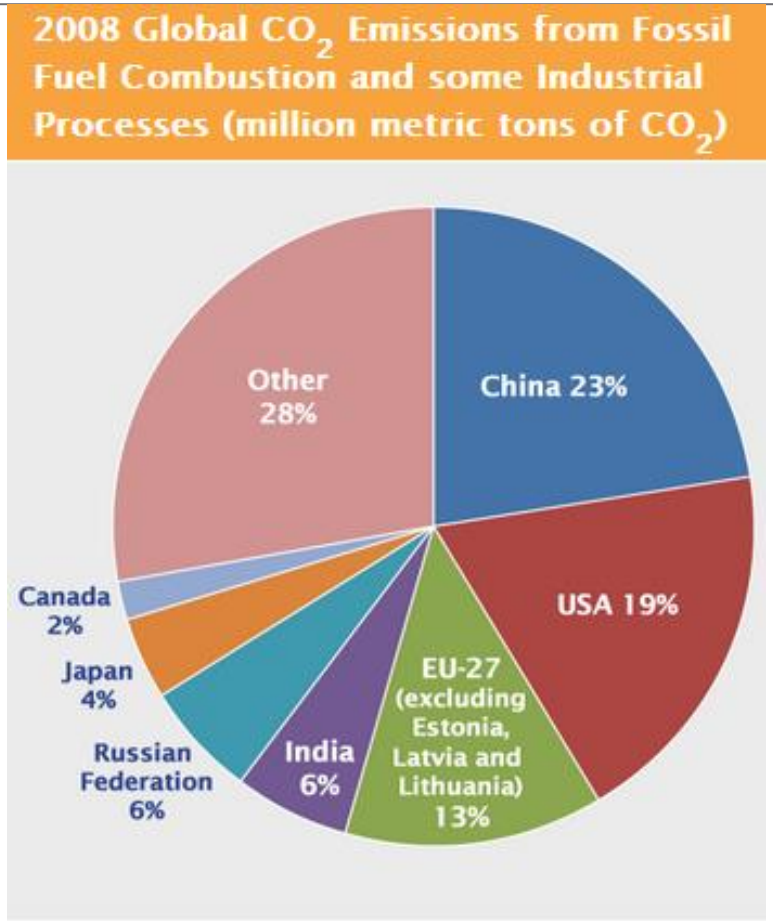

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