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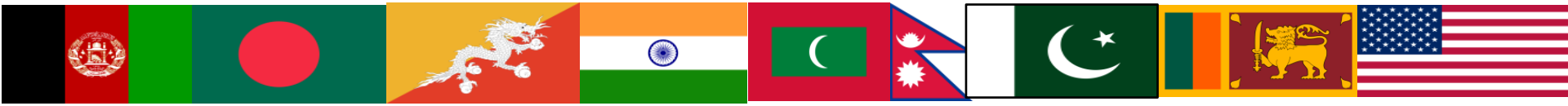
IRADe Integrated Research and Action for Development

Presentation on the draft interim findings of the study on **"Assessment of the Electricity Trading Potential in the South Asia Region"**

6th August 2015



Presentation Outline

- Project Objective and Scope of Work as per Terms of Reference
- Methodology and Key Assumptions
- Findings/Analysis on Demand-Supply Projections & Trading Potential of the South-Asian Nations:
  1. Bangladesh
  2. Bhutan
  3. Nepal
  4. India
  5. Sri Lanka
  6. Pakistan
  7. Afghanistan
  8. Maldives
- Way Forward
- ICF's Integrated Planning Model (IPM®)
- Appendices

Project Objective and Scope of Work

Project Objective:

To identify the electricity trading potential of the South Asian nations (Bangladesh, Bhutan, Nepal, India, Sri Lanka, Pakistan, Maldives and Afghanistan) over a period of next 20 years by reviewing the existing long term Demand-Supply projections of the participating countries.

Scope of Work:

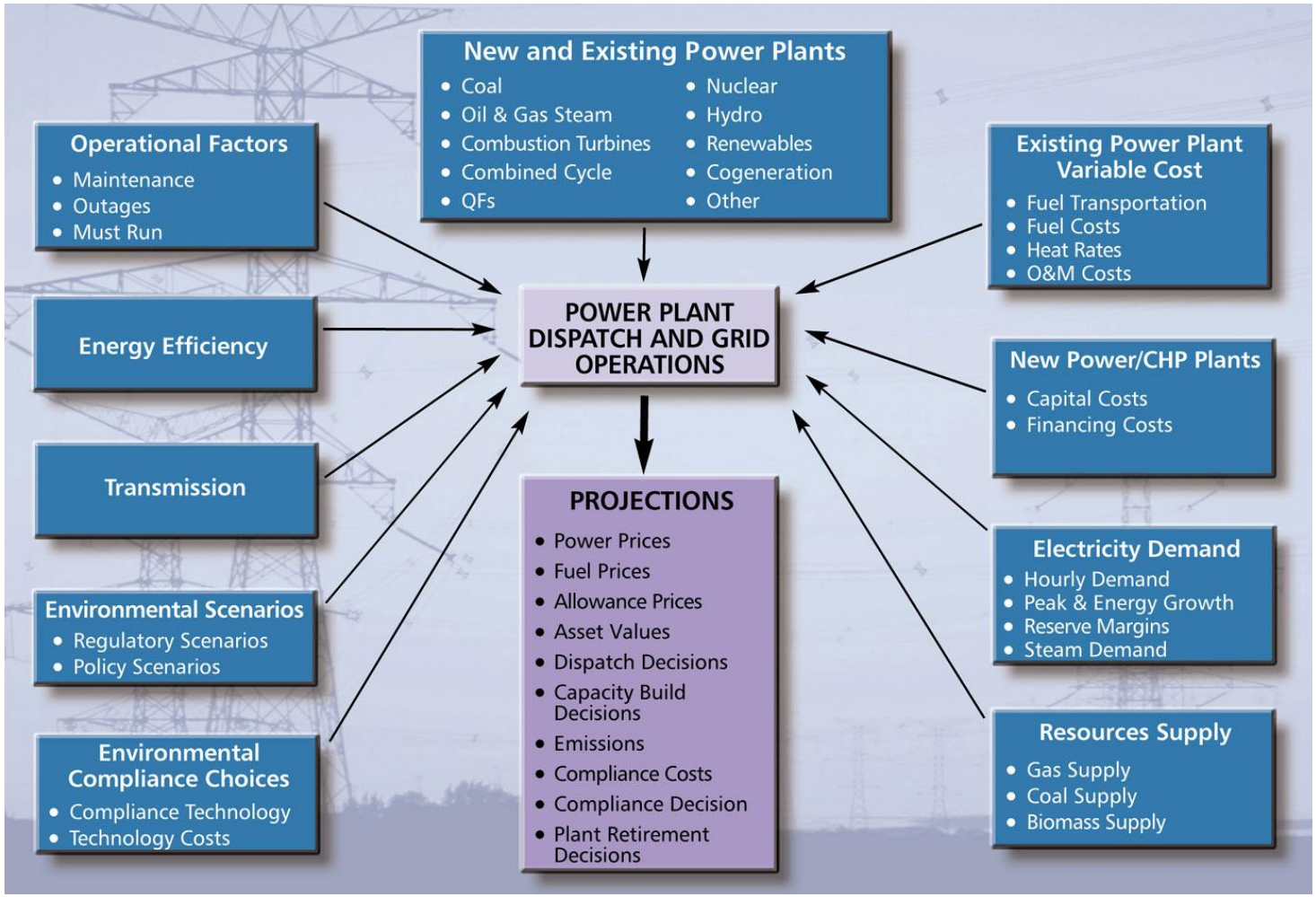
1. Study to account all types of generating plants viz Hydro, Thermal, Nuclear and Renewable.
2. Collect, compile, review and analyze the existing/prevailing long term Demand-Supply (D-S) projections/data available in respect of each South Asian country. This shall include different generation capacity addition scenarios.
3. Assess whether existing D-S projections have adequately been taken up and have explored the Cross Border Electricity Trade (CBET) potentials of each South Asian country from the trading perspectives and in the time horizon of 10-20 years.
4. If the data including the prospective generation capacity addition projections are not available from various sources for the time horizon of 10-20 years, a proper methodology* to be adopted to arrive at reasonable D-S projections to explore the CBET potential of each South Asian country.
5. The above D-S projections shall include the year wise trading opportunities that arise out of seasonal variations, time zone difference, difference in load curve, different weekends and holidays being followed in each South Asian nation.

Introduction to ICF's South Asia Integrated Planning Model (SA-IPM®)

SA-IPM® is an excellent and versatile long range planning model

- SA-IPM® is a long-term capacity expansion and production costing model for electric power systems including generation, transmission, and process/district heat production from co-generation and stand-alone boilers
- It is a multi-regional, deterministic, dynamic, linear programming model
- Utilizes Dynamic Optimization Framework with an Objective Function of Minimizing the Present Value of Total System Cost subject to:
    - Electricity & Steam Demand Constraints
    - Reserve Margin Constraints
    - Environmental Constraints
    - Transmission Constraints
    - Fuel Constraints
    - Other Operational Constraints
- Simulates rational expectations for perfect foresight providing the framework for inter-temporal decision making

Integrated Planning Model's (SA-IPM®) Framework



More details on IPM in Appendix

SA-IPM® Uses Easy to Comprehend yet Extremely Powerful Linear Programming Methodology

- Objective Function of SA-IPM® is to minimize present value of the total system costs and unserved load
- Major Types of Constraints in SA-IPM® - Energy Constraints and Capacity Constraints, Dispatch Constraints, Fuel Constraints, Environmental and other constraints
- Cost Coefficients in Objective Function – Mathematical equations and definitions of all constraints mentioned above are provided in Appendix

Project Work Flow

Demand-Supply Review and Data Collection

Data Collected through secondary sources and Task Force members in the following countries:

India, Bangladesh, Bhutan, Nepal, Pakistan, Sri Lanka, Afghanistan, Maldives

Demand-Supply review (i) Historical and (ii) Projection

Scenario Modeling (unconstrained)

Scenario Modeling with no constraints on inter-country transmission flow among following countries undertaken:

India, Bangladesh, Bhutan, Nepal

Trading potential between countries

Scenario Analysis

- Constrained Transmission Sensitivity Analysis
- Constrained Capacity Addition Sensitivity Analysis
- Increased 'Imported Coal' Price Sensitivity Analysis
- Increased Renewable Capacity Addition Sensitivity Analysis

Methodology & Key Assumptions

Project Approach

The overall project approach has been divided into following three parts:

1. **Power Sector Historical Analysis and Current Overview:**
   a) Review of historical Demand-Supply trends. Collation of data on historical –
      i. Peak load and energy demand
      ii. Capacity addition and generation
      iii. Energy and peak deficits
   b) Analysis of Existing and Future Transmission Capacity

2. **Power Market Outlook (2014 to 2034 – 20 Years)**: Unconstrained* case development using ICF's SA-IPM® (South Asia Integrated Planning Model). Towards populating the modeling framework, ICF developed assumptions on demand, supply, future generation and transmission builds, fuel supply and renewable forecasts besides other areas.

3. **Scenario Analysis**: Analysis to assess the impact of variables on trading potential for same timeframe as in unconstrained scenario.

*The modelling case with no constraints on inter-country transmission flow.

SA-IPM® is a long-term capacity expansion and production costing model for electric power systems including generation and transmission. It is a multi-regional, deterministic, dynamic, linear programming model.

Methodology for Estimation of Unrestricted Electricity Demand and Peak Demand Forecast

Unrestricted electricity demand (GWh) forecast for all countries (except India[#] and Sri Lanka[##]) has been estimated using the following methodology:

- The actual electricity demand for 2014 has been used as the as base Energy Demand
- For the period 2015-2034, the electricity demand has been computed as the product of GDP and electricity elasticity[*] for each year
- GDP forecast for each country has been developed by using The World Bank's GDP growth forecast
- Electricity Elasticity for each country has been calculated by studying the relationship between the electricity demand and the GDP over last 10 years. The elasticity value is assumed to linearly decline to unity by the year 2024 and remains the same up to 2034.

Peak demand (MW) forecast, if unavailable in the respective national power plan document, has been estimated by using 5 year compound annual growth rate (CAGR).

[#]In case of India, electricity demand forecast available in 18th EPS has been used

[##]In case of Sri Lanka, demand forecast is available in Ceylon Electricity Board's Generation Expansion Plan 2013

[*]Electricity Elasticity refers to the percentage change in energy demand to achieve one per cent change in national GDP

[**]if data on the same is available

Demand Side Assumptions

- Electricity demand is considered at wholesale level, i.e. demand that a plant has to meet at its plant bus bar
- Energy Efficiency (EE) and Demand Side Management (DSM) measures are accounted for in total electricity forecast
- Total of 32 zones are considered:
  - Each of the 28 state of India is considered as a separate zone
  - Bangladesh, Bhutan, Sri Lanka and Nepal are considered as individual zones
- Hourly load (of 8760 hours) profile of each zone is modeled separately
- Unrestricted demand is modeled which does not include latent demand
  - Latent demand captured only through increasing per-capita consumption
- No captive/off-grid demand considered since it is expected to merge with mainstream grid-connected demand over time
- Price elasticity of demand is not considered i.e. for every hour demand does not change with power prices
- No load shedding assumed so as to consider the unconstrained demand of the system for realistic estimation of CBET
- All modeling (where ever applicable) is done in 2014 Real INR

Supply Side Assumptions

- Supply is modeled at generation unit level i.e. for each plant operating in the system
- No captive/off-grid supply is considered since it is expected to merge with mainstream grid-connected supply over time
- Long term PPAs of plants are modeled
- Power supply is modeled from each existing and new plant. All such plants are modeled with their detailed financial and operational parameters. Plant's availability is modeled along with its maintenance schedule. Operating characteristics of each unit considered
  - Nameplate capacity and derated capacity
  - Net station heat rate
  - Net availability of plant based on sent-out energy to grid
  - Fuel supply and fuel supply agreements
  - Delivered fuel cost to each plant
  - Fuel transportation cost to each plant
  - Operation and maintenance cost of each plant
  - Minimum operating characteristics of plants considered (for example coal, nuclear etc.)
  - Must run or self-dispatch characteristics of plants modeled (for example wind, solar, reliability must-run plants, etc.)
- Supply is categorized as follows:
  - Existing – List of plants currently in operation
  - Firm – List of plants under construction and likely to be operational in span of next 4-5 years, this includes capacity that are under construction and are in advanced stage of development
  - Potential plants – SA-IPM® forecasts capacity additions in the long-term (more than 5 years) based on long run marginal cost of each capacity type. Cost and efficiency assumptions for each plant type are provided in the model.

