Clean Energy Technology R&D Needs of Emerging Economies in Asia

A Comparative Analysis of Clean Energy Technology Contexts and Challenges In the Region

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IEA Experts' Group on R&D Priority Setting and Evaluation (EGRD)

Organized by
International Energy Agency
In Conjunction with
Ministry of Science and Technology
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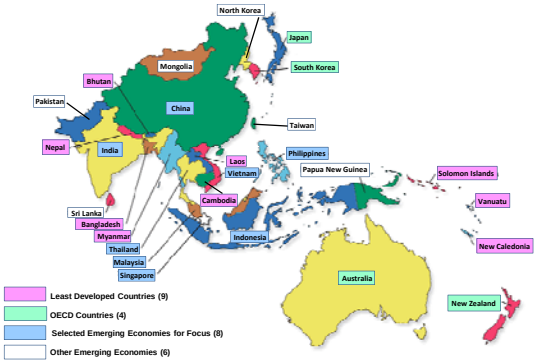
Asia-Pacific Region

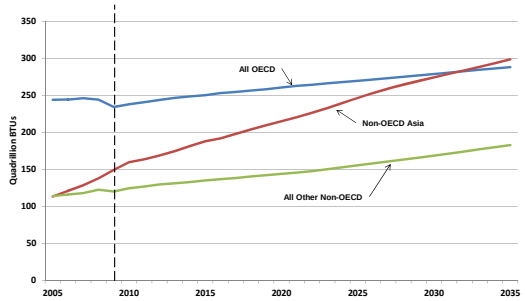


Desired Meeting Outcomes

- Clarify understanding and identify drivers of future energy demand in the Emerging Economies of Asia;
- Characterize attributes of desired future energy systems, noting common and distinctive features;
- Identify clean energy technologies and associated R&D needs and opportunities;
- Form insights on energy R&D investment priorities of emerging economies, individually and collectively;
- Identify R&D gaps and opportunities, particular to the region;
- List considerations for future IEA and non-member country R&D portfolio planners; and
- Explore existing and preferred "modalities" for enhanced international S&T cooperation.

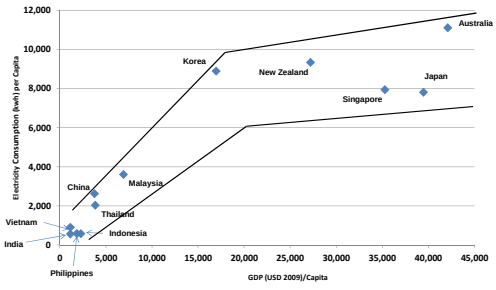
REGIONAL CONTEXTS AND CHALLENGES

Non-OECD Nations Drive the Increase in Primary Energy Demand



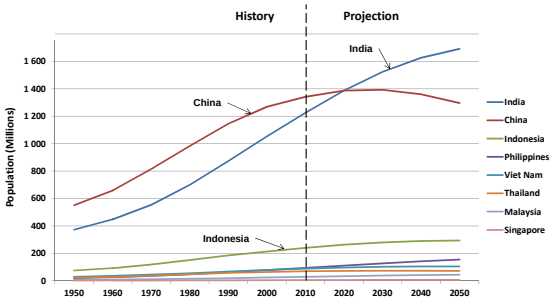
Source: Gruenspecht, H, "International Energy Outlook 2011," U.S. Energy Information Administration, presentation, Sept 19, 2011.

Rising Energy Aspirations



Source: World Bank:
– 2009 kwh/Capita
– 2009 GDP/Capita

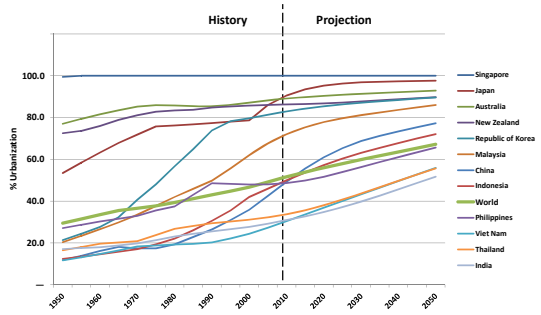
Population Trends and Forecasts (History & Projection 1950 – 2050)