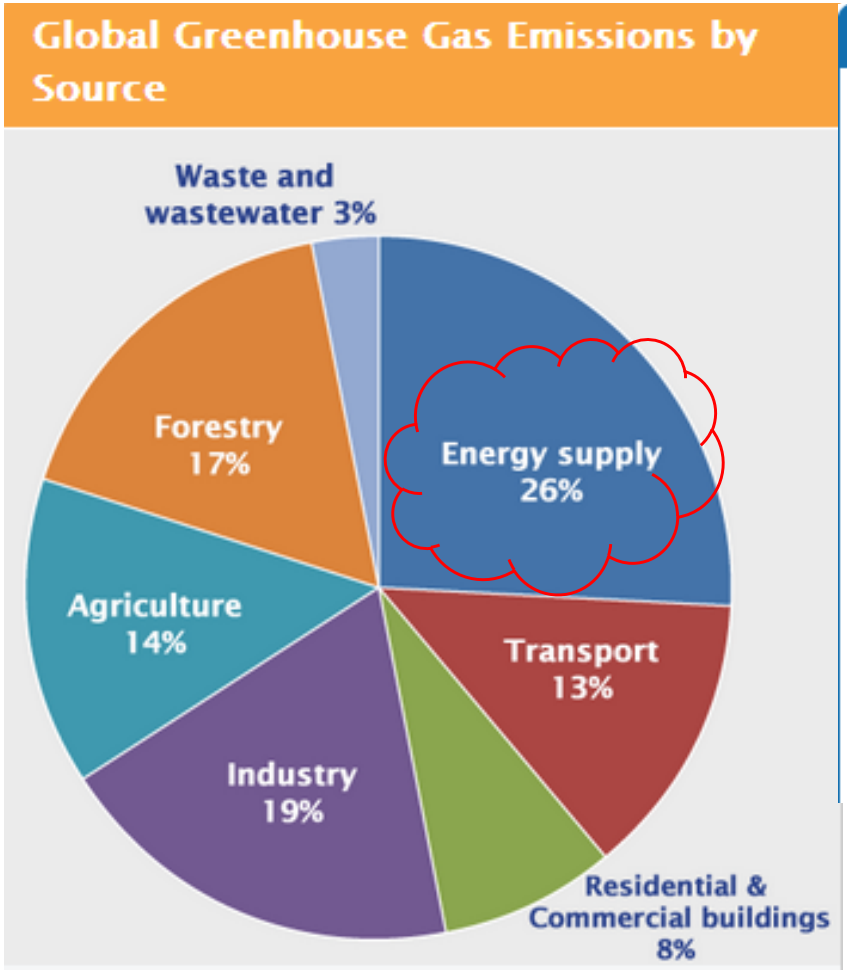
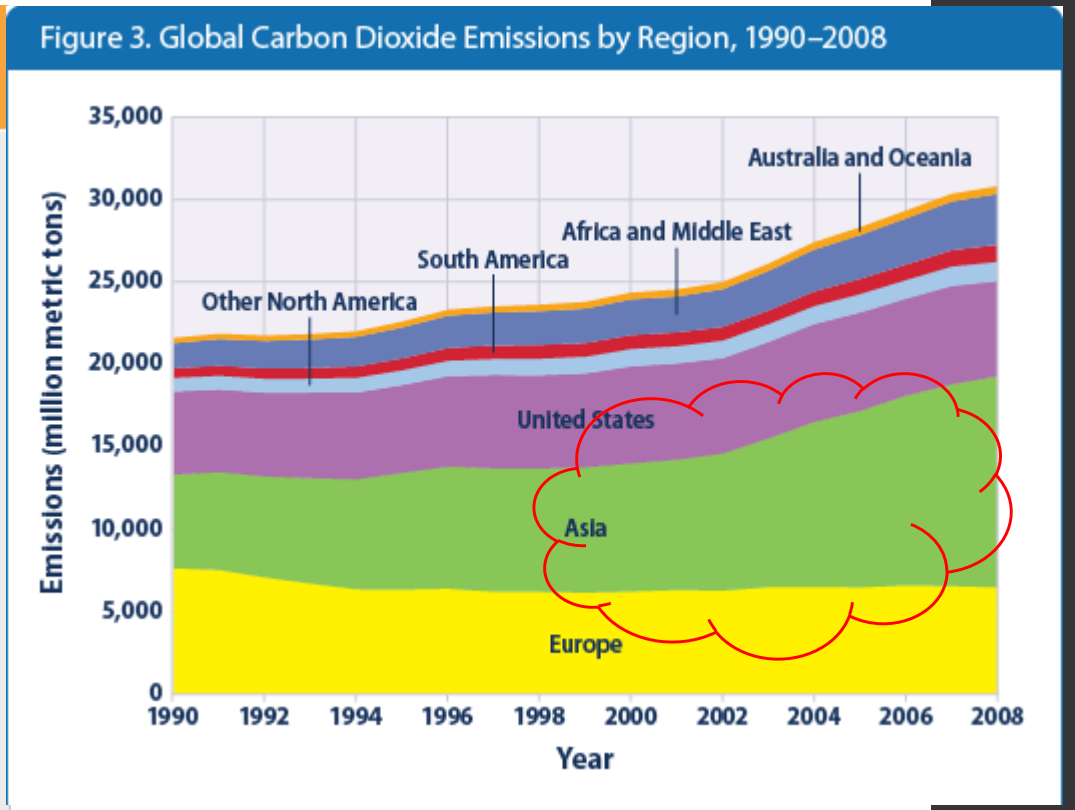