Renewable Capacity

- Renewable capacity gets dispatched based on Renewable Purchase Policy
- Following RE capacities considered:
  - Solar-PV/TH, Wind, Biomass, Small-hydro
  - Hourly generation profile of each type is also considered
  - Zone-wise load factors of each RE type (as applicable) are considered
- Zone-wise RE potential is considered
- No curtailments due to grid congestion are considered

Fuel Assumptions (Coal & Gas)

- Domestic coal
  - Domestic supply considered from each coal supply region
  - Fuel supply agreements are modeled
  - Fuel cost is considered separately for each coal supply region along with related transportation cost
  - A plant can source coal from more than one region
  - Option of using imported coal is provided to all the power plants in the system
- Imported coal
  - Supply is considered unconstrained
  - Prices are indexed to international coal index of Indonesian coal (HBA), New Castle (Australia), and Richard Bay (South Africa)
    - Cost of insurance and freight along with import duty, coal cess and other taxes are also considered
    - Fuel's inland transportation cost is also modeled
- Domestic gas
  - Domestic supply considered from each gas supply region
  - Supply to power sector is considered based on historical allocation levels
  - Fuel supply agreements are modeled
  - Fuel cost is considered separately for each gas supply region along with related transportation cost through pipeline
- Imported gas (primarily R-LNG)
  - Supply is considered unconstrained
  - Prices are indexed to international R-LNG (i.e. JCC)
    - Cost of insurance and freight along with import duty and other taxes are also considered
    - Fuel's inland transportation cost is also modeled based on pipeline tariffs

Transmission

- The model treats each zone as a separate power market and connects these zones through the inter-zone transmission network for any possible power flow between them
- Transmission capacity is defined by Total Transfer Capacity (TTC) and Available Transfer Capacity (ATC)
  - ATC = TTC – Reserve Margin
  - Each transmission line is assigned an ATC (in MW) which defines maximum capacity that can be transferred over the link for each hour
- Reserve margin on each transmission line is also considered along with transmission charges and losses
- Transmission Grid:
  - Existing – List of lines currently in operation with detailed operational characteristics
  - Firm – List of lines under construction and likely to be operational in span of next 4-5 years;
  - Potential Links – SA-IPM® forecasts line capacity beyond the time it is not firm based on long run operational cost. Cost and efficiency assumptions for such lines is provided in the model.
- Please note that SA-IPM® is not a branched out load flow model

Assumptions for Potential Plants (1)

- For unplanned/potential plants (which model itself forecasts), following cost items are considered:
  - Capital cost of plant
  - Net station heat rate
  - Net availability of plant based on sent-out energy to grid
  - Fuel supply options
  - Delivered fuel cost to plant from each of the supply options
  - Operation and maintenance cost
  - Minimum operating characteristics of plant are also considered (for example coal, nuclear etc.)
  - Must run or self-dispatch characteristics of plants modeled (for example wind, solar, hydro etc.)

Assumptions for Potential Plants (2)

- Capital cost components

All figures in INR Crore/MW

Fuel Type	2022	2027	2034
Super Critical Coal	5.92	6.17	6.41
Lignite	5.92	6.17	6.41
Combined Cycle	4.69	4.89	5.08
CT	3.35	3.49	3.63
Nuclear - PHWR/LWR	16.40	16.79	17.15
Nuclear - FBR	19.48	19.94	20.36
Hydro (RoR)	10.25	10.49	10.72
Hydro (Storage based)	12.30	12.59	12.86
Wind	5.45	5.13	4.77
Small Hydro	7.64	7.82	7.99
Solar PV	6.21	5.57	5.30
Solar Thermal	11.55	11.10	10.92
Biomass	5.54	5.67	5.79

Other Key Assumptions

- SA-IPM is a model which simulates the power sector by solving linear programming (LP) equations to meet the demand subjected to various constraints on supply, capacity, generation, fuel supply, environmental compliance with the objective of minimizing the NPV of system cost.
- Linearization of demand curve for similar demand levels: For a typical run year, modeling is performed for 40 price points (4 seasons and 10 segments) to represent a power market in most effective way
- Model has capability to provide forecast for 25 years, however in this study forecast has been provided till 2034
- The forecast of various parameters (demand, supply, generation mix, capacity mix, new capacity requirement, transmission and trading potential etc.) is provided in further sections for each country
- All hourly profiles have been converted from local time to Indian Standard Time (IST)

Findings/Analysis on the Demand-Supply Projections and Trading Potential of the South Asian Nations

1 BANGLADESH

Bangladesh – Macroeconomic Overview

General Overview (Source: World Bank, 2014)

- Political System : Unitary Parliamentary Constitutional Republic
- Land Area* : 147,570 km^2
- Population : 158.5 million
- GDP : 173.8 billion (current $)
- Real GDP / Capita : 1096.6 (current $)

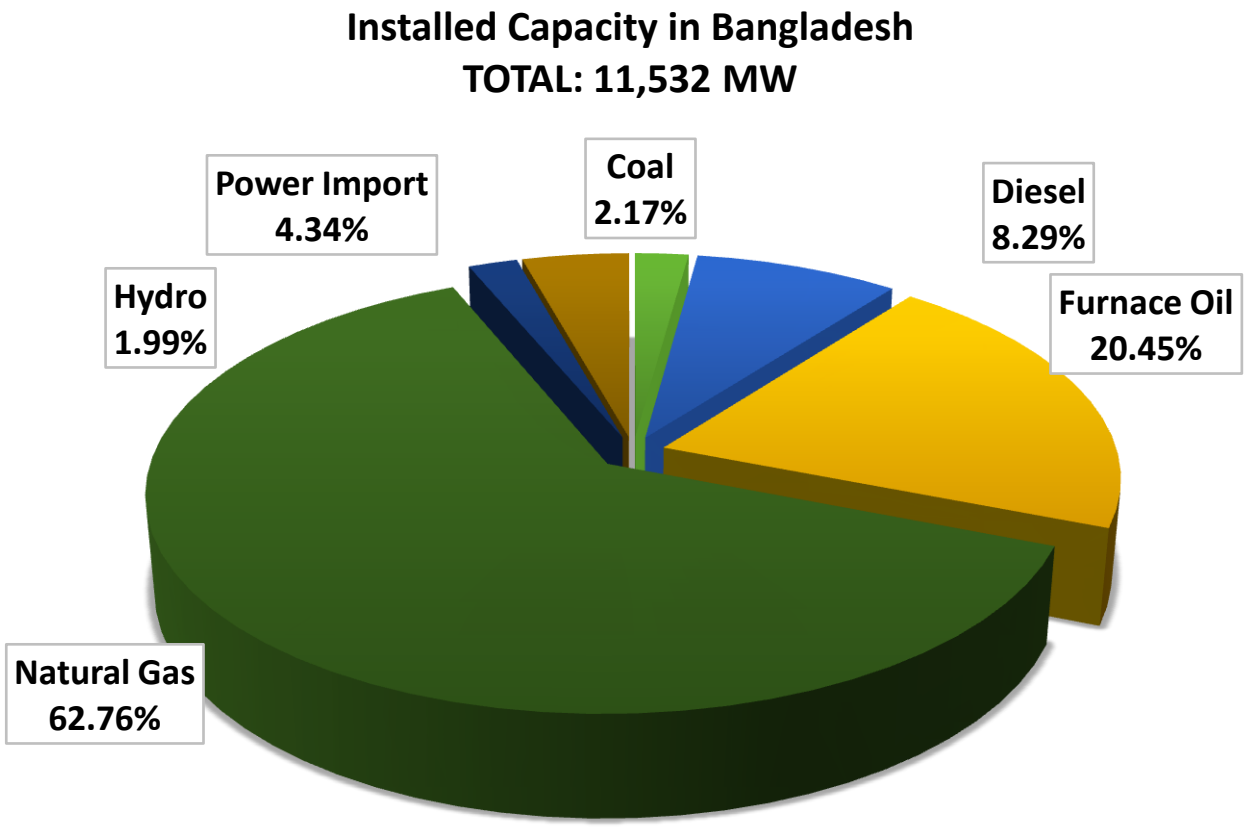
Power Sector Overview

- Installed Capacity : 11,532 MW
- Access to Electricity#: 59.6% (World Bank, 2012)

*Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

#Access to electricity is the percentage of population with access to electricity.

Bangladesh – Capacity Mix Dominated by Natural Gas and Furnace Oil

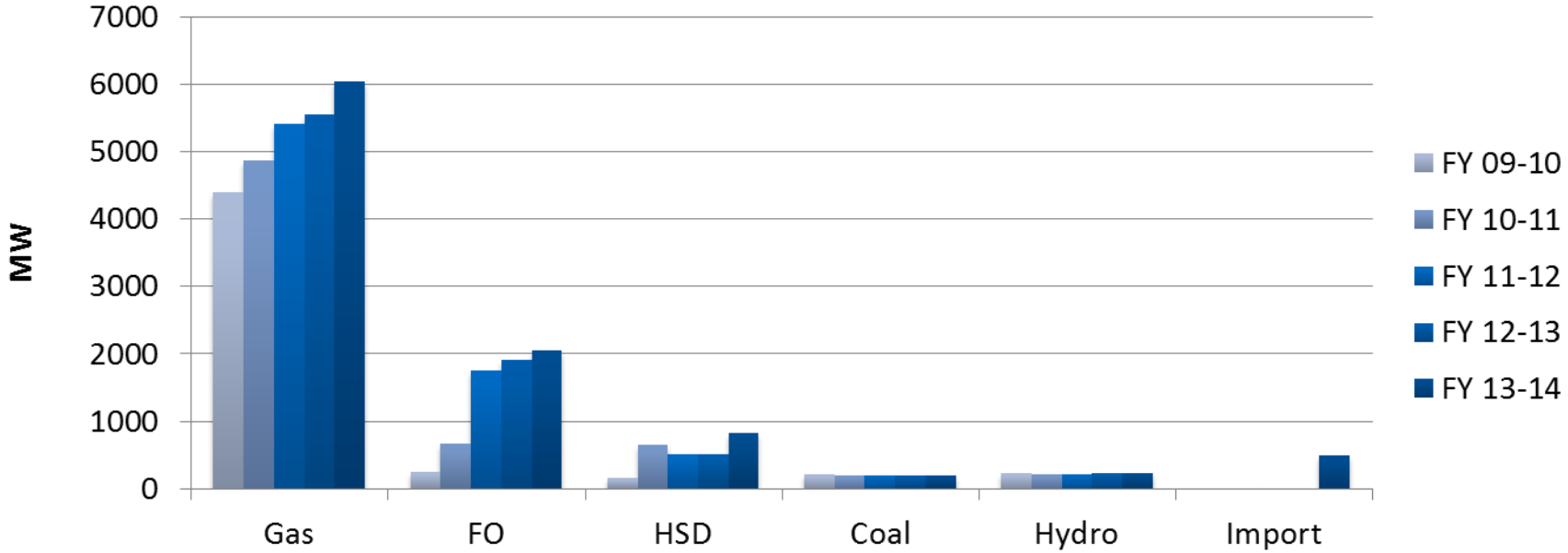


Fuel Type	Capacity (MW)
Coal	250
Diesel	956
Furnace Oil	2,358
Gas	7,238
Hydro	230
Import	500