*United Nations, Department of Economic and Social Affairs, Population Division (2012). World Population Prospects: The 2010 Revision

Note: 8 Emerging Economies: 2010, 45% of World Population 2050, 40% of World Population

Trends Toward Urbanization (History & Projection 1950 – 2050)



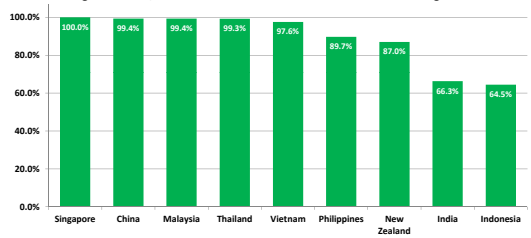
*United Nations, Department of Economic and Social Affairs, Population Division (2012). World Urbanization Prospects: The 2011 Revision

Note: Growth in Urban Population from 2010 to 2050 estimated to be about 1 Billion People

Access to Electricity

Where there is no access to electricity from a grid, local energy may be supplied from diesel generation, solar panels, small wind generators, or biomass.

Rural electrification strategy
- **Distribution extension**
- **Mini-grids**
- **Isolated off-grid**



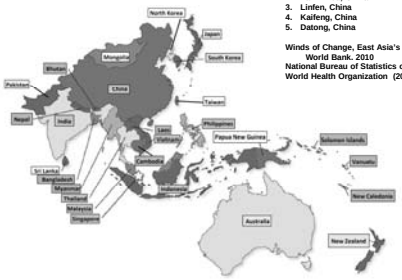
Source: The World Bank, World Development Indicators, Databank, WDI-GDF, 2009

Urban Air Quality Challenges

East Asia has Many of the Worlds Most Air-Polluted Cities (μg/m³)

1. Ulaanbaatar, Mongolia
2. Panzhihua, China
3. Linfen, China
4. Kaifeng, China
5. Datong, China
6. Taiyuan, China
7. Beijing, China
8. New Delhi, India
9. Hanoi, Vietnam
10. Jakarta, Indonesia

Winds of Change, East Asia's Sustainable Energy Future, World Bank. 2010
National Bureau of Statistics of P.R. China (2006)
World Health Organization (2006)



Clean Water and Sanitation Challenges

Box 7.1 Progress toward Target for Proportion of Population with Access to Improved Drinking Water

Early Achievers	
Armenia	Singapore
China, People's Republic of	Sri Lanka
Georgia	Thailand
India	Tonga
Korea, Republic of	Tuvalu
Kyrgyz Republic	Vanuatu
Malaysia	Viet Nam
Nepal	
On Track	
Afghanistan	Mongolia
Cambodia	Philippines
Kiribati	Timor-Leste
Micronesia, Federated States of	
Slow Progress	
Azerbaijan	Myanmar
Bangladesh	Pakistan
Bhutan	Palau
Cook Islands	Solomon Islands
Indonesia	Tajikistan
Lao PDR	Turkmenistan
Maldives	
No Progress/Regressing	
Kazakhstan	Samoa
Marshall Islands	Uzbekistan
Papua New Guinea	

Source: Derived from Table 7.3.

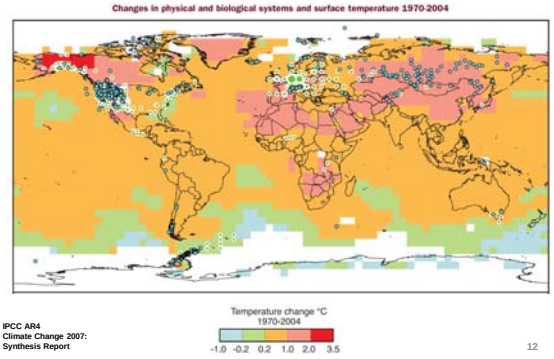
Box 7.2 Progress toward Target for Proportion of Population Using Improved Sanitation Facilities

Early Achievers	
Cook Islands	Singapore
Korea, Republic of	Sri Lanka
Malaysia	Thailand
Maldives	Uzbekistan
Myanmar	Viet Nam
Samoa	
On Track	
Lao PDR	Tajikistan
Palau	Timor-Leste
Philippines	
Slow Progress	
Afghanistan	Kiribati
Armenia	Marshall Islands
Bangladesh	Mongolia
Bhutan	Nepal
Cambodia	Pakistan
China, People's Republic of	Solomon Islands
India	Tuvalu
Indonesia	Vanuatu
Kazakhstan	
No Progress/Regressing	
Azerbaijan	Papua New Guinea
Georgia	Tonga
Kyrgyz Republic	Turkmenistan
Micronesia, Federated States of	

Source: Derived from Table 7.3.