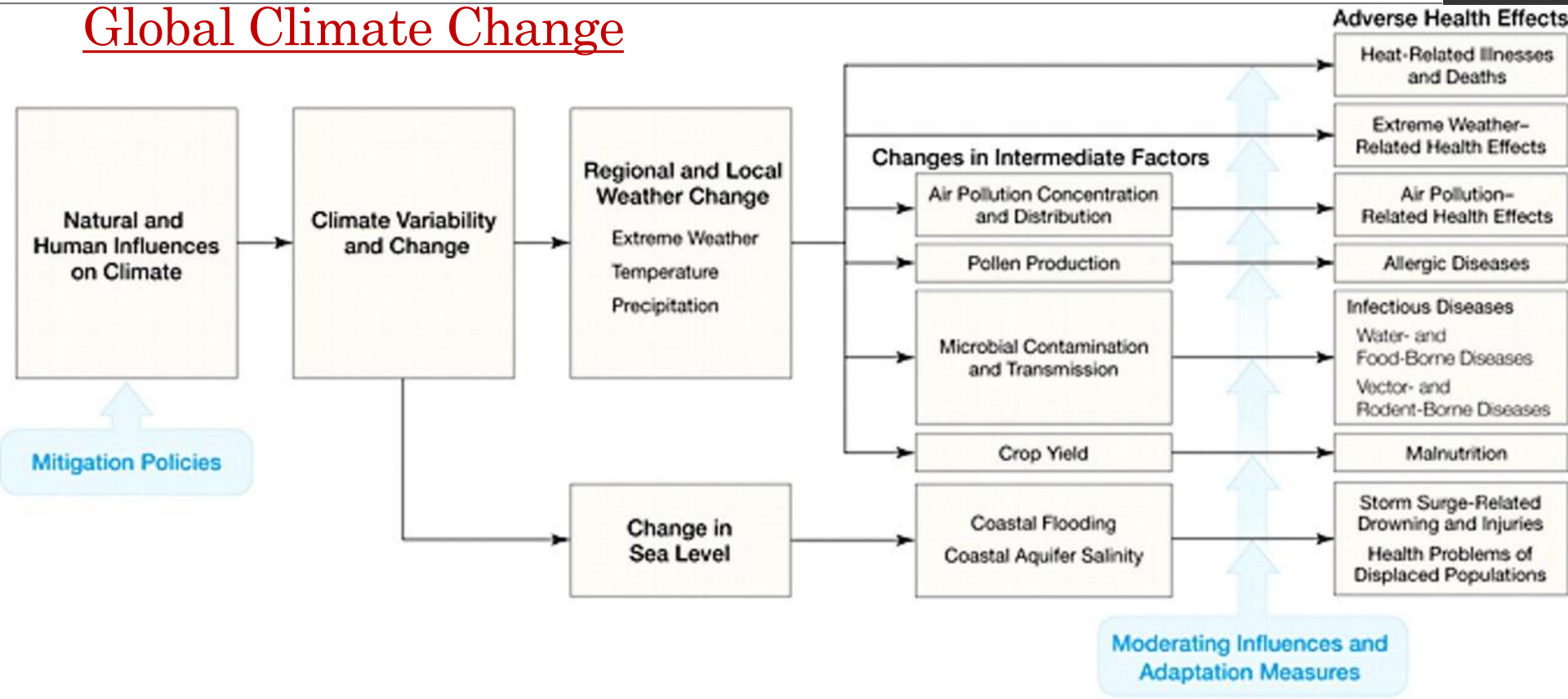


Energy Supply emissions mostly CO_2 (some non-CO_2 in industry and other energy related).

Non-energy emissions are CO_2 (land use) and non-CO_2 (Agriculture and waste)

Social and Environmental Cost : Greenhouse Gas Emission

Global Climate Change



Mitigation Policies for Reduction of Greenhouse Gas Emissions
- Energy Efficiency
- Use of Renewable Energy Sources
- Forest Preservation

Moderating Influences
- Population Density and Growth
- Level of Technological Development
- Standard of Living and Local Environmental Condition
- Preexisting Health Status
- Quality and Access to Health Care
- Public Health Infrastructure

Adaptation Measures
- Vaccination Programs
- Disease Surveillance
- Protective Technologies
- Weather Forecasting and Warning Systems
- Emergency Management and Disaster Preparedness
- Public Health Education and Prevention
- Legislation and Administration

Social and Environmental Cost : Greenhouse Gas Emission

Health Impact

- Increase harmful effects on human body due to the change of weather
- Reduce cold effect
- More accidents due to natural disasters
- More disease, infection
- Reduce body immunity
- Promote the development of disease-carrying owners
- Lengthen the epidemic period, etc.