As on 31st May 2015

Source: Bangladesh Power Development Board, 2015

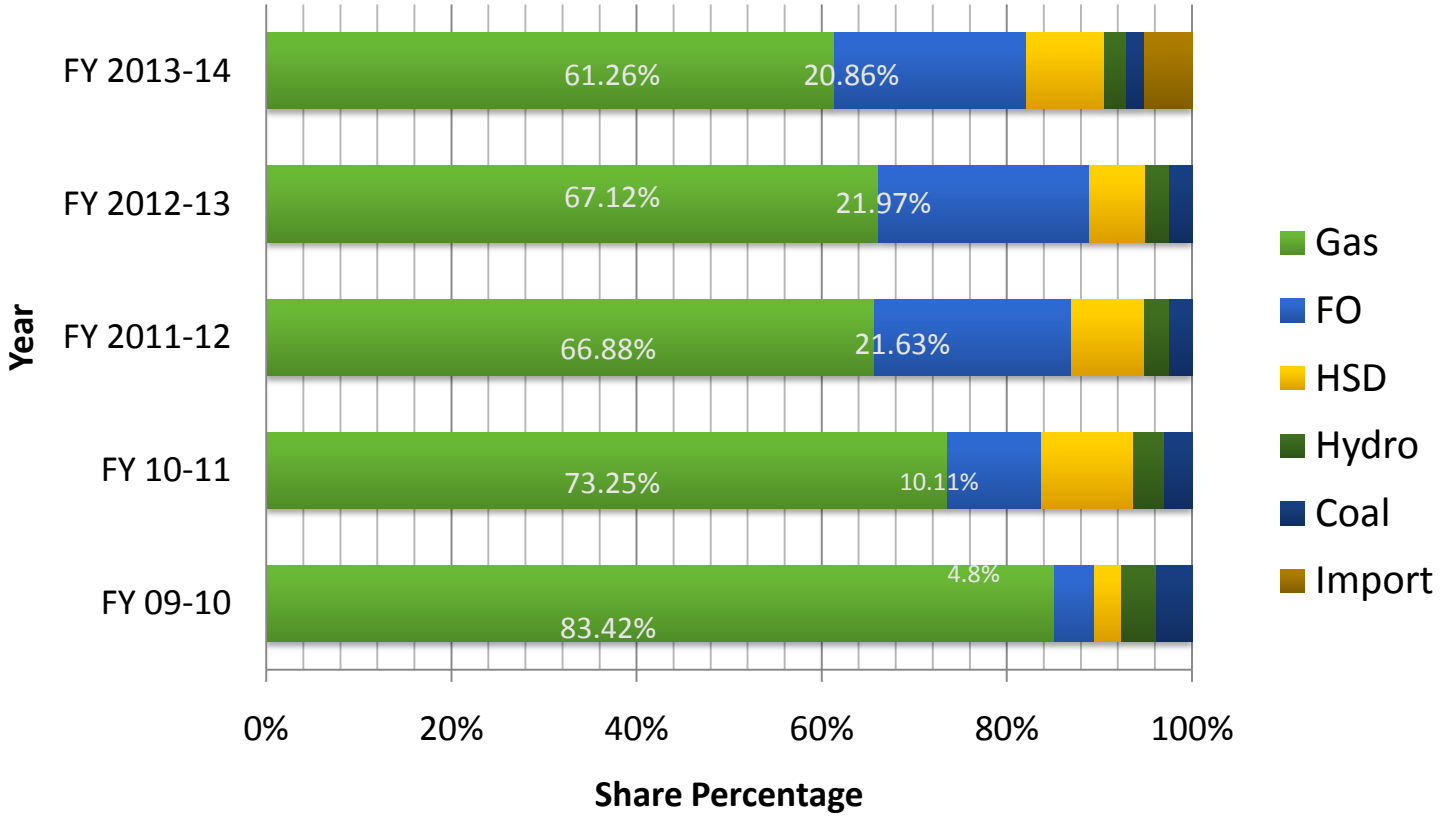
Bangladesh – Historical Capacity Additions by Fuel Type



	FY 09-10	FY 10-11	FY 11-12	FY 12-13	FY 13-14	CAGR
Gas	4,397	4,863	5,417	5,555	6,034	6.53%
FO	256	671	1,752	1,906	2,050	51.58%
HSD	168	656	512	512	825	37.45%
Coal	220	200	200	200	200	-1.87%
Hydro	230	220	220	230	230	0.02%
Import	0	0	0	0	500	
Total	5,271	6,610	8,101	8,403	9,839	13.30%

Source: Bangladesh Power Development Board, 2015

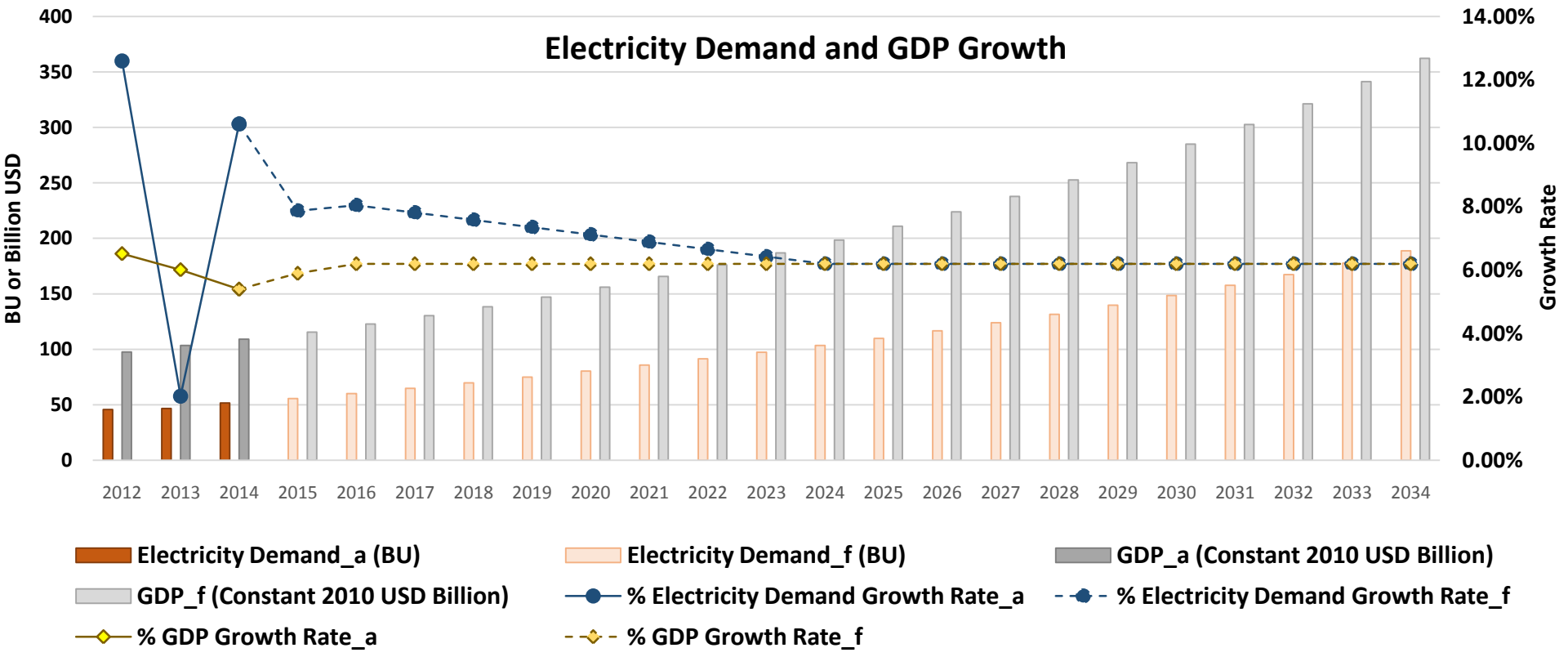
Bangladesh – Share Percentage of Capacity by Fuel Type



Source: Bangladesh Power Development Board, 2015

- Bangladesh has been predominantly dependent on natural gas as primary source of energy
- Increase in percentage share of FO and HSD due to easy availability through imports and shortages in supply of gas.

Bangladesh – GDP & Electricity Demand Growth

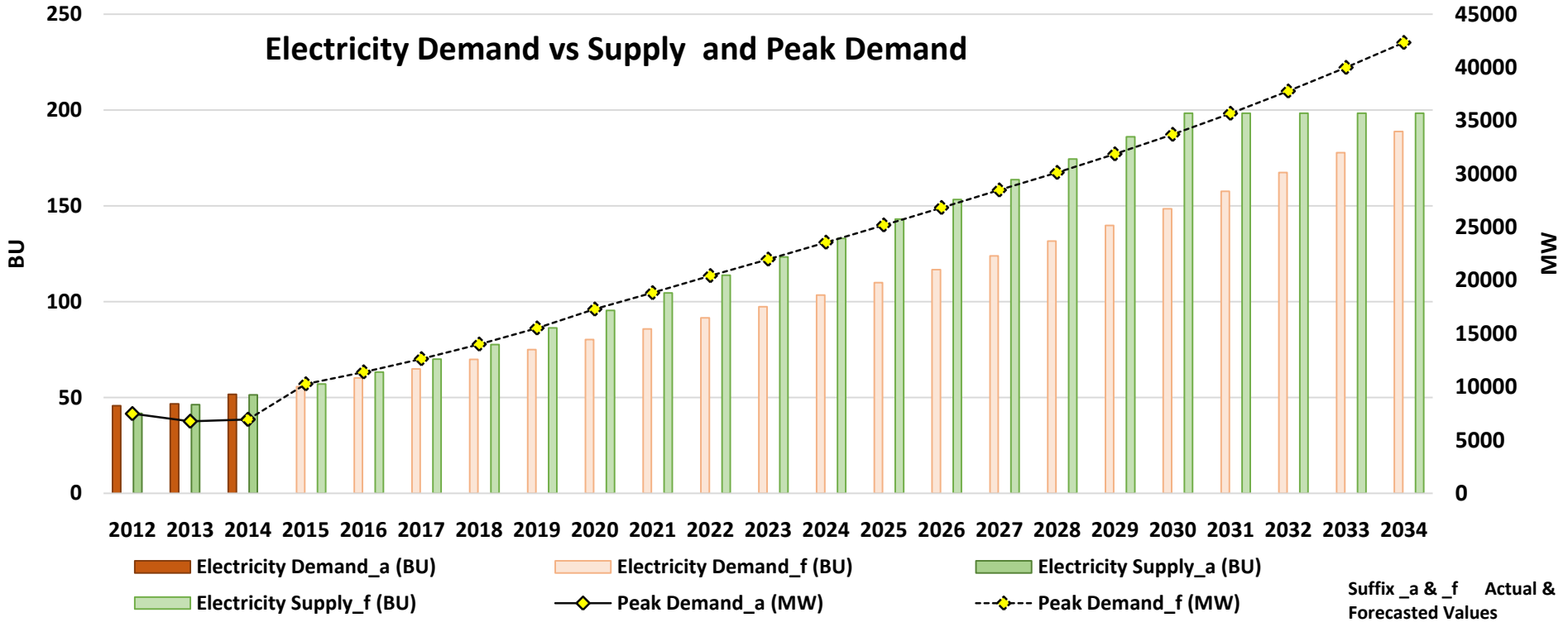


Suffix _a & _f Actual & Forecasted Values

GDP (absolute value & growth rate)		Electricity Demand	
Till 2014	2015 Onwards	Till 2014	2015 Onwards
The World Bank	The World Bank forecast; growth rate kept constant 2016 onwards	BPDP	ICF Analysis