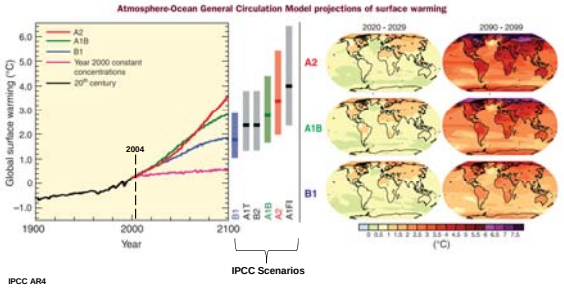
"Key Indicators for Asia and Pacific - 2011," Asia Development Bank, August 2011

Warming Climate – History (35 Years, 1970-2004)



IPCC AR4
Climate Change 2007:
Synthesis Report

Warming Climate – Futures
IPCC Scenarios to 2100



IPCC AR4
Climate Change 2007:
Synthesis Report

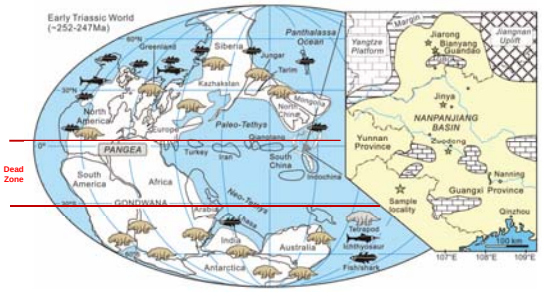
Climate Impacts on Energy Systems

Technology	Δ Air Temp	Δ Water Temp	Δ Water Availability	Δ Wind Speed	Δ Sea Level	Floods	Heat Waves	Storms	Sum
Coal	1	2	1-3	_	_	3	1	_	9
Oil	1	2	1-3	_	_	3	1	1	10
Natural Gas	1	2	1-3	_	_	3	1	1	10
Nuclear	1	2	1-3	_	2*	3	1	_	11
Hydropower	_	_	1-3	_	_	3	_	1	6
Wind	_	_	_	1-3	3*	1	_	1-3	8
Photovoltaic	1	_	_	1	_	1	1	1	5
CSP/Solar tracking	_	_	2	2	–	1	1	2	8
Biomass/biofuel	1	2	2	_	3*	3	1	_	12
Geothermal	_	1	_	_	_	1	_	_	2
Ocean	_	1	_	_	1	N/A	_	3	5
T&D Grids	3	_	_	1	3*	1-2	1	2-3	12
End Use	2	_	_	_	_	_	3	_	5

Δ = change in; CSP = concentrating power
* Higher severity in costal or low-lying areas
Notes: 3 = Severe impact; 2 = medium impact; 1 = limited impact; N/A = not applicable

Asian Development Bank (2012), "Climate Risk and Adaptation in the Electric Power Sector" Table 15

Triassic Sub-Equatorial Dead-Zone*



* During the early Triassic period in ancient Earth history (252 - 247 million years ago), massive amounts of CO2 and other GHG gases (e.g., methane) emerged from buried coal regimes in an extended period of volcanism in the Siberian Traps. Sun Yadong documents global warming (+20° C) and mass extinctions of higher like-forms in the sub-equatorial region.
Source: Yadong Sun, et all, "Lethally Hot Temperatures During the Early Triassic Greenhouse," *Science*, 338, 366 (2012).