Social and Environmental Cost : Greenhouse Gas Emission

Environmental Impact

- Impact of Sea Level Rise
- Impact of Changes in Storm, Surge and Precipitation

Sea Level Rise and Coastal Flooding Impacts Viewer

The National Oceanic and Atmospheric Administration has developed a tool to visualize the potential impacts of sea level rise on coastal communities. The viewer is currently operational for Mississippi, Alabama, Texas, and Florida, with additional coastal counties to be added in the near future.

Social and Environmental Cost : Greenhouse Gas Emission

Environmental Impact

- Impact of Temperature, Energy Demand and Energy Supply
- Impact of Water Availability
- Impact of Wind Speed, Cloud Cover and Renewable Energy
- Changes in the Timing of Seasonal Life-Cycle Events

Social and Environmental Cost : Greenhouse Gas Emission

Environmental Impact

- Flood and Storm Occur in Coastal Area
- Lost of wetlands and erosion of sea coast
- Affect on coastal infrastructure

Group Discussion

1. The Environmental Cost and Social Cost of Hydro Power Plant Construction.
2. Environmental Cost and Social Cost of Coal Combustion Thermal Power Plant

Content

1. Current Energy Status and Future Energy Scenarios
2. Environmental Cost and Social Cost

3. Ethics and Behavior Change Issues

Part 3: Ethics and Behavior Change Issues

1. Overview of Behavior

2. Ethics and Behavior Change Issues

3. Propose Solutions

Overview of Behavior

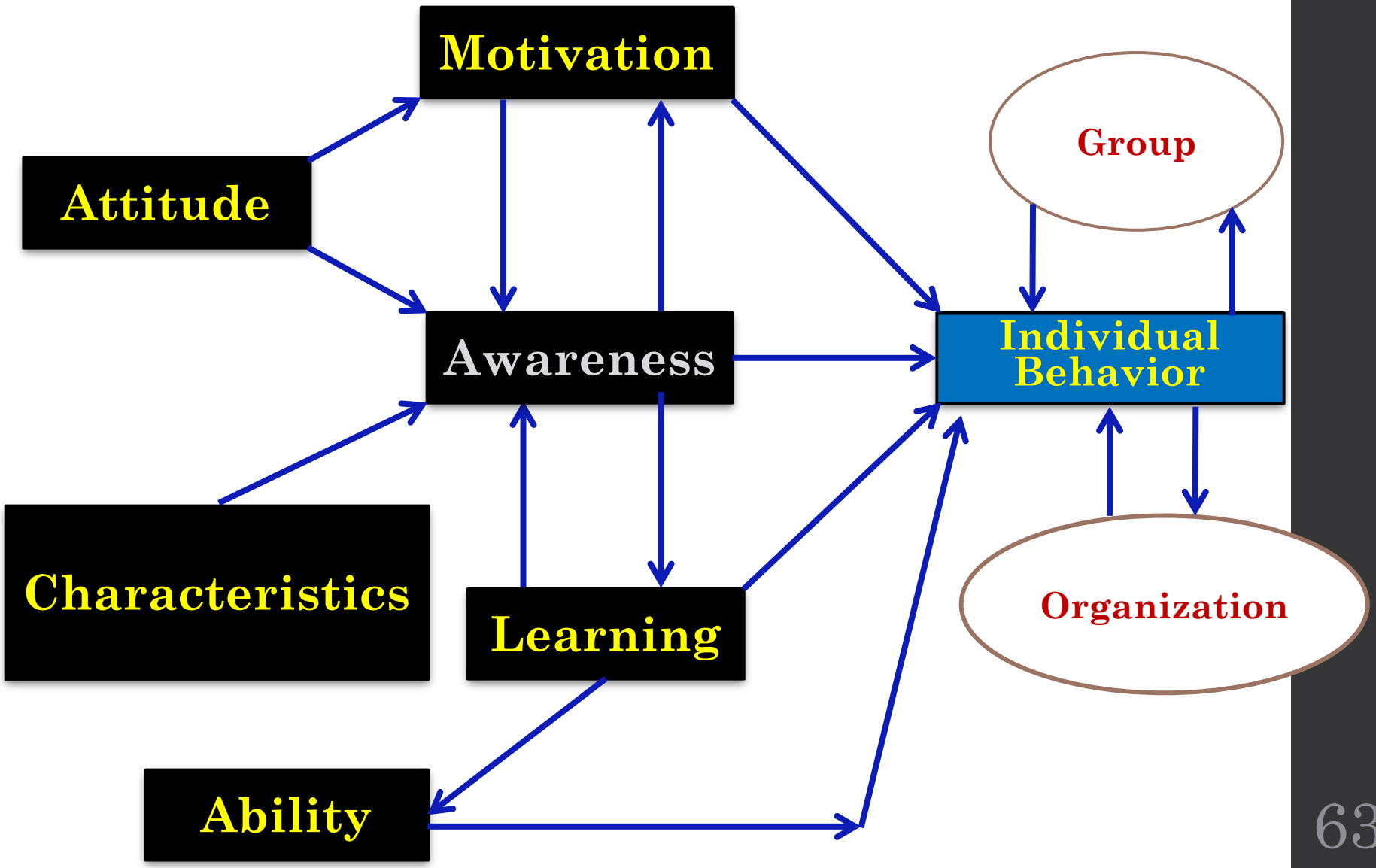
The **Human Behavior** refers to the range of behaviors exhibited by humans and which are influenced by culture, attitudes, emotions, values and ethics…

