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CLEAN ENERGY MINISTERIAL
Accelerating the Transition to Clean Energy Technologies

Country Profiling for Clean Energy Grid Integration Network

Assessment of Variable RE Grid Integration Requirements

Sagun Tripathi
Associate, ICF International
New Delhi

Objectives of the Study

- To characterize power systems in Southeast Asian countries by reviewing their current installed capacity, generation mix, demand/supply scenario and transmission infrastructure
- To evaluate their energy policies/capacity addition plans with a view to determine the extent to which renewables would play a role in meeting future power requirements
- To assess their readiness to absorb planned renewable energy capacities into their power systems while maintaining grid stability and security
- Since wind and solar are primarily responsible for the element of ***variability*** in system operations, this study mostly focuses on the assessment of their potentials and deployment plans in the countries under consideration

Countries Profiled

1. Bangladesh
2. Cambodia
3. India
4. Indonesia
5. Lao PDR
6. Malaysia
7. Nepal
8. Papua New Guinea
9. Philippines
10. Thailand
11. Viet Nam

SECTION 1: EXECUTIVE & COUNTRY SUMMARIES

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Executive Summary (1)

Country	Assessment of Power Sector Plans/Policies	Key Barriers/Challenges to Large-Scale RE Grid Integration	Intervention Areas
Bangladesh	Focus on fuel diversification to reduce dependence on liquid fuels and natural gas; less emphasis on grid-connected RE in future plans	Weak grid; lack of robust resource assessment data for wind and solar; inexperience in developing RE projects	Requirement of early stage interventions such as transmission network planning and grid interconnection studies; capacity building; resource assessment
Cambodia	Focus on harnessing vast hydro potential and utilizing coal reserves; less emphasis on grid-connected RE in future plans	Limited potential for wind; inexperience in developing RE projects; weak grid	Requirement of early stage interventions such as RE grid integration studies; capacity building; resource assessment
India	Future plans propose significant RE capacity additions; requirement of multidisciplinary interventions to ensure smooth VRE gird integration	Adoption of forecasting and scheduling in system operations; evacuation of RE to load centers; lack of integrated resource planning; limited grid connectivity	Multi-sectoral interventions required in areas of scheduling & forecasting, energy storage, ancillary services, integrated resource planning, financial health of distribution utilities, project financing
Indonesia	Focus on ramping up capacity while maintaining the fuel mix (dominated by coal, hydro, gas and geothermal)	Limited potential for wind and solar; limited grid connectivity; complex regulatory environment; lack of skilled personnel	Technical assistance could in the form of transmission network planning and grid interconnection studies; capacity building
Lao PDR	Targeting 30% of energy consumption from RE by 2025; more emphasis on hydro- and biomass-based capacities	Limited potential for wind; weak grid; lack of an integrated national energy policy	Requirement of early stage interventions such as energy sector policy formulation; resource assessment; capacity building; transmission network planning studies

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Executive Summary (2)

Country	Assessment of Power Sector Plans/Policies	Key Barriers/Challenges to Large-Scale RE Grid Integration	Intervention Areas
Malaysia	Focus on developing coal- and gas-based capacities; more emphasis on distributed solar generation (rooftop PV)	Lack of resource assessment data for wind	Technical assistance could be in the form of distribution network impact studies; resource assessment for wind; grid interconnection studies (esp. b/w Sabah and Sarawak)
Nepal	Underdeveloped power sector; focus entirely on developing hydropower and improving energy access	Limited grid connectivity; weak grid; limited potential for wind and solar	Requirement of early stage interventions such as transmission network planning and grid interconnection studies; distribution network impact studies; resource assessment; capacity building
Papua New Guinea	Focus on grid expansion and improving reliability of supply; grid integration issues to emerge as RE share to reach 25% by 2030	Outdated grid infrastructure; limited grid connectivity; lack of resource assessment data for wind and solar	Requirement of early stage interventions such as T&D network planning; distribution network loss reduction strategies; resource assessment; capacity building
Philippines	Focus on development of indigenous fuels to reduce dependence on imports; geothermal and wind power expansion plans to present multiple grid integration challenges	Limited grid connectivity; wind power evacuation in Luzon island; limited potential for solar	Technical assistance could be in the form of transmission network planning and grid interconnection studies (to prevent wind curtailments in the future); capacity building
Thailand	Focus on fuel diversification by including more RE (solar, biomass and wind) for greater energy security; various issues likely to emerge	Realizable wind potential limited by mountainous terrain and grid inaccessibility	Technical assistance could be in the form of transmission network planning and grid interconnection studies; capacity building
Viet Nam	Coal and gas seen as power sources of the future; overall share of RE in 2030 expected to be about 4-5% only	Solar potential limited by mountainous terrain; RE integration contingent on development of grid	Technical assistance could be in the form of transmission network planning and grid interconnection studies; balancing requirement assessment; capacity building

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BANGLADESH – Summary

- Power Sector Summary
  - Natural gas, solid biomass and waste dominate Bangladesh's primary energy consumption followed by coal, oil and hydro
  - Installed generation capacity of 11,877 MW[#] – dominated by gas and liquid fuels (HFO and HSD); outdated and vastly underdeveloped transmission network
  - Bangladesh is keen to diversify its fuel mix by introducing more coal and gas/LNG based capacities
  - Very low per capita electricity consumption at 232.56 kWh (FY 2013-14)[#] - therefore major impetus on improving energy access
- RE Plans, Policies and Deployment
  - Marginal wind and solar capacities in the country: 2 MW of wind and only small-scale pilot solar rooftop PV installations
  - Renewable Energy Policy 2008: Energy production from renewables to be 5% by 2015 and 10% by 2020
  - Power System Master Plan proposes RE capacity additions of 2,000 MW by 2030 but their share would only be ~6% of the total installed capacity
- VRE Grid Integration Outlook
  - Renewable energy development in the country is still in its nascent stages
  - Early stage interventions required to facilitate development and integration of RE
    - Transmission network planning and grid interconnection studies, capacity building

[#]*Source: Bangladesh Power Development Board Annual Report 2013-14*

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CAMBODIA – Summary

- Power Sector
  - Low level of electricity access in the country; generation and capacity mixes dominated by hydro power, coal and liquid fuels (diesel and FO)
  - Major overhaul of transmission network underway
  - Very low per capita electricity consumption at 207 kWh (2012)[#] - therefore major impetus on improving energy access
- RE Plans, Policies and Deployment
  - Marginal wind and solar capacities in the country: 2 MW of solar and one pilot wind project
  - Renewable Energy Policy aims to achieve 100% electrification in rural areas by 2020
- VRE Grid Integration Outlook
  - Capacity addition plans are mostly focused on harnessing the vast hydro potential of the country and setting up some coal-based capacities
  - Development of grid-connected renewable energy development not a priority in the near-term
    - However, RE is expected to play a critical role in achieving target of 100% electricity access
  - Early stage interventions required to facilitate development and integration of RE
    - Distribution network impact studies, capacity building, resource assessment

[#]*Source: Report on Power Sector of Kingdom of Cambodia 2015 Edition, Electricity Authority of Cambodia*

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INDIA - Summary

- Power Sector
  - Has grown steadily (CAGR ~8%) as a result of the country's dynamic economic growth and modernization over the past decade
  - Energy access still remains a challenge for a large percentage of the population (consequently low per capita electricity consumption of 957 kWh in FY 2013-14[#])
  - Generation capacity of 280,329 MW[#] – dominated by coal and hydro, with increasing share of RE in recent years
- RE Plans, Policies and Deployment
  - Aggressive capacity addition targets of 100 GW of solar and 60 GW of wind by 2022 (almost 50% of current capacity); 40% capacity from non-fossil fuels by 2022
  - Commitment to reduce emissions by 33-35% by 2030 from 2005 levels
  - Current installed capacities: ~24 GW of wind and ~4 GW of solar
- VRE Grid Integration Outlook
  - Absorbing such significant amounts of RE will bring with it a plethora of challenges and issues
  - Requirement for interventions across the value chain to streamline integration of variable RE into the grid
  - Focus areas: scheduling & forecasting, energy storage, ancillary services market, integrated resource planning, financial health of distribution utilities, project financing

[#]*Source: Central Electricity Authority*

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INDONESIA - Summary

- Power Sector
  - Indonesia is reorienting its energy production from serving primarily export markets to meeting its growing domestic consumption
  - Generation capacity of 50,989.6 MW[#] – only 12.85% based on non-fossil fuels
  - Current focus is on ramping up capacity (coal, combined-cycle, hydro and geothermal) to meet growing internal demand and expanding the grid to reach far-flung areas
- RE Plans, Policies and Deployment
  - Indonesia has rich geothermal resources (installed capacity of ~1,345 MW)
  - Good potential for solar but nascent market (only ~ 9 MW installed so far); wind is concentrated in eastern regions where evacuation is an issue
  - Plans to increase share of RE to 19% of total energy portfolio by 2019 and 25% by 2025 – major focus on geothermal and hydro (limited variability and uncertainty)
- VRE Grid Integration Outlook
  - 2014 National Energy Policy aims to achieve 100% electrification by 2020
    - Emphasis on centralized/communal solar power plants and small-scale and dispersed solar home systems
  - Early stage interventions required to facilitate development and integration of RE
    - Transmission network planning and grid interconnection studies, capacity building

[#]*Source: Handbook of Energy and Economic Statistics of Indonesia 2014*

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LAO PDR - Summary

- Power Sector
  - Primary sources of energy are wood, fuel oil and coal
  - Generation capacity of 2,954.5 MW[#] – entirely based on hydro
  - Country trades power with Viet Nam, China and Thailand
  - First thermal power (3x626 MW) plant under construction in Hongsa
  - Main focus areas are increased electricity access and hydropower development
- RE Plans, Policies and Deployment
  - No wind capacity; only 285 kWp of solar installed
  - Renewable Energy Development Strategy 2011 proposes development of mini-hydro and biomass based capacities
  - Less emphasis on solar and wind development due to lack of resource assessment data
- VRE Grid Integration Outlook
  - Technical assistance could be in the form of energy sector policy formulation, resource assessment and capacity building

**Source: The World Bank*

[#]Source: Department of Energy Business, Ministry of Energy and Mines, Lao DPR

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MALAYSIA - Summary

- Power Sector
  - Country is endowed with rich fossil fuel reserves – LNG, oil and natural gas
  - Generation capacity of 24,970 MW[#] – dominated by coal and natural gas
  - High per capita electricity consumption of 4,114 kWh (2013)[#] as compared to other SE Asian countries
  - Gas shortages in Peninsular Malaysia and growing electricity demand in recent years have spurred the use of other fuels such as coal, diesel, and renewable sources
- RE Plans, Policies and Deployment
  - Current capacity dominated by solar PV (~217 MW) and biomass (~68 MW)
  - Landmark regulation: Renewable Energy Act 2011
  - Less focus on grid-connected RE and more thrust on ramping up rooftop solar PV installed capacity due to limited availability of land
  - RE capacity targets of 2,080 MW by 2020, 4,000 MW by 2030 and 21.4 GW by 2050
- VRE Grid Integration Outlook
  - Technical assistance could be in the form of distribution network impact studies given Malaysia's aggressive rooftop solar PV capacity addition targets

**Source: The World Bank*

[#]Source: Malaysia Energy Statistics Handbook 2015

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NEPAL - Summary

- Power Sector
  - Underdeveloped power sector with low electrification rate and acute shortages during non-monsoon seasons
  - Generation capacity of 787,087 kW[#] – dominated by hydro
  - Extremely low per capita electricity consumption of 119 kWh (2012)[*]
  - Current priorities are to harness the vast hydropower resources in the country and to improve energy access in rural areas
- RE Plans, Policies and Deployment
  - National Energy Strategy 2010 envisions development of alternative energy technologies such as biogas, solar, wind, etc.
  - However, grid-connected RE projects do not feature in capacity expansion plans
  - Only limited small-scale solar applications; no utility scale wind or solar power
- VRE Grid Integration Outlook
  - Proposed capacity expansion plans focus only on enhancing hydro-based capacities
  - Small-scale and distributed RE (wind and solar) to play an important role in achieving electrification targets
  - Early stage interventions required to facilitate development and integration of RE
    - Transmission network planning and grid interconnection studies, capacity building, resource assessment

**Source: The World Bank*

[#]Source: Nepal Electricity Authority Annual Report 2014

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PAPUA NEW GUINEA - Summary

- Power Sector
  - Largely rudimentary power system with only 10% of population having access to electricity (extremely low per capita electricity consumption: 467.42 kWh* in 2012)
  - Generation capacity of 582 MW# – dominated by state-owned hydro power plants and captive diesel generators
  - Power sector infrastructure requires rehabilitation, extension of grids to urban areas and expansion of distributed generation to service rural communities
- RE Plans, Policies and Deployment
  - Solar thermal and photovoltaic applications are limited; wind energy is currently not being used, only pilot projects installed
  - 53 MW of geothermal power capacity installed on Lihir Island
  - Vision 2050 envisages 100% electricity access; share of renewables (including hydro) targeted at 25% by 2030
- VRE Grid Integration Outlook
  - Grid integration issues to gain importance as share of RE in 2030 capacity mix expected to be 25%
  - Early stage interventions required to facilitate development and integration of RE
    - Transmission network planning and grid interconnection studies, capacity building, resource assessment

**Source: The World Bank*

#Source: Analysis of Population and Total Energy Consumption Data for PNG (2012)

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PHILIPPINES - Summary

- Power Sector
  - Characterized by high tariffs and unreliable power supply in some areas
  - Generation capacity of 17,944 MW[#] – dominated by fossil fuels (coal, oil and natural gas), although significant contribution of RE to electricity generation in regional grids
  - Energy independence and market reforms are the main strategic focuses of the government's energy development plan
- RE Plans, Policies and Deployment
  - Potential for renewable energy is high, although only small investments have yet taken place for its development
  - 372 MW of wind and 105 MW of solar installed so far
  - Target to triple RE installed capacity by 2030 to ~ 15 GW (~3.4 GW geothermal, ~8.7 GW hydro and ~2.4 GW wind)
- VRE Grid Integration Outlook
  - Significant wind power capacity addition plans in Luzon region likely to present multiple grid integration challenges
    - Evacuation issues already being faced in some areas
  - Wind resource assessment has been carried out by NREL
  - Technical assistance could be in the form of transmission network planning and grid interconnection studies (to prevent wind curtailments in the future), capacity building

**Source: The World Bank*

[#]Source: Philippines Power Statistics 2014

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THAILAND - Summary

- Power Sector
  - Heavily reliant on fossil fuels (coal and gas) for electricity generation
  - Multi-tier structure with state-owned enterprise EGAT and large and small IPPs
  - Generation capacity of 7,366.95 MW[#] (EGAT's share ~41%)
  - Emphasis on diversifying the energy mix for greater energy security and to reduce dependence on fossil fuels (esp. imported oil)
- RE Plans, Policies and Deployment
  - Current RE based dominated by biomass (~2.4 GW) and solar (~960 MW)
  - Power Development Plan proposes significant variable RE capacity additions; thrust on harnessing huge solar and biomass potentials in the country (solar – 2 GW, wind - 1.8 GW)
- VRE Grid Integration Outlook
  - Capacity expansion plans would give rise to various grid integration related issues
    - Solar power evacuation issues being faced in northern Thailand due to transmission constraints
  - Technical assistance could be in the form of transmission network planning and grid interconnection studies, capacity building

**Source: The World Bank*

[#]Source: Electricity Generating Authority of Thailand (EGAT)

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Viet Nam - Summary

- Power Sector
  - Characterized by rapid demand growth, which has consistently surpassed GDP growth rate
  - Generation capacity of 33,802 MW[#] – traditionally dominated by hydro, increasing share of coal and gas in the last decade
  - Frequent power failures occur during dry season and times of peak demand due to insufficient backup generation capacity and weak T&D network
  - Coal and gas seen as the primary energy sources of the future
- RE Plans, Policies and Deployment
  - Except for hydropower, markets for renewable energies such as wind and solar power are in early stages of development
  - Current installed capacities: 52 MW of wind and ~4 MW of solar
  - National Power Development Master Plan proposes significant RE capacity additions by 2030, although their overall share in generation capacity would be low (4-5%)
    - Renewable Energy projected to grow from 1,670 MW to 5,196 MW by 2030
- VRE Grid Integration Outlook
  - Capacity expansion plans would give rise to various grid integration related issues
  - Technical assistance could be in the form of transmission network planning and grid interconnection studies, balancing requirement assessment, capacity building

**Source: The World Bank*

[#]Source: Operation Report Year 2014, National Despatch Centre

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SECTION 2: APPENDIX

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BANGLADESH

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BANGLADESH – Summary

- Macroeconomic Overview
  - GDP current: $173.8 billion (2014)*
  - Population: 159.1 million (2014)*
  - Land area: 147,500 km^2
  - CO_2 emissions: 0.4 metric tons per capita (2011)*
- Power Sector
  - Natural gas, solid biomass and waste dominate Bangladesh's primary energy consumption followed by coal, oil and hydro
  - Generation Capacity: 11,877 MW# – dominated by gas and liquid fuels (HFO and HSD)
- VRE Grid Integration Outlook
  - Bangladesh is keen to diversify its fuel mix by introducing more coal and gas/LNG based capacities
  - Renewable energy development in the country is still in its nascent stages
  - Power System Master Plan proposes RE capacity additions of 2,000 MW by 2030 but their share would only be ~6% of the total installed capacity

**Source: The World Bank*
#Source: Bangladesh Power Development Board Annual Report 2013-14

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Bangladesh – Energy Scenario Highlights

- Petroleum and other liquids
  - Bangladesh is a net importer of crude oil and other liquids
  - Oil consumption has been increasing after 2010 to make up for shortages in natural gas esp. in the power sector
- Natural gas
  - 8th largest producer in the Asia-Pacific region (all of it consumed domestically)
  - Production from onshore fields expected to plateau in the near-term; country plans to launch offshore exploration activities
  - Bangladesh is building an offshore LNG terminal and prioritizing natural gas imports to relieve gas shortage issues
- Electricity
  - Electricity generation has steadily increased over the last decade to meet the growing demand, straining the grid in the process
  - Bangladesh plans to diversify its fuel mix to reduce dependence on gas and for greater energy security
- Nuclear
  - Safe technology; expected to be future base load option

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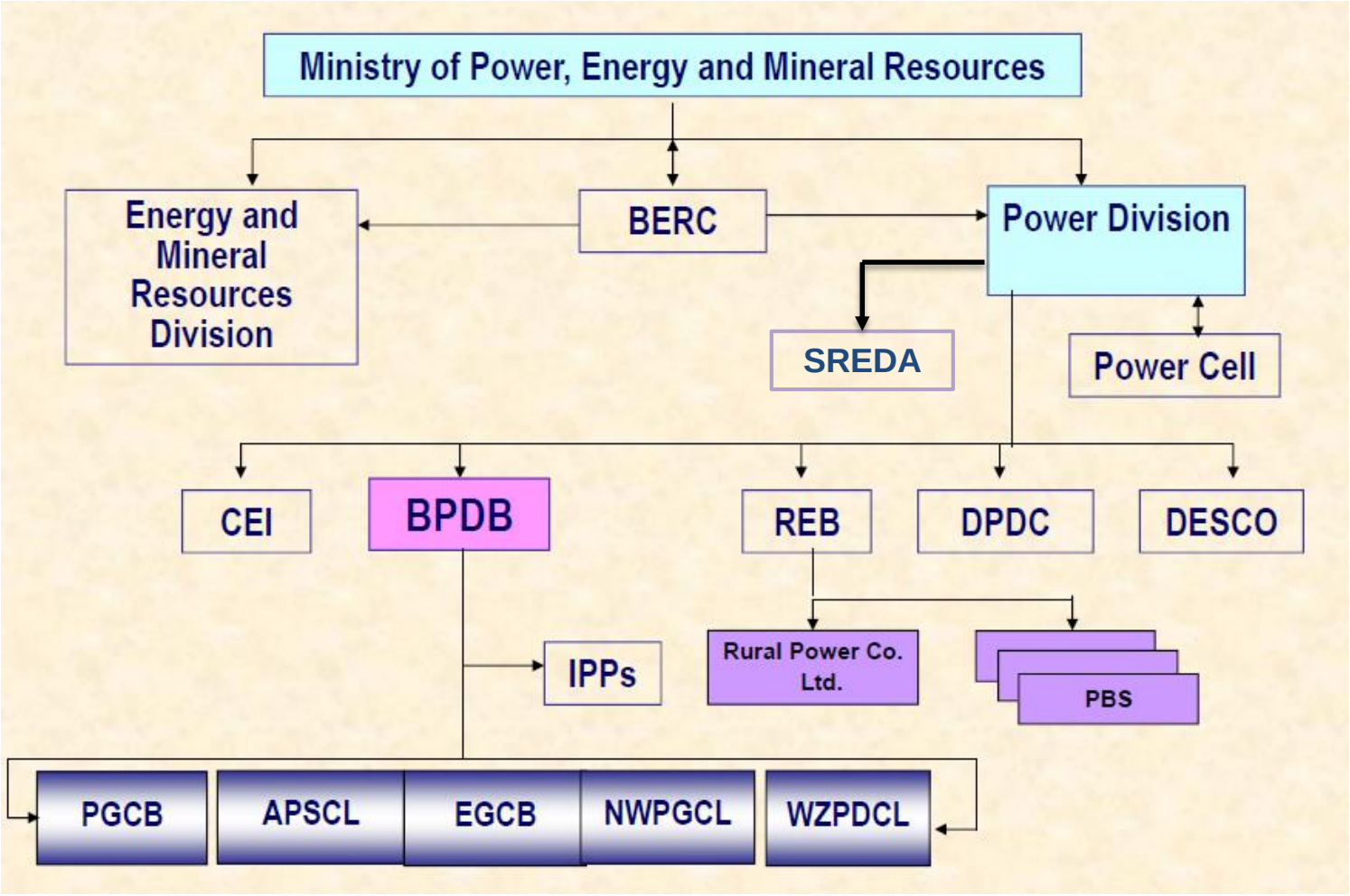
Bangladesh – Power Sector Structure



BERC – Bangladesh Energy Regulatory Commission, CEI – Chief Electrical Inspector, BPDB – Bangladesh Power Development Board, REB – Rural Electrification Board, DPDC – Dhaka Power Distribution Company, DESCO – Dhaka Electricity Supply Company, PGCB – Power Grid Company of Bangladesh Limited, APSCL – Ashuganj Power Station Company Limited, EGCB – Electricity Generation Company of Bangladesh, NWPGCL – North West Power Generation Company Limited, WZPDCL – West Zone Power Distribution Company Limited, SREDA – Sustainable and Renewable Energy Development Authority of Bangladesh

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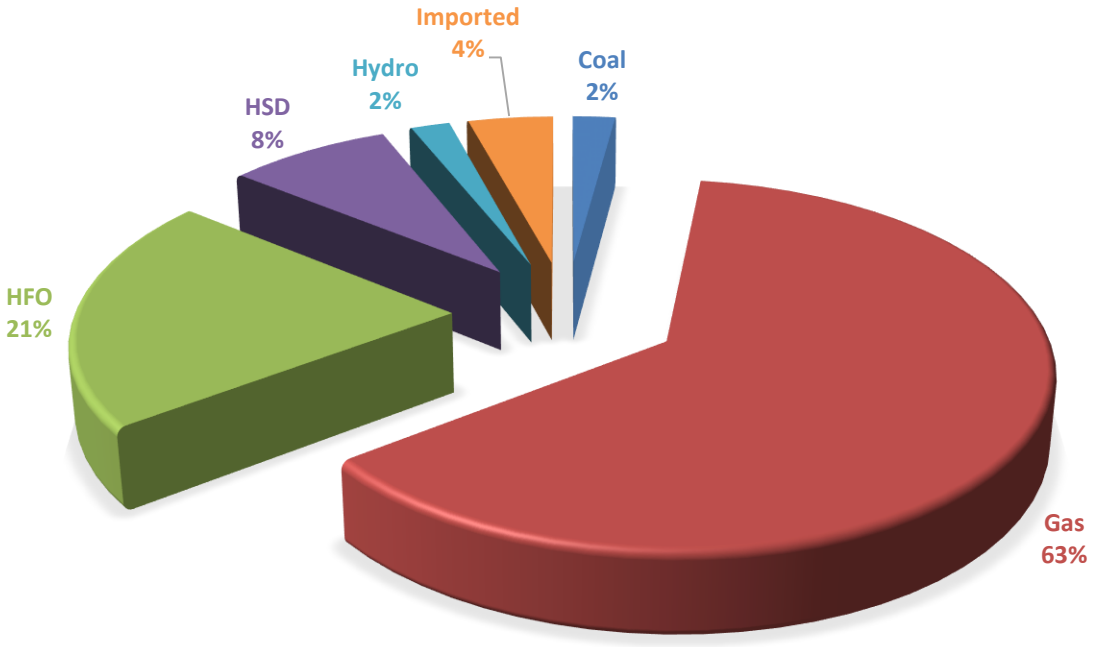
Bangladesh – Overall Generation Capacity Mix

As on November 2015



Sector	Installed Capacity (MW)
Coal	250
Gas	7,434
Heavy Furnace Oil (HFO)	2,507
High Speed Diesel (HSD)	956
Hydro	230
Imported	500
Total	**11,877**

Source: Bangladesh Power Development Board

- Historically, rich reserves and an easy availability has resulted in Bangladesh being heavily reliant on natural gas and liquid fuels for its power production
- Recent shortages in supply of natural gas have resulted in frequent blackouts
- Country also imports power from neighboring Bhutan and India

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Bangladesh – RE Capacity Mix

- Marginal wind and solar capacities in the country
  - Wind: Only pilot projects; close to 2 MW
  - Solar: Mostly in the form of rooftop PV and small-scale applications such as pumps, refrigerators, water heaters, etc.

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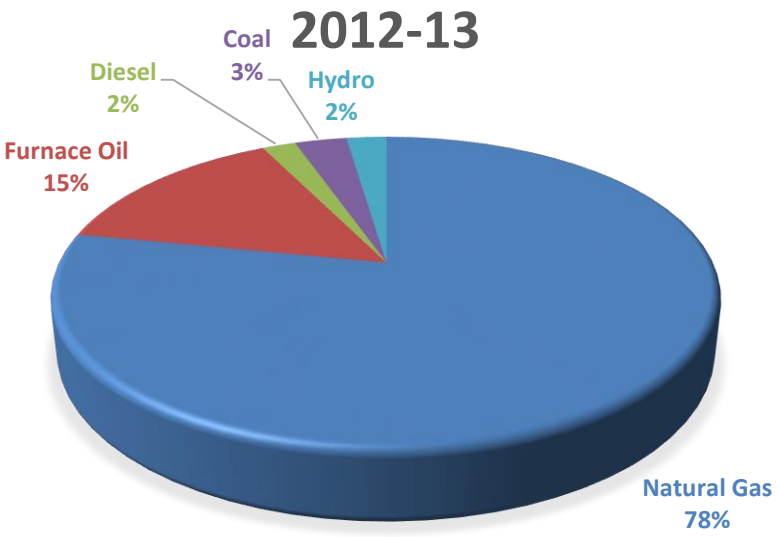
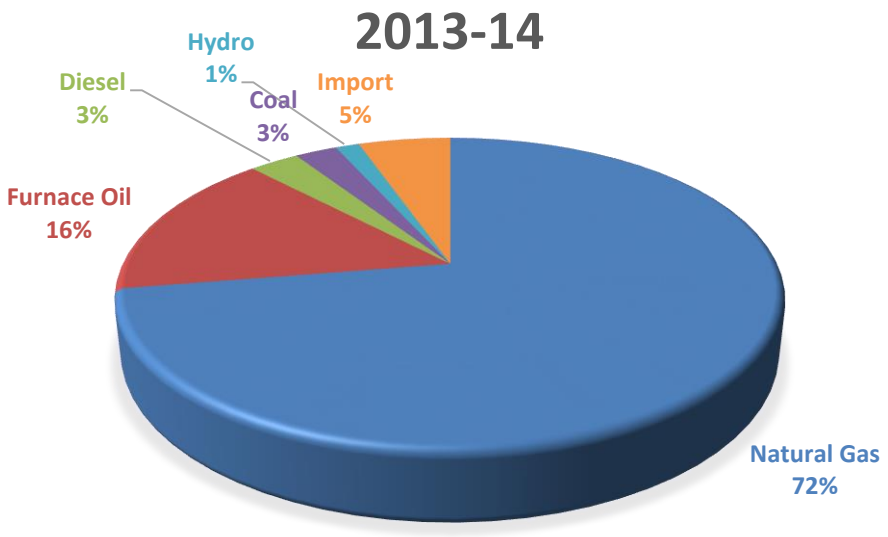
Bangladesh – Electricity Generation Mix

Total Generation: 38,229 million kWh



Total Generation: 42,195 million kWh



- Bangladesh has started importing power from India after completion of 500 MW Baharampur-Bheramara cross-border power transmission link
  - Capacity proposed to be increased to 1,000 MW by 2018

Source: Bangladesh Power Development Board Annual Report 2013-14

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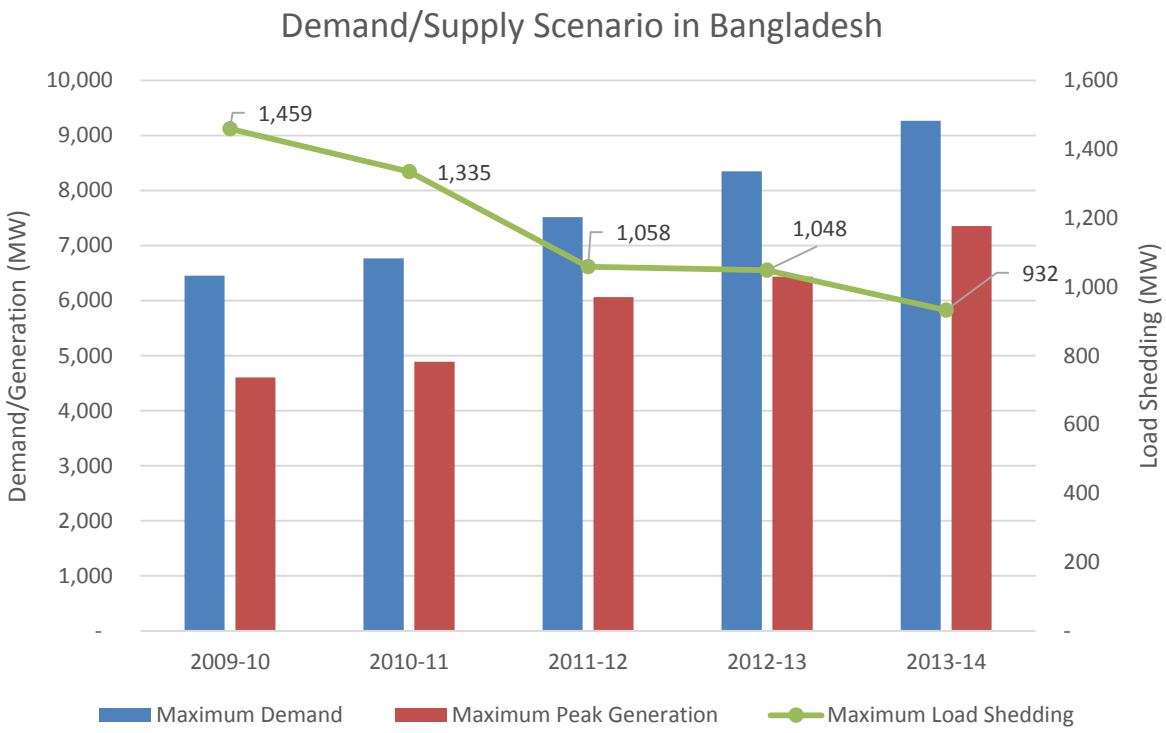
Bangladesh – Demand/Supply Situation



Source: Bangladesh Power Development Board Annual Report 2013-14

- Although load shedding has declined over the years, still large parts of the country remain underserved
- Primarily a result of fuel shortages and inadequate capacity