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Context Summary

- Non-OECD Asian Economies will Dominate Future Global Energy Demand
- Accompanied by Rising Aspirations for Electricity use per Capita
- Underpinned by Rising Population & Trends Toward Urbanization
- Attended by Growing Concerns About the Environment
  - Dominated by Urban Air Quality Concerns, but also
  - Other Concerns: Water, Sanitation & Deforestation
  - Forecasts Suggest Fresh Water Supply Will Be a Growing Concern
- Energy Access Remains a Challenge in Some Countries
- Climate Change & Global Warming Present Daunting Challenges
  - With Expected Impacts on Energy Infrastructure and Systems, and
  - Potentially Profound Longer-Term Effects on Civil Society
- Hugh Opportunities to Shape Future with Innovation & New Technology

ENERGY PARTICULARS

Varied Natural Energy Resources*

	Coal	Oil	NG	Fissile Material	Geo-thermal	Solar**	Wind	Hydro	Biomass	Ocean***
Australia	P, E	P, NI	P, NE	P, E	A	A	A	A	A	AM
China	P, NI	P, NI	P, NI	A, P, I	A	A	A	A	A	A
India	P, NI	P, NI	P, I	A, P, I	Plan	A	A	A	A	Plan
Indonesia	P, E	P, NI	P, E	NU	A	AM	AM	A	AM	NU
Japan	I	P, NI	P, I	I	A	A	A	A	A	Plan
Rep of Korea	P, I	P, NI	P, I	I	A	A	A	A	A	A
Malaysia	P, I	P, NE	P, NE	NU	Plan	AM	Plan	A	A	Plan
New Zealand	P, E	P, NI	P	NU	A	A	A	A	A	Plan
Philippines	P, NI	P, NI	P	NU	A	A	A	A	A	Plan
Singapore	NU	NI	I	NU	Plan	A	AM	NU	AM	Plan
Thailand	P, NI	P, NI	P, I	NU	A	AM	AM	AM	A	NU
Vietnam	P, E	P, NI	P, I	NU	Plan	AM	A	A	A	Plan

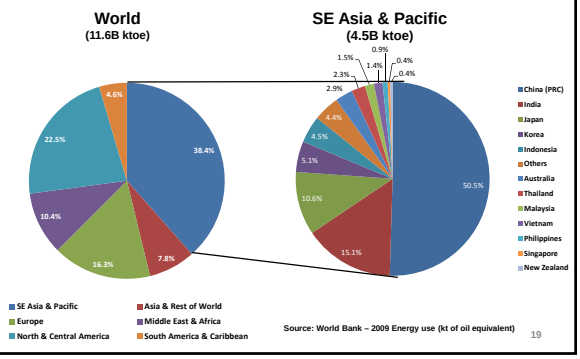
P = Producer
NE = Net Exporter
E = Exporter
NI = Net Importer
I = Importer

A = Available - in use
AM = Available - minimum use
NU = Not Used
Plan = Planned

**Solar: Includes PV, CSP, and local applications
***Ocean: Includes Wave and Tidal

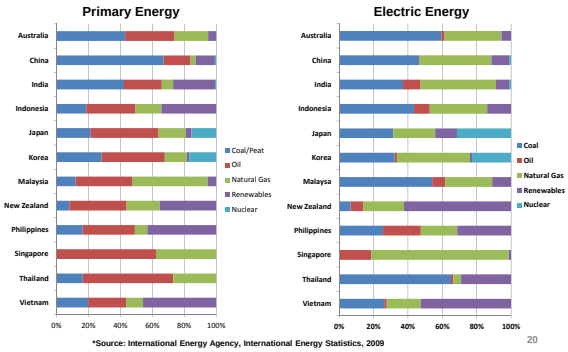
*Sources: Renewable Energy and Energy Efficiency Partnership (REEEP) – REEGLE
CIA World Factbook, 2012
Asia Development Bank Key Indicators, 2011
US-DOE-EIA, International Energy Statistics, 2010
American Nuclear Society, "Nuclear News," March 2012

Primary Energy Use
(Kilotons of Oil Equivalent, 2009)