Source: Bangladesh Power Development Board, 2015

Bangladesh – Electricity Demand vs Supply & Peak Demand



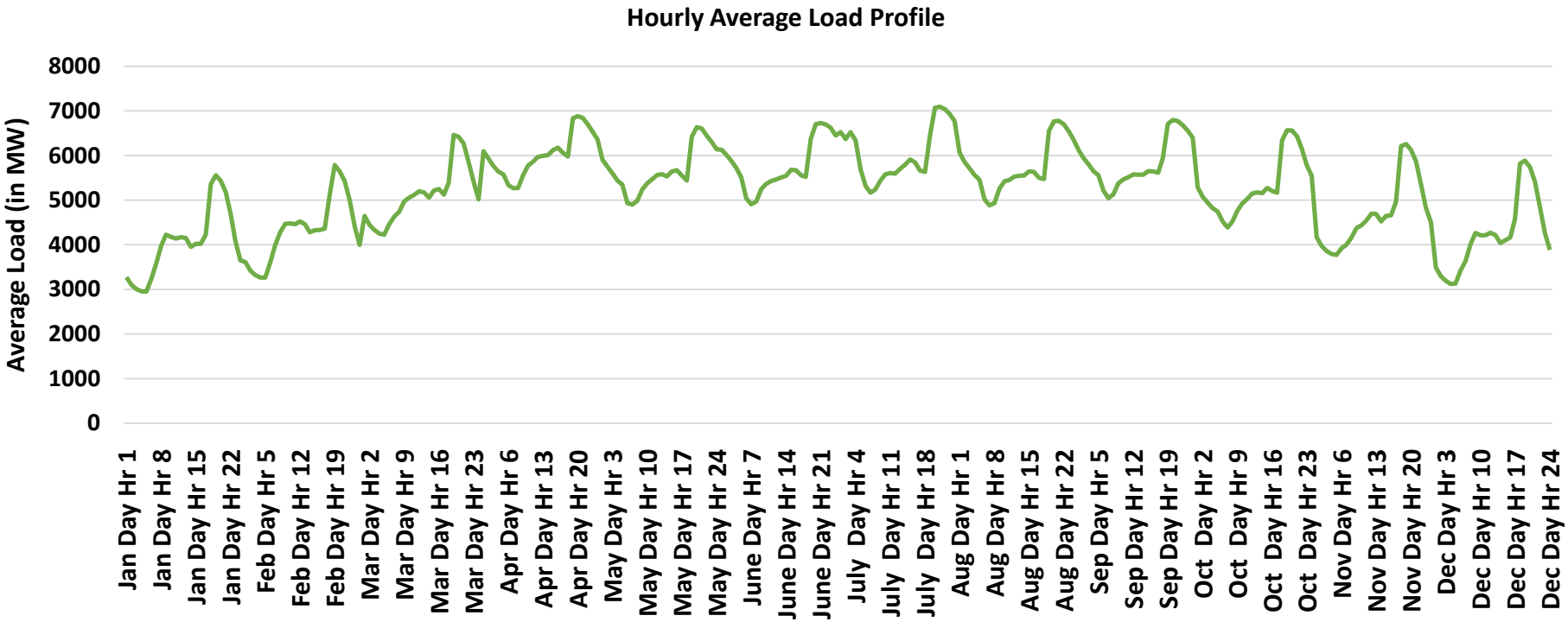
Electricity Demand		Electricity Supply		Peak Demand	
Till 2014	From 2015	Till 2030	From 2031	Till 2030	From 2031
BPDP	ICF Analysis	BPDP	Assumed Constant at 2030 supply	BPDP	Estimated using 5-yr CAGR

Source: Bangladesh Power Development Board, 2015

- Bangladesh is importing about 500 MW of power
  - 250 MW of this is imported from NTPC
  - 250 MW is sourced through PTC via a 3-year contract
- It is proposed to upgrade this 500 MW link to 1000 MW

Assumptions (Brief Overview) – Unconstrained Case

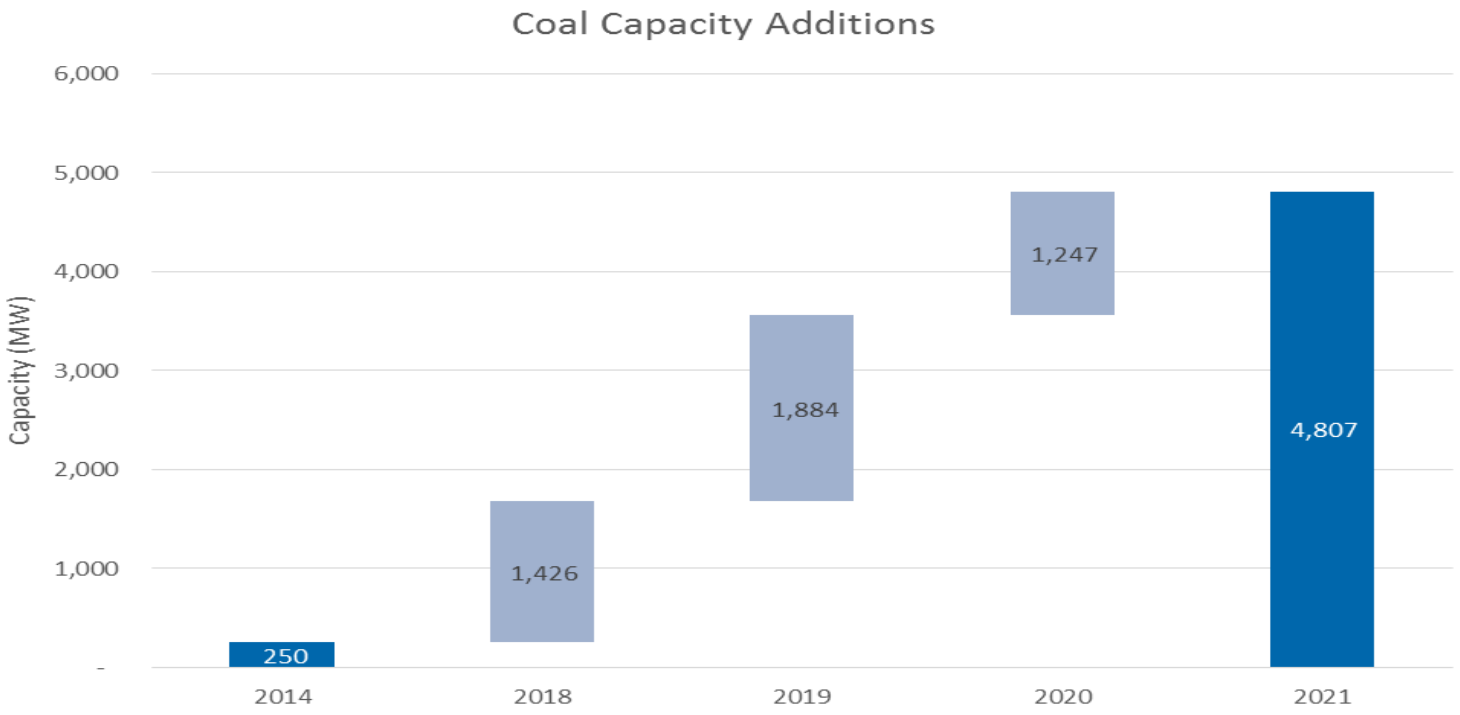
Bangladesh Load Profile - 2014



- Latest data available for 2014
- Average demand increases during summer months (May – August)
- Daily peak hours from 6:00 PM to 10:00 PM
- Bangladesh generally peaks during following months: April, July, August and September

Source: Bangladesh Power Development Board

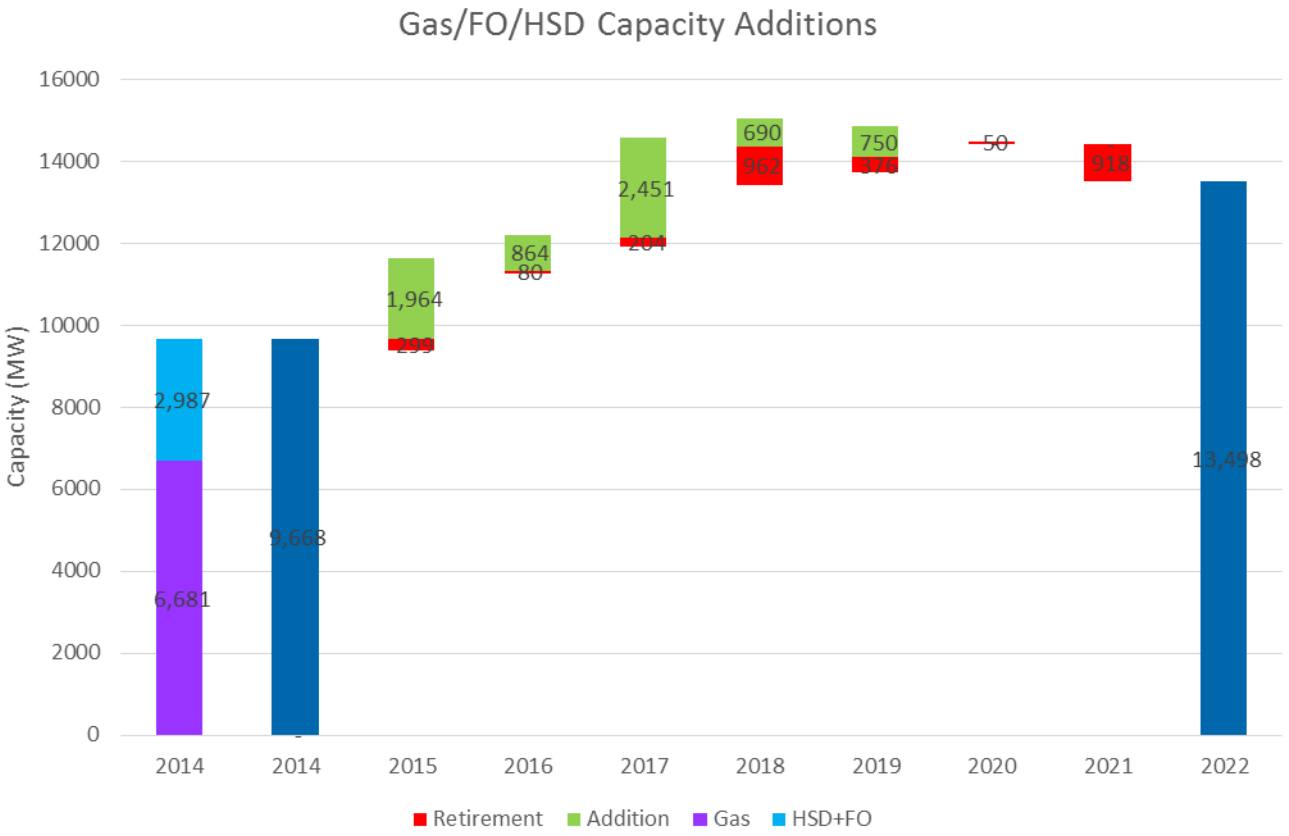
Firm Capacity Additions – Coal (till 2020)



- Firm capacity addition plans considered till end of 2021
- Key additions:
  - 2018 – Khulna (630 MW), Munshiganj (522 MW)
  - 2019 - Rampal (1320 MW)
  - 2020 – Dhaka (635 MW), Chittagong (612 MW)

Source: Bangladesh Power Development Board, 2015

Firm Capacity Additions & Retirements (till 2020)– Gas/FO/HSD (1)



- Significant additions planned in 2015 and 2017
- Major retirements in 2018 and 2021

Source: Bangladesh Power Development Board, 2015

Firm Capacity Additions & Retirements – Gas/FO/HSD (2)

Year	Key Additions	Key Retirements
2015	Ashugonj South (373 MW), Siddirganj (200 MW), Bibiana-II (222 MW)	Khulna (110 MW), Bhola (33 MW)
2016	Shajibazar (216 MW), Kusiara (163 MW), Sirajgonj (150 MW), Shikalbaha (150 MW)	Barisal (20 MW), Saidpur (20 MW)
2017	Bheramara (414 MW), Ashugonj North (381 MW), Bibiana-III (274 MW), Ghorasal (254 MW), Bibiana South (252 MW), Sirajganj (249 MW)	Ashugonj Stage 1 (64 MW), Ashugonj Stage 2 (64 MW)
2018	Ghorasal 6th Unit (206 MW), Bibiana South (383 MW)	Khulna (110 MW), Bheramara (105 MW), Ghorasal (100 MW)
2019	Keranigonj (750 MW)	Haripur (110 MW), Siddirgonj (96 MW)
2020	Nil	Ghorasal (210 MW), Ashugonj (150 MW), Khulna (115 MW), Madangonj (102 MW), Noapara (101 MW)