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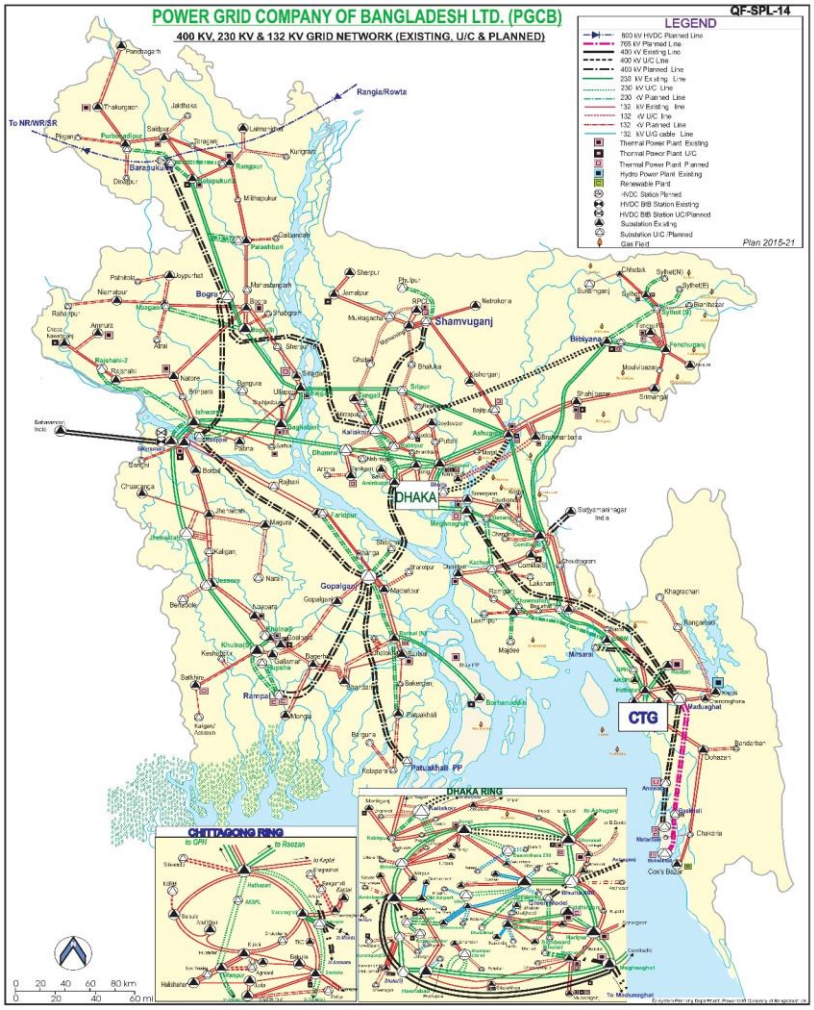
Bangladesh – Transmission Infrastructure

- Vastly underdeveloped and outdated transmission and distribution infrastructure coupled with inadequate generation capacity results in severe power shortages in Bangladesh
  - Country was plunged into a nationwide blackout on 5th November, 2014 after failure of transmission link with India
  - BPDB reported 94 incidents of power failure in FY 2014 with a total duration of 21 hours and 19 minutes
  - More than a third of the population still has no access to electricity
  - Cost of supply interruptions to the economy is estimated to be around 0.5% of annual GDP (~870 million USD)
  - Shortages affecting people's quality of life and crippling businesses activities
- Several high-voltage transmission lines and substations are being constructed as per the Power System Master Plan



Source: Power Grid Company of Bangladesh
http://www.pgcb.org.bd/PGCB/?a=pages/geo-map.php

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Bangladesh – Energy Strategy

- Guiding document: Power System Master Plan 2010
- Key objectives:
  - To maintain domestic primary energy supply over 50%
  - To diversify fuel portfolio of power system (proposed fuel composition ratio as of 2030: coal 50%, natural gas 25%, others 25%)
    - Construction of imported coal and gas fired power stations
    - Introduction of LNG facilities
    - Increased import of hydro power from neighboring countries
    - Development of domestic renewable energy
  - To realize a low carbon society by introducing a high efficient power supply and low CO_2 emission technology
- Renewable Energy Policy 2008
  - Envisions that 5% of total energy production will have to be achieved from renewables by 2015 and 10% by 2020

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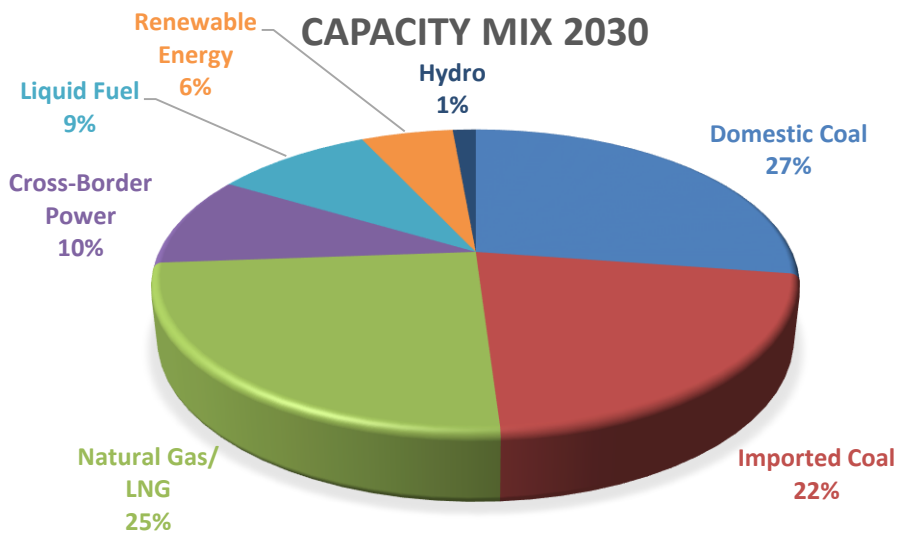
Bangladesh – Capacity Addition Plans



- Bangladesh is keen to diversify its energy mix and reduce dependence on gas and liquid fuels
  - Focus on enhancing coal (domestic as well as imported) based capacity
- 500 MW Solar Power Mission has been recently launched to promote distributed and as well as grid-connected solar capacity additions
- 3 MW grid connected solar PV plant being implemented at Sharishabari, Jamalpur on BOOT basis
- BPDB has planned to implement 50-200 MW wind power at Parky Beach area, Anawara, Chittagong on IPP basis

Sector	Proposed Capacity by 2030 (MW)
Domestic Coal	9,850
Imported Coal	7,800
Natural Gas/LNG	8,956
Cross-Border Power	3,500
Liquid Fuel	3,428
Renewable Energy	2,000
Hydro	500
Total	**36,034**

Source: Bangladesh Power System Master Plan 2010

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Bangladesh – RE Potential

- Solar
  - Implemented projects are mostly either in the form of rooftop installations or solar energy-based applications (pumps, street lights, refrigerators, etc.)
  - Several utility-scale power plants are in the pipeline under the '*500 MW Solar Power Mission*'
  - Total solar power potential not known; monthly averaged daily solar radiation varies from 3.2 – 6.1 kWh/m^2 per day[1]
- Wind
  - Potential limited to coastal areas, off-shore islands, river sides and other inland open areas
  - Total installed capacity is close to 2 MW only
    - 4x225 kW wind plant in Muhuri Dam area of Sonagazi and 50x20 kW wind-battery hybrid plant at Kutubdia Island[2]
    - Steps are being taken to install 15 MW capacity across the coastal regions of Bangladesh
    - 60 MW project in Cox's Bazar and 100 MW project in Anawara, Chittagong are being implemented on IPP basis
  - Overall realizable wind power potential is yet to be determined
    - 19 potential sites have been identified and wind monitoring stations are being installed for resource assessment

[1]http://www.hindawi.com/journals/isrn/2012/401761/

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CAMBODIA

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CAMBODIA – Summary

- Macroeconomic Overview
  - GDP current: $16.71 billion (2014)*
  - Population: 15.33 million (2014)*
  - Land area: 181,035 km^2
  - CO_2 emissions: 0.3 metric tons per capita (2011)*
- Power Sector
  - Low level of electricity access in the country; generation and capacity mixes dominated by hydro power, coal and liquid fuels (diesel and FO)
  - Generation Capacity: 1,511.34 MW# (December, 2014)
- VRE Grid Integration Outlook
  - Capacity addition plans are mostly focused on harnessing the vast hydro potential of the country and setting up some coal-based capacities
  - Development of grid-connected renewable energy development not a priority in the near-term
    - However, RE is expected to play a critical role in achieving target of 100% electricity access

**Source: The World Bank*

#Source: Report on Power Sector of Kingdom of Cambodia 2015 Edition, Electricity Authority of Cambodia

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Cambodia – Energy Scenario Highlights

- Cambodia is primarily an agrarian economy with 85% of the population living in rural areas and engaged in agricultural activities
  - For heating, majority of households use fuel-wood, charcoal and agricultural residues and for electricity they use old car batteries and kerosene light bulbs
- Until 2008, Cambodia was heavily dependent on imported diesel/fuel oil for its electricity generation
  - Since 2009, it has started importing greater volumes of power from Lao PDR, Thailand and Viet Nam after upgrading its cross-border transmission links and has also ramped up its hydro-based capacity
- Oil and Gas
  - Oil reserves have been found off the shores of Cambodia and preliminary exploration activities have begun
- Coal
  - Reserves identified and three units under construction in Sihanoukville
- RE
  - Biomass gasification and distributed solar PV likely to contribute to improving energy access in rural areas; potential of biogas and biofuels has also been demonstrated through pilots
  - Little potential for wind and geothermal energy; lack of experience in setting up grid-connected solar plants despite strong potential

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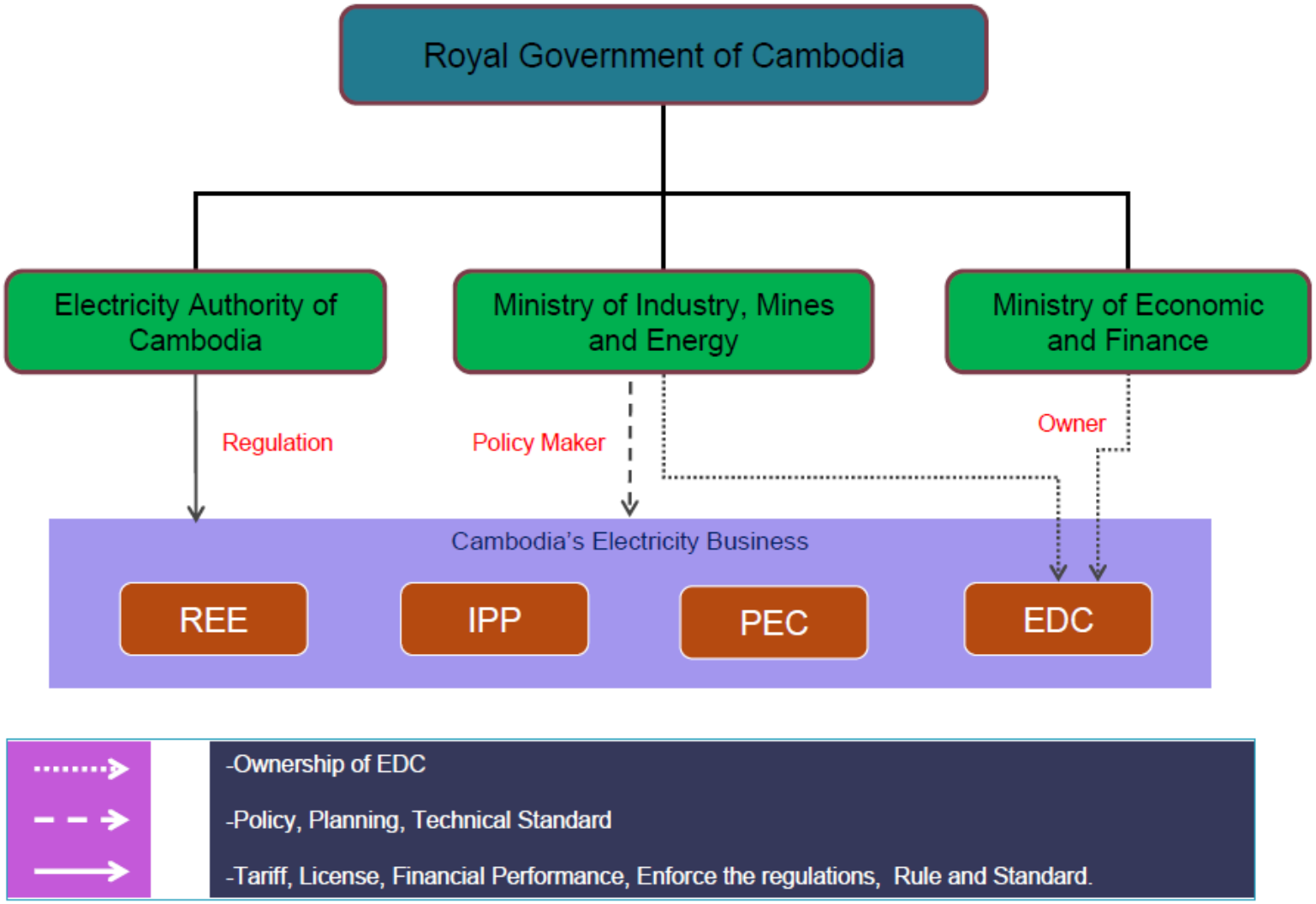
Cambodia – Power Sector Structure



EDC - Electricité du Cambodge, REE – Rural Electricity Enterprises, PEC – Provincial Electricity Company

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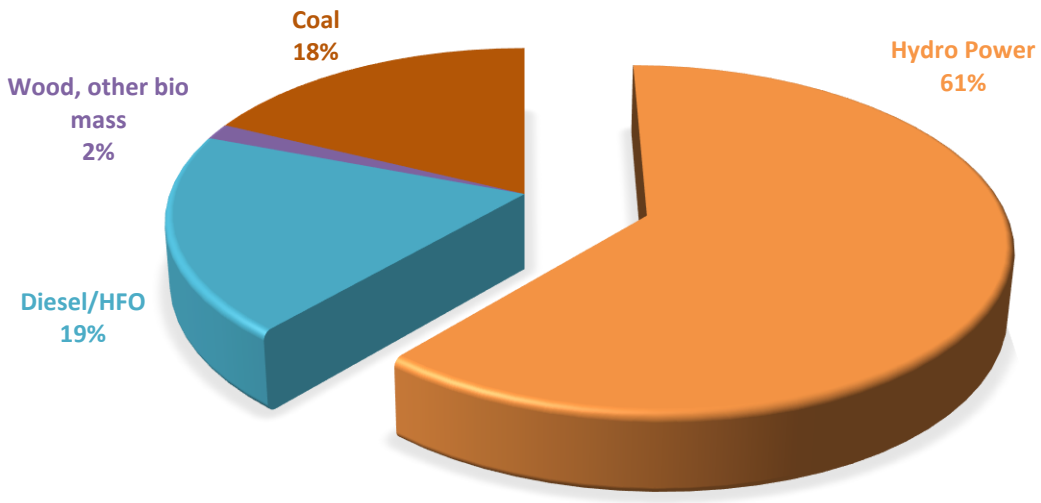
Cambodia – Overall Generation Capacity Mix

Total Capacity as on 31st December, 2014 – 1,511 MW



Sector	Installed Capacity (kW)
Hydro Power	929,430
Diesel/FHO	291,268
Wood, other biomass	22,640
Coal	268,000
Total	**1,511,338**

Source: Report on Power Sector of Kingdom of Cambodia 2015 Edition, Electricity Authority of Cambodia

- Cambodia has significantly increased its hydro generation capacity over the last few years to reduce its dependence on imports and diesel/furnace oil
- Efforts underway to tap extensive hydropower potential in the country (>10,000 MW)

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Cambodia – RE Capacity Mix

- Solar
  - Only about 2 MWp had been installed as of 2012
  - Mainly driven by donor-funded pilot projects (World Bank, JICA, UNIDO, KOICA, etc.)
  - Solar energy market is emerging; about 20 companies have started importing and selling solar power products
- Wind
  - Deployment of wind energy is in the early stages
  - Only one pilot has been implemented so far (Preah Sihanouk province in 2010)
    - Co-funded by Cambodia's Sihanoukville Port Authority (48%), Belgium (28%) and EU (24%)
  - Investments in the wind sector have been scarce due to lack of:
    - Policy directives and incentive schemes
    - Evacuation infrastructure and access to nearby grid

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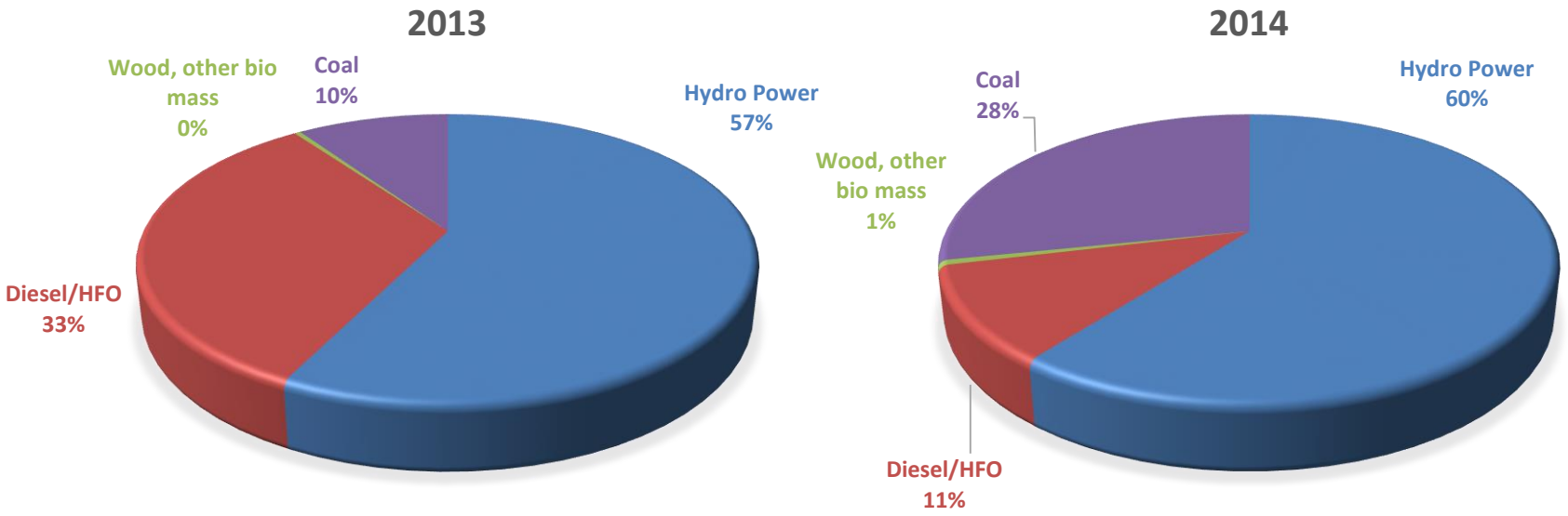
Cambodia – Electricity Generation Mix



Total Generation: 1,769.96 million kWh

Total Generation: 3,058.36 million kWh

- Almost ~73% increase in generation in 2014 from 2013 primarily due to ramping up of hydro power (246 MW) and coal-based (135 MW) capacity
- Reduction in consumption of diesel/HFO

Source: Report on Power Sector of Kingdom of Cambodia 2015 Edition, Electricity Authority of Cambodia

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Cambodia – Demand/Supply Situation

- Cambodia experiences recurring power cuts due to several reasons:
  - Mismatch between rate of growth in demand and generation capacity; long gestation period of power projects
  - Limited imports from neighboring countries
    - Viet Nam has been forced to curtail its exports to Cambodia due to its own internal shortages
    - Imports from Thailand have been affected by technical constraints in the transmission line b/w the two countries
- Government is raising generation from hydropower plants and encouraging hotels, guesthouses and other commercial establishments to switch to diesel power during times of peak demand to curb power outages
  - Results in higher GHG emissions
- Data on supply/demand unavailable

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Cambodia – Transmission Infrastructure

- Cambodia's power sector was severely damaged during long periods of conflict and civil war
  - Rate of household electrification is amongst the lowest in SE Asia
- Since 2005, a primary focus of Cambodia's power sector development has been to build high-voltage transmission lines to connect the various isolated systems that supply most provincial towns
  - By 2012, four high-voltage lines totaling 505.95 km were in operation
  - Development of three distinct grid systems in the southern, eastern and northeastern economic zones and several high-voltage lines is progressing
- Grid system comprising of high-voltage lines and substations is termed as the "National Grid"
  - National Grid imports electricity from Viet Nam and Thailand during dry season
  - The two systems are not operated in parallel, hence Cambodia imports power from these countries at different times

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Cambodia – Energy Strategy

- Power Sector Strategy (1999-2016)
  - To provide an adequate supply of energy throughout Cambodia at a reasonable and affordable price, which facilitates investment in Cambodia and development of national economy
  - To encourage exploration and environmentally and socially acceptable development of energy resources needed for supply to all sectors of the economy
  - To encourage the efficient use of energy and to minimize the detrimental environmental effects resulting from energy supply and consumption
- Rural Electrification by Renewable Energy Policy
  - 100% electrification in rural areas by 2020
  - 70% of rural households have access to quality electricity services by 2030
  - Emphasis on distributed solar and biomass

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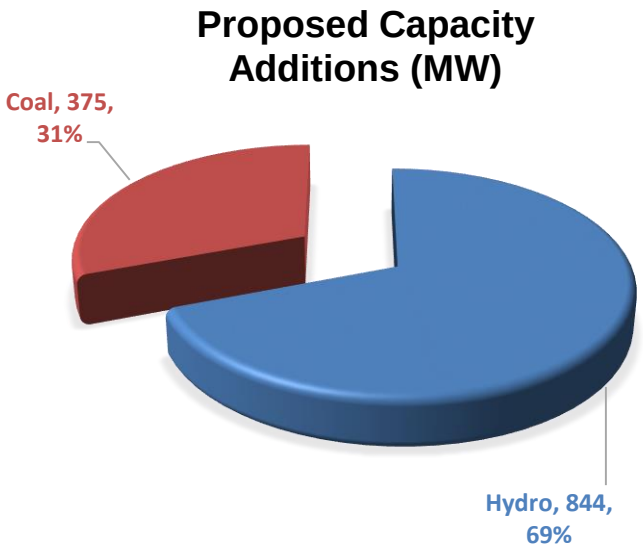
Cambodia – Capacity Addition Plans

Plant Name	Type	Capacity
Stung Tatay Hydroelectric Project	Hydro	3 x 82 MW
Sihanoukville	Coal	2 x 120 MW
Sihanoukville	Coal	1 x 135 MW
Sesan Hydroelectric Project	Hydro	5 x 80 MW
Stung Cheay Areng Hydroelectric Project	Hydro	3 x 36 MW
Prek Laang Hydroelectric Project	Hydro	1 x 90 MW



Source: Report on Power Sector of Kingdom of Cambodia 2015 Edition, Electricity Authority of Cambodia

- Cambodia is keen to tap into its vast hydropower resources
- Despite having rich RE resources, capacity additions have been hindered due to lack of experience and funds and inadequate resource assessment data
  - Situation is expected to improve after the implementation of Renewable Energy Action Plan

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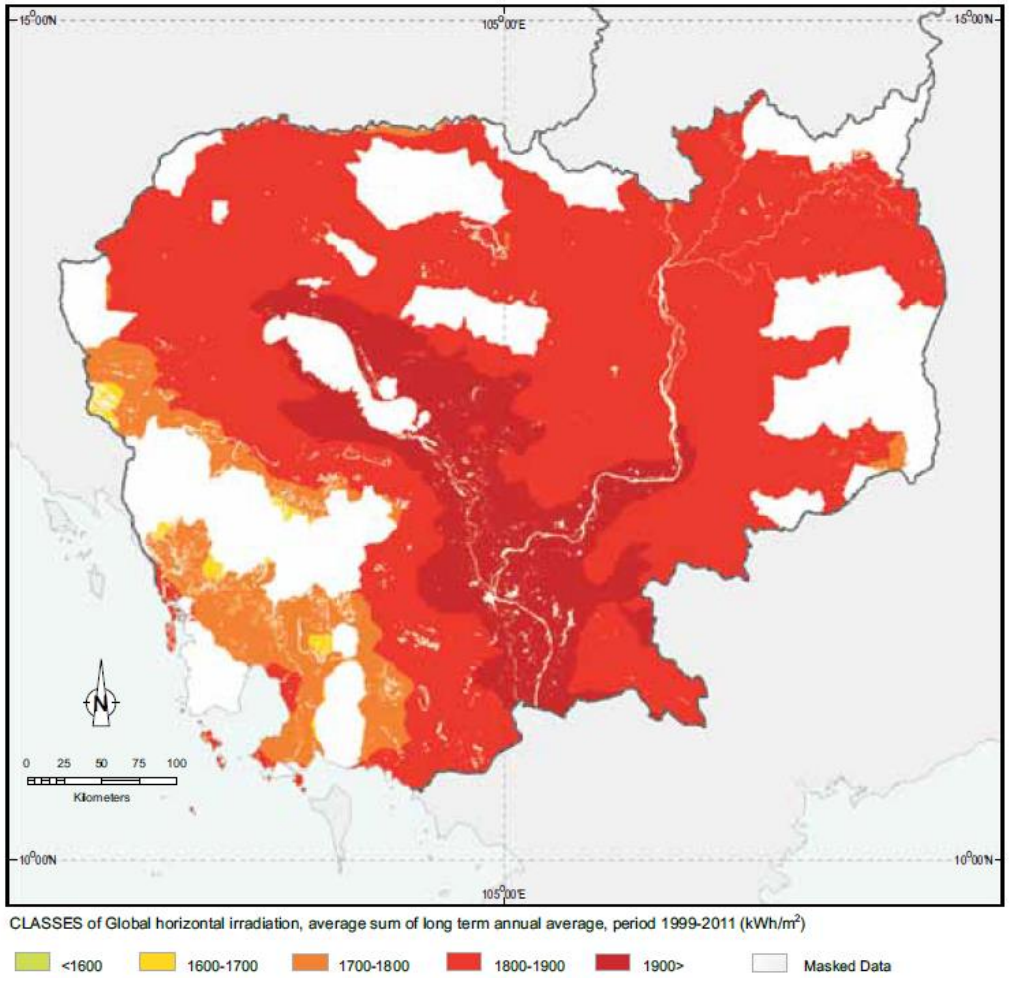
Cambodia – RE Potential

- Solar
  - Cambodia has rich solar resources
  - Total potential estimated to be 8,074 MWp
  - As of 2012, only 2 MWp realized
- Wind
  - Technical potential estimated to be 18 MW at the lower limit (5% of grid capacity) or 72 MW at the upper limit (20% of grid capacity)
  - So far, only a single wind turbine has been pilot-tested in Sihanoukville
  - Wind energy potential limited by lack of adequate wind and weakness of the grid
    - Only 3% of the country's land area has wind speeds higher than 6 m/s

Solar Resource Map of Cambodia



Source: Renewable Energy Developments and Potential in the Greater Mekong Region

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INDIA

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INDIA - Summary

- Macroeconomic Overview
  - GDP current: $2.067 trillion (2014)*
  - Population: 1.295 billion (2014)*
  - Land area: 2,973,190 km^2
  - CO_2 emissions: 1.7 metric tons per capita (2011)*
- Power Sector
  - Has grown steadily (CAGR ~8%) as a result of the country's dynamic economic growth and modernization over the past decade
  - Energy access still remains a challenge for a large percentage of the population
  - Generation Capacity: 280,329 MW# – dominated by coal and hydro, with increasing share of RE in recent years
- VRE Grid Integration Outlook
  - India has announced aggressive RE capacity addition targets (100 GW of solar and 60 GW of wind by 2022)
  - Absorbing such significant amounts of RE will bring with it a plethora of challenges and issues
  - Requirement for interventions across the value chain to streamline integration of variable RE into the grid

**Source: The World Bank*
#Source: Central Electricity Authority

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India – Energy Scenario Highlights

- India was the fourth-largest energy consumer in the world in 2011 after China, United States and Russia
- India has become increasingly dependent on imported fossil fuels despite having large coal reserves and a healthy growth in natural gas production
- India's National Sample Survey Organization estimates that about 25% of the population (over 300 million people) lack basic access to electricity, while electrified areas suffer from rolling electricity blackouts
  - Last mile connectivity considered to be the biggest challenge in providing universal energy access
  - Investment in transmission & distribution networks discouraged by low revenue collections from rural consumers on account of highly subsidized tariffs
- Demand is expected to grow steadily as more and more people migrate to the cities and urban households shift away from traditional biomass and waste to other energy sources such as hydrocarbons, nuclear, biofuels and renewables
- Current administration seeks to balance the country's growing need for electricity with environmental concerns from the use of coal and other energy sources to produce electricity

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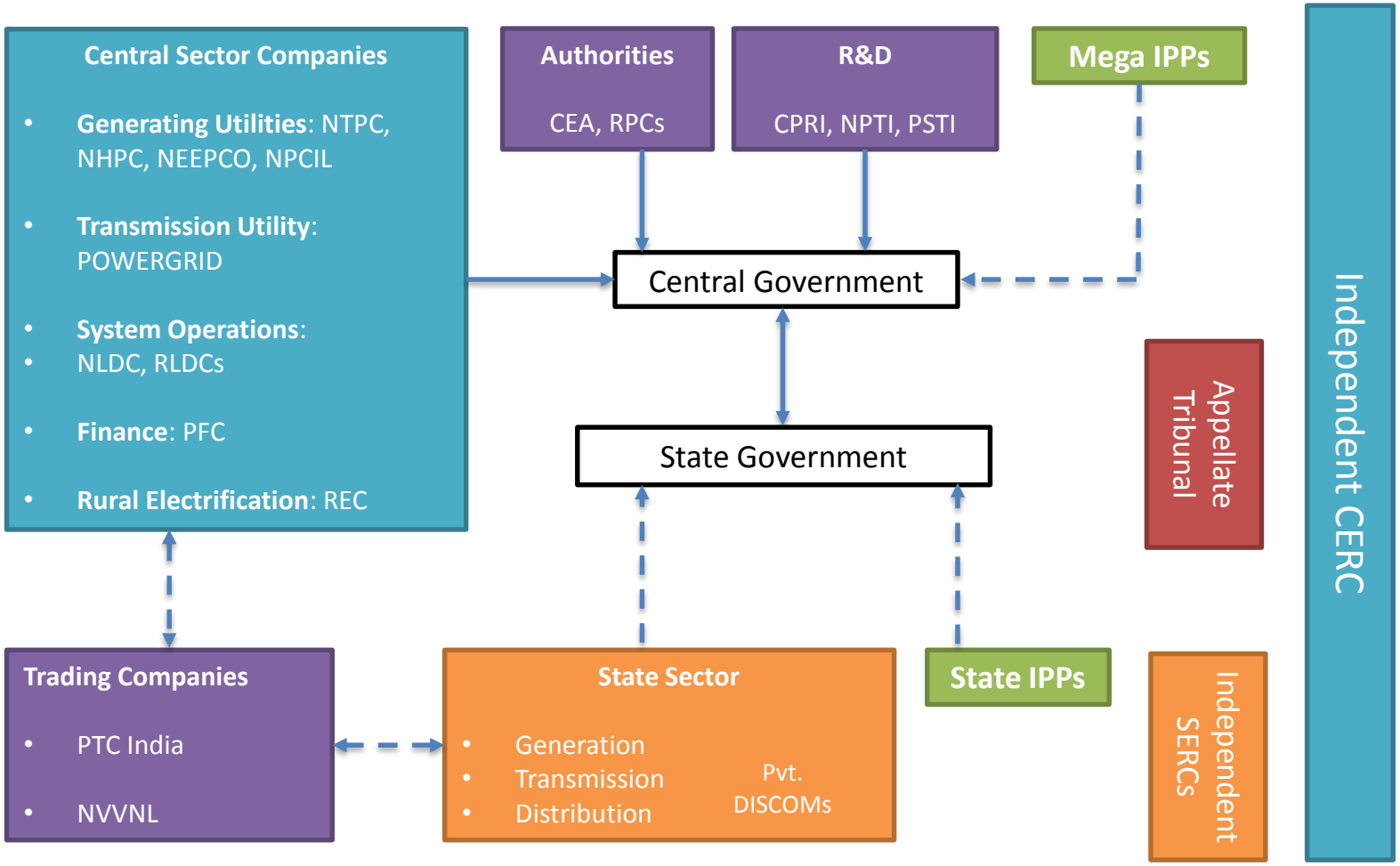
India – Power Sector Structure