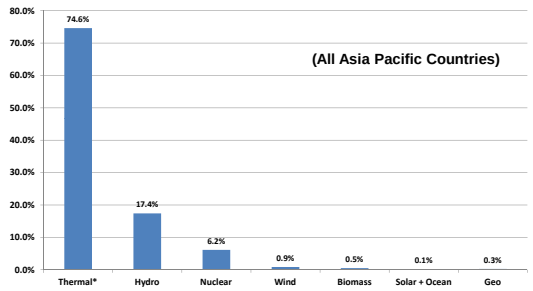
Source: World Bank – 2009 Energy use (kt of oil equivalent)

Dominant Forms Energy Supply 2009*



*Source: International Energy Agency, International Energy Statistics, 2009

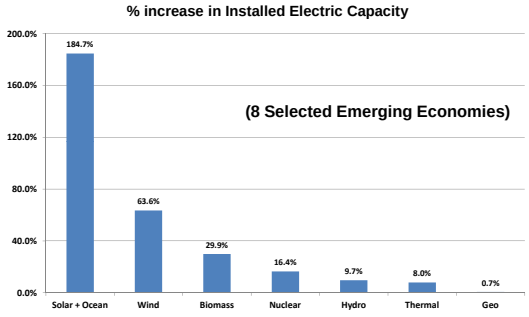
% Installed Electric Capacity by Technology (2010)



*Thermal Sources of Power are Dominated by Combustion of Coal, Oil and Natural Gas

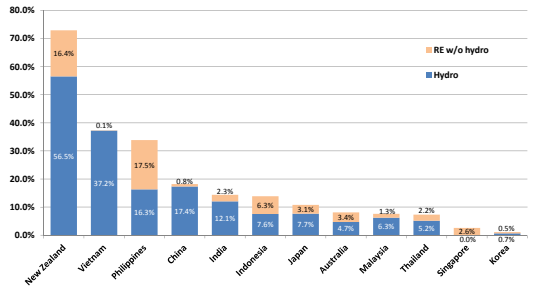
U.S. Energy Information Administration (EIA), International Energy Statistics,

Growth Rates of Technology Types (2009 – 2010)



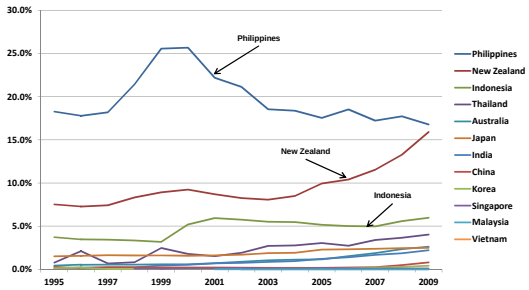
U.S. Energy Information Administration (EIA), International Energy Statistics,

Percent of Electric Generation from Renewable sources (2009)



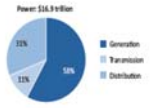
U.S. Energy Information Administration (EIA), International Energy Statistics,

Annual Growth Renewable Electric Energy (Excluding Hydro)



Source: The World Bank, World Development Indicators, Databank, WDI-GDF, 2009

Power Sector Investment Trends 2011-2035



- Over 2/5ths of global investment in the power sector goes to T&D, with almost 3/4th of this for distribution networks.
- Nearly 2/3rds of investment is in the non-OECD to meet growing demand.

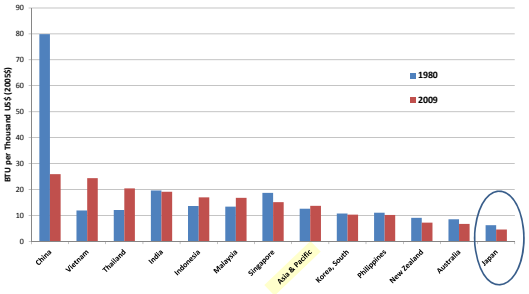
Source: IEA, WEO 2011, New Policies Scenario

Investment in New Power Plants, 2011-2035
OECD, Non-OECD, and World Total ($ Billion)

	OECD	Non-OECD	World
Coal	634	1151	1785
Gas	372	545	917
Oil	27	59	86
Total Fossil	*1033*	*1755*	*2788*
Nuclear	540	585	1125
Biomass	359	305	664
Hydro	272	1134	1406
Wind	1210	932	2142
Geothermal	28	42	71
Solar PV	701	544	1245
Concentrating Solar	129	156	285
Marine	64	2	66
Total Renewable	*2763*	*3115*	*5879*
Total	4336	5456	9791