Source: Bangladesh Power Development Board, 2015

Firm Capacity Additions – Renewable

- Table below shows firm capacity addition for Wind and Solar along with expected online date

Plant Name	Capacity (MW)	Type	Online Date	Current Status
Cox's Bazar	60	Wind	December, 2015	Achieved: 40 %
Kaptai Solar	8	Solar	June, 2016	Tender Under Evaluation
Dhorola Solar Park	30	Solar	Dec, 2016	LOI issued

Source: Bangladesh Power Development Board, 2015

Fuel – Domestic Coal and Domestic Gas

- Domestic coal for power sector
  - Supply
    - Kept constant for supply to 250 MW existing coal plant
    - No new capacity addition on domestic coal considered (Based on firm capacity addition list)
  - Fuel cost
    - Dispatch cost of coal plant based on domestic coal has been assumed constant at INR 0.60/kWh (in 2014 Real INR)
      - Based on data received from Power Cell, Bangladesh
- Domestic gas for power sector (domestic onshore + off-shore)
  - Supply
    - Assumed to be 1100 mmcfd (or 33 MMSCMD) for 2015-16 and increasing to 1500 mmcfd by 2018, decreasing to 850 mmcfd by 2025 and 950 mmcfd by 2030. Assumed to remain at 2030 level up to 2034 (as per PSMP 2015).
  - Fuel cost
    - Dispatch cost of gas plant based on domestic gas has been assumed constant at INR 2.11/kWh (in 2014 Real INR)
      - Based on data received from Power Cell, Bangladesh

Fuel – Imported Coal and R-LNG

- Imported coal for power sector
  - Supply: No constraint
  - Fuel cost: Linked to Indonesia coal price index

- R-LNG for power sector
  - Supply: No constraint
  - Fuel cost: Linked to JCC

Transmission Links

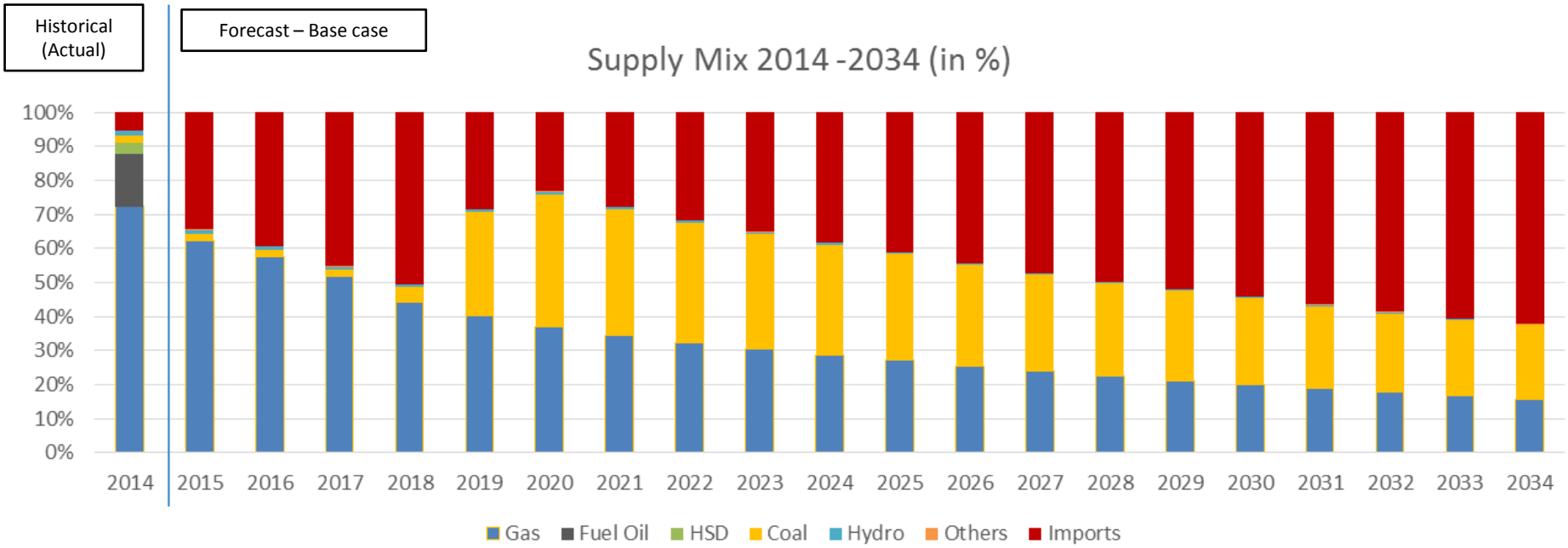
- Currently, Bangladesh has 500 MW link with Indian grid (BAHARAMPUR-BHERAMARA)
  - Augmentation of this link in 2018 is expected to add another 500 MW of capacity
- India-Bangladesh is expected to add another 100 MW link (TRIPURA-COMILLA) by June 2016

For the current unconstrained transmission case, no transmission constraint between Bangladesh and neighboring countries is considered

Source: ICF Research 2015

Results – Unconstrained Case

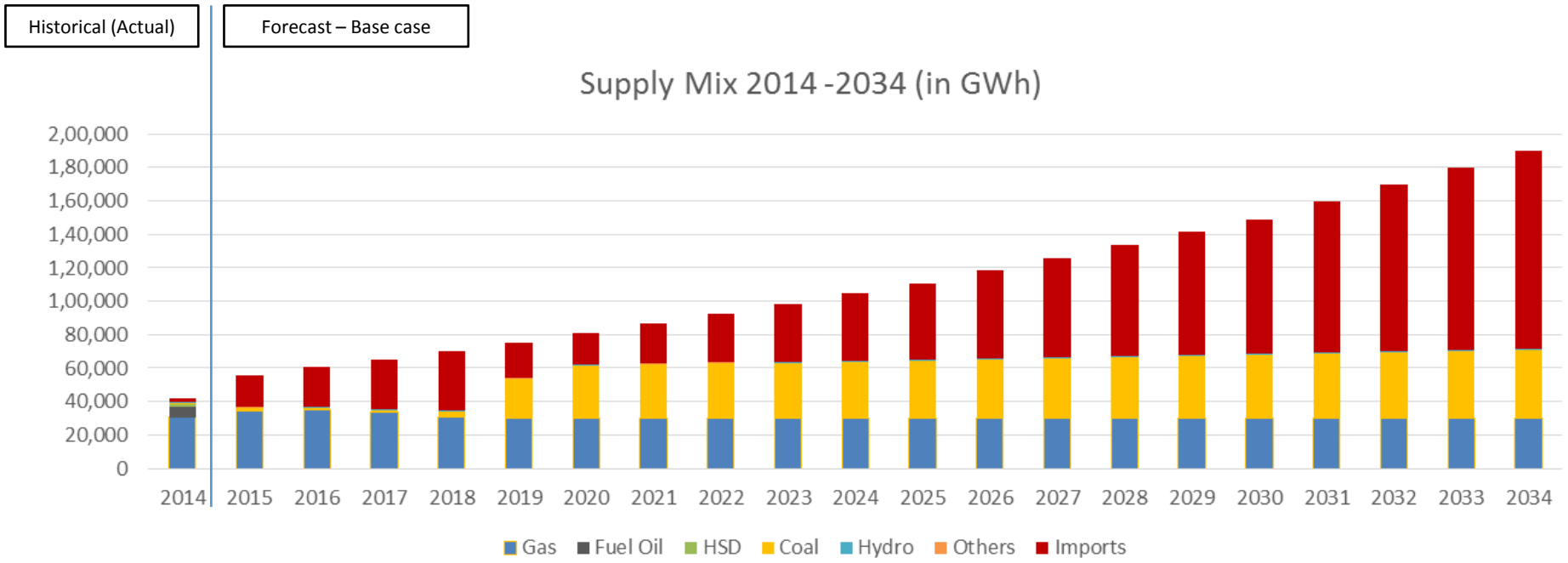
Bangladesh Supply Mix 2014-2034



- Imports are cheaper than Fuel oil and HSD capacity, thereby replacing them from supply mix
- Imports are cheaper than LNG based power, thereby replacing them as well
- Domestic gas being cheaper than imports is able to run at its full potential

Source: ICF Analysis

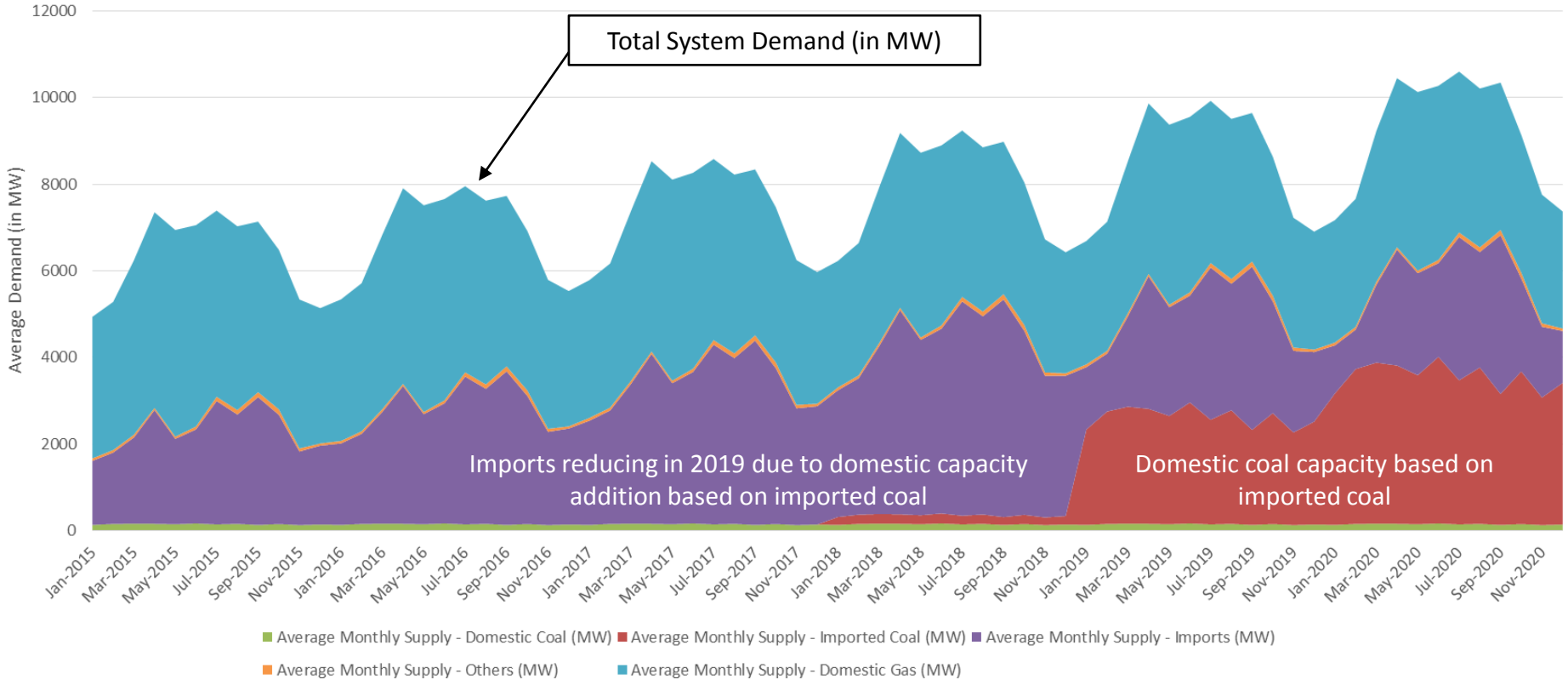
Bangladesh Supply Mix 2014-2034



- Expensive units like FO/HSD are replaced by imports from India
- Bangladesh to increasingly depend on imports as imports are cheaper
- Bangladesh to not set-up new capacity as it can access cheaper imports from India
- Share of imports to fall in 2019 due to firm capacity addition plan
- Imports and coal based capacity to meet base load requirement, where as gas capacity based on domestic gas to be used as mid-merit or peaking capacity