Why do we need to change behavior?

Behavioral change in Energy Use

- **Green Economic Approach**
- **Selection of Energy Substitute**

Ethics and Behavior Change



Ethics and Behavior Change

FOAM Framework: Focus on Opportunity, Ability and Motivation

- F –Focus: Study on behavior, study on Objectives
- O –Opportunity: Approach, Product, Social Values
- A –Ability: Knowledge and Social Support
- M –Motivation: Belief and Attitude

Ethics and Behavior Change

FOAM > < KAP

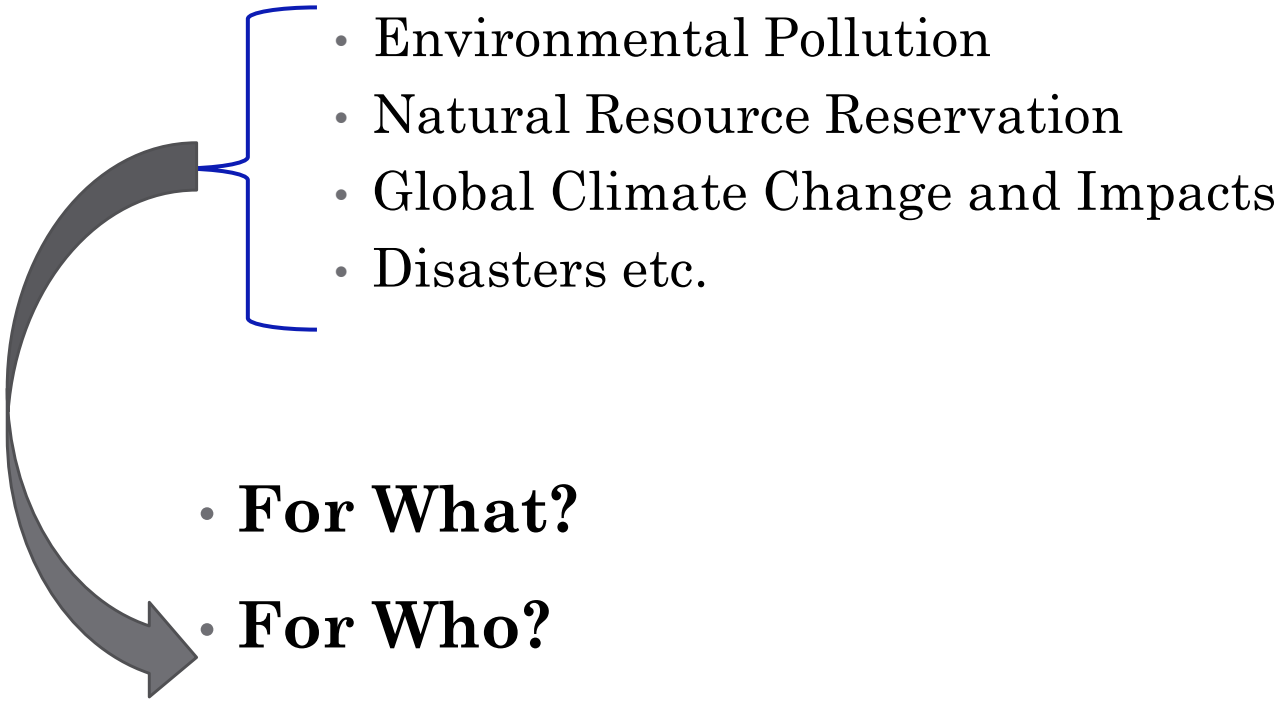
- K –Knowledge A –Attitude and P –Practice
- KAP cannot show the nature of problem
- KAP is unable to answer WHY?
- *Method: awareness improvement only*
- FOAM: F –more focus on behavior and objective,