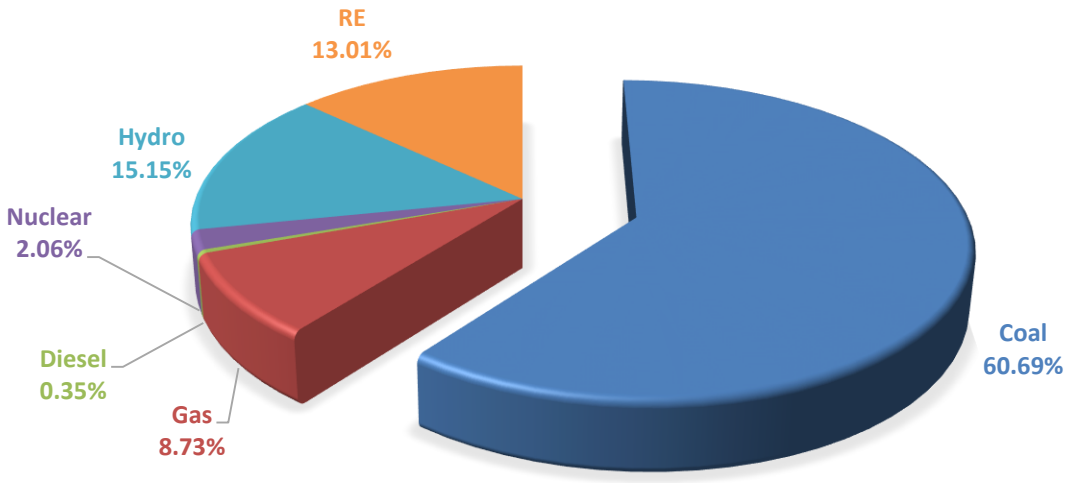


Source: Indian Power Sector Overview (http://www.sari-energy.org/pagefiles/what_we_do/activities/energy_exchange_market_program-bangladesh_july-2009/IEX_Indian_Power_Sector_overview-130709.pdf)

NTPC – National Thermal Power Corporation, NHPC – National Hydroelectric Power Corporation, NEEPCO – North Eastern Electric Power Corporation, NPCIL – Nuclear Power Corporation of India Limited, NLDC – National Load Despatch Center, RLDC – Regional Load Despatch Center, PFC – Power Finance Corporation, REC – Rural Electrification Corporation, PTC – Power Trading Corporation, NVVNL – NTPC Vidyut Vyapar Nigam Limited, CEA – Central Electricity Authority, RPC – Regional Power Committee, CPRI – Central Power Research Institute, NPTI – National Power Training Institute, PSTI – Power Systems Training Institute, CERC – Central Electricity Regulatory Commission, SERC – State Electricity Regulatory Commission, DISCOM – Distribution Company, IPP – Independent Power Producer

India – Overall Generation Capacity Mix

Total Capacity as on 31st October, 2015 – 280,329 MW



Sector	Generation Capacity (MW)
Coal	170,138
Gas	24,473
Diesel	994
Nuclear	5,780
Hydro	42,473
RE	36,471
Total	**280,329**

Source: Central Electricity Authority

- India is the 4th largest power system in the world after the United States, China and Russia
- Capacity has been traditionally dominated by coal and hydro and more recently, renewable energy sources

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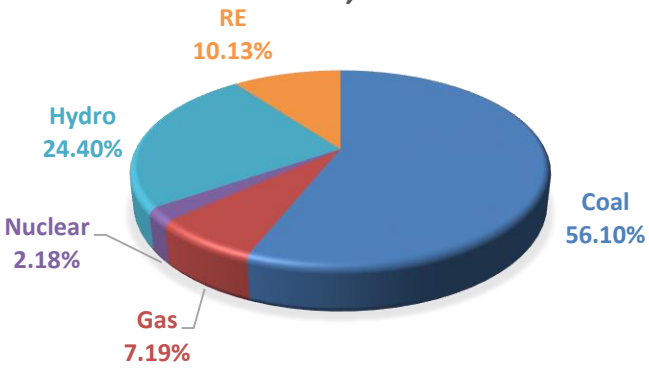
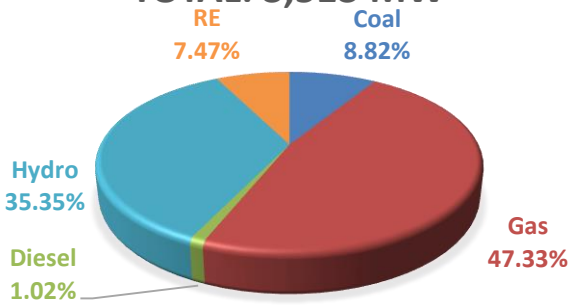
India – Zone-wise Installed Capacity

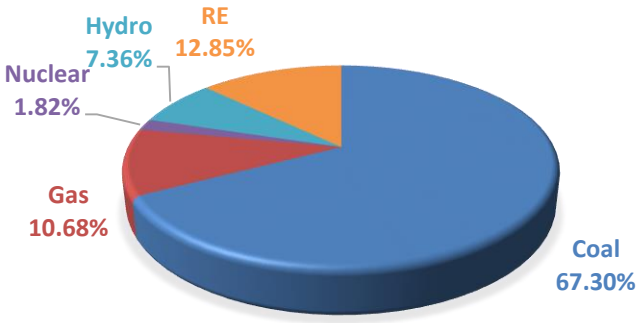
NORTHERN REGION
TOTAL: 74,163 MW



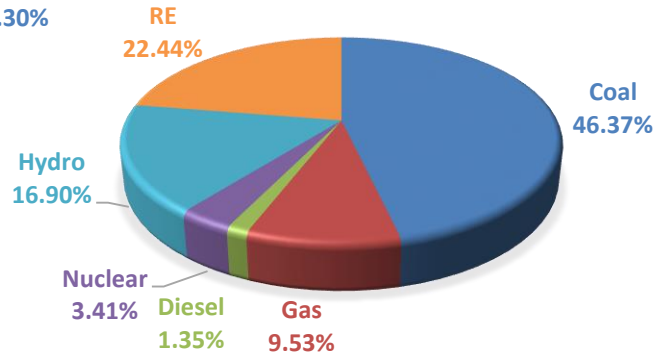
NORTHEASTERN REGION
TOTAL: 3,513 MW



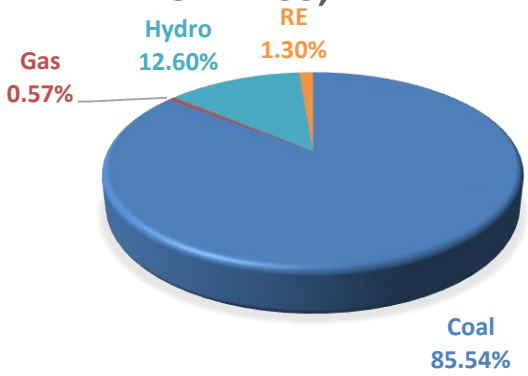
WESTERN REGION
TOTAL: 101,248 MW



SOUTHERN REGION
TOTAL: 67,937 MW



EASTERN REGION
TOTAL: 33,417 MW



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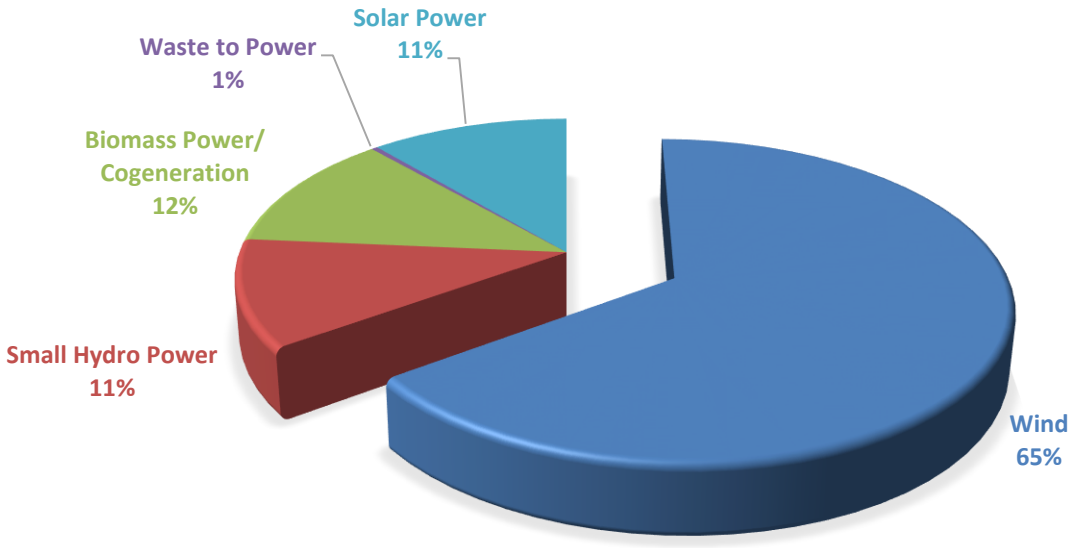
India – RE Capacity Mix

Total Capacity as on 31st October, 2015 – 36, 471 MW



Sector	Generation Capacity (MW)
Wind	23,763
Small Hydro Power	4,102
Biomass Power/Cogeneration	4,419
Waste to Power	127
Solar Power	4,061
Total	**36,471**

Source: Central Electricity Authority

- RE capacity has been historically dominated by wind
- Recently, the focus has shifted towards solar energy with the announcement of unprecedented capacity addition targets – 100 GW by 2022 (40 GW distributed and 60 GW grid-connected)
  - Target to add another 60 GW of wind by 2022
- Significant untapped potential of both wind and solar energy

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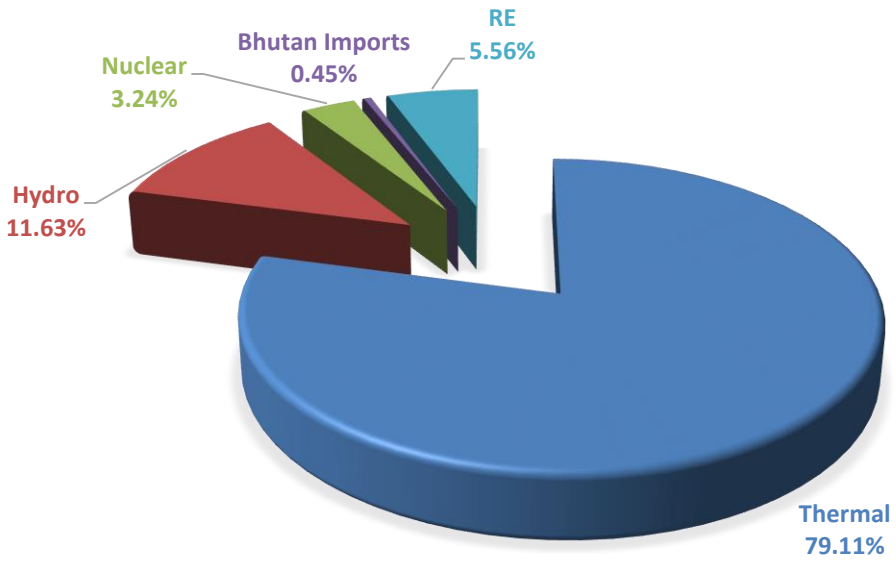
India – Electricity Generation Mix

Total generation was ~ 1.1 trillion kWh in 2014-15



Sector	Generation (10^6 kWh)
Thermal	878,320.83
Hydro	129,111.14
Nuclear	359,73.15
RE	61,780.801
Bhutan Imports	4,997.39
Total	**1,110,183.31**

Source: Central Electricity Authority

- Thermal consists of coal, gas and diesel
  - Generation of gas plants has declined in recent times due to unavailability of gas
- India imports hydro power from Bhutan during monsoon season
- Renewables contribute only ~5.6% to electricity (as compared to ~13% of capacity) generation on account of their low capacity factors

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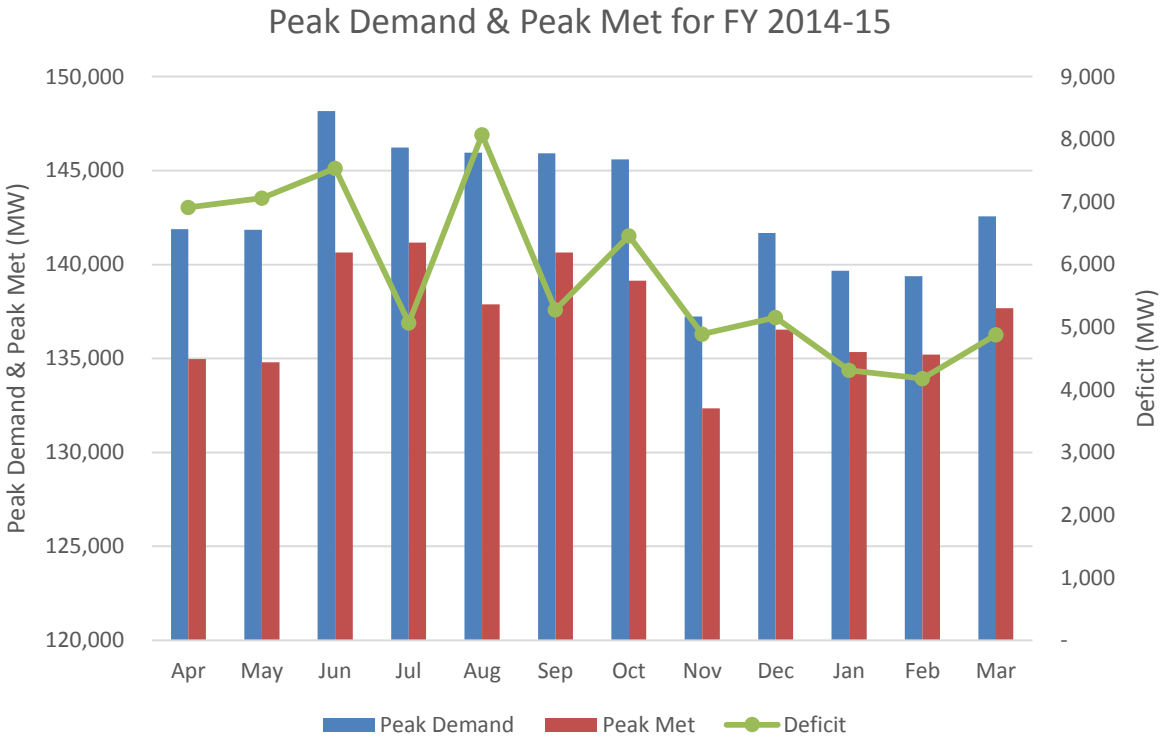
India – Demand/Supply Situation



Source: Central Electricity Authority

- Maximum deficits experienced in northern and southern regions due to inadequacy of T&D infrastructure and generation capacity
- Seasonal variation in supply and demand with peak deficits during summer
- Similar trends observed in previous years, although peak deficit has declined owing to generation capacity additions

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India – Transmission Infrastructure

- Despite having an installed capacity of ~243-258 GW and peak demand of ~148 GW during FY 2014-15 (ending March 31st, 2015), peak demand deficit was still around 6%
  - Transmission capacity not sufficient to evacuate power to regions facing shortages
  - Several instances of wind curtailment reported in the wind-rich state of Tamil Nadu
- Primarily because investments in T&D infrastructure have not kept pace with growth in generation capacity
- Projects have been delayed due to difficulties in acquiring land and obtaining necessary clearances
- Increased focus on ramping up transmission infrastructure through various programs:
  - Green Corridors Program
  - Integrated Power Development Scheme
  - Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)

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India – Energy Strategy

- Focus on rural electrification
  - 24x7 power to all by 2019
- Development of renewable sources of energy
  - 100 GW solar and 75 GW wind by 2022
- Emphasis on increasing domestic coal production
  - Target of one billion tons of coal production by 2020
- Promotion of energy efficiency
  - Target to save 10% of current energy consumption
- Upgrading transmission and distribution network
  - Green Energy Corridor project being rolled out to ensure evacuation from renewable energy plants
  - National Smart Grid Mission approved to bring efficiency in power supply network and facilitate reduction in losses and outages
- Improving financial condition of power utilities
  - Ujwal Discom Assurance Yojna (UDAY) scheme launched recently for financial turnaround and revival of power distribution companies

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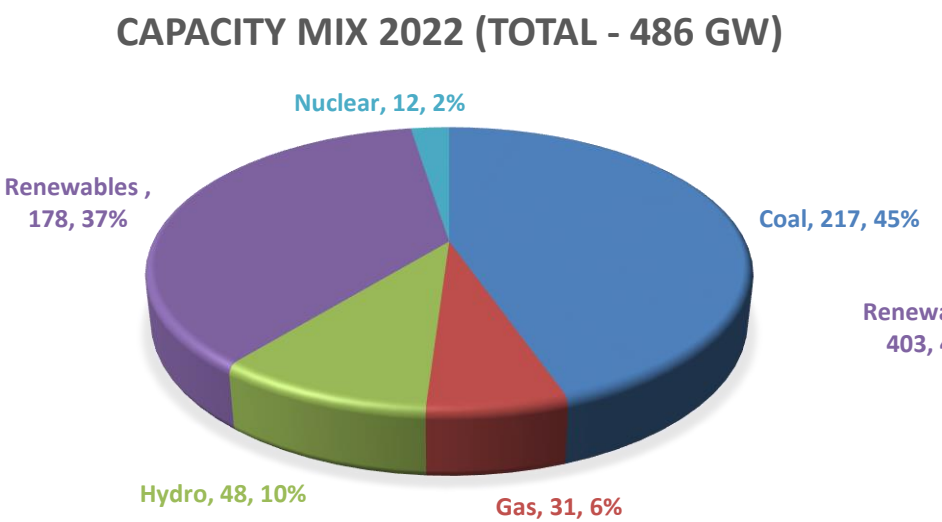
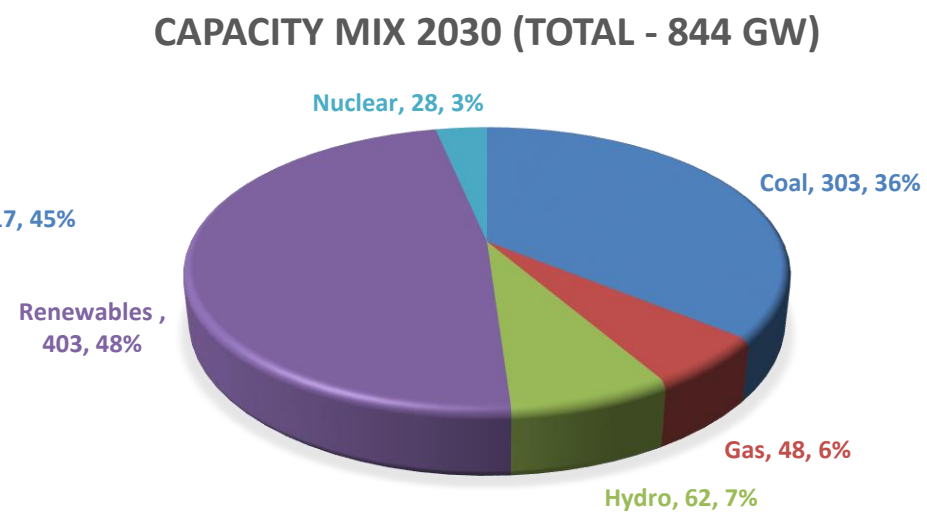
India – Capacity Addition Plans

- In its Intended Nationally Determined Contribution to the UNFCCC India has pledged to reduce its emissions by 33-35% from 2005 levels by 2030
  - Document states target of 40% power (unclear whether generation or capacity) from non-fossil fuels (Nuclear, Large & Small Hydro, Wind, Solar PV/thermal and Biomass)
- Solar power to reach 8% of total consumption by 2022 (National Tariff Policy, 2016)
- Assuming 40% as ***generation*** target from non-fossil fuels, expected capacity mixes for India in 2022 and 2030 (generated using ICF's proprietary power sector planning model IPM®):





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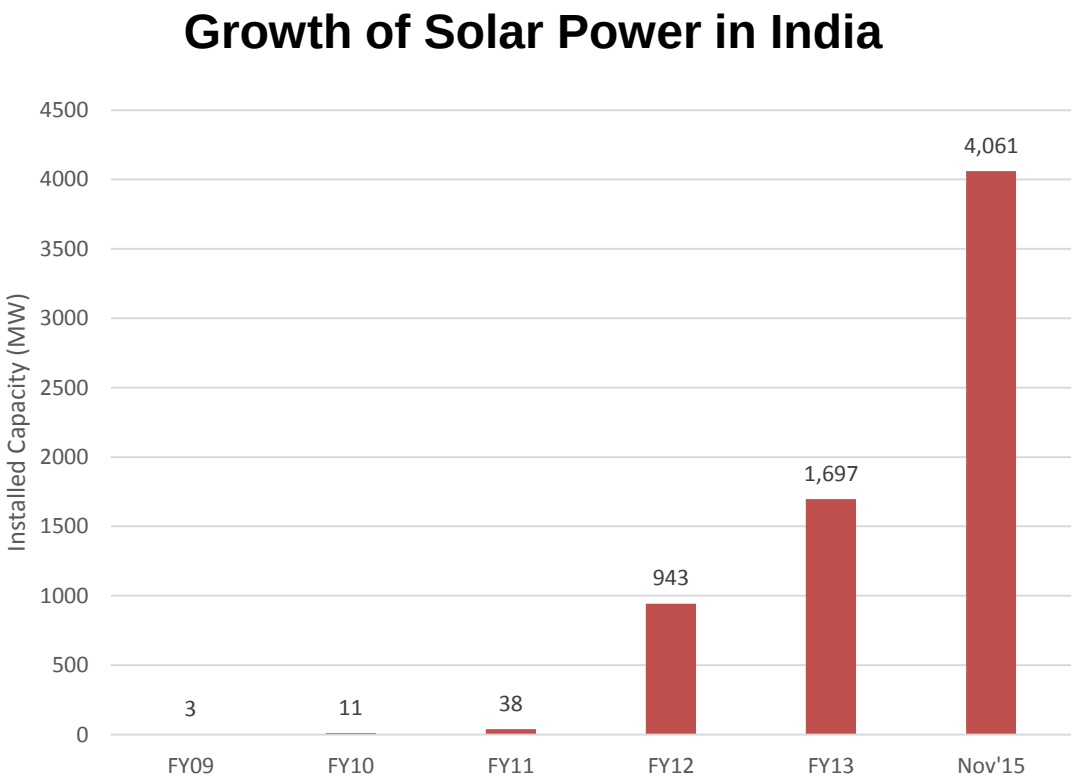
India – RE Potential (1)

- Total solar potential in the country is estimated to be 746 GWp
  - Key solar-rich states: Rajasthan, Gujarat, Maharashtra and Jammu & Kashmir
- Solar industry received a major impetus in 2010 after the launch of the Jawaharlal Nehru National Solar Mission
  - Seen as a critical link to attaining universal energy access
- Sharp decline in solar tariffs with implementation of reverse-bidding mechanism and technology improvements
  - Lowest bid received from SunEdison at INR 4.63/kWh in a recent auction
- Emphasis on enhancing local manufacturing capacity and job creation through Domestic Content Requirement (DCR)



Source: Ministry of New and Renewable Energy Annual Report 2014-15

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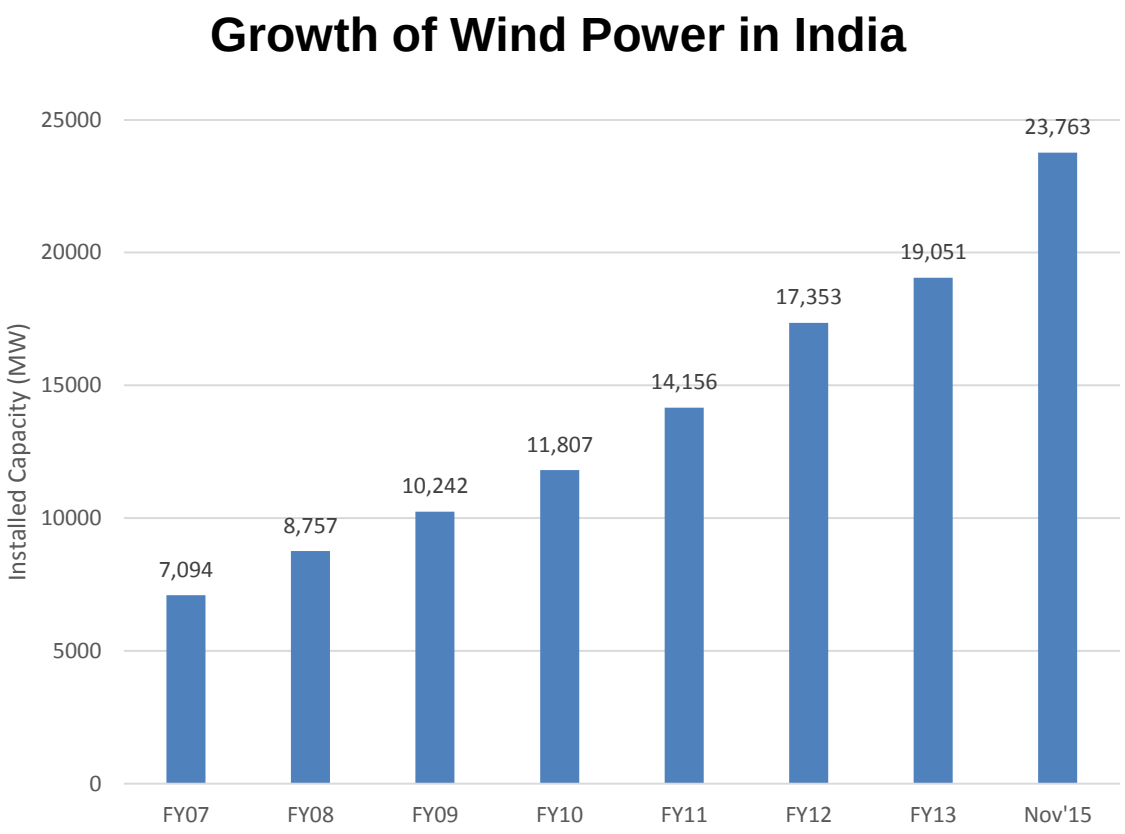
India – RE Potential (2)

- Total wind power potential in the country has been estimated to be 302 GW at 100m hub height by National Institute of Wind Energy (NIWE)
- Fastest growing constituent of the RE sector
  - Result of favorable policies such as Accelerated Depreciation, Generation Based Incentive (GBI), high Feed-in-Tariffs (FiTs), etc.
- India has the 5th largest wind power fleet in the world
  - Key wind-rich states: Tamil Nadu, Maharashtra, Madhya Pradesh and Gujarat
- Issues of evacuation and curtailment in a few states
  - Forecasting pilot recently implemented in Tamil Nadu has shown promising results



Source: Ministry of New and Renewable Energy Annual Report 2014-15

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INDONESIA

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INDONESIA - Summary

- Macroeconomic Overview
  - GDP current: $888.5 billion (2014)*
  - Population: 254.5 million (2014)*
  - Land area: 1,811,570 km^2
  - CO_2 emissions: 2.3 metric tons per capita (2011)*
- Power Sector
  - Primary energy supply is mainly based on country's rich fossil-fuel reserves (oil, gas and coal)
  - Generation Capacity: 50,989.6 MW# – only 12.85% based on non-fossil fuels
- VRE Grid Integration Outlook
  - Current focus is on ramping up capacity (coal, combined-cycle, hydro and geothermal) to meet growing internal demand and expanding the grid to reach far-flung areas
  - 2014 National Energy Policy aims to achieve 100% electrification by 2020
    - Emphasis on centralized/communal solar power plants and small-scale and dispersed solar home systems

**Source: The World Bank*

#Source: Handbook of Energy and Economic Statistics of Indonesia 2014

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Indonesia – Power Sector Structure

- Unavailable

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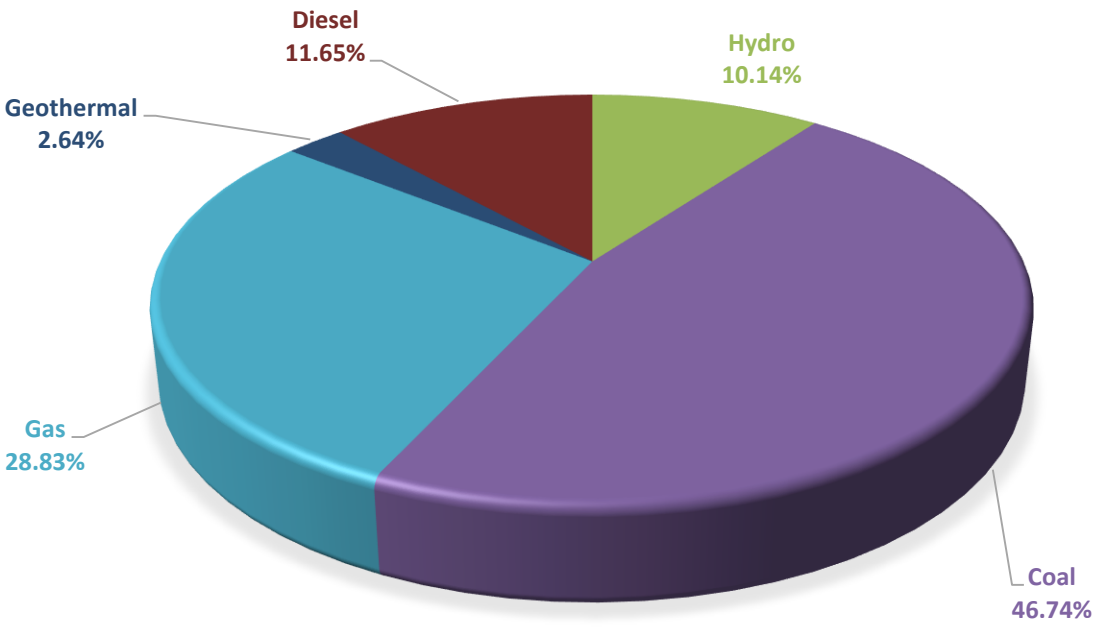
Indonesia – Overall Generation Capacity Mix

As on 31.12.2013



Sector	Capacity (MW)
Hydro	5,058.87
Coal	23,812.53
Gas	14,689.41
Geothermal	1,345.40
Diesel	5,935
Others*	41.65
Total	**50,989.60**

- Perusahaan Listrik Negara (PLN), the state-owned utility, owns and operates about 70% of the generation capacity
- Others includes solar, wind, waste to power and coal gasification

Source: Handbook of Energy and Economic Statistics of Indonesia, 2014

**Others includes wind, coal gasification, solar and Waste to Power (WtP)*

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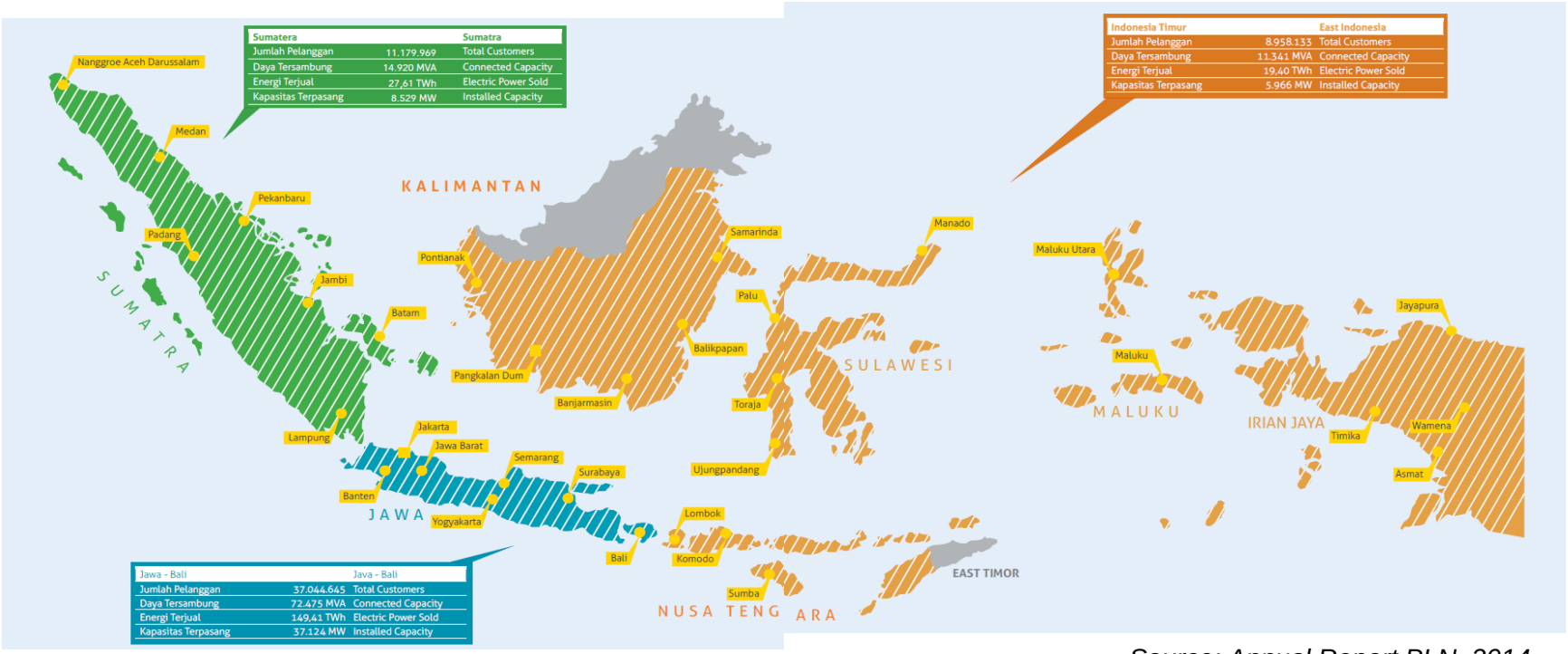
Indonesia – Zonal Demarcations