Source: IEA WEO 2011, Totals may not add due to rounding

Energy Intensity
BTU per 1000$ U.S. (2005 Dollars)



U.S. Energy Information Administration (EIA), International Energy Statistics,

Energy Circumstances Summary
Focus Mainly on 8 Emerging Economies

- All, Except Singapore, Have Developed Coal, Oil and Gas Resources
- All are Importers or Net-Importers of either Coal, Oil or Gas
- Electricity is Produced Mainly from Coal & Natural Gas and, Where Available, Hydro
- Nuclear Power Plays a Relatively Minor Role in Selected Countries
- Almost all forms of Renewable Energy are Available and Used
- Renewable Energy is Fastest Growing, but from a Relatively Small Base
- Renewable Energy (Excluding Hydro) is Fastest Growing in Philippines New Zealand, and Indonesia
- Traditional fuels are expected to account for nearly 80% of primary energy use in Asia and the Pacific in 2030 (ADB 2009)
- Investment in Power Sector over the Next 25 Years is Expected to be $16.9 Trillion USD (IEA-WEO 2011)
  - Two-Thirds will be in Non-OECD Countries
- Compared to Japan, Lots of Room for Energy Efficiency Improvements

TECHNOLOGY PATHWAYS FOR THE 21ST CENTURY

&

CHARGE TO PARTICIPANTS

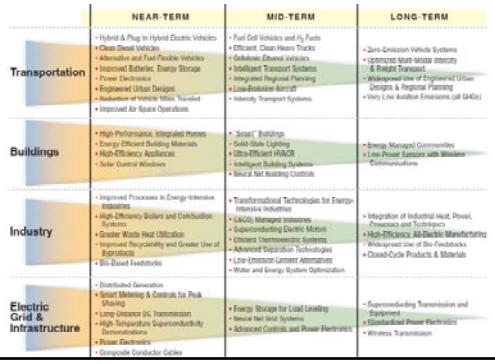
Clean Energy Technology Pathways for the 21st Century

Charge - - Illuminate These Topics

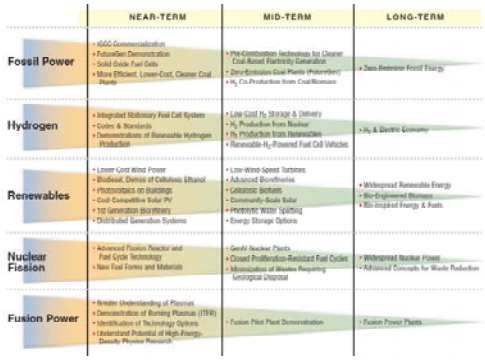
- What are the drivers underlying future energy demand in this region?
- What are the similarities and the distinctions between energy systems of the developed and emerging counties?
- What, if any, are key barriers inhibiting accelerated development and deployment of clean energy technologies?
- What insights are on R&D investment priorities of emerging economies, individually, collectively?
- What are the preferred modalities for enhanced international S&T cooperation?
- What implications are there for future IEA and non-member country R&D portfolio planning, cooperation and collaboration?
- What are the most important actions that IEA and its Member Countries could make in enhancing R&D collaboration with emerging economies?

BACK-UP

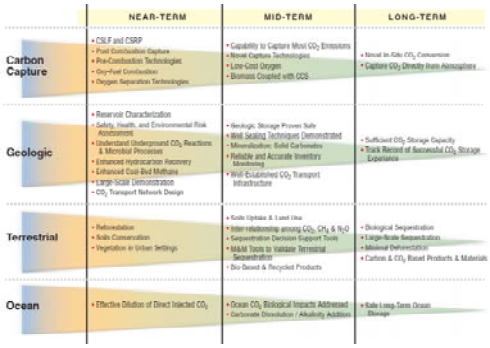
Pathways for Energy End-Use & Infrastructure



Pathways for Clean Energy Supply



Pathways for CCUS



Pathways for Reducing Non-CO_2 Greenhouse Gases

Pathways for Measuring GHG Emissions