  O –indicate Opportunities to change behavior;

  A –indicate the Ability to change behavior;

  M –indicate the Motivation and barrier in changing behavior
- FOAM can show the nature of problem
- FOAM is able to answer WHY? and HOW?
- *Method: In order to change behavior*

Why do We need to Change Behavior ?



Sustainable Development

For Everybody

Energy Product and Use

- Awareness
- Natural Resource Degradation
- Ineffective use of equipment and energy consumption
- Inappropriate planning
- Strongly depend on conventional energy (non-renewable energy)
- Not yet pay much attention on Renewable Energy

Why do We need to Change Behavior?

- Improve productivity by reducing waste
- Improve efficiency
- Improve economic benefits
- Waste prevent instead of waste treatment
- Apply for Environmental Standard
- Improve health and living condition
- Improve living standard

Why do We need to Change Behavior?

Cambodia Case:

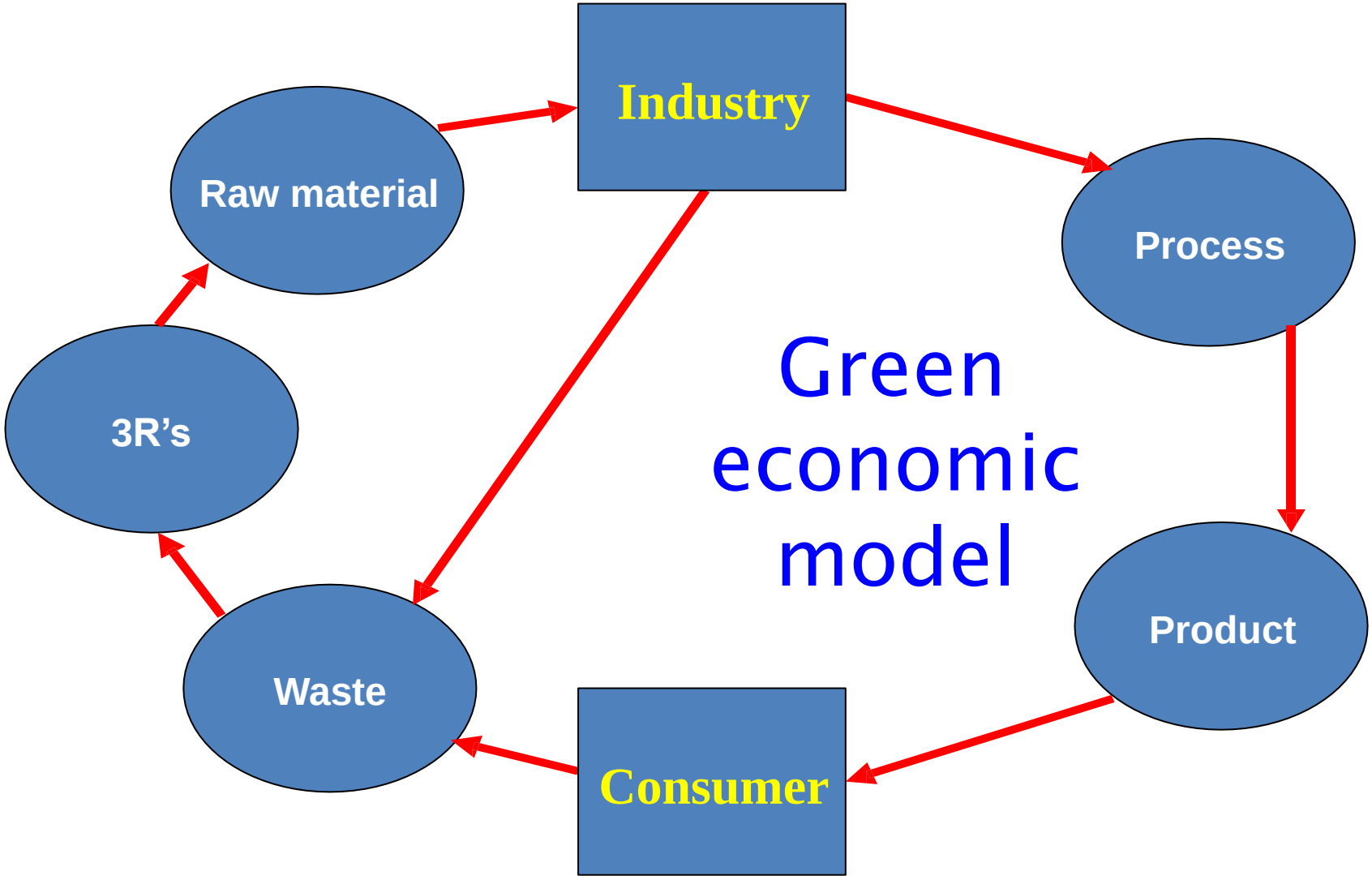
- Difficult in operation of water reservations
- Increasing price of Oil and Gas
- Increasing of Power Demand due to global temperature rising
- Reducing emission requires high technology and big investment
- Electricity transmission/distribution systems are Overhead lines –increasing losses due to temperature rise.
- People do not understand well about Energy Reservation

Proposed Solutions

Introduce Green Economic / Green Products

- Production, Distribution, Energy Consumption and Services Activities
- Above activities can improve the living standard but produce environmental impacts
- Green investment / green productivity: Consider on waste management, 3R (Recycle, Reuse, Reduce), Green Technology etc.,

Proposed Solutions



Proposed Solutions

- Enhance producer responsibility →

  Polluter Pay's Principle

- Cleaner production → Reduce Emission
- Eco-industrial zones and Environmental Education: Enhance community awareness law, policy and regulations

Proposed Solutions

- Enhance producer responsibility →

"Polluter Pay's Principle"

Why do Producers need to take responsibility?

- **Only producers can reduce the product prices through input selection and recycle**
- **Only producers can decide to select raw materials**
- **Only producers can make decision on investment of pollution prevention and control technologies**