	Sumatera	Indonesia Timur	Java Bali
Total Customers	11,179,969	8,958,133	37,044,645
Connected Capacity	14,920 MVA	11,341 MVA	72,475 MVA
Electric Power Sold	27.61 TWh	19.40 TWh	149.41 TWh
Installed Capacity	8,529 MW	5,966 MW	37,124 MW



Source: Annual Report PLN, 2014

Indonesia – RE Capacity Mix

- Geothermal
  - Indonesia is home to approximately 40% of the world's geothermal resources
  - Installed capacity stands at 1,345.40 MW
  - Geothermal generation comparatively less uncertain and variable than wind or solar
- Solar
  - Indonesia has strong solar power potential although the market is still in its early stages
  - Country has installed 9.02 MW of solar power
    - Mostly in the form of rooftop PV cells in urban areas
- Wind
  - Potential for wind power is limited due to lack of wind along the equator
  - Windiest regions are the less populated eastern islands that lack proper transmission infrastructure to evacuate wind power
  - Few small-scale wind farms have been installed accounting for only 1.1 MW of installed capacity

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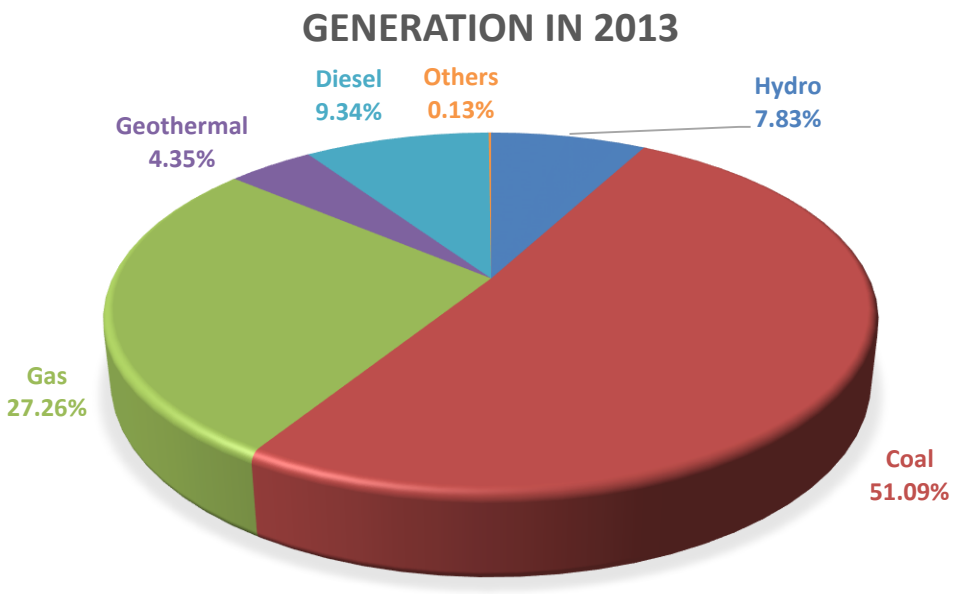
Indonesia – Electricity Generation Mix

In 2013



Sector	Generation (GWh)
Hydro	16,930
Coal	110,452
Gas	58,922
Geothermal	9,414
Diesel	20,193
Others	274
Total	**216,185**

- Almost ~90% of generation from fossil fuels
- Indonesia's primary power consumers are residential (42% market share), industrial (33%), and commercial (18%)

Source: Handbook of Energy and Economic Statistics of Indonesia, 2014

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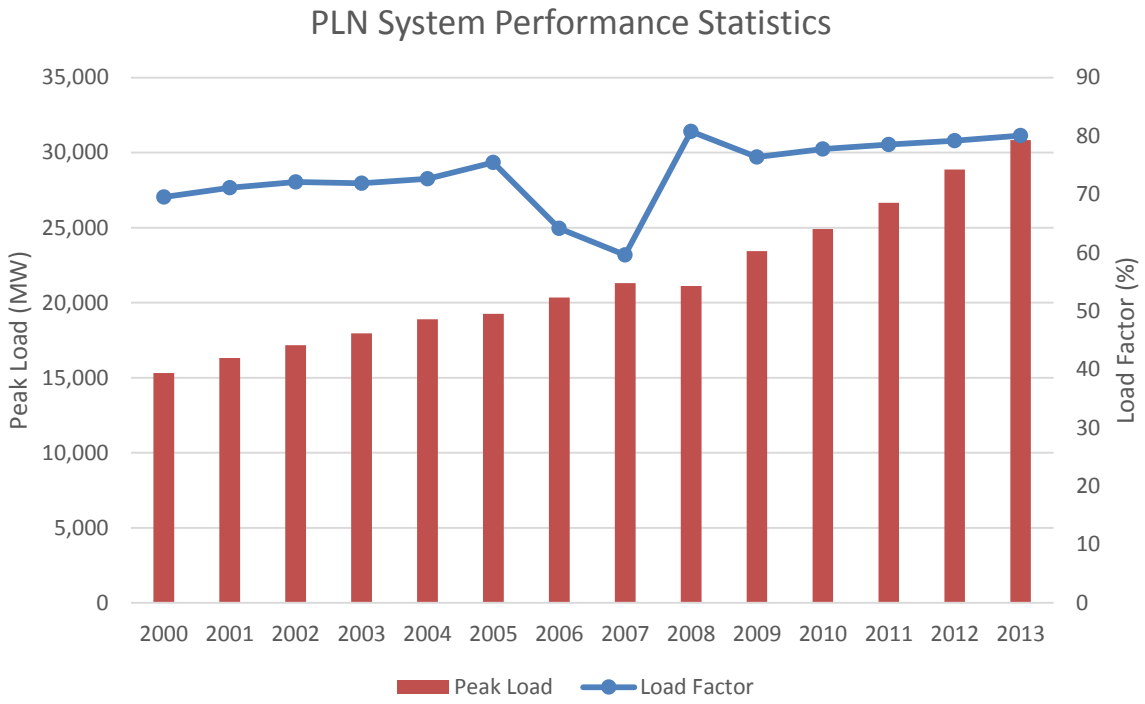
Indonesia – Demand/Supply Situation



Source: Handbook of Energy and Economic Statistics of Indonesia, 2014

- Robust economic growth over the past decade has given rise to increased demand for electricity as indicated by a rising load factor
- Despite having abundant domestic resources, Indonesia faces frequent blackouts
- Indonesia is further aiming to improve its electrification ratio from 80.4% in 2013 to 98% in 2022
  - Total electricity sales expected to reach 386 TWh by 2022 from 207 TWh in 2014 and 189 TWh in 2013

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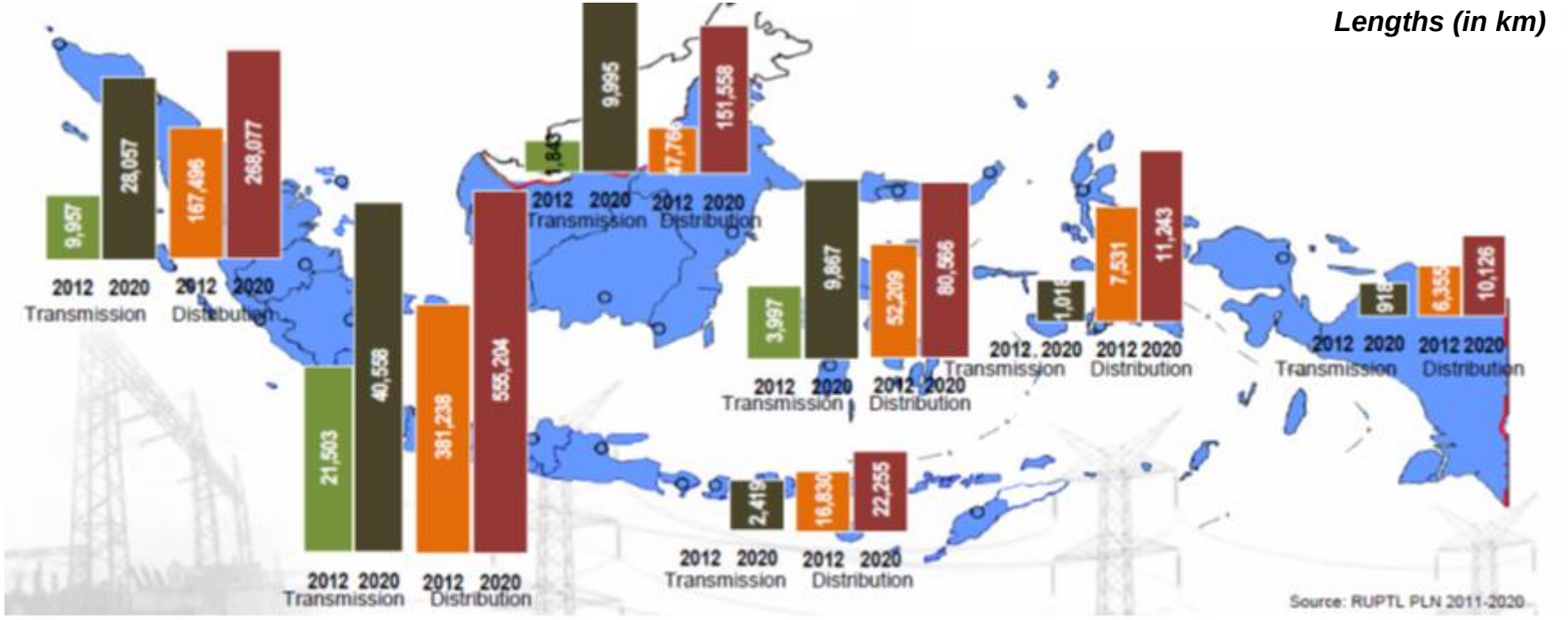
Indonesia – Transmission Infrastructure



Source: Indonesia Electricity Infrastructure Development, 2012
http://energy-indonesia.com/03dge/0120918-01.pdf

- Power system is well interconnected in the Java-Bali and Sumatra systems
- Current priorities:
  - Upgrading Java-Sumatra system to enable evacuation of power from Sumsel-10 mine-mouth coal-fired power plant in Sumatra of 600 MW capacity
  - Reducing congestion in Java-Bali and Sumatra system lines
  - Accelerating rural electrification and developing Sumatra-Malaysia peninsula interconnection system

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Indonesia – Energy Strategy

- Focus on utilizing rich domestic coal reserves by enhancing coal-based capacity
  - 37.9 GW of new coal-fired power plants planned by 2022 (out of a total 59.5 GW of new capacity)
- Improving electrification ratios in poorly served and underserved rural areas
- Upgrading T&D infrastructure for last mile connectivity and evacuation of power to load centers
- Major emphasis on increasing the share of grid-connected renewable energy in the energy mix by ramping up geothermal and hydro capacities
- Rural electrification to be achieved through centralized/communal solar power plants and small-scale and dispersed solar home systems

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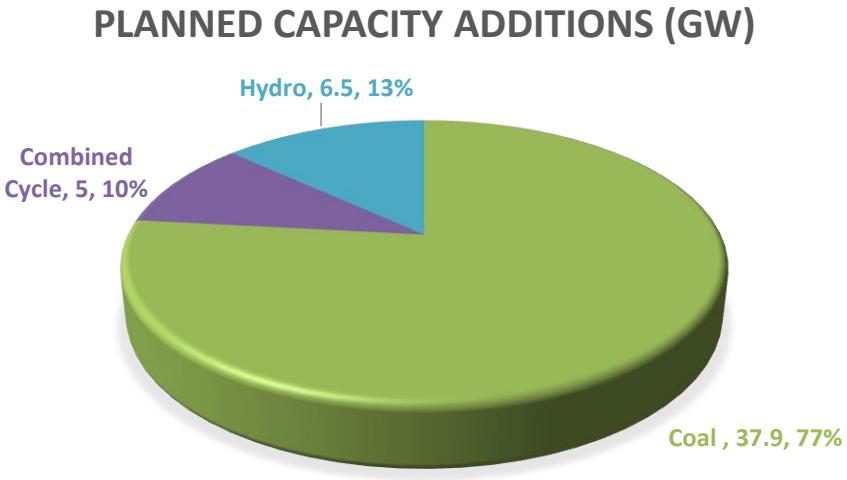
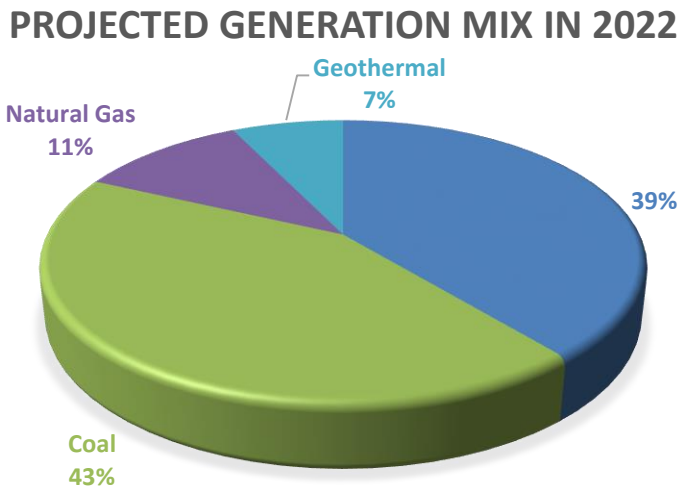
Indonesia – Capacity Addition Plans (1)

- Additional capacity of 59.5 GW required by 2022 to meet demand
  - PLN and IPPs to develop 16.9 GW and 25.5 GW respectively
  - Remaining 17.1 GW unallocated
- New coal-fired plants dominate the additional generation capacity to be developed (37.9 GW)
- Energy mix in 2022 will be dominated by coal and natural gas

Source: Executive Summary, PLN Electricity Supply Business Plan (2013-2022)





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Indonesia – Capacity Addition Plans (2)

- Indonesia plans to increase the use of renewable energy (including hydropower) to 19% of the total energy portfolio by 2019 and to a minimum of 25% by 2025
- Indonesia is 3rd largest geothermal energy generator in the world after US and Philippines
  - Has a potential of 29 GW of geothermal capacity, only 5% of which has currently been developed
  - New government's 35 GW Electricity Program, launched in mid-2015, includes 1.2 GW of additional geothermal capacity by 2019
- PLN's development plan for new and renewable energy:
  - Focus on development of mini-hydro power plants to meet local demand
  - PLN to develop solar power plants in 1,000 locations/islands to improve electrification ratios

PLN's Development Plan for New and Renewable Energy

No	New and renewable energy power plant	Capacity	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	TOTAL
1	Mini Hydro	MW	33	42	96	149	237	192	186	156	190	200	1,481
2	Solar Power	MWp	6	104	75	54	36	60	75	75	75	75	634
3	Wind Power	MW	-	-	50	20	20	20	30	40	50	50	280
4	Biomass	MW	48	10	15	20	30	40	50	50	50	50	363
5	Ocean	MW	-	-	1	-	1	3	3	5	5	10	28
TOTAL		**MW**	**87**	**156**	**237**	**243**	**324**	**315**	**344**	**326**	**370**	**385**	**2,786**
	Biofuel PP	*Thousand Kilo Liter*	*15*	*400*	*400*	*500*	*500*	*600*	*600*	*600*	*600*	*600*	*4,815*

Source: Executive Summary, Electricity Supply Business Plan (2013-2022)

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Indonesia – RE Potential

Energy Source	Installed Capacity	Resource Potential	Undeveloped Potential
Hydropower	5,058.87 MW	75 GW	93.25%
Geothermal	1,345.40 MW	29 GW	95.36%
Solar	9.02 MW	560 GWp	~100%
Wind	1.1 MW	107 GW	~100%
Ocean	0.28 MW	61 GW	~100%

Source: Renewable Energy Market Assessment Report: Indonesia
http://trade.gov/td/energy/Indonesia%20Renewable%20Energy%20Assessment%20(FINAL).pdf

- Government has mandated that geothermal energy provide at least 5% of the nation's electricity by 2025
- Offshore wind likely to offer more investment opportunities due to Indonesia's lengthy coastlines and consistent ocean winds
- Solar power deployment has been hampered by a lack of household buy-in and skilled maintenance personnel for installing solar cells

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LAO PDR

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LAO PDR - Summary

- Macroeconomic Overview
  - GDP current: $11.77 billion (2014)*
  - Population: 6.689 million (2014)*
  - Land area: 230,800 km^2
  - CO_2 emissions: 0.2 metric tons per capita (2011)*
- Power Sector
  - Primary sources of energy are wood, fuel oil and coal
  - Generation Capacity: 2,954.5 MW# – entirely based on hydro
  - Country trades power with Viet Nam, China and Thailand
  - First thermal power (3x626 MW) plant under construction in Hongsa
- VRE Grid Integration Outlook
  - Main focus areas are increased electricity access and hydropower development
  - Renewable Energy Development Strategy 2011 proposes development of mini-hydro and biomass based capacities
  - Less emphasis on solar and wind development due to lack of resource assessment data

**Source: The World Bank*

#Source: Department of Energy Business, Ministry of Energy and Mines, Lao DPR

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Lao PDR – Energy Scenario Highlights

- Energy use in the country is mainly in the form of traditional fuels, i.e. the use of biomass such as wood and charcoal for cooking and heating in rural areas
- Hydropower is the most abundant resource in the country
  - Total potential estimated to be around 26,000 MW
- All petroleum products consumed in the country are imported
- Difficulties being faced in formulating energy policies
  - Lack of an integrated national policy
  - Lack of data and information on all sub-sectors of energy
  - Mandate among agencies not clearly described and coordinated

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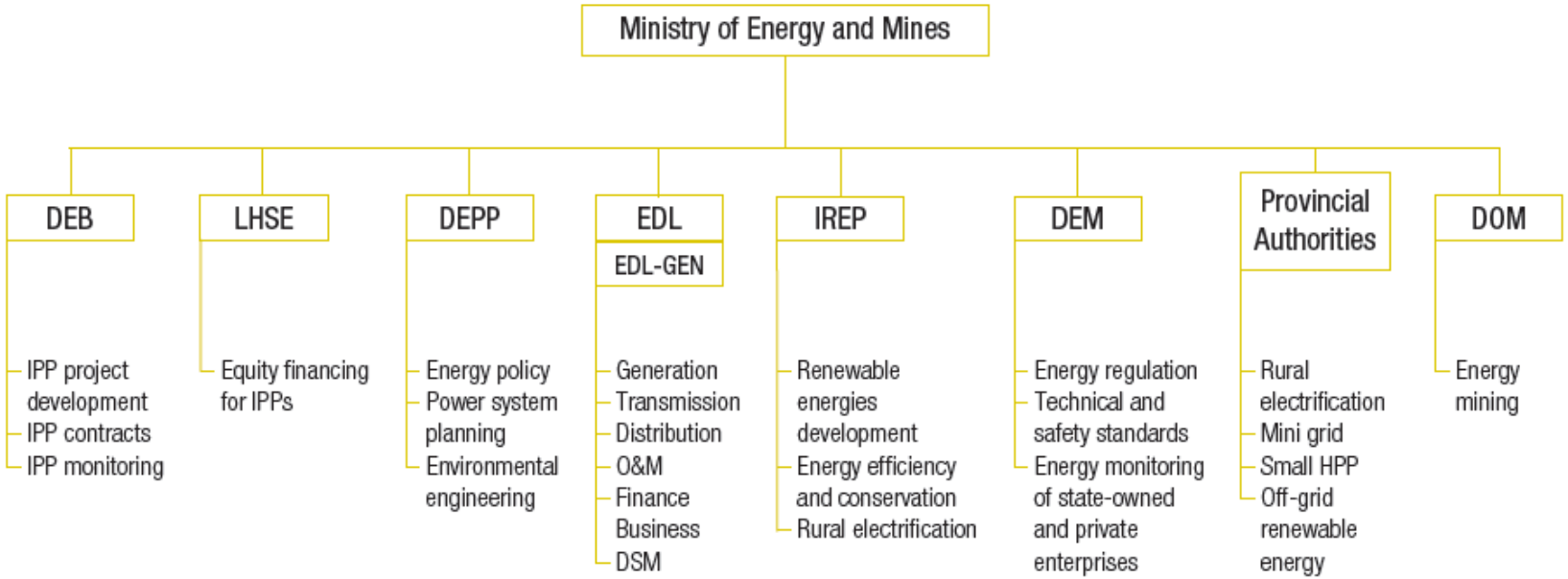
Lao PDR – Power Sector Structure



DEB = Department of Energy Business, DEM = Department of Energy Management, DEPP = Department of Energy Policy and Planning, DOM = Department of Mines, DSM = demand-side management, EDL = Electricité du Laos, EDL-GEN = EDL Generation Public Company, HPP = hydropower plant, IPP = independent power producer, IREP = Institute of Renewable Energy Promotion, LHSE = Lao Holding State Enterprise, O&M = operation and maintenance.

Source: Ministry of Energy and Mines.

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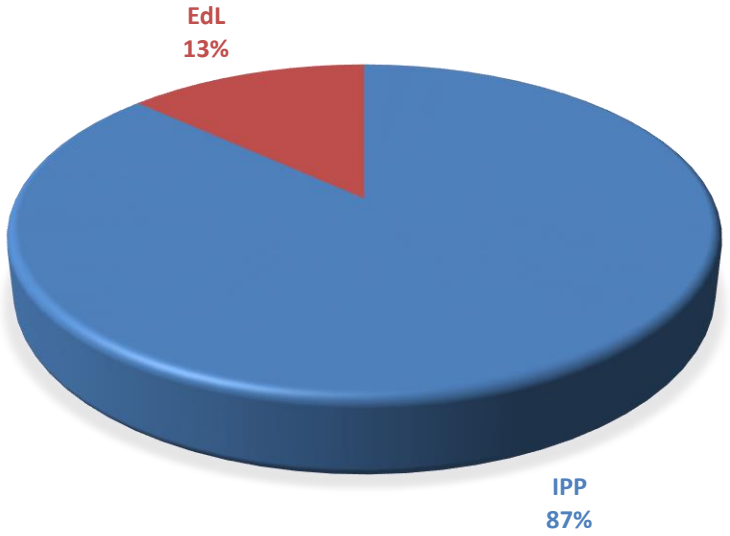
Lao PDR – Overall Generation Capacity Mix

As on June 2015

- Country has **only** hydro-based capacity
  - Almost 87% capacity owned by private IPPs with partial ownership of EdL
  - Only ~13% of installed capacity fully-owned by Electricité du Laos (EdL)
- Oil and gas sector in early stages of exploration
- Hongsa Power Project is the first coal-fired power plant in the country (Lao PDR gets only 20%, rest sold to Thailand)
  - Unit I commissioned on June 2, 2015 (626 MW)
  - Unit II commissioned on November 3, 2015 (626 MW)
  - Unit III to be commissioned in March, 2016
- Another 3,182.2 MW of capacity under construction



Owner	Hydro Capacity
IPPs	2,565 MW
EdL	389.5 MW
TOTAL	**2,954.5 MW**

Source: Department of Energy Business, Ministry of Energy and Mines, Lao DPR

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Lao PDR – RE Capacity Mix

- Only 285 kWp of solar PV capacity in pilot plants
- No wind capacity installed

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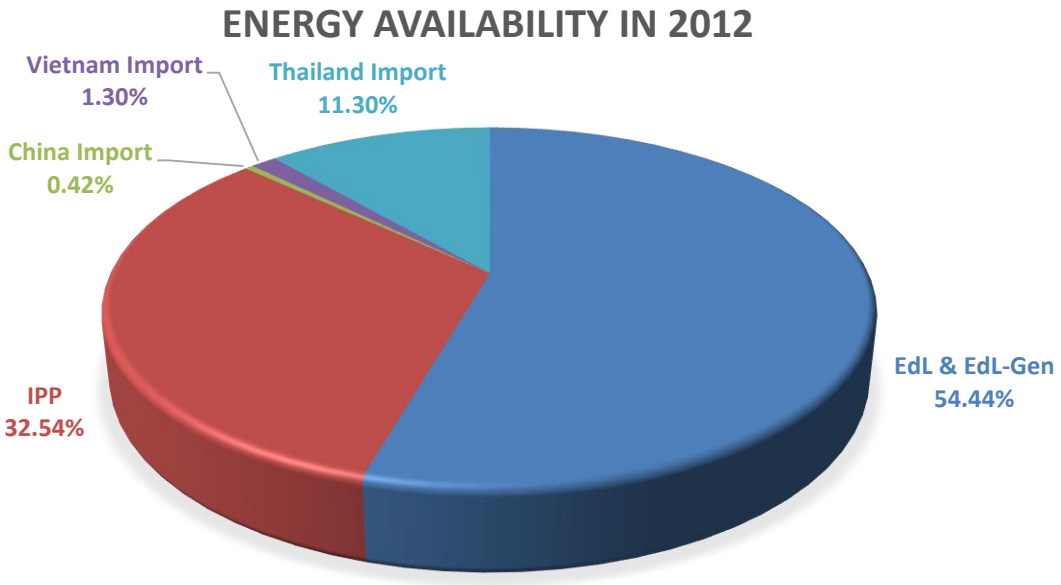
Lao PDR – Electricity Generation Mix



Sector	Generation (GWh)
EdL & EdL-Gen	4,713.68
IPP	2,817.77
China Import	36.50
Viet Nam Import	112.69
Thailand Import	978.14
Total	**8,658.78**

Source: Electricity Statistics 2012, Planning and Finance Office, Electricité du Laos

1 MU = 10^6 kWh

- Electricity consumption is dominated by residential and transport sectors, followed by industry
- Lao PDR also sells power to neighboring countries under existing PPAs
- Plants selling power:
  - Nam Ngum 1 + Nam Leuk + Nam Mang 3: ~154 MUs
  - Xeset Systems: ~155 MUs

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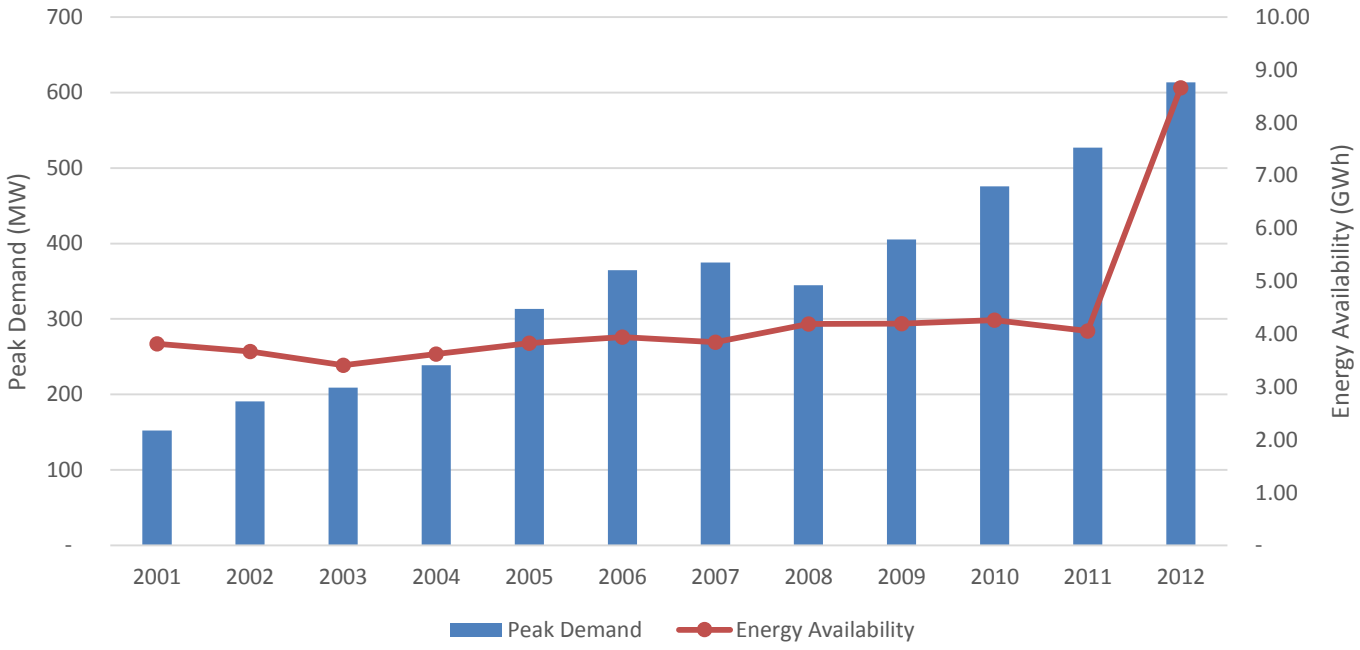
Lao PDR – Demand/Supply Situation



Source: Electricity Statistics 2012, Planning and Finance Office, Electricité du Laos

- Generation has significantly increased in recent years due to the addition of Houay Ho and Namlik 1-2 hydro power plants and increase in imports from Thailand
- Heavy dependence on hydro power results in large parts of the country experiencing frequent blackouts, especially during the dry seasons

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Lao PDR – Transmission Infrastructure

- EdL's transmission system consists of four separate grids
  - These grids operate in four different areas comprising of 115 kV and lower voltage lines and substations
  - Each of these grids is also connected to Thailand, Viet Nam and China for power import at the 22 kV, 35 kV and 115 kV levels
- Focus thus far has been on reducing technical losses
  - T&D losses have been reduced from 27% in 1994 to 12% in 2009 by minimizing the length of low voltage lines in rural areas
  - Energy meters on outgoing feeders have been introduced to keep mechanical losses in check
- Planning and construction of high-voltage transmission systems catering to export-oriented hydropower projects is envisaged under the Greater Mekong Subregion (GMS) Masterplan
- Extension of the grid to rural areas remains a priority area

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Lao PDR – Energy Strategy

- Promotion of power exports and ramping up of domestic supply
  - Emphasis on diversifying the capacity mix and reducing dependence on hydro power to avoid power shortages during dry seasons
- Development and enhancement of legal and regulatory framework to facilitate power sector development
- Promotion of energy efficiency measures for reduction of power consumption
- Capacity building on technical know-how and expertise through international collaborations
- Key policy: National Policy on Environmental and Social Sustainability of the Hydropower Sector in Lao PDR (2005)

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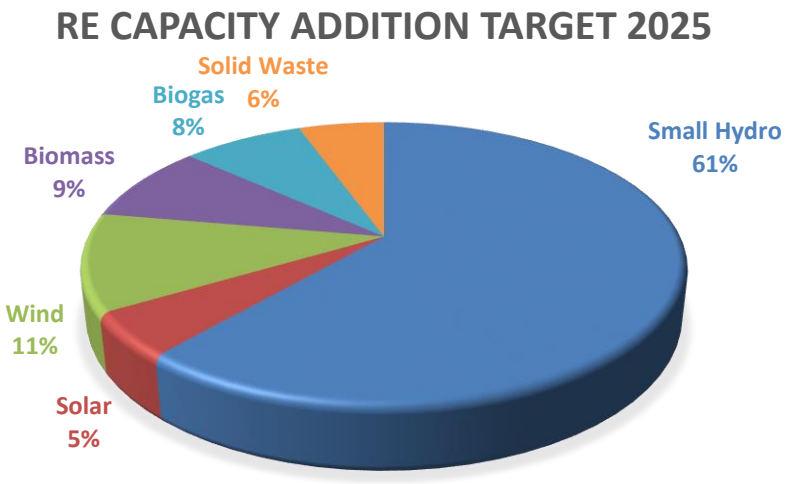
Lao PDR – Capacity Addition Plans

- Renewable Energy Development Strategy in Lao PDR (2011) targets:
  - To improve electrification rate from 70% to 90% by 2020
  - To increase the share of renewable energies (other than large-scale hydro) to 30% of the total energy consumption by 2025
  - To reach 10% of total transport energy consumption from bio-fuels to reduce dependence on imports by 2025
    - Ethanol and biodiesel production to reach 150 and 300 million liters respectively
  - Emphasis on development of hydro and biomass-based capacities as there is lack of resource assessment data for wind and solar