Source: ICF Analysis

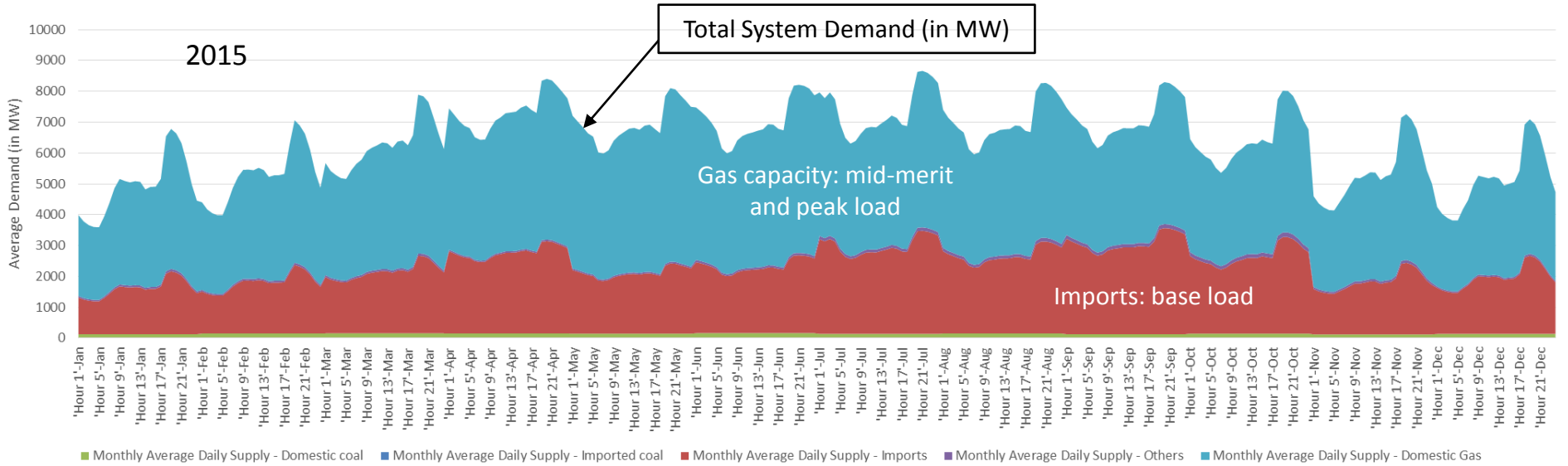
Bangladesh Average Monthly Electricity Supply Stack 2015 – 2020

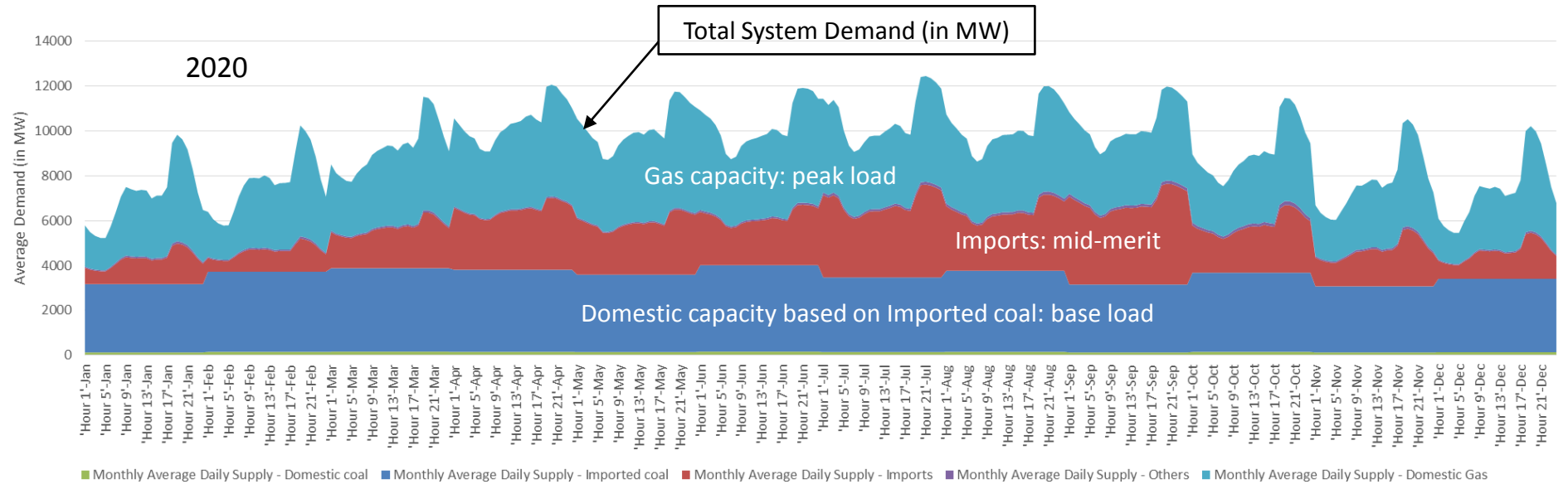


Source: ICF Analysis

Bangladesh Average Daily Electricity Supply Stack for 2015 and 2020

Source: ICF Analysis





Bangladesh Import/Export Summary

Bangladesh	Annual average (Import) - MW	Annual Net Imports (BUs)
2015	2,193	19.2
2016	2,715	23.8
2017	3,356	29.4
2018	4,032	35.3
2019	2,439	21.4
2020	2,146	18.8
2021	2,751	24.1
2022	3,357	29.4
2023	3,962	34.7
2024	4,568	40.0
2025	5,173	45.3
2026	5,980	52.4
2027	6,786	59.4
2028	7,592	66.5
2029	8,399	73.6
2030	9,205	80.6
2031	10,278	90.0
2032	11,350	99.4
2033	12,422	108.8
2034	13,494	118.2

Bangladesh	Daily Peak (Export) - MW	Daily Peak (Import) - MW	Monthly Peak (Export) - MW	Monthly Peak (Import) - MW
2015	0	4,000	0	3,441
2016	0	4,737	0	4,126
2017	0	5,632	0	4,953
2018	0	6,610	0	5,864
2019	156	5,226	0	4,561
2020	1,065	5,174	0	4,495

- In the near term (i.e. 2015 to 2020), there is a maximum annual average import potential for ~4,000 MW
- By 2020, Bangladesh has potential to export ~1,000 MW of power during few hours in a year due to addition of imported-coal based capacity
- In the medium-term to long-term, annual average electricity trading potential of almost ~13,000 MW has been estimated

Source: ICF Analysis

Summary of Findings

- Analysis shows that importing power is cheaper as compared to setting up new capacity
- Expensive units like FO/HSD can be potentially replaced by cheaper imports
- Share of imports to fall in 2019 due to firm capacity additions of plants based on imported coal
- Imports and coal based capacity may be considered to meet base load requirement, whereas gas capacity based on domestic gas may be used as mid-merit or peaking capacity
- In near term (i.e. 2015 to 2020), transmission link capacity of ~7,000 MW may be required to meet overall import requirements by Bangladesh

2 BHUTAN

Bhutan – Macroeconomic Overview

General Overview (Source: World Bank, 2014)

- Political System : Unitary Parliamentary Constitutional Monarchy
- Land Area* : 47,000 km^2
- Population : 765,600
- GDP : 1.8 billion (current $)
- Real GDP / Capita : 2379.2 (current $)

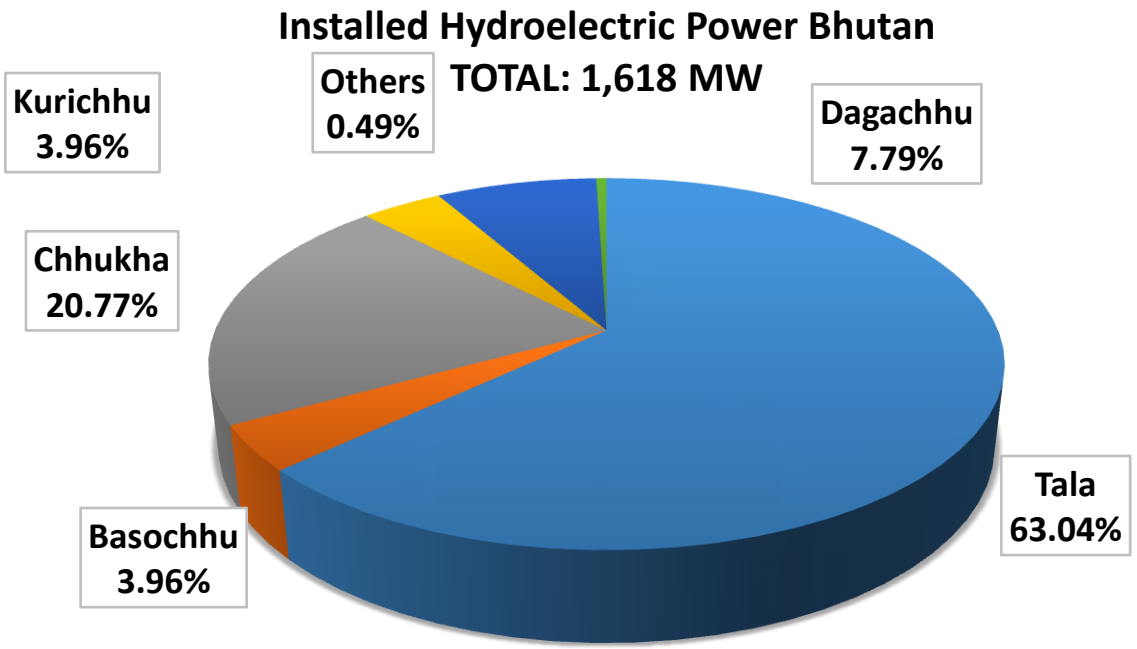
Power Sector Overview

- Installed Capacity : 1,492 MW
- Access to Electricity#: 75.56% (World Bank, 2012)

*Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

#Access to electricity is the percentage of population with access to electricity.