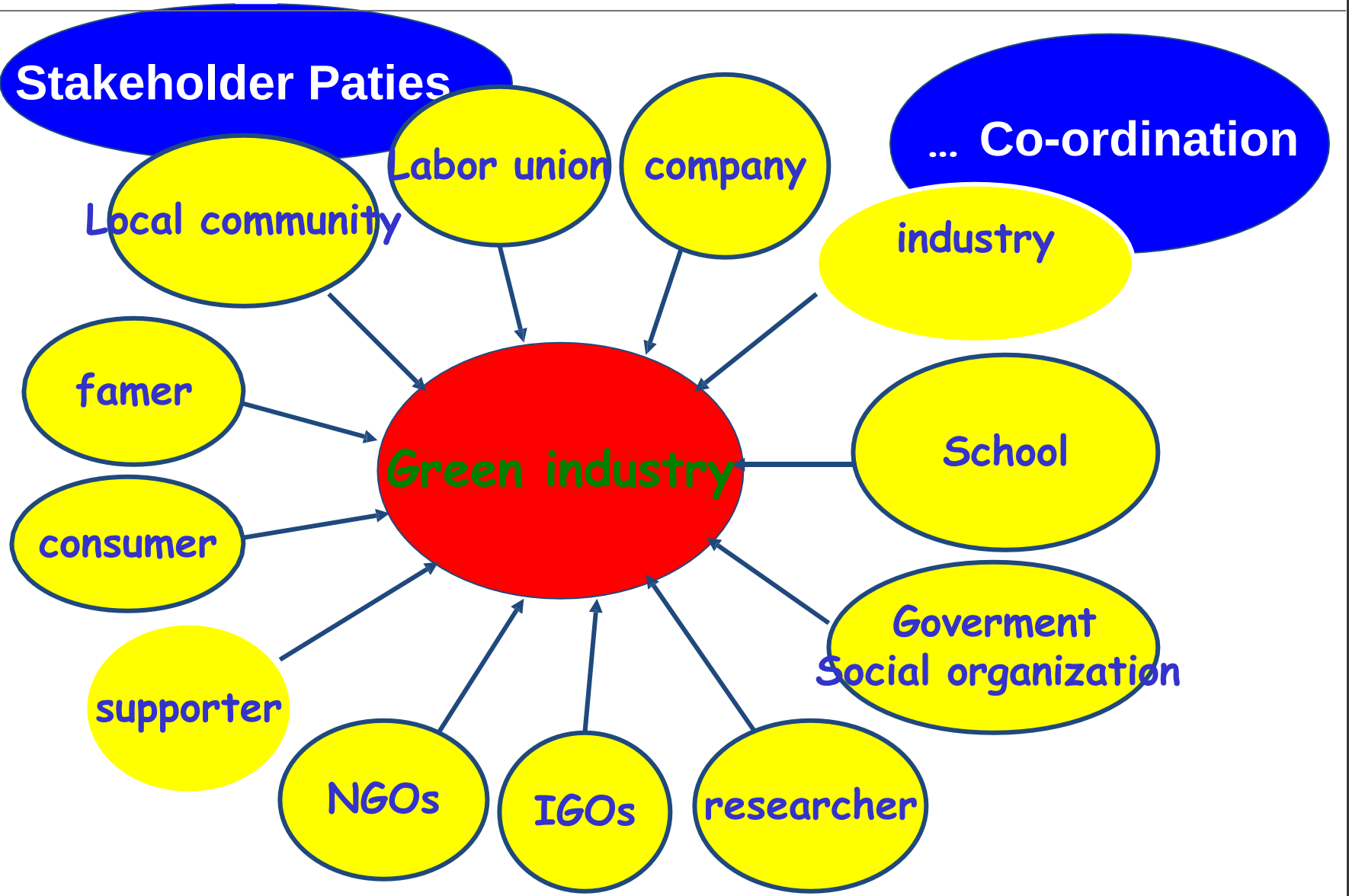
Proposed Solutions

- Behavioral Change: Community Commitment

“Role of Community”

- Awareness improvement of Community
- Provide information on energy use and support research activities in order to increase the energy efficiency, mitigate environmental pollution
- Participate in environmental protection campaigns, sustainable resource usage programs

Proposed Solutions



Proposed Solutions

- Behavioral Change: Using *Energy Saving Products*
- Behavioral Change: Create *Energy Saving Habits*

Light bulb *(reduce 80% Energy): LED or CFL*

Group Discussion

1. Behavioral Change: Using *Natural Resources*

2. Behavioral Change: Using *Energy Saving Products*

3. Behavioral Change: Create *Energy Saving Habits*

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