Sector	Planned Capacity by 2025 (MW)
Small Hydro	400
Solar	33
Wind	73
Biomass	58
Biogas	51
Solid Waste	36
Total	**651**



Source: Renewable Energy Development Strategy in Lao DPR (2011)

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Lao PDR – RE Potential

- Solar
  - Total technical potential estimated to be 8,812 MWp
  - However, mountainous topography, particularly in the north, limits the extent to which large scale PV systems can be installed despite suitable intensities for solar PV integration
  - As of 2011, only 285 kWp of solar PV has been installed in pilot plants
- Wind
  - Lao PDR has considerable wind resources, with 20% of the total land area having wind speeds greater than 6 m/s
  - However, technical potential is much less because of limitations of the generation and transmission system
  - Technical potential estimated to be 100 MW at the lower limit (5% of grid capacity) or 380 MW at the upper limit (20% of grid capacity)
  - No wind generation capacity has been installed in the country yet

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MALAYSIA

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MALAYSIA - Summary

- Macroeconomic Overview
  - GDP current: $326.9 billion (2014)*
  - Population: 29.90 million (2014)*
  - Land area: 328,550 km^2
  - CO_2 emissions: 7.9 metric tons per capita (2011)*
- Power Sector
  - Country is endowed with rich fossil fuel reserves – LNG, oil and natural gas
  - Generation Capacity: 24,970 MW# – dominated by coal and natural gas
- VRE Grid Integration Outlook
  - Gas shortages in Peninsular Malaysia and growing electricity demand in recent years have spurred the use of other fuels such as coal, diesel, and renewable sources
  - Current capacity addition plans only involve enhancing coal and gas-based capacities
  - Less focus on grid-connected RE and more thrust on ramping up rooftop solar PV installed capacity

**Source: The World Bank*
#Source: Malaysia Energy Statistics Handbook 2015

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Malaysia – Energy Scenario Highlights

- Malaysia is the world's second-largest exporter of liquefied natural gas and the second-largest oil and natural gas producer in Southeast Asia
  - Strategically located amid important routes for seaborne energy trade
- In light of recent fuel shortages, Malaysia has unveiled several upstream and downstream oil and natural gas projects to enhance output from terminals
- Country is focused on securing energy through cost-effective means and diversifying its fuel supply mix to meet growing demands of economic development and increased manufacturing capacity
  - Diversification to be achieved through coal imports and investments in renewable energy (mainly rooftop solar)

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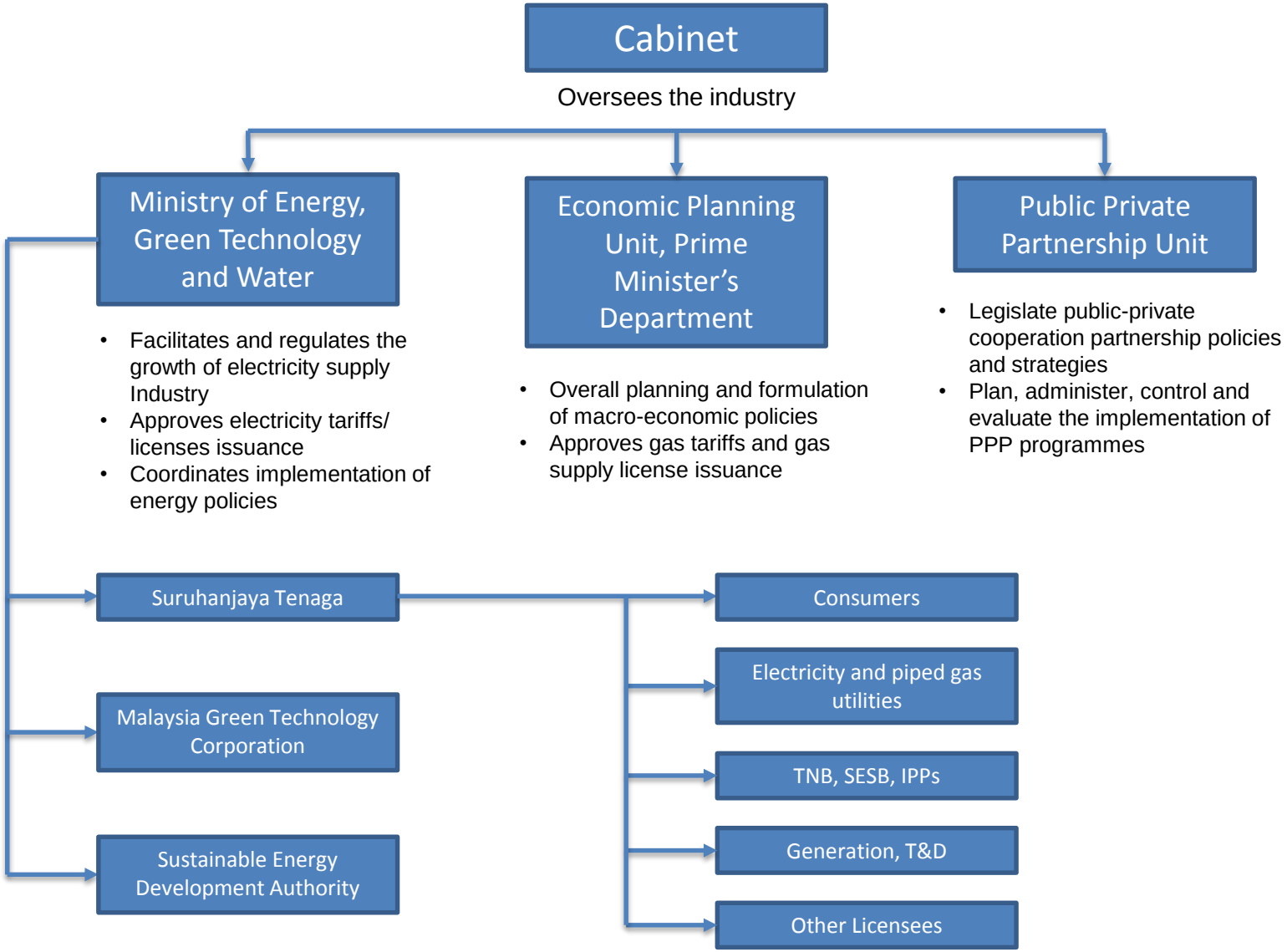
Malaysia – Power Sector Structure



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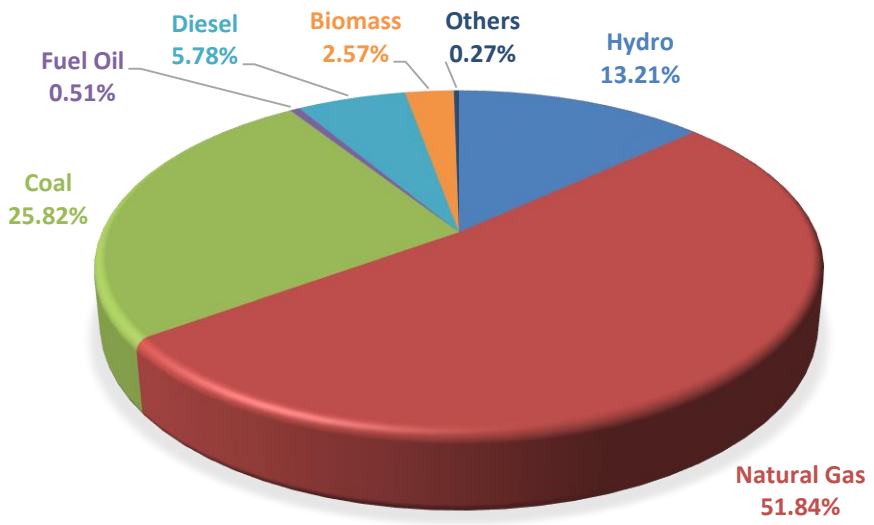
Malaysia – Overall Generation Capacity Mix

As on 31.12.2013



Sector	Capacity (MW)
Hydro	3,931
Natural Gas	15,421
Coal	7,680
Fuel Oil	152
Diesel	1,719
Biomass	765
Others	80
Total	**24,970**

- Natural gas, coal and liquid fuels account for almost ~84% of installed capacity
  - Many of these gas plants are located in Peninsular Malaysia, and some have dual-fuel capabilities allowing for greater flexibility in fuel type
- Hydro capacity is mostly located in Peninsular Malaysia and Sarawak regions

Source: Malaysia Energy Statistics Handbook 2015

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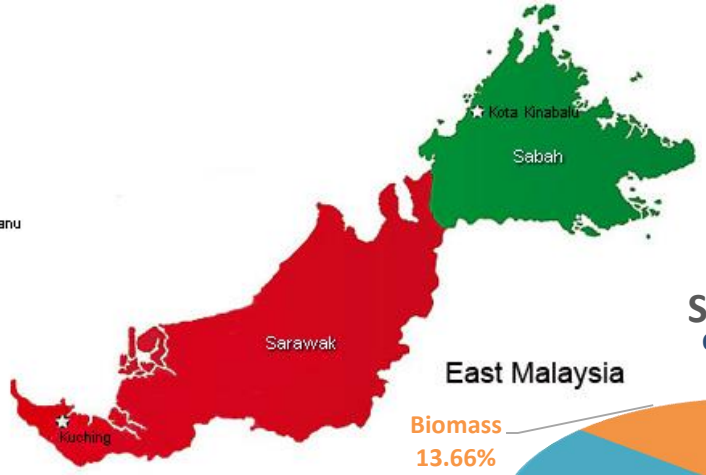
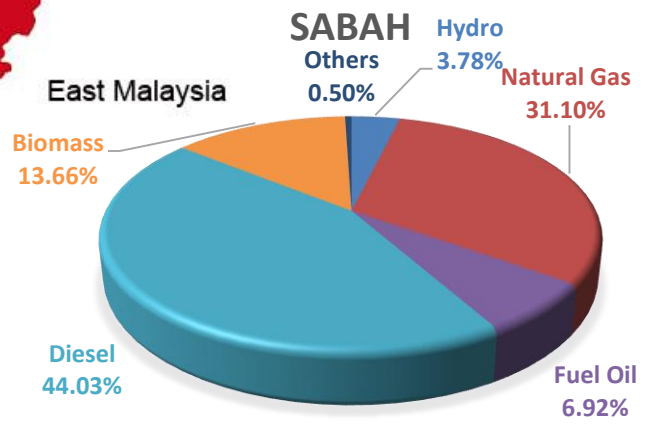
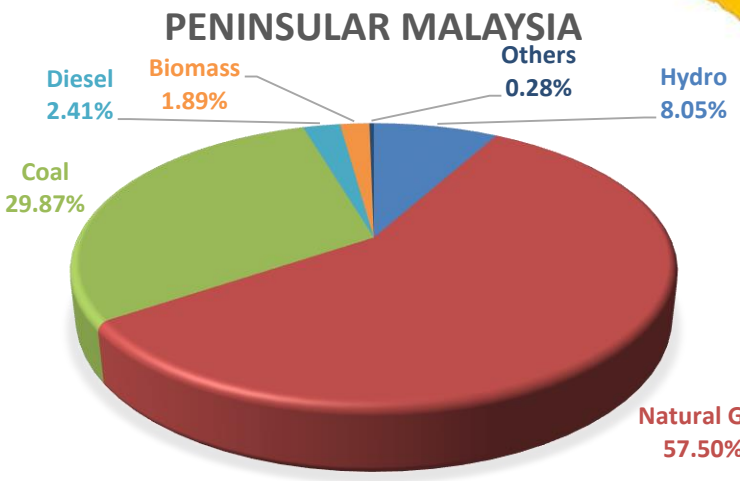
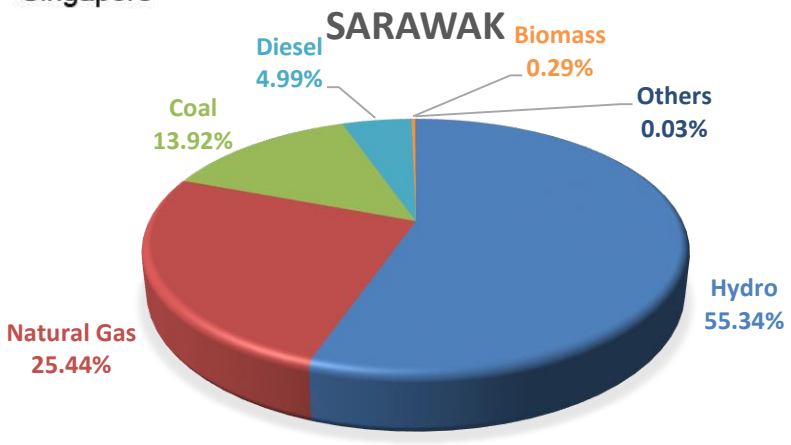
Malaysia – Zone-wise Installed Capacity Mix

Source: Malaysia Energy Statistics Handbook 2015









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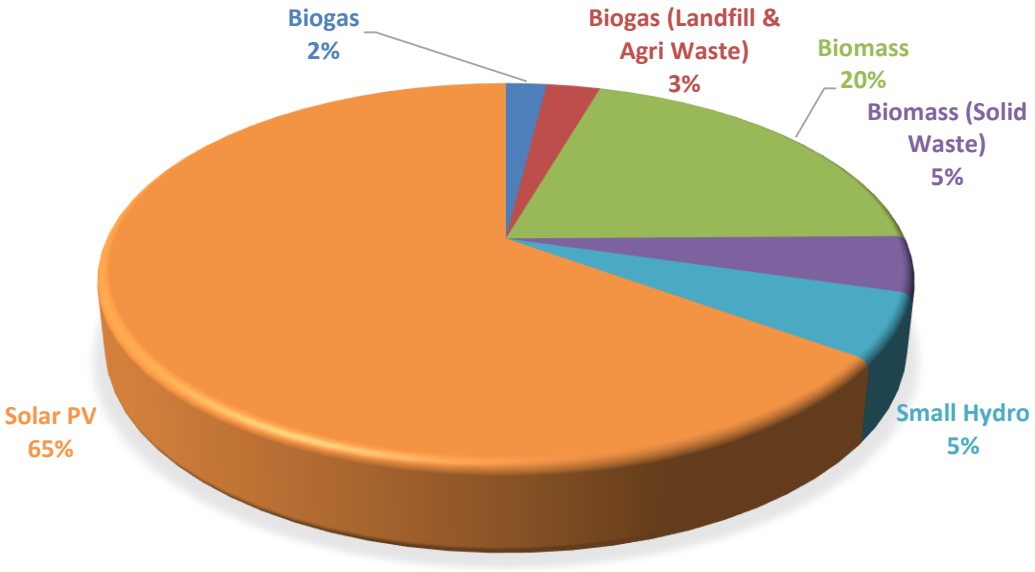
Malaysia – RE Capacity Mix

Latest numbers



Sector	Installed Capacity (MW)
Biogas	6.48
Biogas (Landfill & Agri Waste)	8.56
Biomass	67.9
Biomass (Solid Waste)	15.9
Small Hydro	18.3
Solar PV	217.46
Total	**334.6**

Source: Sustainable Energy Development Authority (SEDA), Malaysia

- Renewable energy capacity in Malaysia has been traditionally dominated by biomass-based technologies and roof-top solar
- Solar PV has received a major impetus in recent years due to favorable feed-in-tariffs and tax incentives
- Country is also one of the biggest exporter of palm-oil, a primary raw material in biodiesel production
  - Although Malaysia itself produces no significant quantities of ethanol
  - Most of it is exported to Singapore for further refining

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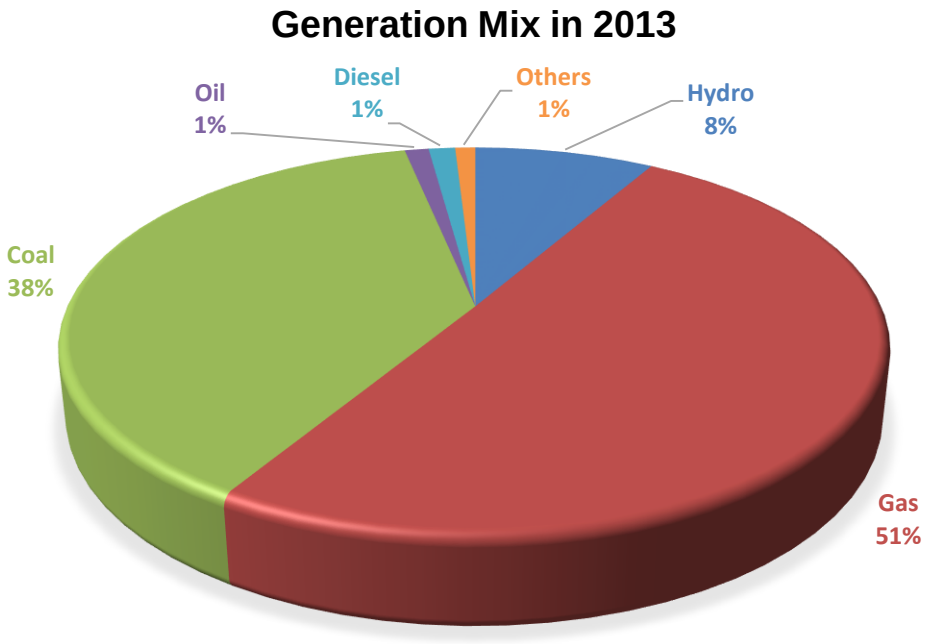
Malaysia – Electricity Generation Mix



Sector	Generation (GWh)
Hydro	11,799
Gas	71,174
Coal	53,663
Oil	1,571
Diesel	1,741
Others	1,318
Total	**141,266**

Source: Malaysia Energy Statistics Handbook 2015

- Generation is heavily dominated by gas, coal and liquid fuels
- Tightness of natural gas supply in Peninsular Malaysia in recent years, caused by the state's production declines resulted in power outages
  - This has resulted in increased use of coal-fired and more expensive fuel oil and diesel-fired generation

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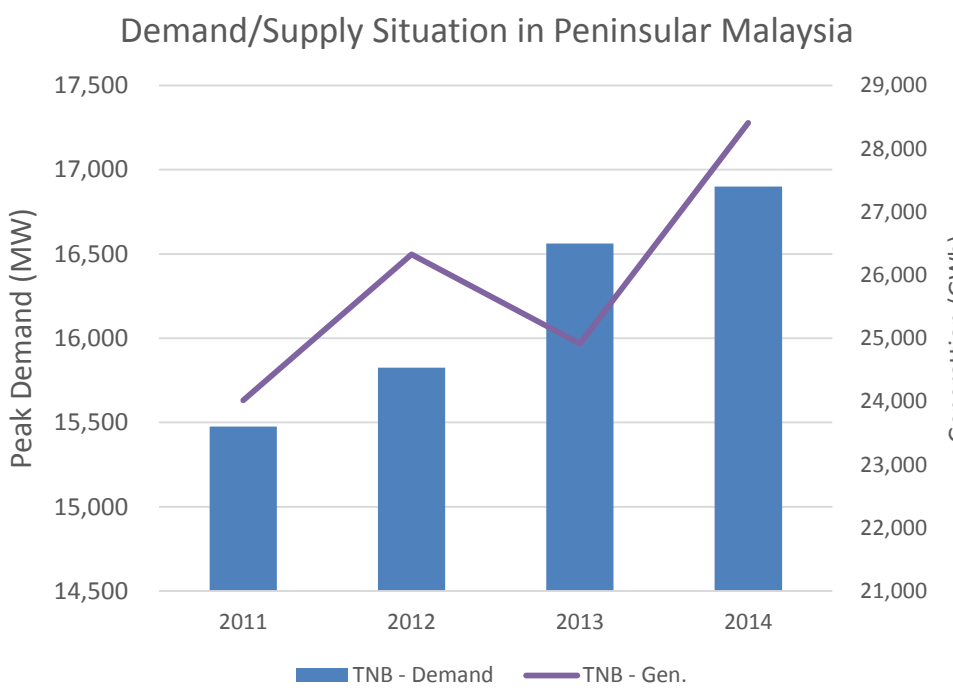
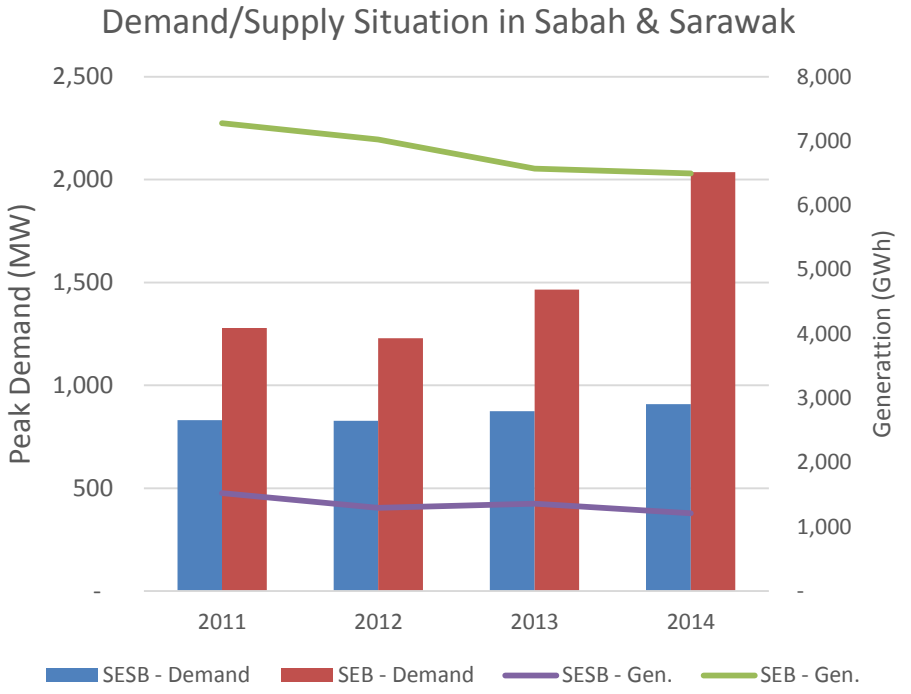
Malaysia – Demand/Supply Situation





Source: Malaysia Energy Statistics Handbook 2015

- Sarawak Energy Berhad (SEB) serves the Sarawak region, TNB operates in Peninsular Malaysia and Sabah Electricity Sdn. Bhd. (SESB) supplies electricity to Sabah
- Industrial and commercial sectors are the largest consumers of electricity in Malaysia
- Power supply has been mostly sufficient with only a few shortages in recent years

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Malaysia – Transmission Infrastructure

- Malaysia has a very robust grid that is separated into three main parts: Peninsular Malaysia, Sabah and Sarawak
- It has one of the highest electrification ratios in the ASEAN region (99.4% in 2012), courtesy of the Rural Electrification Program of the government
- Country has a wide network of high-voltage transmission lines (over 650 km of 500 kV and 10,000 km of 275 kV lines)
- Future efforts focus on incorporating smart grid technologies and interconnecting Peninsular Malaysia with Sarawak and Sabah regions via underwater cables

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Malaysia – Energy Strategy

- Malaysian National Renewable Energy Policy and Action Plan (approved by cabinet on 2nd April, 2010)
- Key objectives:
  - Introduce legal and regulatory framework
  - Provide conducive business environment for RE
  - Intensify human capital development
  - Create public awareness and RE advocacy programs
  - Enhance RE research & development
- Landmark regulation: Renewable Energy Act 2011
- Major thrust on roof-top solar PV (technical potential of ~ 7.8 TWh); well developed Feed-in-Tariff mechanism

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Malaysia – Capacity Addition Plans (1)

- Tenaga Nasional Berhad (TNB) is constructing a 1,071 MW combined-cycle gas turbine plant in Penang, Peninsular Malaysia which is scheduled to be completed at the end of 2015
- Two 300 MW gas-fired plants are being constructed in Sabah, including the Kimanis Power Plant, which will purchase gas from the Sabah oil and gas terminal in 2015
- Malaysia signed construction contracts for the country's first use of ultra-supercritical coal technology for two power plants located at Manjung 4 and Tanjung Bin on Peninsular Malaysia
  - These plants are scheduled to add 2 GW of coal-fired capacity by 2016
- Joint venture consisting of Mitsui of Japan and a subsidiary of Malaysia's Ministry of Finance is constructing a 2 GW coal-fired plant, Jimah East Power, to commence electricity generation by 2018

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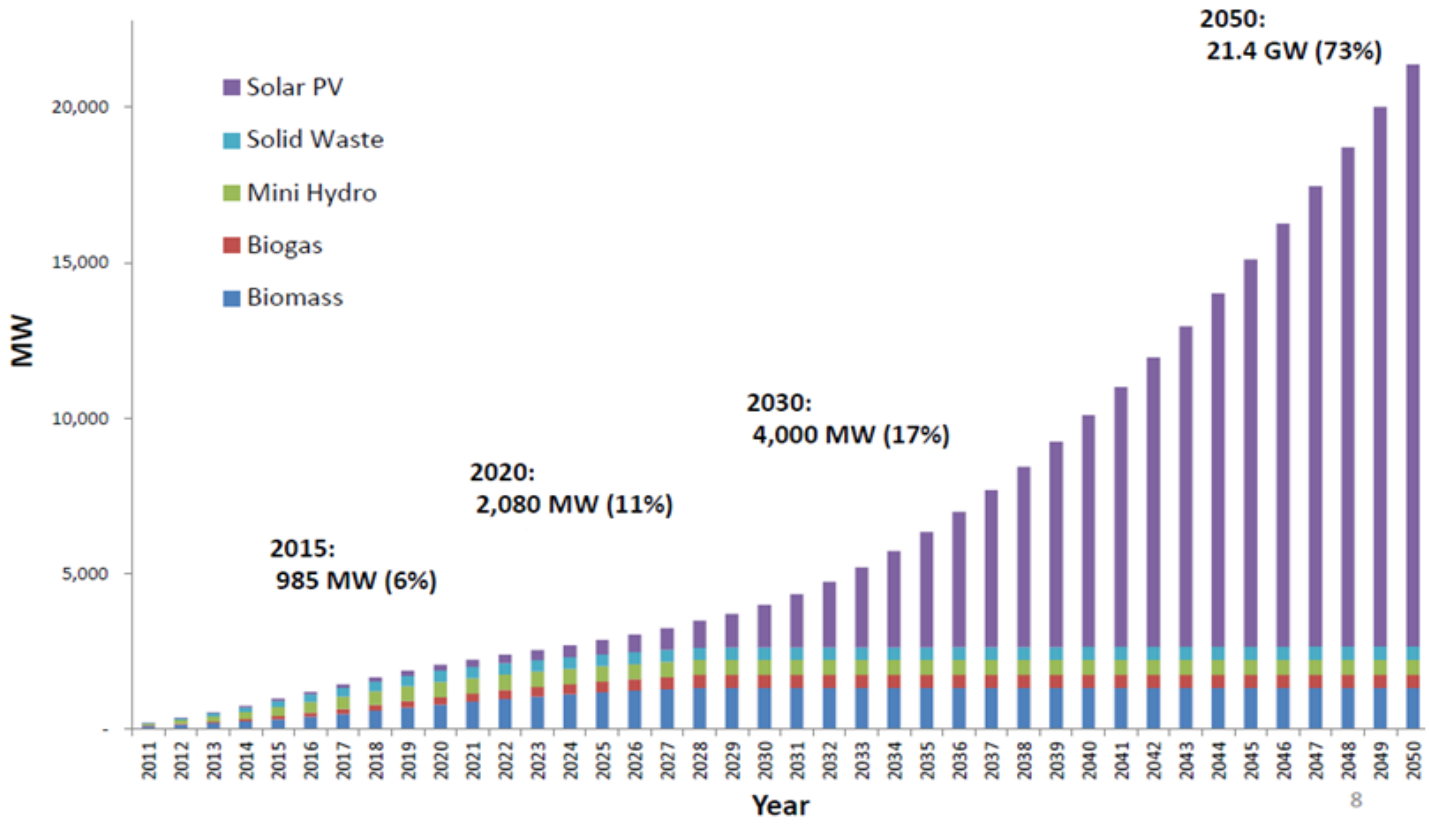
Malaysia – Capacity Addition Plans (2)

- National RE Targets (Cumulative RE Installed Capacity and Ratio to Peak Demand)
  - Excludes targets under EPP 10 – Solar Power Capacity Initiative



Source: Sustainable Energy Development Authority (SEDA), Malaysia
http://www.mida.gov.my/env3/uploads/events/Sabah04122012/SEDA.pdf

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Malaysia – Capacity Addition Plans (3)

- Entry Point Project (EPP) 10
- Solar Power Capacity Initiative under ***National Key Economic Area***
- Target – 1.25 GW solar power capacity connected to the grid by 2020

Year	Solar Power Capacity (Cumulative)	RE Capacity (Cumulative)	RE Capacity Mix
2011	20 MW	219 MW	1%
2015	295 MW	1,275 MW	7%
2020	1,250 MW	3,140 MW	14%
2030	3,100 MW	7,088 MW	25%

Source: The Renewable Energy Roadmap, Sustainable Energy Development Authority (SEDA), Malaysia

Malaysia – RE Potential

- Solar
  - Technical potential of PV ~ 7.8 TWh
  - About 21% of residential and commercial electricity demand in 2005
- Wind
  - A few studies and research papers have analyzed wind energy potential along the coastal regions
  - Data on overall wind power potential in the country is unavailable

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NEPAL

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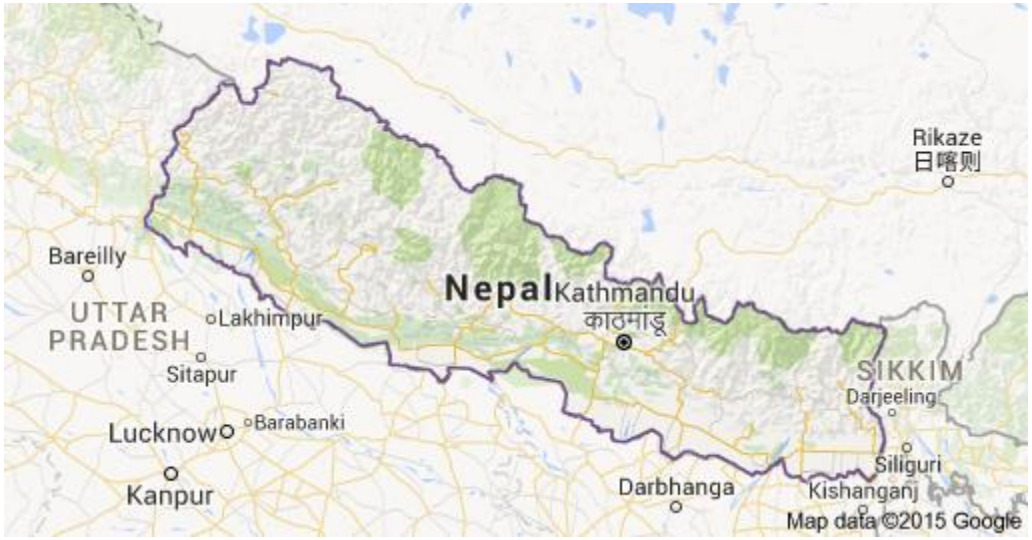
NEPAL - Summary



- Macroeconomic Overview
  - GDP current: $19.64 billion (2014)*
  - Population: 28.17 million (2014)*
  - Land area: 143,350 km^2
  - CO_2 emissions: 0.2 metric tons per capita (2011)*
- Power Sector
  - Underdeveloped power sector with low electrification rate and acute shortages during non-monsoon seasons
  - Generation Capacity: 787,087 kW# – dominated by hydro
- VRE Grid Integration Outlook
  - Current priorities are to harness the vast hydropower resources in the country and to improve energy access in rural areas
  - Small-scale and distributed RE (wind and solar) to play an important role in achieving electrification targets
  - Proposed capacity expansion plans focus only on enhancing hydro-based capacities

**Source: The World Bank*
#Source: Nepal Electricity Authority Annual Report 2014

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Nepal – Energy Scenario Highlights

- Nepal has no known major oil, gas, or coal reserves, and its rough geographical terrain makes providing electricity to remote communities a big challenge
- Country is yet to utilize its vast hydropower (total potential – 83 GW, economically viable – 42 GW), solar and wind resources
- Very low electrification ratios and per capita electricity consumption
  - Primary energy demand is met through biomass products
- Inadequate planning, delays in project execution, and significant underinvestment in baseload electricity-generating capacity have resulted in Nepal experiencing widespread load shedding, particularly in winter
- Chronic and acute electricity shortages have been a serious impediment to moving the economy forward, and have already resulted in a decline in the country's overall productivity
- Focus is on hydropower development to boost economic growth