Bhutan – Hydro Capacity

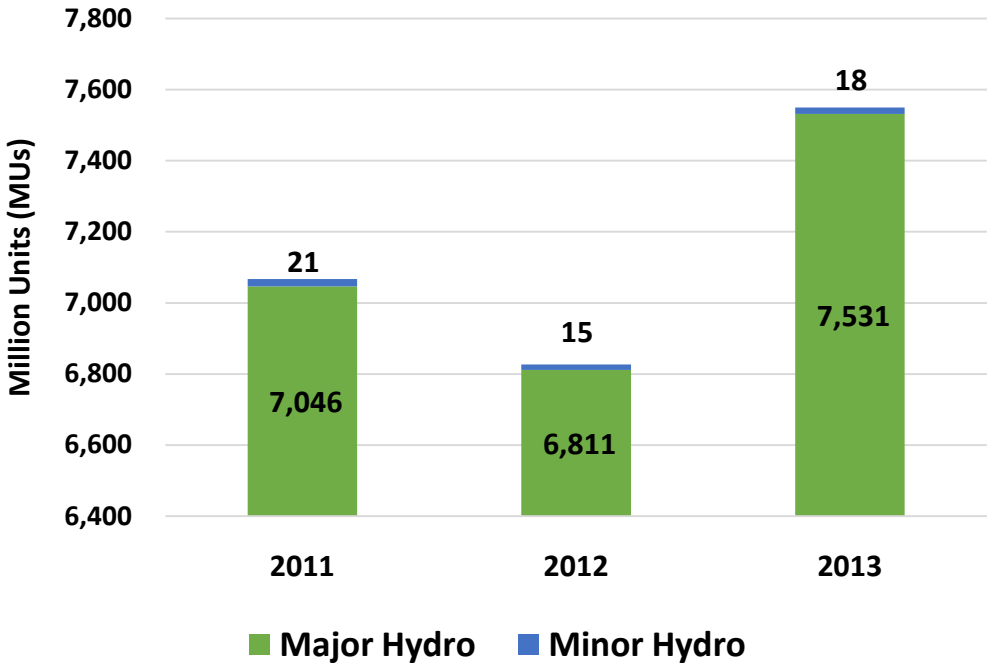


Plant	Capacity (MW)
Tala	1,020
Basochchu	64
Chhukha	336
Kurichhu	64
Dagachhhu	126
Others	8

As on 31st May 2015

Source: Department of Hydropower and Power Systems, Royal Government of Bhutan, 2015

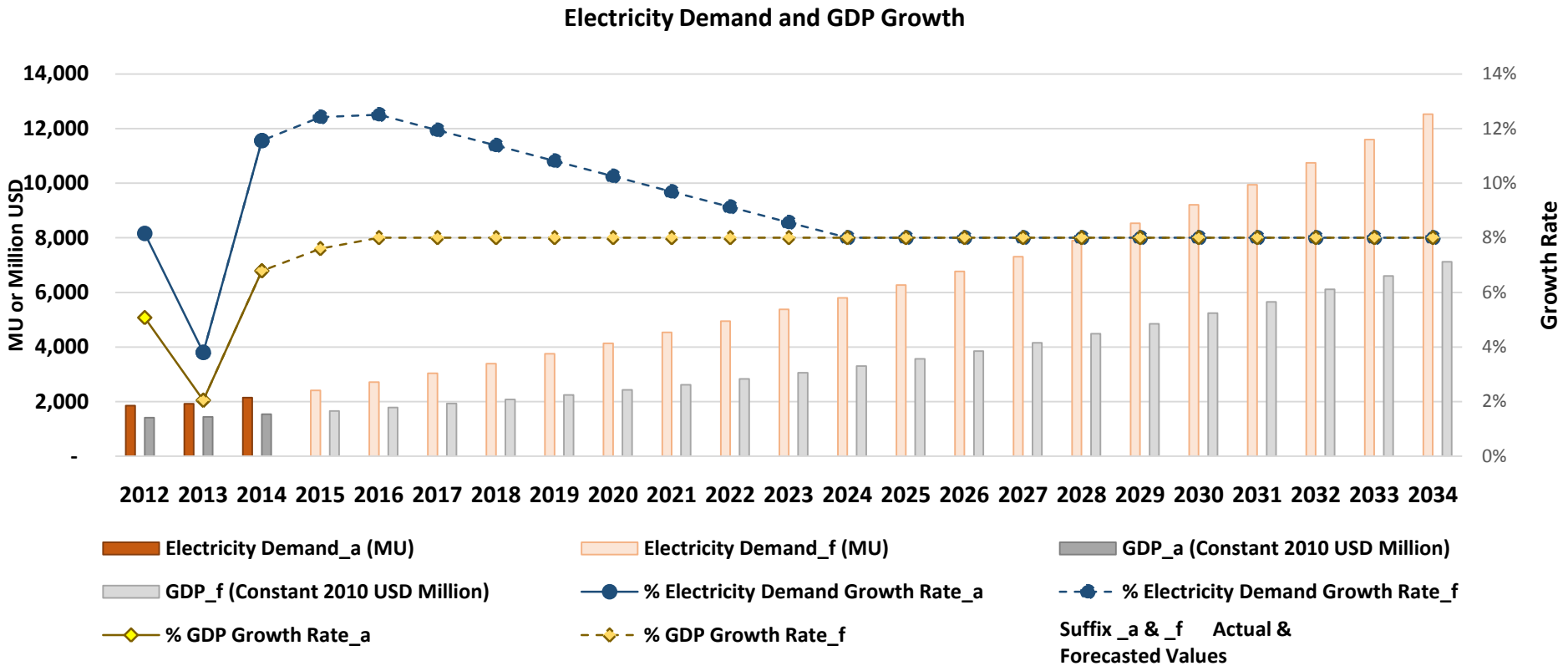
Bhutan – Generation Trends



- Reasons for low generation during the year 2012
  - Tamshing Micro Hydel, less water intake due to channel breakdown
  - Kuengarabten Micro Hydel shut down from July 2011 due to breakdown of water canal
  - Low generation at Lhuntse attributed to constant breakdown of Gangzur Hydel due to old age of the machine
  - Tingtibi Mini Hydel shut down due to AVR problem for three months

Source: Power Data Book 2013, Bhutan Power Corporation Limited

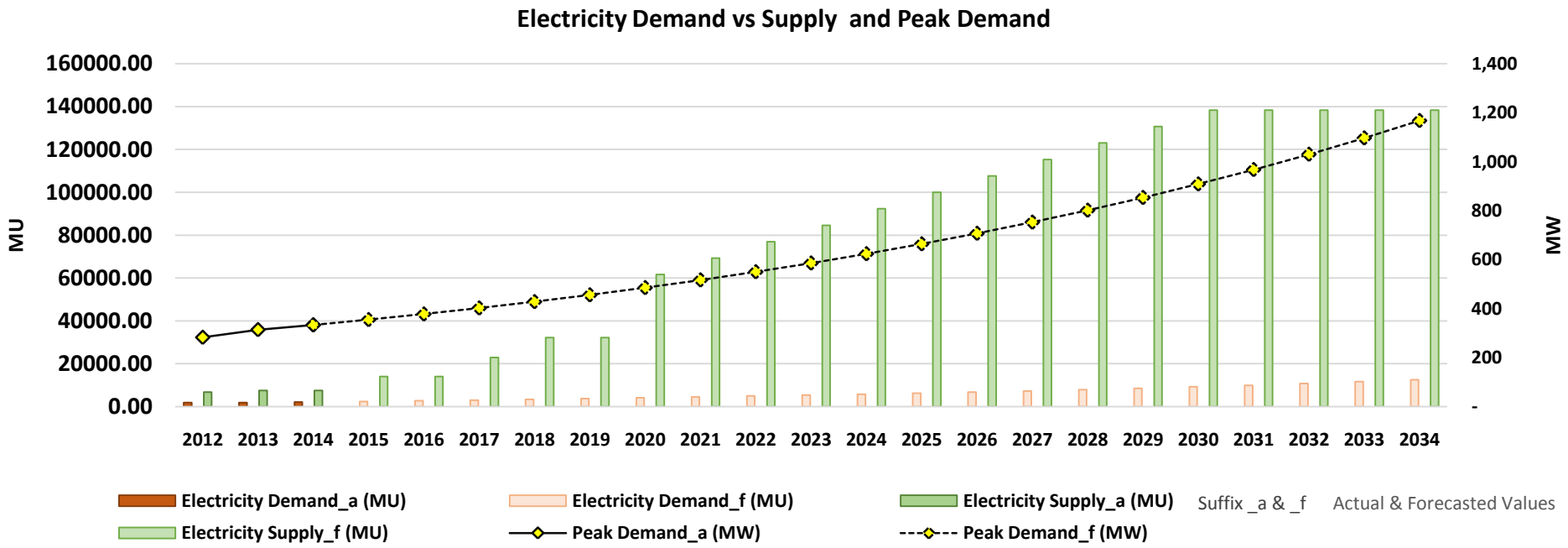
Bhutan – GDP & Electricity Demand Growth



Data Source:

GDP (absolute value & growth rate)		Electricity Demand	
Till 2014	2015 Onwards	Till 2013	From 2014
The World Bank	The World Bank forecast; growth rate kept constant 2016 onwards	Bhutan Annual Statistical Yearbook	ICF Analysis

Bhutan – Electricity Demand vs Supply & Peak Demand



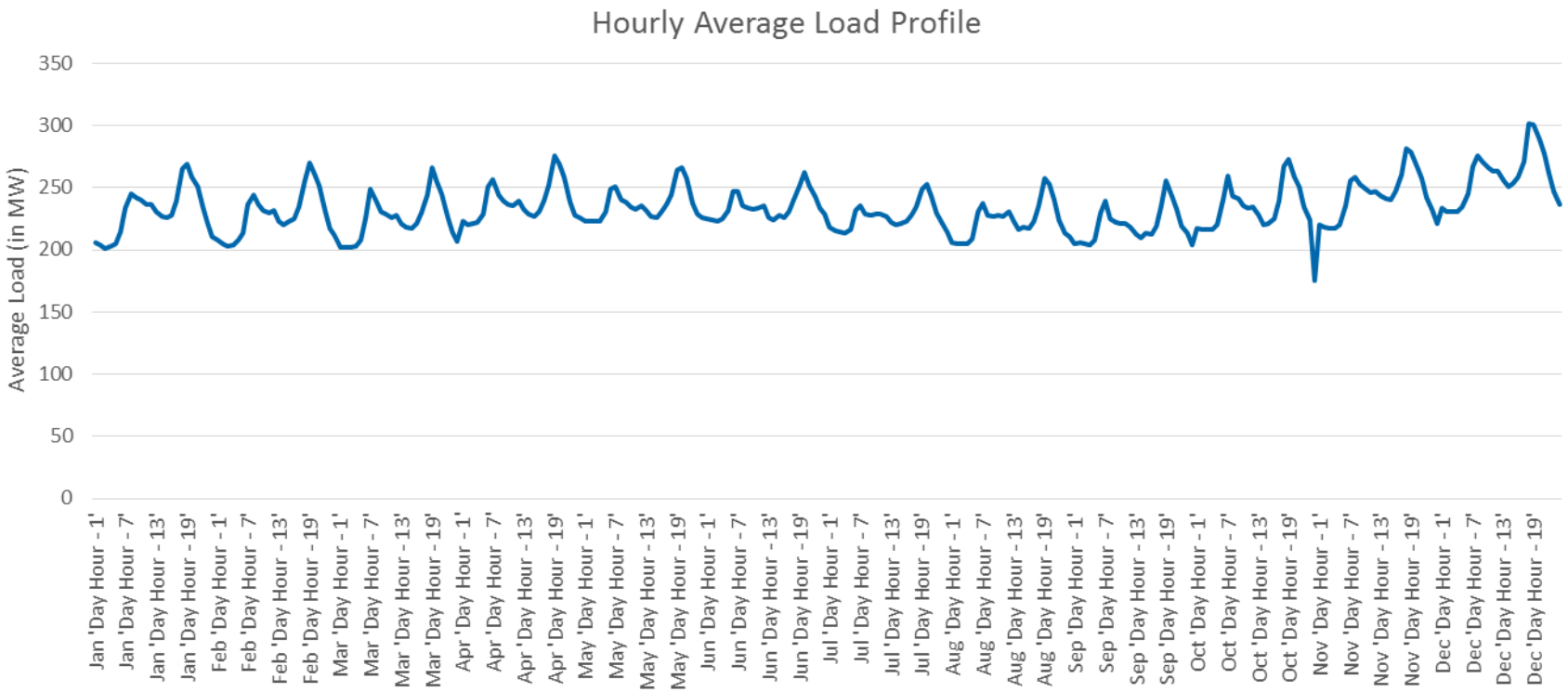
Data Source: GoB – Government of Bhutan

Electricity Demand		Electricity Supply		Peak Demand	
Till 2013	From 2014	Till 2013	From 2014	Till 2030	From 2031
Bhutan Annual Statistical Yearbook	ICF Analysis	Bhutan Annual Statistical Yearbook	Department of Hydropower and Power Systems, GoB	Department of Hydropower and Power Systems, GoB	Estimated using 5-yr CAGR

- Currently Bhutan is exporting about 1,300 MW of power from Chhukha, Kurichhu, Tala and Basochhu – I&II power Plants
- 126 MW Dagachhu Power Plant (built under PPP mode) has been commissioned and is participating in power markets operational in India

Assumptions (Brief Overview) – Unconstrained Case

Bhutan – Hourly Load Profile 2014



- Bhutan – winter peaking, with maximum demand in months of Nov-Dec-Jan

Source: Department of Hydropower and Power Systems, Royal Government of Bhutan, 2015