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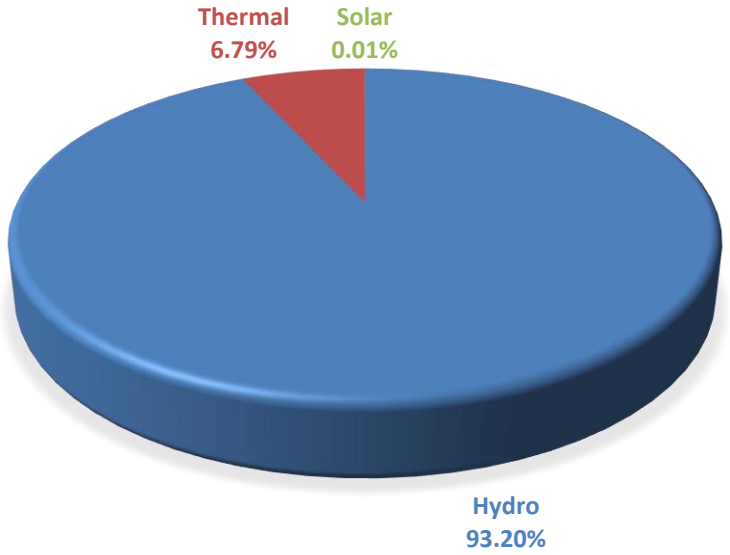
Nepal – Overall Generation Capacity Mix

End of FY 2014-15



Sector	Capacity (kW)
Hydro	733,577
Thermal	53,410
Solar	100
Total	**787,087**

Source: Nepal Electricity Authority Annual Report 2014

- Existing hydro capacity only ~1.6% of the theoretical realizable potential
  - Storage type hydropower plants represent only 13% of the capacity; rest is run-of-the-river type
- Thermal capacity is based on diesel fuel, which is mainly imported from India
- Renewable energy development still in its nascent stages

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Nepal – RE Capacity Mix

- Solar
  - Solar power installations have only been in form of Solar Home Systems (SHS), solar PV systems and other small-scale applications such as pumps, dryers, cookers, etc.
  - No utility scale solar power plants in the country
- Wind
  - Wind energy is in very early stages of development with no capacity installed currently
  - As of July'13, 10 potential sites have been identified and feasibility studies of solar-wind hybrid projects has been carried out

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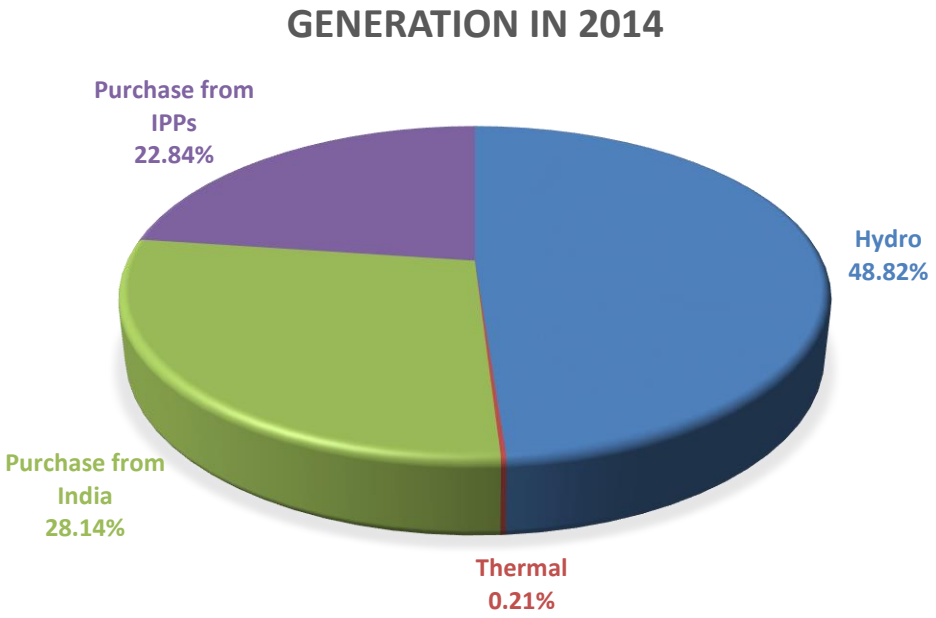
Nepal – Electricity Generation Mix

In 2014



Sector	Generation (GWh)
Hydro	2,288.23
Thermal	9.65
Purchase from India	1,318.75
Purchase from IPPs	1,070.47
Total	**4,687.1**

Source: Nepal Electricity Authority (NEA) Annual Report 2014

- Hydropower is the primary source of electricity in the country, which is seasonal in nature
- Majority of the hydro power stations are run-of-the-river type
  - Nepal becomes power deficit during dry seasons (esp. winter) when demand rises sharply
  - Country then becomes dependent on imports from India and power from diesel-fired generating stations

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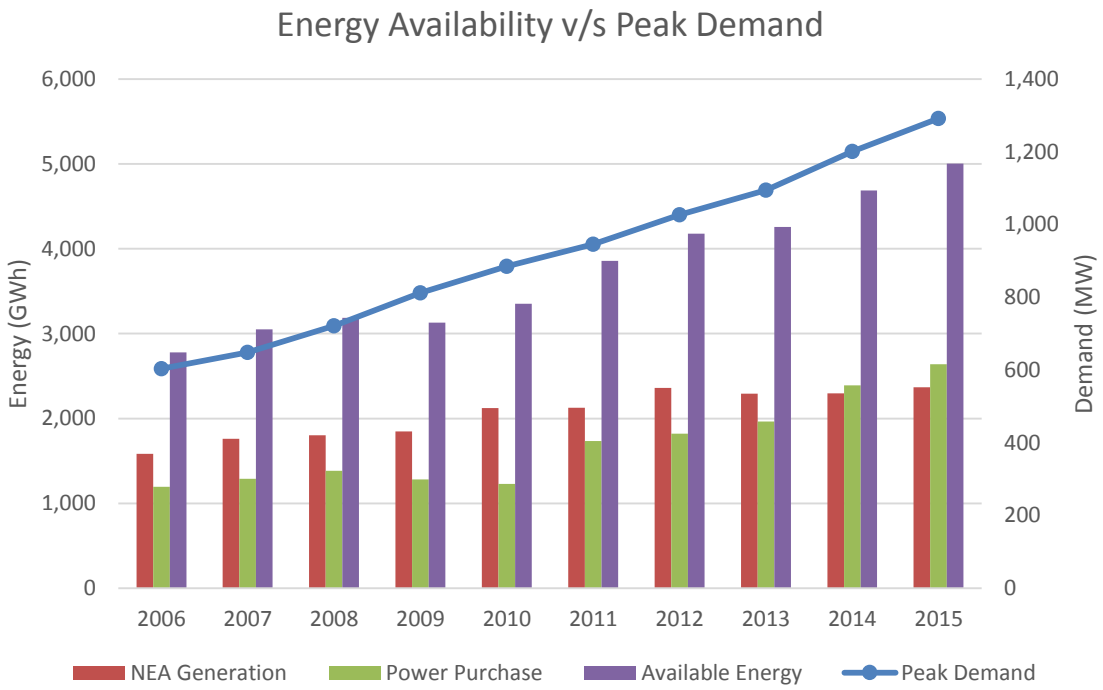
Nepal – Demand/Supply Situation



Source: Nepal Electricity Authority (NEA) Annual Report 2014

- Demand has been steadily growing due to increasing commercial and industrial activities
- Nepal faces acute power shortages, especially during the dry winter months since most of its generation capacity is based on hydropower which is of the run-of-the-river type
  - In 2010, peak demand deficit in dry and wet seasons was 440 MW (~50%) and 160 MW (~20%) respectively
  - In 2011, power deficit was 500 MW during the dry season

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Nepal – Transmission Infrastructure

- Grid yet to reach large parts of the country due to under-investments in the sector
- Many IPPs have been constrained in undertaking new development activities due to power evacuation issues
  - A ring of transmission lines around the Kathmandu valley is being constructed to resolve some of these issues
- Development of large-scale export-oriented hydropower development has also been impeded due to limited transmission connectivity with India
- Transmission Directorate of Nepal Energy Authority is responsible for development, implementation and operation of high-voltage transmission system in Nepal
  - It is implementing several transmission lines and substations (132 kV and above) across the country that are in various stages of completion

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Nepal – Energy Strategy

- Nepal is concentrating efforts on harnessing its vast hydropower resources
- Legal and policy efforts for hydropower development:
  - Electricity Act 1992 and Water Resources Act 1992
    - Encouraging IPP participation in the power sector
    - BOOT as a basis for private sector participation
  - Hydropower Development Policies 1992 and 2001
    - Development of electricity as an export commodity
    - Enhancing access to electricity through rural electrification
  - National Water Plan 2005 and Water Resources Strategy 2002
    - Basin approach for water resources utilization
    - Integrated water resources management
  - National Energy Strategy 2010
    - Making consumption of biomass energy resources sustainable
    - Making hydropower resources the primary source of energy
    - Reduction of dependence on imported fossil fuels
    - Development of alternative energy technologies such as biogas, solar, wind, etc.

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Nepal – Capacity Addition Plans

- Key policies:
  - Hydropower Development Policy (2001)
  - 10,000 MW Initiative
- Focus is to develop an optimal mix of run-of-river and storage-type hydropower projects
- Grid-connected renewable energy does not feature in capacity expansion plans

Capacity Under Construction

No	Project	Capacity (MW)
1	Upper Tamakoshi (hydro)	456
2	Tanahu (hydro)	140
3	Chameliya (hydro)	30
4	Kulekhani (hydro)	14
5	Upper Trisuli 3A (hydro)	60
6	Raghughat (hydro)	32
7	Upper Sanjen (hydro)	14.6
8	Sanjen (hydro)	42.5
9	Rasuwagadhi (hydro)	111
10	Madhya Bhotekoshi (hydro)	102
11	Upper Trisuli 3B (hydro)	42
TOTAL		**1,044.1 MW**

Planned and Proposed

No	Project	Capacity (MW)
1	Upper Arun (hydro)	335
2	Upper Modi A (hydro)	42
3	Upper Modi (hydro)	18.2
4	Dudh Kosi Storage (hydro)	640
5	Tamor Storage (hydro)	530
6	Uttar Ganga Storage (hydro)	300
7	Tamakoshi V (hydro)	87
8	Upper Bheri (hydro)	85
9	Chainpur Seti (hydro)	140
TOTAL		**2,177.2 MW**

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Nepal – RE Potential

- Nepal's Alternative Energy Promotion Center (AEPC) conducted a Solar and Wind Energy Resource Assessment (SWERA) Project in 2003
  - Approx. 6,074 km^2 of area has wind power density greater than 300 W/m^2
  - 3,000 MW could be generated from just 10% of this area
  - Commercial potential for solar power estimated to be around 2,100 MW

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PAPUA NEW GUINEA

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PAPUA NEW GUINEA - Summary

- Macroeconomic Overview
  - GDP current: $15.41 billion (2014)*
  - Population: 7.464 million (2014)*
  - Land area: 452,860 km^2
  - CO_2 emissions: 0.7 metric tons per capita (2011)*
- Power Sector
  - Largely rudimentary power system with only 10% of population having access to electricity
  - Generation Capacity: 582 MW# – dominated by state-owned hydro power plants and captive diesel generators
- VRE Grid Integration Outlook
  - Power sector infrastructure requires rehabilitation, extension of grids to urban areas and expansion of distributed generation to service rural communities
  - Grid integration issues to gain importance as share of RE in 2030 capacity mix expected to be 25%

**Source: The World Bank*

#Source: Analysis of Population and Total Energy Consumption Data for PNG (2012)

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PNG – Energy Scenario Highlights

- Vast country with only 12.5% of the population estimated to be living in urban areas
  - Only these people have access to grid connected electricity; however, supply is often unreliable
- PNG is served by three main grids:
  - Port Moresby system (heavily dependent on diesel generation)
  - Ramu system (serving the Lae-Madang-Highlands areas)
  - Gazelle Peninsula system
  - Besides, there are a number of smaller grids catering to smaller urban centers, which are predominantly powered by diesel
- Because of unreliability of the power supply, urban areas have considerable self-generation and backup generation facilities
  - Mining industry, which is one of the main drivers of PNG's economy, largely depends on captive power stations for its operations
- Lack of funding for upgrading and rehabilitation and even for routine maintenance is leading to a further deterioration in services
  - Energy losses have continued to increase, primarily because of outdated and poorly maintained transmission and distribution lines, and inadequate substation sizing
- Supplying reliable and affordable electricity is thus essential to make a positive impact on the socioeconomic well-being of PNG's people and on the economic development of the country

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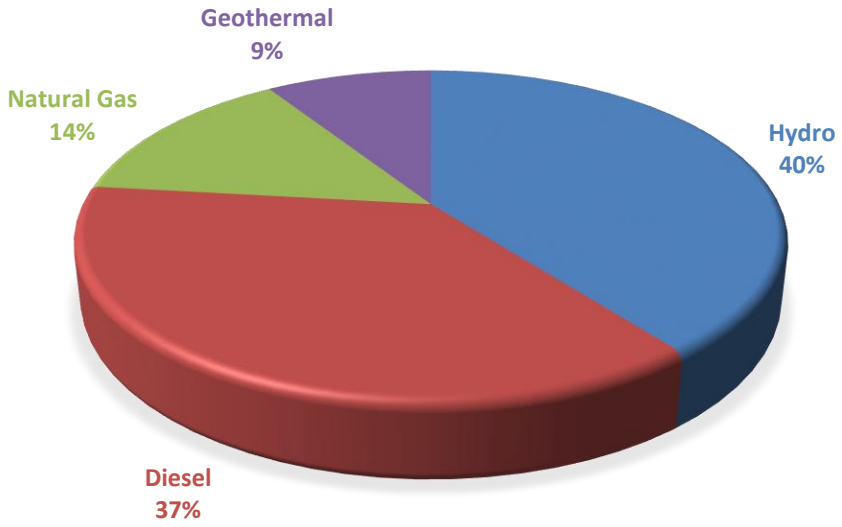
PNG – Overall Generation Capacity Mix



Sector	Generation Capacity (MW)
Hydro	230
Diesel	217
Natural Gas	82
Geothermal	53
Total	**582**

Source: PNG Sector Assessment Summary (Power), ADB 2010

- PNG Power Limited, the state-owned utility manages about 300 MW of installed capacity
- Remaining capacity comprises of:
  - Self-generation systems owned and operated by industrial facilities
  - Private generators supplying the main grids or rural communities

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PNG – RE Capacity Mix

- Solar thermal and photovoltaic applications are limited
- Wind energy is currently not being used, only pilot projects installed
- PNG has only geothermal energy as grid-connected RE
  - Total capacity estimated to be 53 MW, mostly on Lihir Island
  - Captive plant owned and operated by Lihir Gold, LLC

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PNG – Electricity Generation Mix

PPL Generation, Fuel Consumption and Losses

Year	Actual Generation (MWh)	Fuel Used (liters)	System Losses (MWh)
2007	817,947	3,155,534	146,814
2008	849,678	42,672,915	85,124
2009	895,706	4,232,449	188,785
2010	953,191	5,000,324	200,567

Source: Pacific Lighthouses – Renewable energy opportunities and challenges in the Pacific Islands region, IRENA

- Fuel-wise electricity generation data not available
- Total generation (including IPPs) was 3.35 billion kWh in 2012
- Almost 20% energy losses year on year and increasing dependence on diesel power with growth in demand
- Energy losses have continued to increase, primarily because of:
  - Outdated and poorly maintained T&D lines
  - Inadequate substation sizing

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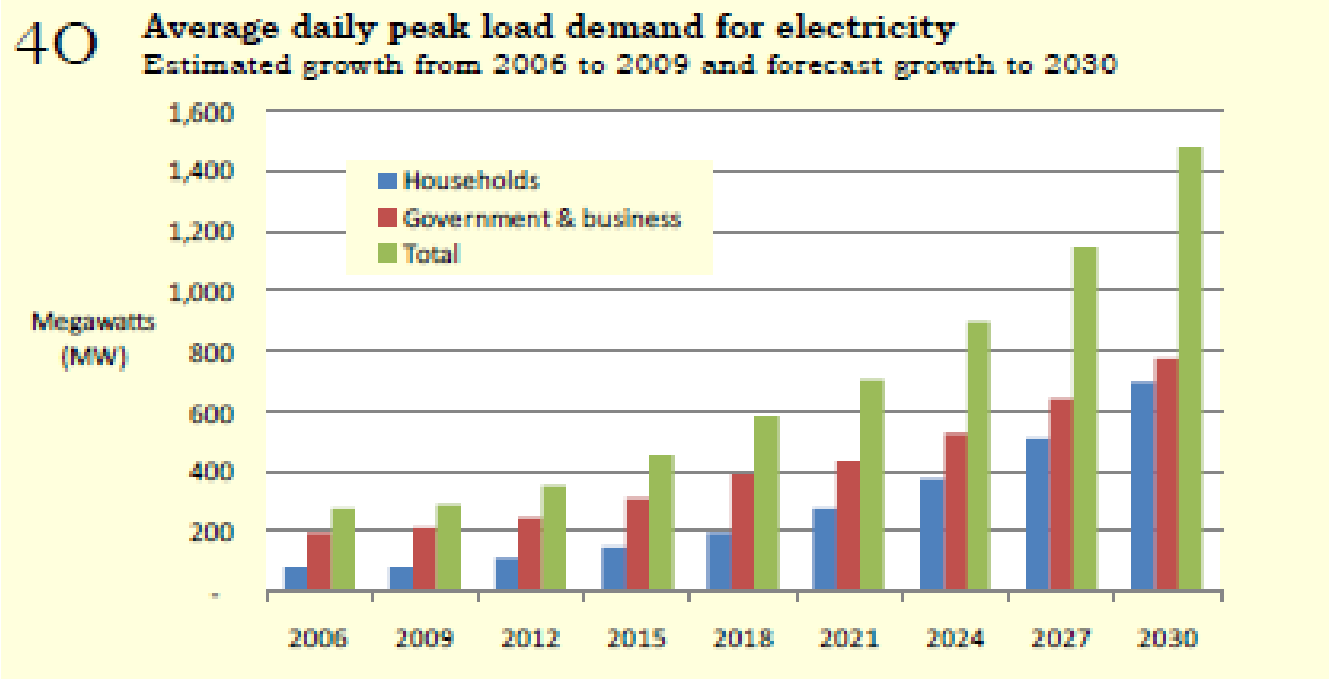
PNG – Demand/Supply Situation



Source: Papua New Guinea Development Strategic Plan, 2010–2030

- Only about 10% of PNG's population has access to grid power, which is largely confined to urban areas; hence the low demand
- Despite low electricity demand, several provinces suffer regular outages that adversely affect businesses and industry due to poor infrastructure

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PNG – Transmission Infrastructure

- State-owned PNG Power manages about 300 MW of installed generation capacity, including the two main grids and 26 smaller urban centers
  - 10 systems are part of the inter-provincial power grid (the Ramu System)
  - Remainder are independent systems
  - Large parts of the country yet to be connected to the power grid
- Current issues and challenges:
  - Unreliability of power in urban areas
  - High up-front costs to extend grid to rural and provincial areas
  - Rehabilitation of existing network to improve reliability
  - Extension of grids to service the growing urban populations
  - Expansion of distributed generation capacity to supply electricity to rural areas

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PNG – Energy Strategy

- Goal: *"All households have access to a reliable and affordable energy supply, and sufficient power is generated and distributed to meet future energy requirements and demand"*
- Energy development is being pursued by following the concept of Six Steps of Energy Ladder
- Emphasis on harnessing hydropower, geothermal and other RE resources
- Development of an electricity super-corridor through areas where electricity can be generated at lowest cost and evacuated via a robust grid to centers of economic activity

Six Steps of Energy Ladder	
Step 1	0ver 80% of households use primitive energy sources such as wood
Step 2	Between 10% and 50% of households use fuels like kerosene for lighting, cooking, etc.
Step 3	At least 50% of households use fuels like kerosene, electricity or gas for lighting and cooking, while less than 10% use electricity (if connected) or gas for lighting, cooking, etc.
Step 4	Between 10% and 50% of households use electricity or gas for lighting, cooking, etc.
Step 5	Between 50% and 70% of households use electricity or gas for lighting, cooking, etc.
Step 6	By 2030 over 70% of households and all businesses have access to reliable, affordable and modern clean energy sources

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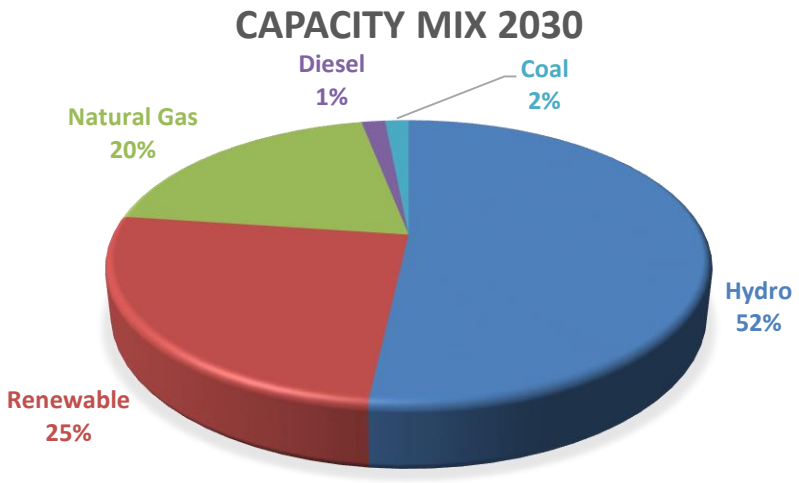
PNG – Capacity Addition Plans

- Vision 2050 – 100% electricity access

Generation Resource (MW)	2010	2015	2020	2025	2030
Hydro	215	430	580	750	1,020
Renewable (non-hydro)	55	90	160	280	500
Natural Gas	70	130	280	390	390
Diesel	160	100	60	40	30
Coal	0	30	30	30	30
TOTAL	**500**	**780**	**1,110**	**1,490**	**1,970**



Source: Papua New Guinea Development Strategic Plan, 2010–2030

- PNG has significant underutilized indigenous energy sources such as hydropower, natural gas, geothermal, and solar-based systems
- Greater development of hydropower resources to support electricity intensive industries
- Plan is to generate 25% of electricity from renewables (geothermal, wind and biomass) and reduce dependence on diesel power generation

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PNG – RE Potential

- Geothermal
  - No systematic geothermal energy assessments have been carried out but initial surveys suggest that at least 7 geothermal sites are located in the northern coast off New Britain
- Wind
  - No systematic wind resource assessment data available
- Solar
  - Amongst the largest potential sources of renewable energy; however few proper solar radiation measurements have been carried out
  - Best locations for solar are the islands in the southern region located away from the mainland due to fewer persistent clouds caused by mountains
- Hydropower
  - Economic potential estimated to be 4,200 MW

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PHILIPPINES

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PHILIPPINES - Summary

- Macroeconomic Overview
  - GDP current: $284.6 billion (2014)*
  - Population: 99.14 million (2014)*
  - Land area: 298,170 km^2
  - CO_2 emissions: 0.9 metric tons per capita (2011)*
- Power Sector
  - Characterized by high tariffs and unreliable power supply in some areas
  - Generation Capacity: 17,944 MW# – dominated by fossil fuels (coal, oil and natural gas), although significant contribution of RE to electricity generation in regional grids
- VRE Grid Integration Outlook
  - Energy independence and market reforms are the main strategic focuses of the government's energy development plan
  - Potential for renewable energy is high, although only small investments have yet taken place for its development
  - Significant wind power capacity addition plans in Luzon region likely to present multiple grid integration challenges

**Source: The World Bank*
#Source: Philippines Power Statistics 2014

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Philippines – Energy Scenario Highlights

- Philippines is an emerging economy and its economy has greatly shifted from agriculture to industry
- Conventional fossil fuels (oil and gas) are the main source for its primary energy demands
- Philippines is a net energy importer in spite of low consumption levels relative to its Southeast Asian neighbours
  - Philippines only produces small volumes of oil, natural gas and coal
  - Heavy dependence on imported fuels makes the country vulnerable to energy supply disruptions and global price fluctuations
- Philippines has one of the most expensive electricity rates in Southeast Asia; main drivers of high tariffs are:
  - Archipelagic geography and reliance on diesel generation
  - Inefficient and small generation, transmission and distribution systems in some areas
  - Low investments in the sector and cost-reflective tariffs with no government subsidies
- Unreliable and high cost of power has impeded the country's economic growth
- Thus, the Government's policy thrust is on:
  - Ensuring energy security by expanded use of renewable energy and accelerated exploration of petroleum and coal
  - Promote energy efficiency as a way of life (esp. in the transport sector) and use of clean alternative fuels and technologies

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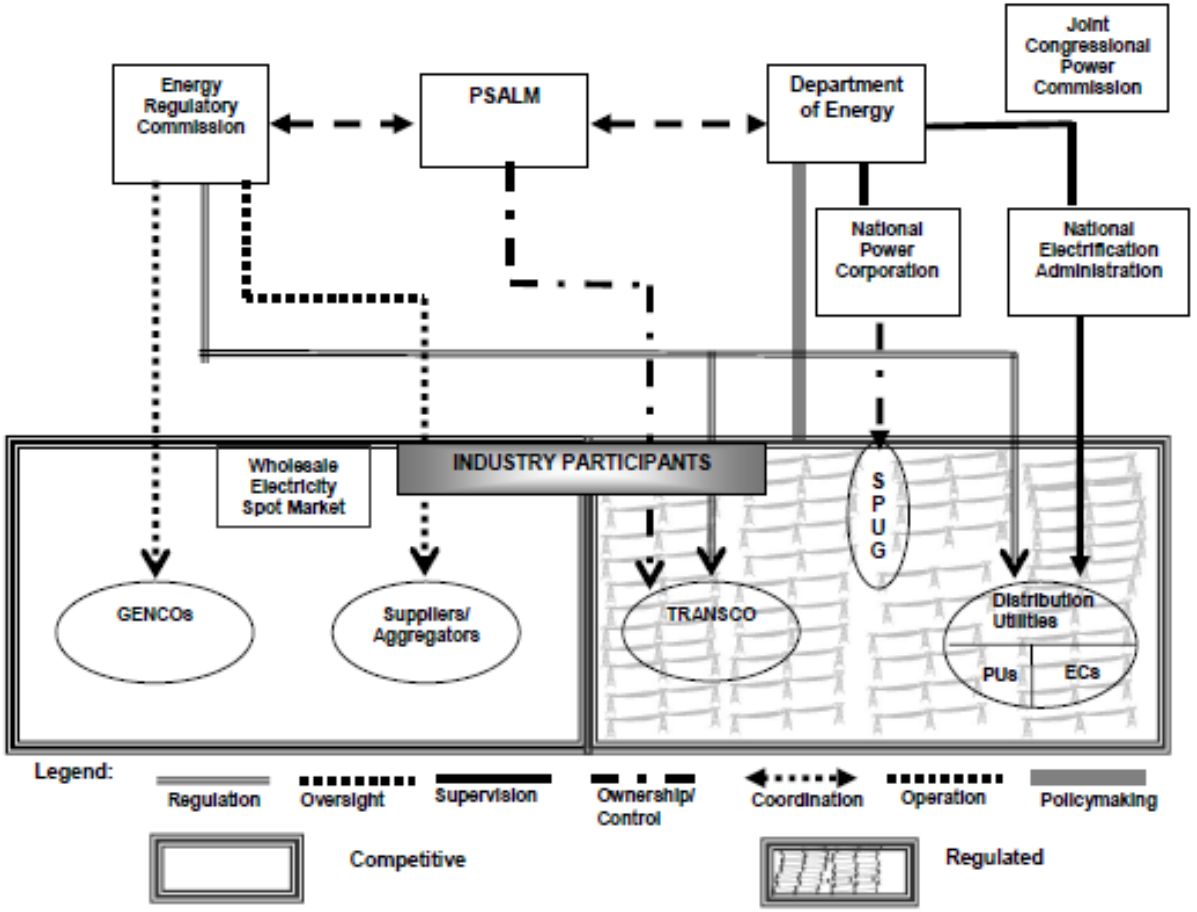
Philippines – Power Sector Structure



EC = electric cooperatives, GENCO = Generation Company, PSALM = Private Sector Assets and Liabilities Management Corporation, PU = privately owned distribution utilities, SPUG = Small Power Utilities Group, TRANSCO = National Transmission Corporation.
Source: PSALM.

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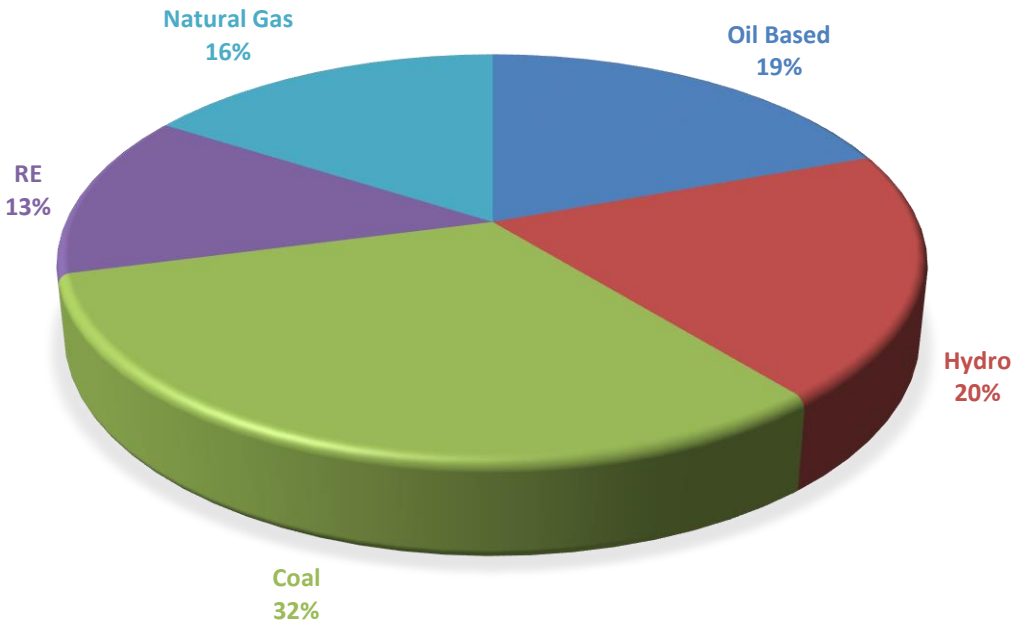
Philippines – Overall Generation Capacity Mix

As on 31.12.2014



Sector	Generation Capacity (MW)
Oil Based	3,476
Hydro	3,543
Coal	5,708
RE	2,400
Natural Gas	2,862
Total	**17,989**

Source: 2014 Philippine Power Statistics

- Power system in the Philippines is dominated by fossil fuels (coal, oil and natural gas) and hydro
- System consists of three major sub-grids:
  - Luzon (mostly coal, oil and natural gas-fired generation)
  - Visayas (geothermal, coal and oil)
  - Mindanao (hydro and oil)

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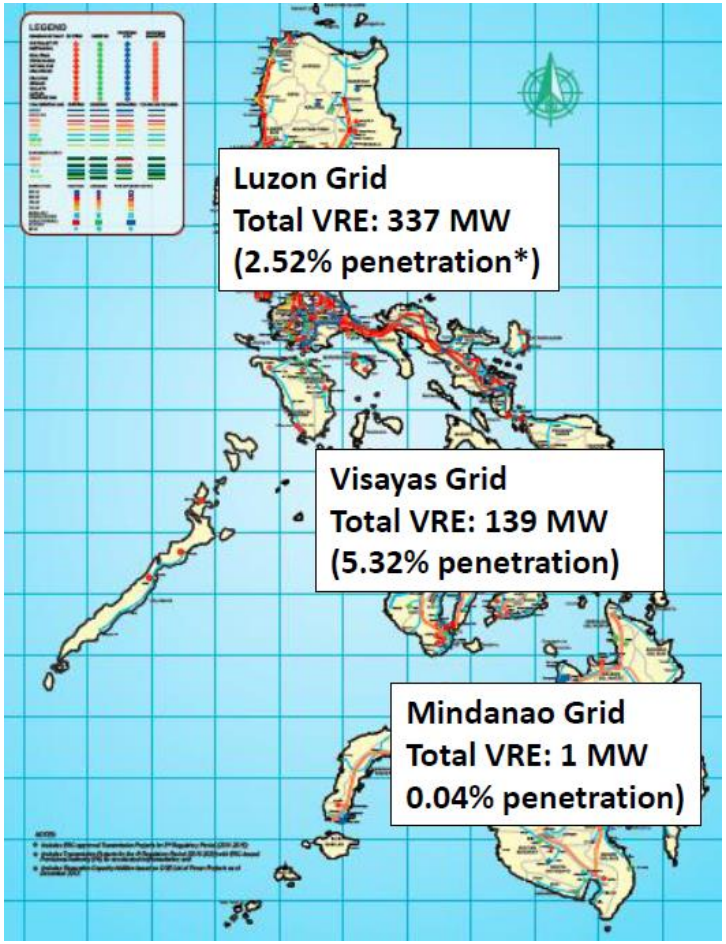
Philippines – RE Capacity Mix

Overall RE Capacity

Sector	Generation Capacity (MW)
Geothermal	1,918
New RE (Wind, Solar, Biomass)	482
Total	**2,400**

Source: 2014 Philippine Power Statistics (as on 31.12.2014)

- Wind
  - Target: 2,345 by 2030
  - 472 MW installed so far, 337 MW on Luzon island
- Solar
  - Target: 500 MW by 2016 and 1,528 MW by 2030
  - 145 MW installed so far



**installed capacity penetration*

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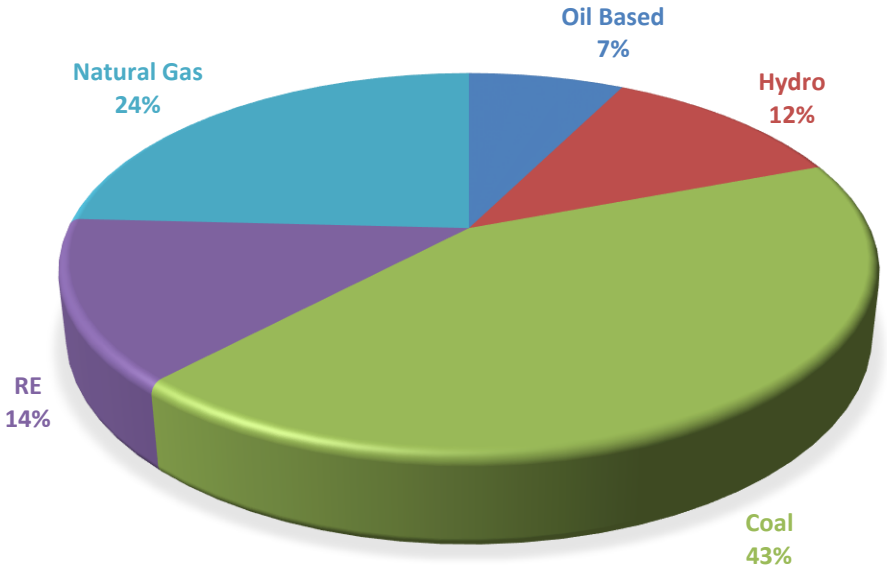
Philippines – Electricity Generation Mix

In 2014



Sector	Generation (MWh)
Coal	33,053,518
Oil Based	5,707,748
Natural Gas	18,690,077
RE	10,672,381
Hydro	9,137,273
Total	**77,260,997**

Source: 2014 Philippine Power Statistics

- Fossil fuels remain the primary source of electricity generation in the country
- Geothermal and hydropower constitute a significant share of electricity generation in regional grids of Visayas and Mindanao respectively

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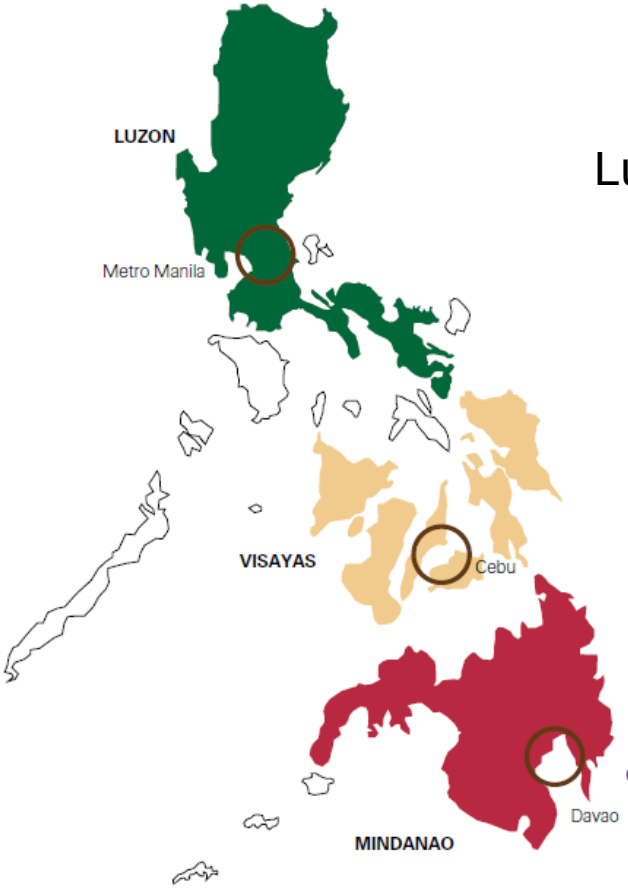
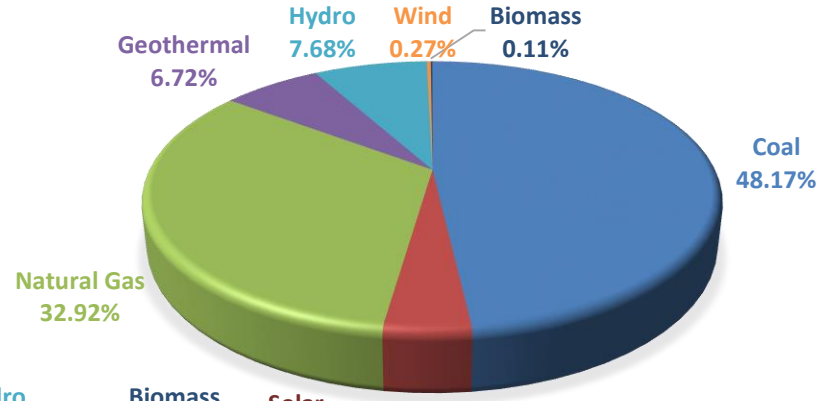
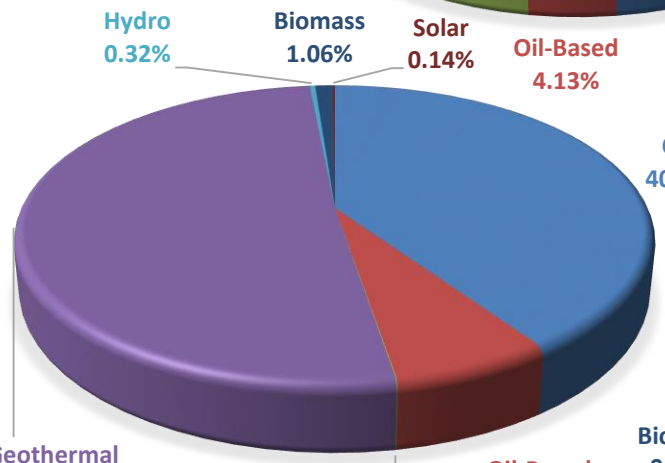
Philippines – Zone-wise Electricity Generation Mix



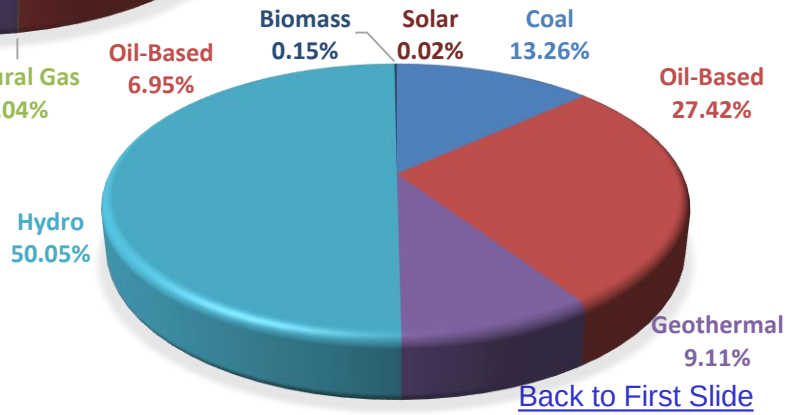
Luzon



Visayas



Mindanao



Source: 2014 Philippine Power Statistics

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Philippines – Demand/Supply Situation

- Philippines faces risk of widespread power cuts due to lack of operating reserves
- To curb these shortages, a voluntary scheme known as the Interruptible Load Program (ILP) is being implemented
  - It encourages participants to voluntarily disconnect from the grid during times of peak demand
- Energy efficiency is also being promoted that will result in energy savings of almost 400 MW

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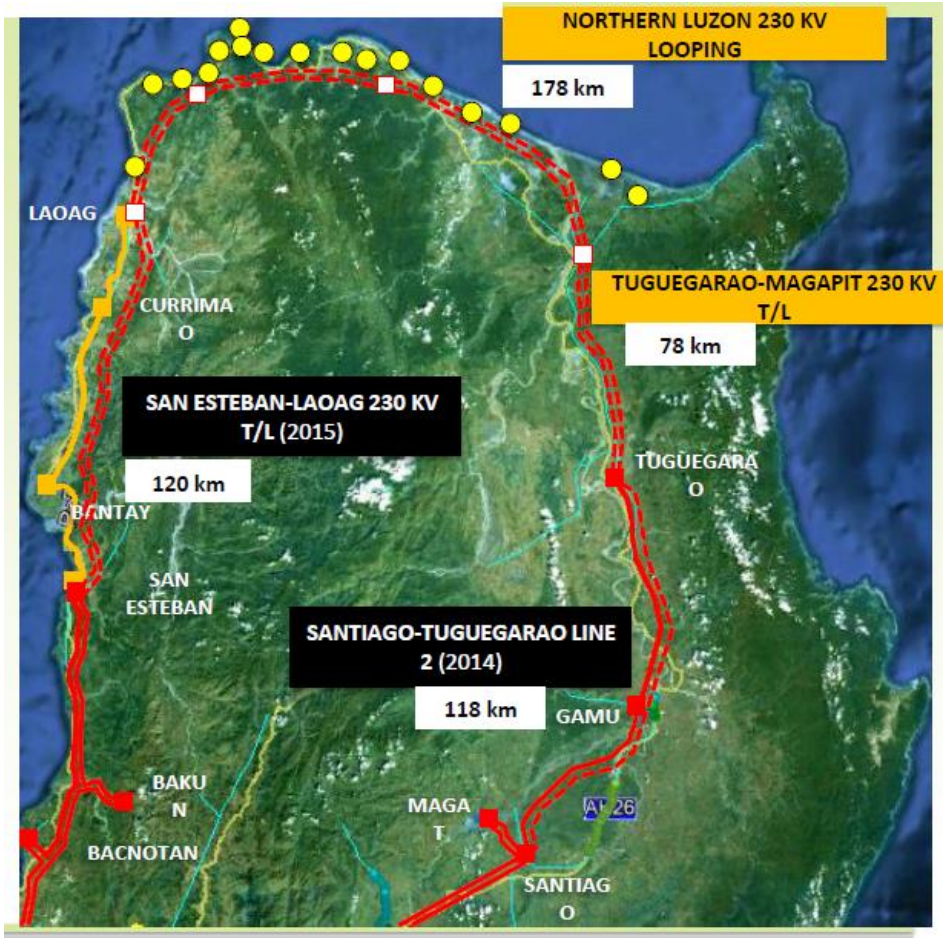
Philippines – Transmission Infrastructure

- NGCP follows its Transmission Development Plan for putting up new transmission lines and upgrading existing systems
- Strengthening of transmission and distribution infrastructure is required to keep pace with growth in generation capacity
- Mindanao is currently not connected with the Luzon-Visayas grid
- Wind power evacuation issues in Luzon:
  - Wind power in Luzon is highly concentrated along the northern coast where local electricity demand is low
  - NGCP is still toiling at the first 230 kV transmission extension dedicated to the northwest tip



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Philippines – Energy Strategy (1)

- Power Sector Reforms
  - Retail Competition and Open Access (RCOA)
  - Adapt Smart Grid Technologies
  - Grid Interconnection
  - Electricity Spot Market
  - RE Market
  - Accelerated Rural Electrification – 90% by 2017 (thru distributed RE)
- Expand Use of Natural Gas
- Push Sustainable Fuels for Transport
  - 30% of all public utility vehicles running on alternative fuels nationwide by 2030
- Make Energy Efficiency a Way of Life – promote ESCO business model
- Expand Capacity and Coverage of Power Supply
- Climate-proof Energy Infrastructure and Facilities

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Philippines – Energy Strategy (2)

- Electric Power Industry Reform Act (EPIRA)
  - Privatization of the National Power Corporation ("NPC")
  - Creation of Transmission Company ("TRANSCO")
  - Creation of Power Sector Asset and Liabilities Management Corporation ("PSALM")
  - Creation of Energy Regulatory Commission ("ERC")
  - Creation of Wholesale Electricity Spot Market ("WESM")
  - Establishment of Open Access for competitive consumers
- Retail competition and open access commenced commercial operations in Luzon and Visayas on 26 June 2013 paving the way for effective competition in the sector
- However, implementation of some of the elements of the reform outlined above has been delayed and real declines in electricity prices are yet to be achieved

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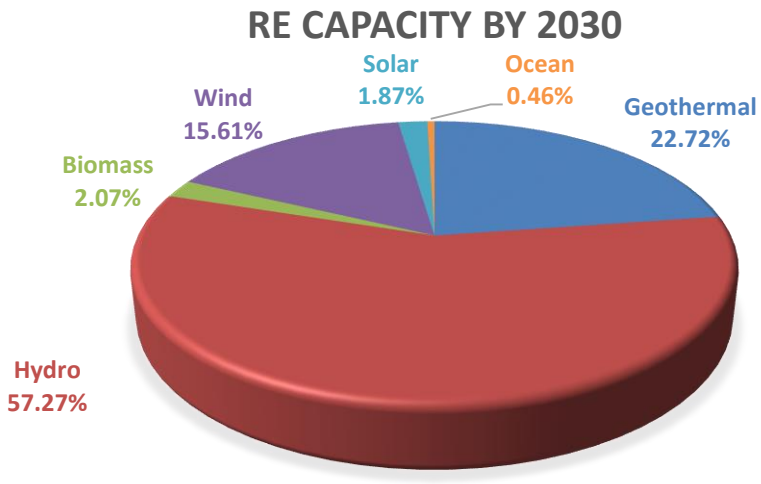
Philippines – Capacity Addition Plans

- Develop Indigenous Energy Resources
  - Promote Fossil Fuels Exploration

Fossil Fuel	2012	2012-2030
Oil (million barrels)	1.64	78.0
Gas (billion cubic feet)	137.8	2,837.8
Condensate (million barrels)	4.75	70.8
Coal (million metric tonnes)	7.4	229.9



  - Triple RE Installed Capacity by 2030 (including hydro) - most of it in Luzon

All figures in MW

Sector	Installed Capacity (2012)	Addition by 2015	Addition by 2020	Addition by 2025	Addition by 2030	Total Capacity Addition (2011-2030)	Total Installed Capacity by 2030
Geothermal	1,966	220	1,100	95	80	1,495	3,461
Hydro	3,400	341.3	3,161	1,891.8	-	5,394.1	8,724.1
Biomass	39	276.7	-	-	-	276.7	315.7
Wind	33	1,048	855	442	-	2,345	2,378
Solar	1	269	5	5	5	284	285
Ocean	-	-	35.5	35	-	70.5	70.5
Total	**5,438**	**2,155**	**5,165.5**	**2,468.8**	**85**	**9,865.3**	**15,304.3**

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Philippines – RE Potential

- Philippines is located in the Pacific Ring of Fire and thus has a high geothermal potential
- Estimated potential for other renewable energy technologies is:
  - 10,500 MW for hydropower
  - 76,600 MW for wind
  - 300 MW for solar (for 2011-2030)
  - 235.7 MW for biomass, and
  - 70 MW for ocean power (for 2011-2030)

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THAILAND

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THAILAND - Summary

- Macroeconomic Overview
  - GDP current: $373.8 billion (2014)*
  - Population: 67.73 million (2014)*
  - Land area: 510,890 km^2
  - CO_2 emissions: 4.5 metric tons per capita (2011)*
- Power Sector
  - Heavily reliant on fossil fuels (coal and gas) for electricity generation
  - Multi-tier structure with state-owned enterprise EGAT and large and small IPPs
  - Generation Capacity: 37,366.95 MW# (EGAT's share ~41%)
- VRE Grid Integration Outlook
  - Emphasis on diversifying the energy mix for greater energy security and to reduce dependence on fossil fuels (esp. imported oil)
  - Power Development Plan proposes significant variable RE capacity additions (solar – 2 GW, wind - 1.8 GW) that would give rise to various grid integration related issues

**Source: The World Bank*
#Source: Electricity Generating Authority of Thailand (EGAT)

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Thailand – Energy Scenario Highlights

- Although Thailand holds large reserves of natural gas, its domestic oil supply is limited and the country relies on imports to sustain its rising fuel demand
  - Imported oil accounts for ~80% of domestic oil consumption
- Petroleum and other liquids account for the greatest share of the country's annual primary energy consumption (~60%), followed closely by natural gas
- Agricultural residues continue to be an important source of energy in rural areas
- Threats to a competitive and stable energy supply include:
  - Rising market prices of oil and gas
  - Scarce and dwindling domestic resources
  - Uncertain reliability of nondomestic sources of energy
  - Increasing domestic demand
- Energy diversification is a prime goal to ensure a sustainable supply of energy

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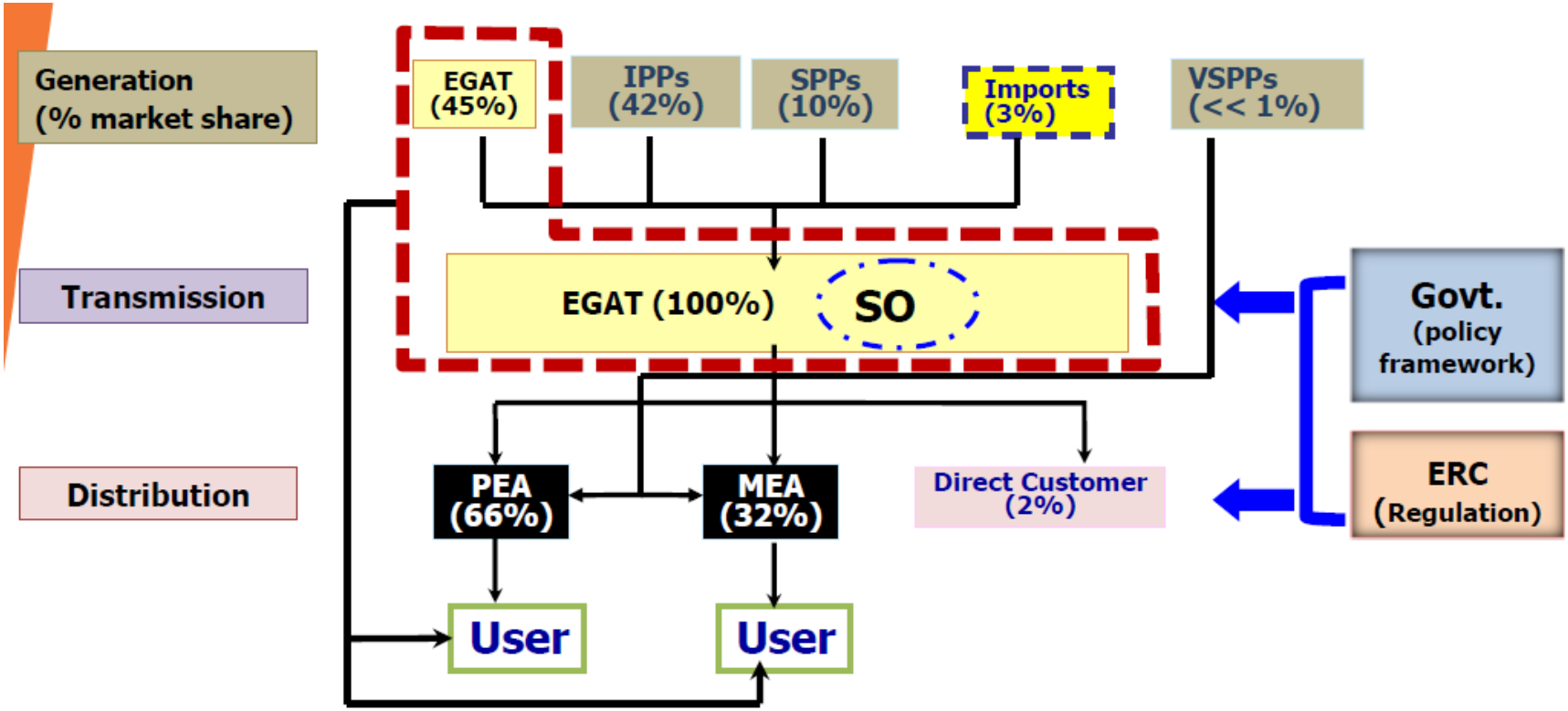
Thailand – Power Sector Structure



EGAT = Electricity Generating Authority of Thailand
MEA = Metropolitan Electricity Authority
PEA = Provincial Electricity Authority

IPPs = Independent Power Producers (Cap. sold to EGAT >= 90 MW)
SPPs = Small Power Producers (Cap. sold to EGAT < 90 MW)
VSPPs = Very Small Power Producers (Cap. sold to MEA/PEA < 10 MW)
ERC = Energy Regulatory Commission

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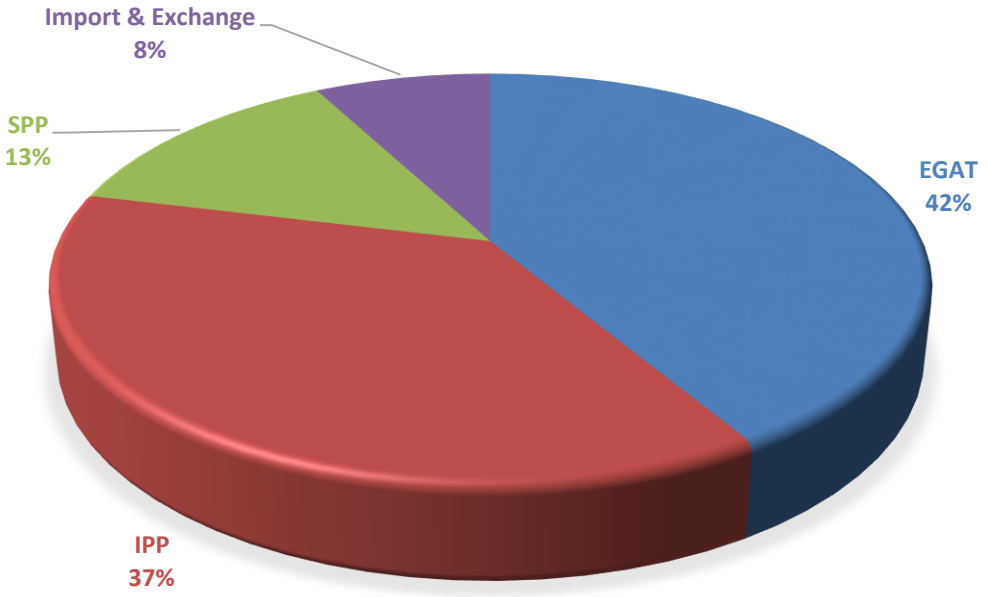
Thailand – Overall Generation Capacity Mix

As on 31.10.2015



Sector	Generation Capacity (MW)
EGAT	15,492.13
IPP	13,966.7
SPP	5,012.52
Import & Exchange	2,895.60
Total	**37,366.95**

Source: EGAT Website

- Electricity Generating Authority of Thailand is the state-owned enterprise, managed by the Ministry of Energy
- EGAT enables limited private participation in power generation through independent power producer (>90 MW), small power producer (10–90 MW) and very small power producer (<10 MW) programs
- Thailand also imports power from neighboring Lao PDR and Malaysia

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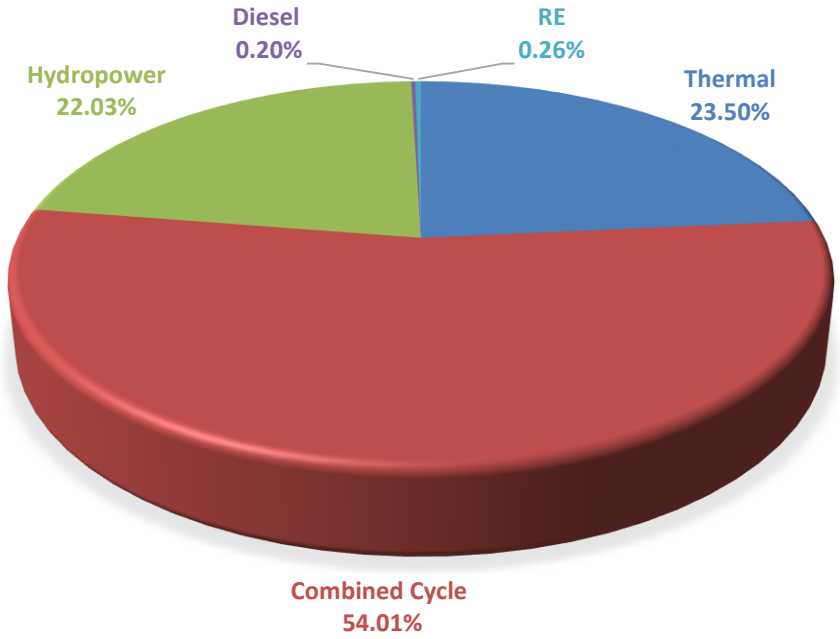
Thailand – EGAT's Generation Capacity Mix

As on 31.10.2015



Sector	Generation Capacity (MW)
Thermal*	3,647
Combined Cycle	8,382
Hydropower	3,418.40
Diesel	30.40
Renewable Energy	40.33
Total	**15,492.13**

Source: EGAT Website

**Thermal includes coal, nuclear and gas*

- Natural gas fired plants dominate EGAT's capacity
- Hydropower capacity comprised of a mix of mini, micro and large power plants with both storage and run-of-river categories
- Despite environmental concerns, EGAT continues to press forward for coal-fired power plants to reduce dependency on natural gas imports for electricity generation

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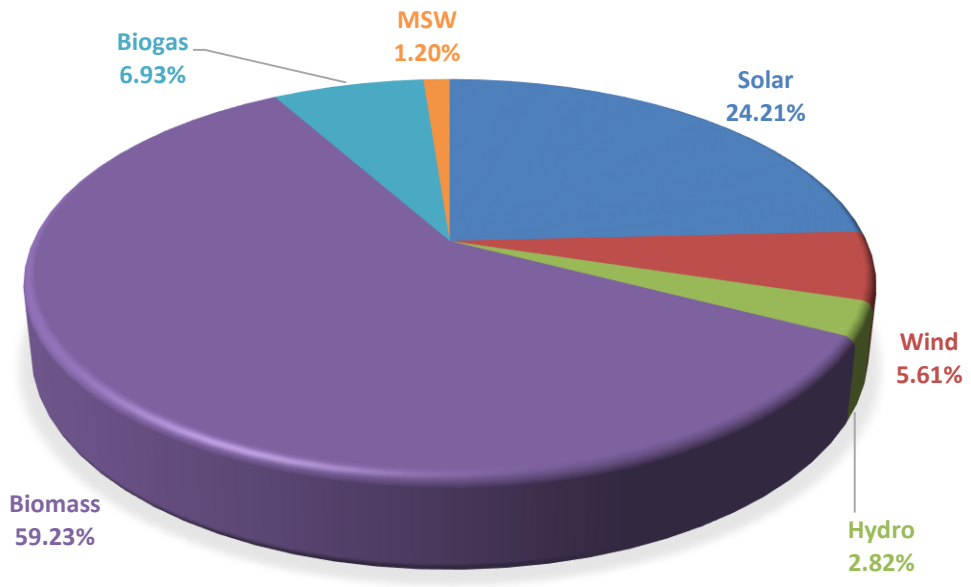
Thailand – RE Capacity Mix (incl. off-grid)

As on 31.03.2014



Sector	Generation Capacity (MW)
Solar	960.95
Wind	222.71
Small Hydro Power	112.05
Biomass	2351.28
Biogas	274.94
MSW	47.48
Total	**3,969.41**

Source: Energy in Thailand: Facts & Figures Q1 2014, Ministry of Energy

TW = Tera Watt (10^12 W)

- Biomass is an important source of renewable energy in Thailand, especially for households and industries in rural areas
- Thailand is actively developing wind energy
- Thailand receives strong solar irradiation and has a high resource potential (~33.4 TWh/year)
  - Robust and generous Feed-in-Tariff mechanism has been the cornerstone of recent investments in solar energy

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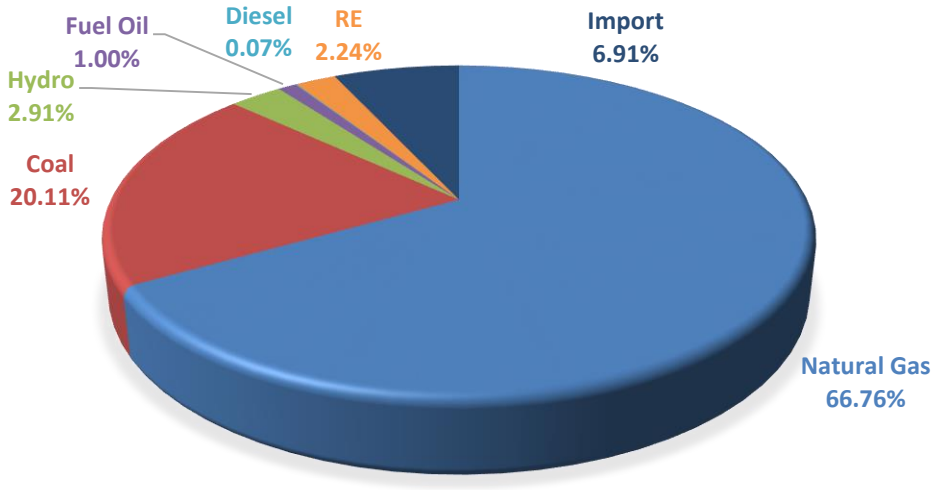
Thailand – Electricity Generation Mix

In 2014



Sector	Generation (GWh)
Natural Gas	118,559.38
Coal	35,711.92
Hydro	5,164.03
Fuel Oil	1,774.42
Diesel	121.48
RE (includes biomass)	3,981.3
Import	12,267.94
Total	**177,580.47**

- Conventional fuels dominate the energy mix
- Electricity generated from renewable energy sources (mainly hydro with small contributions of wind, geothermal and solar) made up only 5.15% of total domestic commercial energy production
- Natural gas represents almost 67% of electricity generation
  - 80% is from the Gulf of Thailand
  - Rest is imported from Myanmar

Source: EGAT Annual Report 2014

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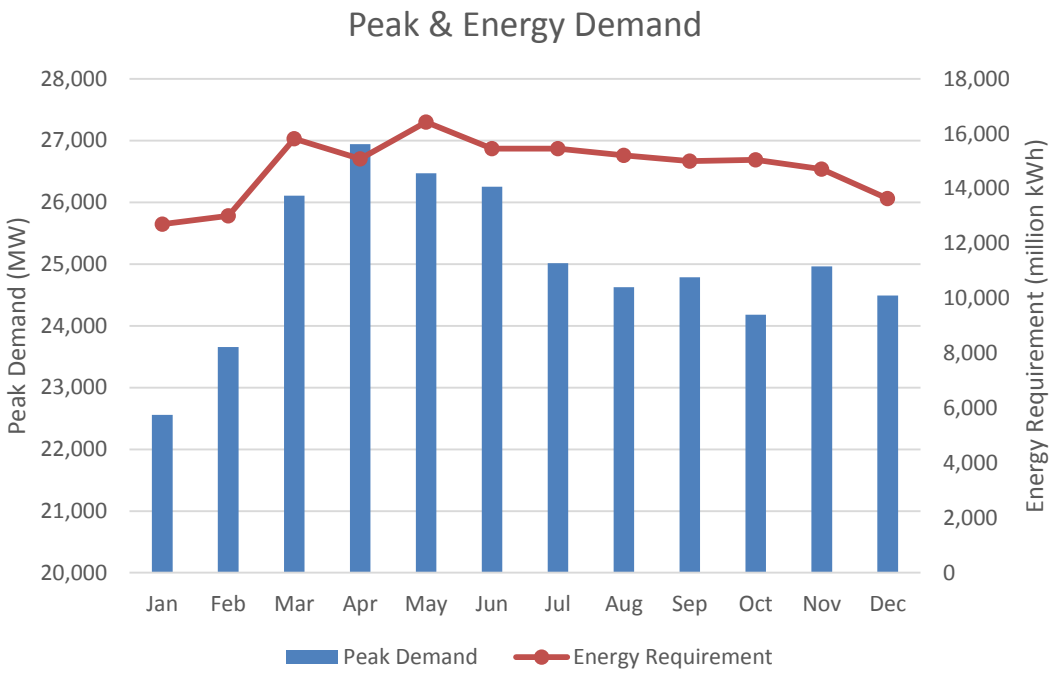
Thailand – Demand/Supply Situation



Source: EGAT Annual Report 2014

- Peak generation requirement occurred on April 23, 2014
- Thailand was able to meet its entire energy requirement in 2014
- Power purchased from domestic private IPPs and neighboring Lao PDR and Malaysia

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Thailand – Transmission Infrastructure

- Thailand has a robust transmission infrastructure that comprises of transmission lines of 32,526.992 circuit-kilometres with 213 substations, 572 delivery points and a total transformer capacity of 88,461.44 MVA
- EGAT continues to implement several improvement, maintenance and expansion projects to increase stability and capability of the power supply system

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Thailand – Energy Strategy

- Thailand Power Development Plan 2010-2030 envisages the following:
  - 20-Year Energy Efficiency Development Plan 2011-2030: Targets 25% reduction in per capita energy consumption by 2030
  - 10-Year Alternative Energy Development Plan 2012-2021: Targets 25% increase in use of RE by 2021

Total capacity (as of Dec. 2011)	32,395 MW
Total added capacity during 2012-2030	55,130 MW
Total capacity retirement during 2012-2030	-16,839 MW
Grand total capacity (at the end of 2030)	**70,686 MW**

Source: Thailand Power Development Plan 2010, Ministry of Energy

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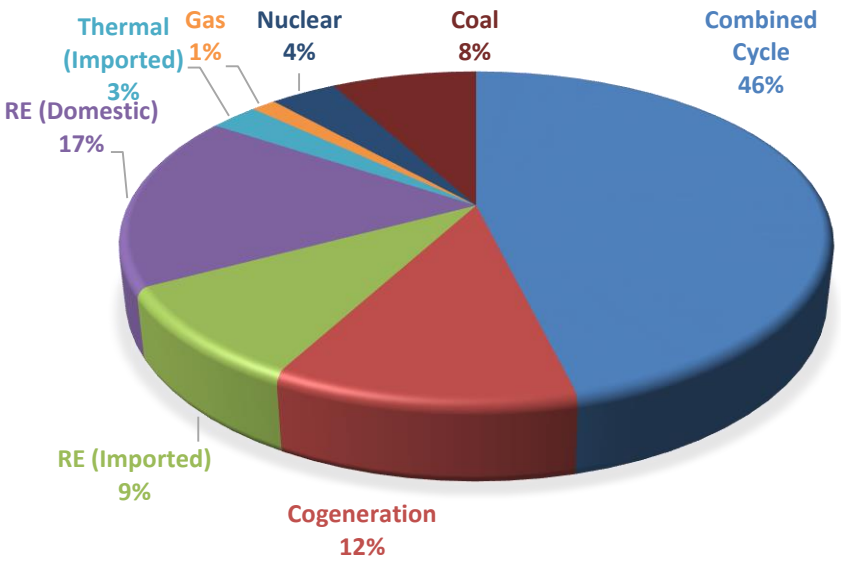
Thailand – Planned Capacity Additions by 2030

Renewable energy power plants	**14,580 MW**
- Power purchase from domestic	9,481 MW
- Power purchase from neighboring countries	5,099 MW
Cogeneration	**6,476 MW**
Combined cycle power plants	**25,451 MW**
Thermal power plants	**8,623 MW**
- Coal-fired power plants	4,400 MW
- Nuclear power plants	2,000 MW
- Gas turbine power plants	750 MW
- Power purchase from neighboring countries	1,473 MW
Total	**55,130 MW**

Source: Thailand Power Development Plan 2010, Ministry of Energy



Source: Thailand Power Development Plan 2010, Ministry of Energy

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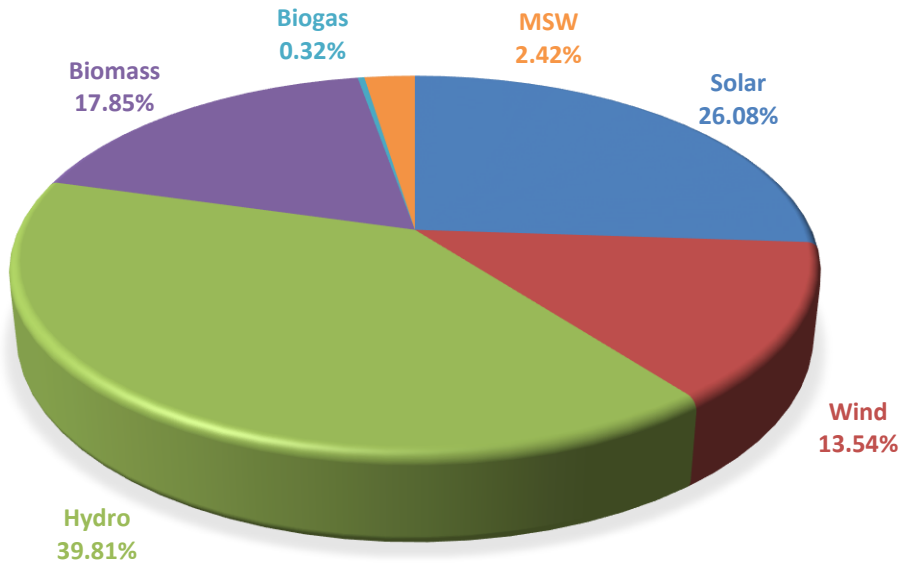
Thailand – Planned RE Capacity Additions by 2030



Sector	Generation Capacity (MW)
Solar	3,802
Wind	1,973.7
Hydro Power	5,804
Biomass	2,602.2
Biogas	46.2
MSW	352.3
Total	**14,580.4**

- Thrust on harnessing the huge hydro and solar potential in the country
- Target is to increase the share of renewable energy and alternative energy uses to 25% by 2030

Source: Thailand Power Development Plan 2010, Ministry of Energy

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Thailand – RE Potential

- Solar
  - Thailand has strong solar irradiation and resource potential
  - Maximum technical potential is estimated to be around 22,801 MWp
  - About 960 MW has been installed (as on 31st March, 2014) with the support of a well-structured institutional framework and generous financial and fiscal incentives
  - Planned capacity additions appear achievable with Thailand's extensive and robust grid system
- Wind
  - Thailand has rich wind resources, although realizable potential is limited because of the extensive protected areas, the difficulty of installing wind turbines in mountainous or remote areas and inaccessibility to a nearby grid
  - However, Thailand's grid is robust and it is likely that wind power can be absorbed at the upper limit of 20% implying a technical potential of 1,600 MW
    - Figure revised to ~2,000 MW in recent capacity addition plans
  - 222 MW achieved till 31.03.2014

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Viet Nam

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Viet Nam - Summary

- Macroeconomic Overview
  - GDP current: $186.2 billion (2014)*
  - Population: 90.73 million (2014)*
  - Land area: 310,070 km^2
  - CO_2 emissions: 2.0 metric tons per capita (2011)*
- Power Sector
  - Characterized by rapid demand growth, which has consistently surpassed GDP growth rate
  - Generation Capacity: 33,802 MW# – traditionally dominated by hydro, increasing share of coal and gas in the last decade
- VRE Grid Integration Outlook
  - Coal and gas seen as the primary energy sources of the future
  - Except for hydropower, markets for renewable energies such as wind and solar power are in early stages of development
  - National Power Development Master Plan proposes significant RE capacity additions by 2030, although their overall share in generation capacity would be low (4-5%)

**Source: The World Bank*
#Source: Operation Report Year 2014, National Despatch Centre

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Viet Nam – Energy Scenario Highlights

- For the last 2 decades, Viet Nam has been an important coal, oil, and natural gas producer, remaining self-sufficient in energy, with substantial proven reserves of fossil fuels and renewable energy resources, including hydro potential
  - Overall, the country has been a net exporter of energy
  - Exports have dropped in recent years due to increase in local demand
- Viet Nam's electricity consumption has grown substantially as a result of its steady economic growth and improved electrification ratio
  - Demand grew at a rate of 14% during 2004-2010; GDP growth rate was 7% during the same period
- Viet Nam has made remarkable progress in expanding access to electricity
  - Percentage of households without electricity reduced from 22% in 1999 to 3% in 2010
- Industry continues to remain the single-most important consumer category accounting for 52% of consumption and contributing 41% to the country's GDP
  - Ensuring reliable electricity supply is therefore imperative to sustaining economic growth at the target of 7.5%-8% per year
- Future development plans for energy supply include:
  - Introducing markets for coal and gas
  - Expanding coal, gas and oil exploitation
  - Increasing the use of renewable energy
  - Introducing nuclear power

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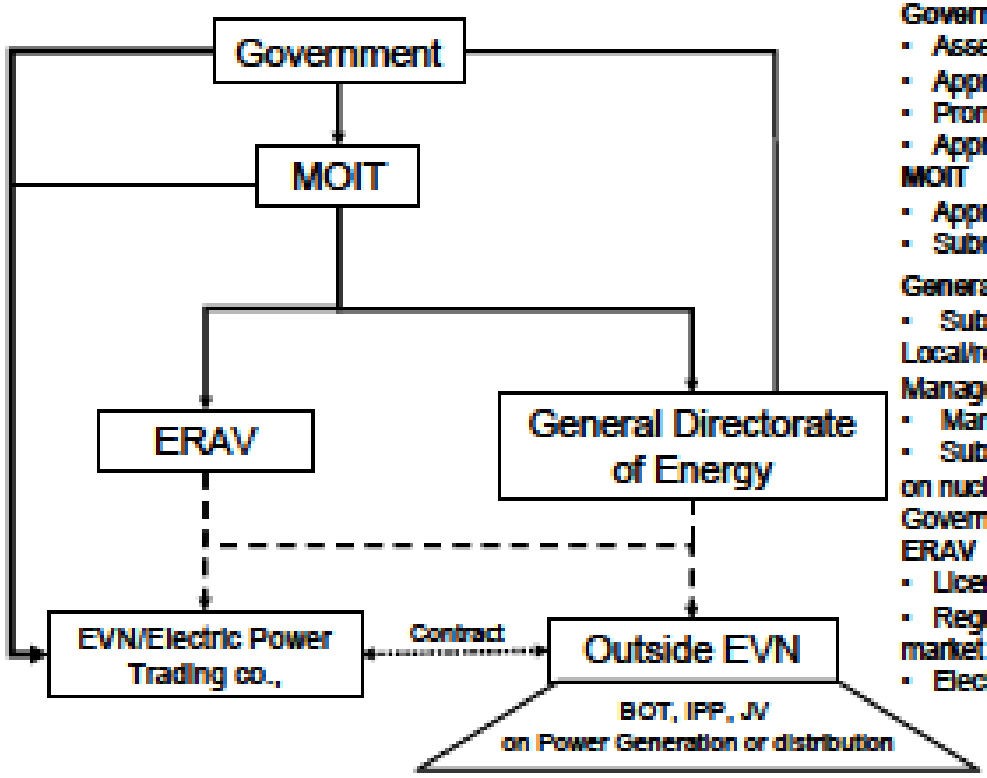
Viet Nam – Power Sector Structure



Government
- Asset owner
- Approve the electricity tariff
- Promulgate legal framework
- Approve PDP, Energy DP, nuclear facility

MOIT
- Approve Local/regional DP, Hydro PDP
- Submit PDP, Energy DP to Government

General Directorate of Energy
- Submit and appraise PDP, Energy DP, Local/regional DP, Hydro PDP to MOIT

Management of such approved DP
- Management of Power BOT projects
- Submit the plan/location/policy/manpower on nuclear power facilities to MOIT and Government

ERAV
- Licensing
- Regulatory body in competitive power market
- Electricity tariff and rates regulating

EVN = Viet Nam Electricity
MOIT = Ministry of Industry & Trade
ERAV = Electricity Regulatory Authority of Viet Nam
PDP = Power Development Plan
DP = Development Plan
BOT = Build-Operate-Transfer

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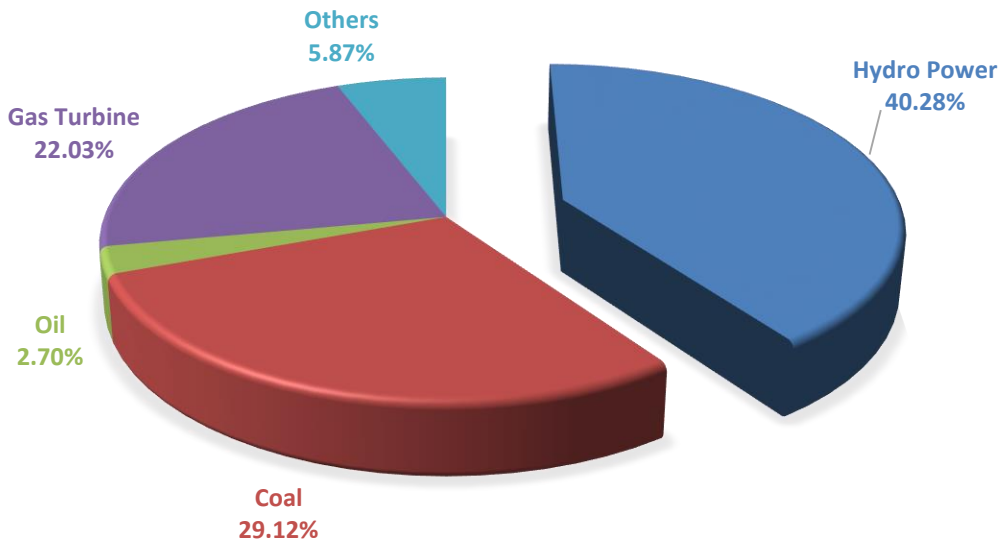
Viet Nam – Overall Generation Capacity Mix

As on 31.12.2014



Sector	Installed Capacity (MW)
Hydro Power	13,617
Coal	9,843
Oil	912
Gas Turbine	7,446
Others*	1,984
Total	**33,802 MW**

- Installed capacity for generating electricity comprises a mix of hydro, gas-fired, oil-fired and coal-fired plants
- Hydro capacity grew significantly in 2012 with the increased entry of IPPs and the completion of the 2,400-MW Son La Hydro Power Plant
  - Coal-fired capacity has also expanded from 10% of the total in 2000 to 23% in 2013 and about 29% in 2014

Source: Operation Report Year 2014, National Despatch Centre

**Others includes diesel and renewables (wind)*

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Viet Nam – RE Capacity Mix

- Wind
  - Current installed capacity stands at 84 MW
  - Three wind farms operational in the country
    - Tuy Phong, 30 MW
    - Phu Quy, 6 MW
    - Bac Lieu, 48 MW
- Solar
  - Current installed capacity estimated to vary from 1.5 MW – 4 MW
  - Mostly in the form of residential and small-scale rural applications

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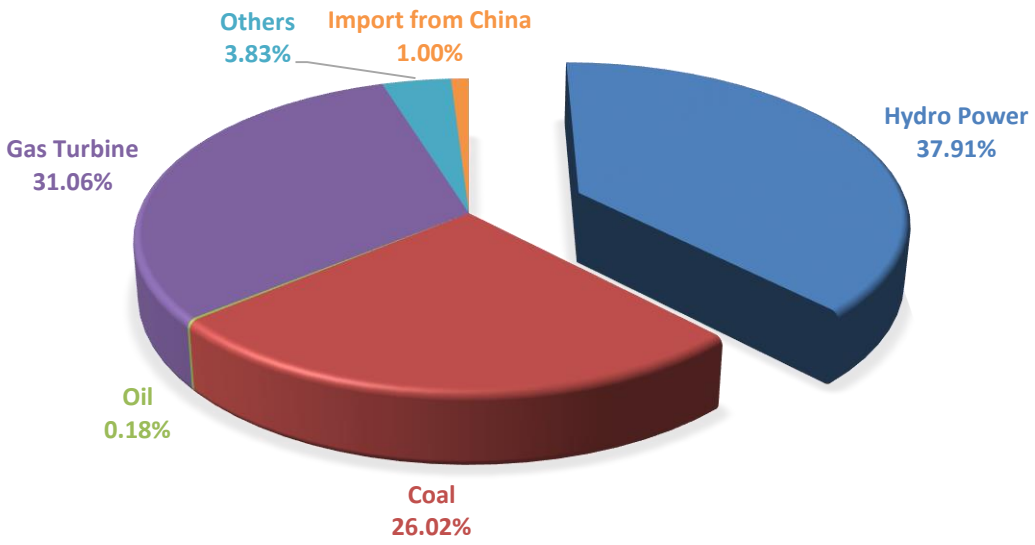
Viet Nam – Electricity Generation Mix

In 2014



Sector	Generation (GWh)
Hydro Power	54,839
Coal	37,645
Oil	254
Gas Turbine	44,930
Import from China	1,441
Others	5,547
Total	**144,656**

Source: Operation Report Year 2014, National Despatch Centre

- Traditionally, Viet Nam relied mostly on hydropower for its power needs
- With rapid growth in gas and coal sources, thermal generation expanded and has become the dominant power source since 2006
- Coal-based generation began to expand more significantly from 2010 after domestic prices of coal were set below world market prices, thus encouraging its greater use for power generation

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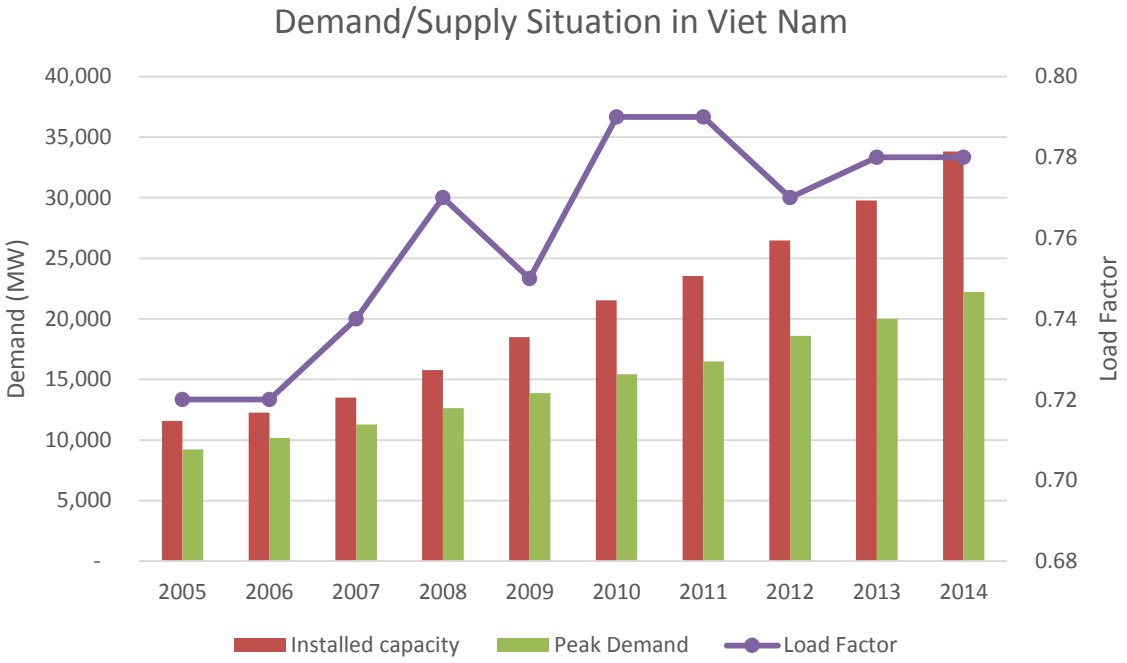
Viet Nam – Demand/Supply Situation



Source: Operation Report Year 2014, National Despatch Centre

- Power demand has grown steadily over the last 10 years (~11%) as a result of a fast growing economy and improvements in standards of living and electrification rates (98% in 2013)
- Frequent power failures occur during dry season and times of peak demand due to insufficient backup generation capacity and weak T&D network
- Enormous difference between peak and off-peak demand results in problems in grid stability because of difficulties in load dispatching

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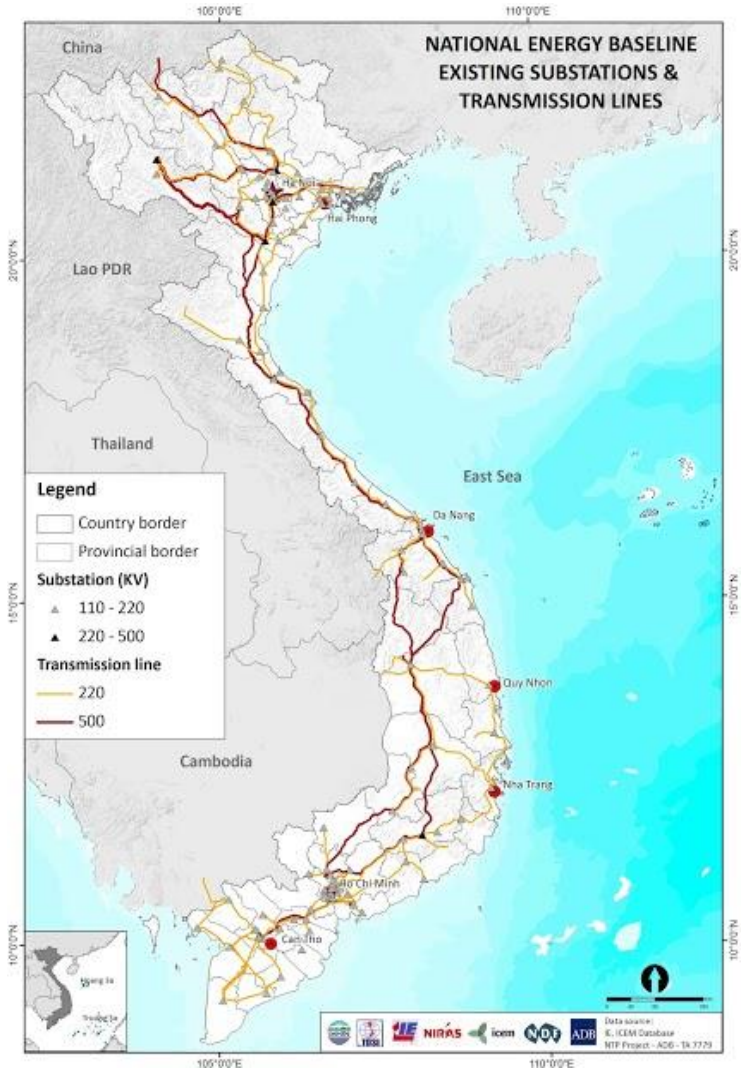
Viet Nam – Transmission Infrastructure

- Viet Nam's grid operates at three voltages – 500 kV, 220 kV and 110 kV
  - 500 kV (North-South) acts as a backbone for the system transferring amongst regions and enabling utilization of surplus output in each region
- Expansion plans have been delayed due to difficulties in securing funds and necessary permits and approvals
  - Subsequently some substations were overloaded, affecting power supply reliability and safety
- Future plans involve development of high-voltage transmission lines and substations

Asset	2011-2015	2016-2020	2021-2025	2026-2030
500 kV line (km)	3,833	4,539	2,234	2,724
220 kV line (km	10,637	5,305	5,552	5,020
500 kV substation	17,100	26,750	24,400	20,400
220 kV substation	35,863	39,063	42,775	53,250



Source: The Prime Minister, 2011. Decision 1208 dated 21 July 2011 approving the national master plan for power development for the 2011-2020 period with the vision to 2030

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Viet Nam – Energy Strategy

- Viet Nam's current energy strategy focuses on:
  - Increasing electricity availability (domestic & imported) from 194-210 billion kWh by 2015 to 330-362 billion kWh by 2020 and 695-834 billion kWh by 2030
  - Prioritizing development of renewable energy to increase share of electricity generated from RE to 4.5% by 2020 and 6% by 2030
  - Reducing average energy elasticity ratio (the ratio between the growth rate of energy consumption and the growth rate of GDP in the same period) to 1.0 by 2020
  - Promoting rural electrification program in rural, mountainous and island areas

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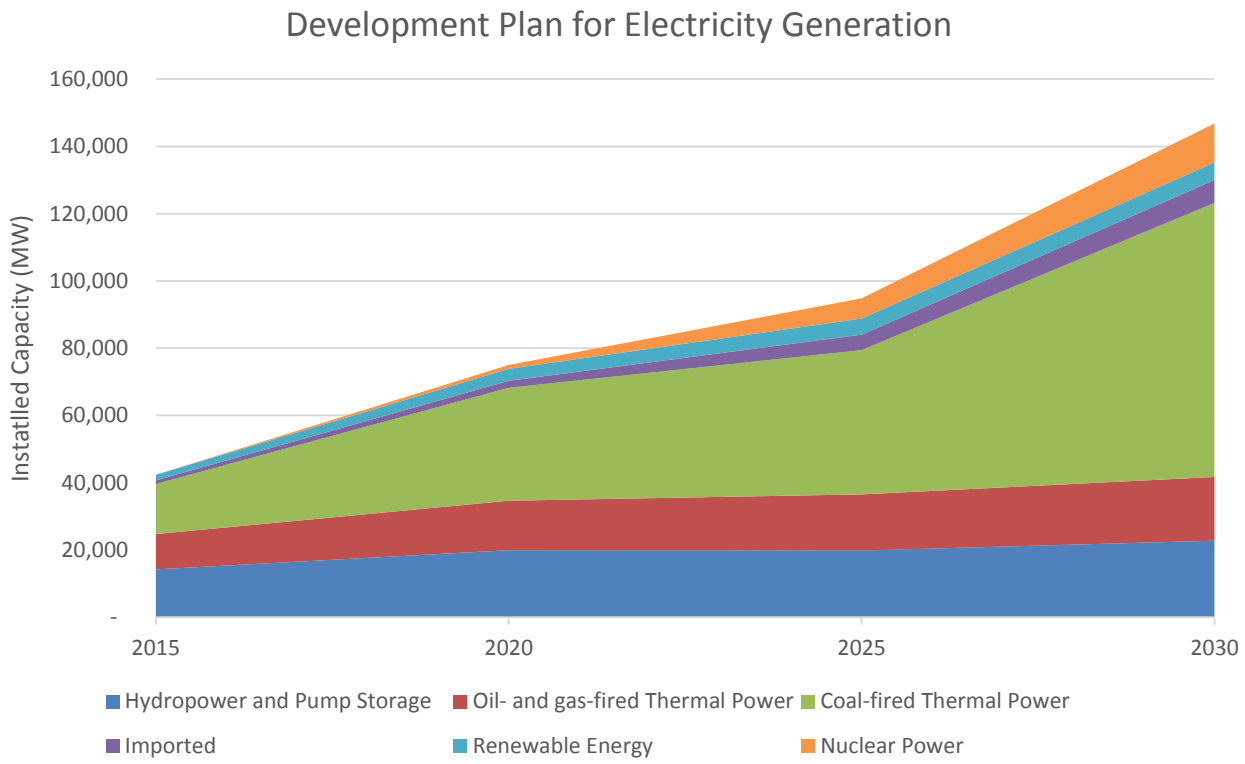
Viet Nam – Capacity Addition Plans (1)



- Massive additions planned in coal-fired capacity from 14,900 MW in 2015 to 81,519 MW in 2030
- Renewable Energy also projected to grow from 1,670 MW to 5,196 MW during the same period
- Significant expansion in power imports as well as nuclear-based capacity

Source: 7th National Power Development Master Plan, 2011-2020

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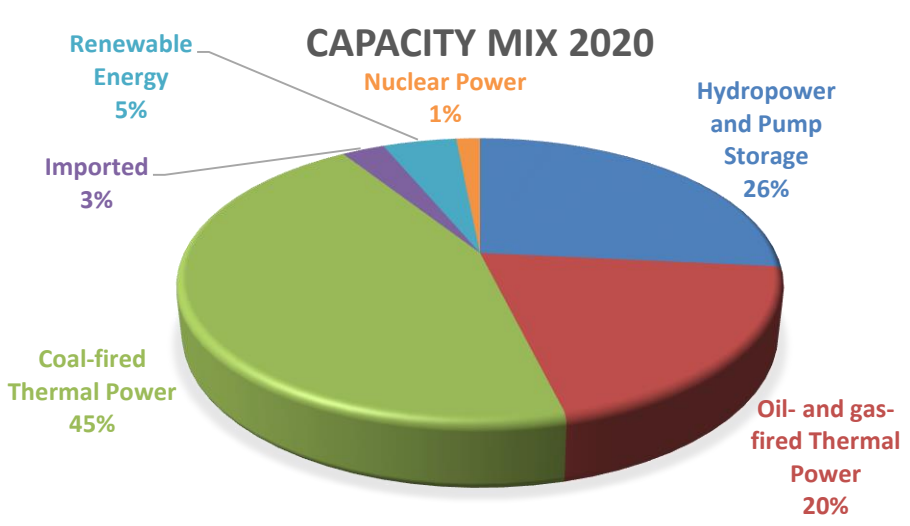
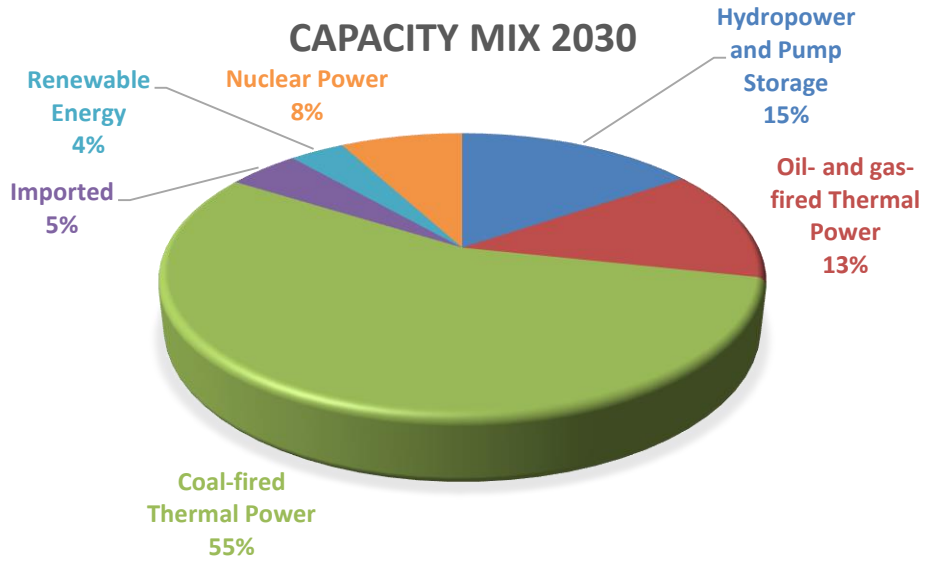
Viet Nam – Capacity Addition Plans (2)

Technology Type	2015	2020	2025	2030
Hydropower and Pump Storage	14,200	19,900	19,800	22,735
Oil- and gas-fired Thermal Power	10,500	14,724	16,700	18,945
Coal-fired Thermal Power	14,900	33,589	42,900	81,519
Imported	1,070	2,071	4,600	6,820
Renewable Energy	1,670	3,566	4,800	5,196
Nuclear Power	-	1,150	6,000	11,584
TOTAL	**42,340**	**75,000**	**94,800**	**146,799**





Source: 7th National Power Development Master Plan, 2011-2020

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Viet Nam – RE Potential

- Solar
  - Viet Nam receives medium solar irradiation, predominantly in the southern parts of the country
  - Realizable potential is limited by mountainous terrain, which occupies almost 1/3rd of the country's total land area
  - Maximum technical potential is estimated to be 13,326 MWp
  - Estimates of installed solar capacity vary from 1.5 MW – 4 MW, mostly in the form of residential and small-scale rural applications
- Wind
  - Country has moderate wind power potential
  - Government incentives combined with a need to develop new sources of energy have encouraged investments in wind power
  - Technical potential estimated to be around 7,000 MW
  - Current capacity stands at 84 MW

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