Bhutan – Capacity Factors & Firm Capacity Additions

Capacity Factors

Month	Average CF (%)
Jan	28%
Feb	24%
Mar	25%
Apr	29%
May	39%
Jun	86%
Jul	105%
Aug	107%
Sep	105%
Oct	80%
Nov	47%
Dec	34%
Annual Average	59%

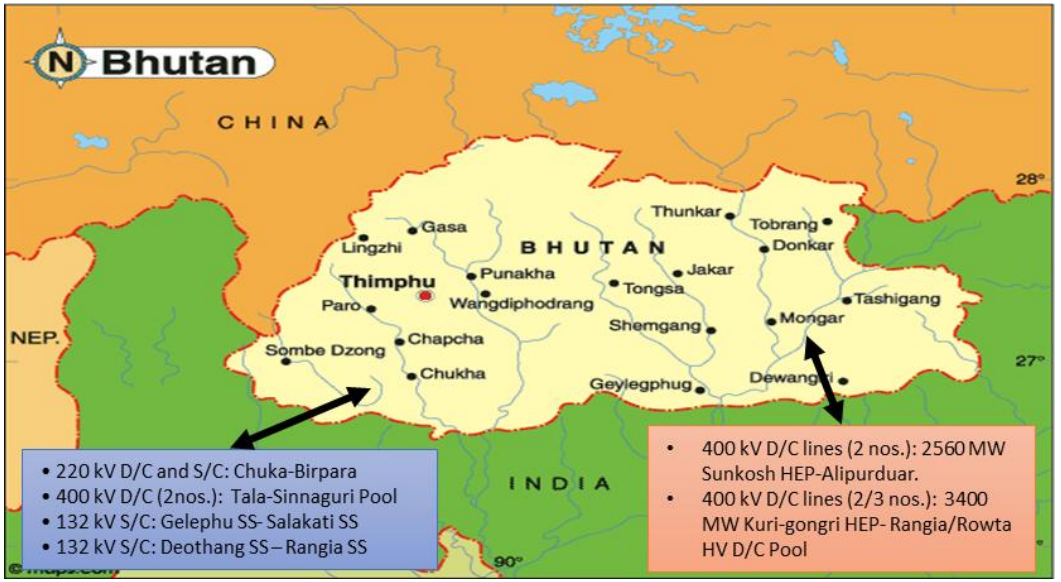
Firm Capacity Additions

Capacity type	Size (MW)	Online Year
Hydro	1,900	2018
Hydro	1,200	2019

Source: Department of Hydropower and Power Systems, Royal Government of Bhutan, 2015

Transmission Links

- Existing links:
  - 220 kV D/C and S/C: Chuka-Birpara
  - 400 kV D/C (2nos.): Tala-Sinnaguri Pool
  - 132 kV S/C: Gelephu SS- Salakati SS
  - 132 kV S/C: Deothang SS – Rangia SS
- Planned links:
  - 400 kV D/C lines (2 nos.): 2560 MW Sunkosh HEP-Alipurduar.
  - 400 kV D/C lines (2/3 nos.): 3400 MW Kuri-gongri HEP- Rangia/Rowta HV D/C Pool

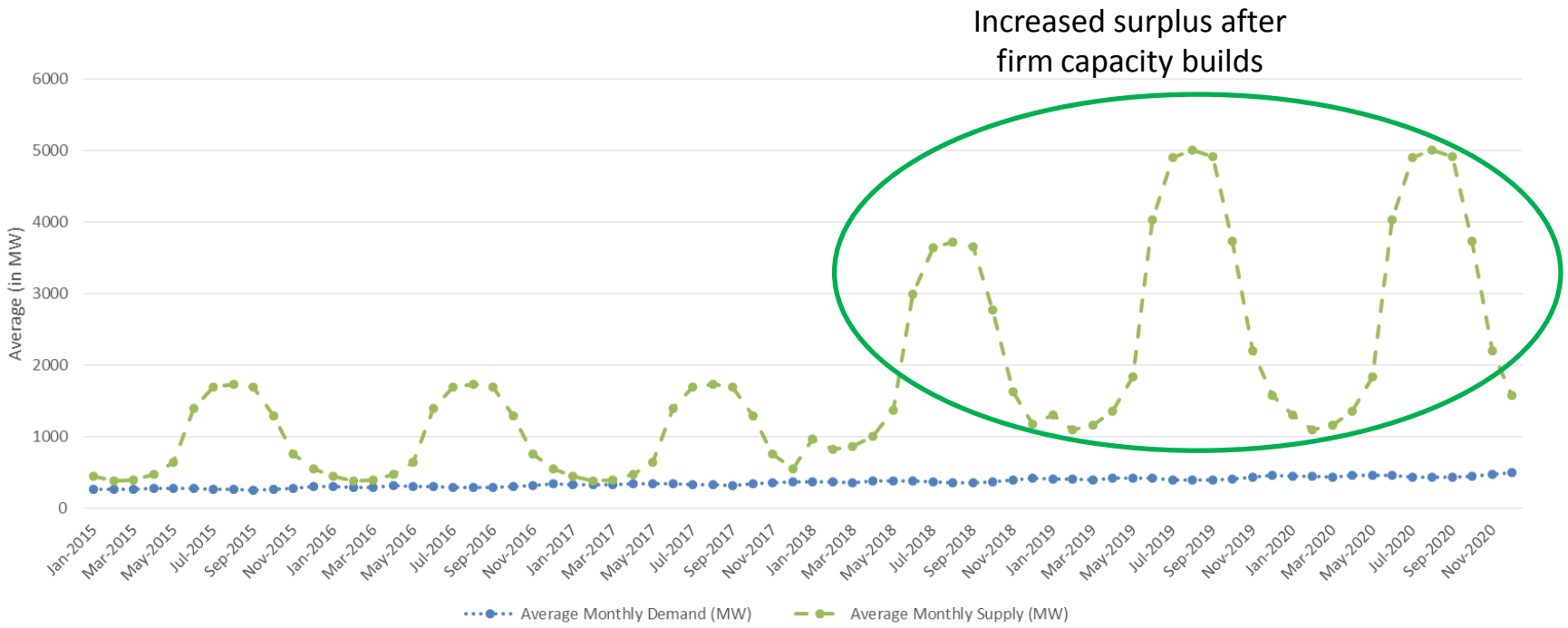


For the current unconstrained transmission case, no transmission constraint between Bhutan and neighboring countries is considered

Source: ICF Research, 2015

Results – Unconstrained Case

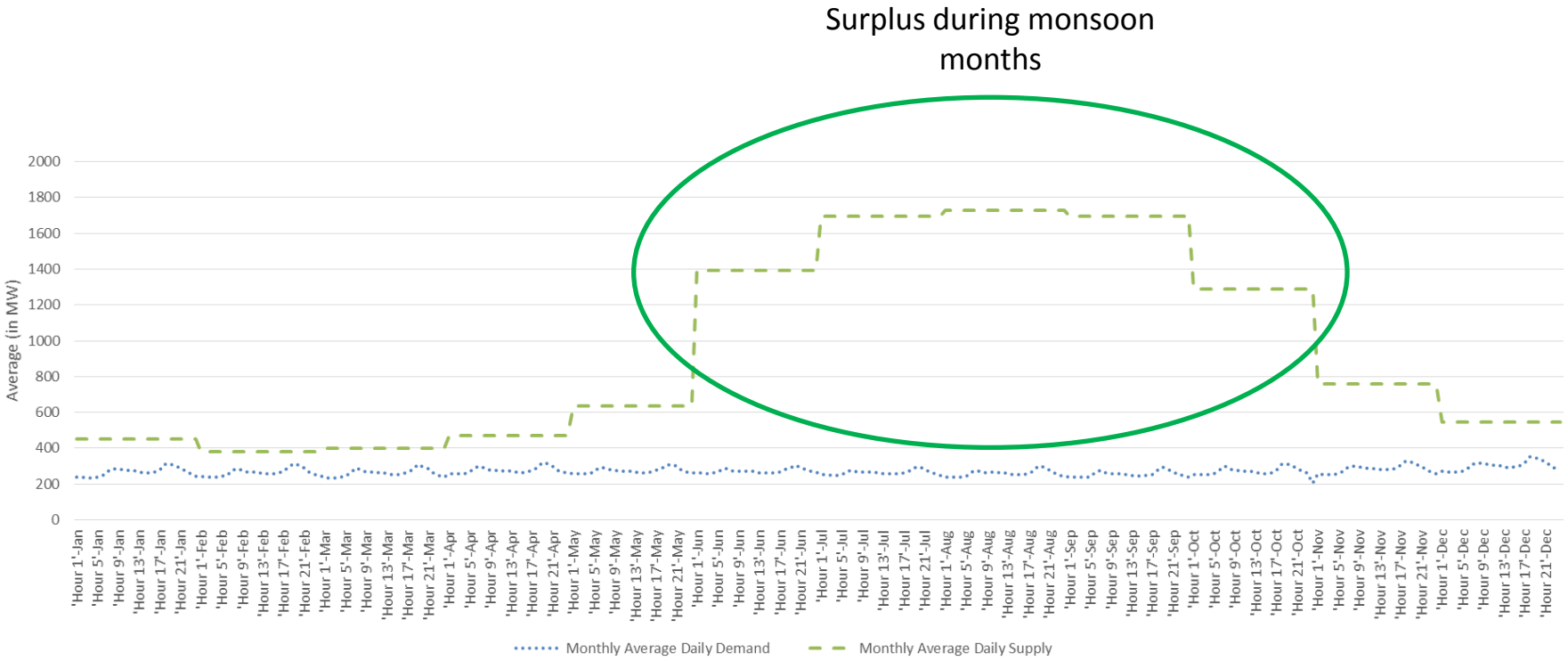
Bhutan Average Monthly Electricity Supply-Demand 2015-2020



- Bhutan is surplus in all seasons and exports to India
- Exports are high during months of June to October

Source: ICF Analysis

Bhutan Monthly Average Daily Electricity Supply-Demand 2015



Source: ICF Analysis

Bhutan Import/Export Summary

Bhutan	Annual average (Export) - MW	Annual (Export) - BUs
2015	686	6.0
2016	654	5.7
2017	620	5.4
2018	1,685	14.8
2019	2,358	20.7
2020	2,320	20.3
2021	2,357	20.6
2022	2,392	21.0
2023	2,425	21.2
2024	2,457	21.5
2025	2,486	21.8
2026	2,510	22.0
2027	2,530	22.2
2028	2,545	22.3
2029	2,555	22.4
2030	2,560	22.4
2031	2,480	21.7
2032	2,393	21.0
2033	2,299	20.1
2034	2,198	19.3

Bhutan	Daily Peak (Export) - MW	Daily Peak (Import) - MW	Monthly Peak (Export) - MW	Monthly Peak (Import) - MW
2015	1,552	0	1,493	0
2016	1,531	0	1,465	0
2017	1,509	39	1,435	11
2018	3,478	0	3,396	0
2019	4,739	0	4,649	0
2020	4,713	0	4,614	0

- In the near term (i.e. 2015 to 2020), there is a maximum annual average import potential for ~2,300 MW
- In the medium-term to long-term, annual average electricity trading has been estimated to remain in the same range (max. ~2,500 MW)

Source: ICF Analysis

Summary of Findings

- As per ICF analysis, Bhutan is expected to export power in all seasons
- Daily peak exports continue to increase with more and more capacity addition
- By 2020, Bhutan is expected to export 21 BUs of electricity (85% of which is concentrated in months of June to October)
- In near term (i.e. 2015 to 2020), a transmission link of ~5,000 MW may be required to meet export potential

3 NEPAL

Nepal – Macroeconomic Overview

General Overview (Source: World Bank, 2014)

- Political System : Federal Parliamentary Republic
- Land Area* : 143,350 km^2
- Population : 28.12 million
- GDP : 19.6 billion (current $)
- Real GDP / Capita : 698.3 (current $)

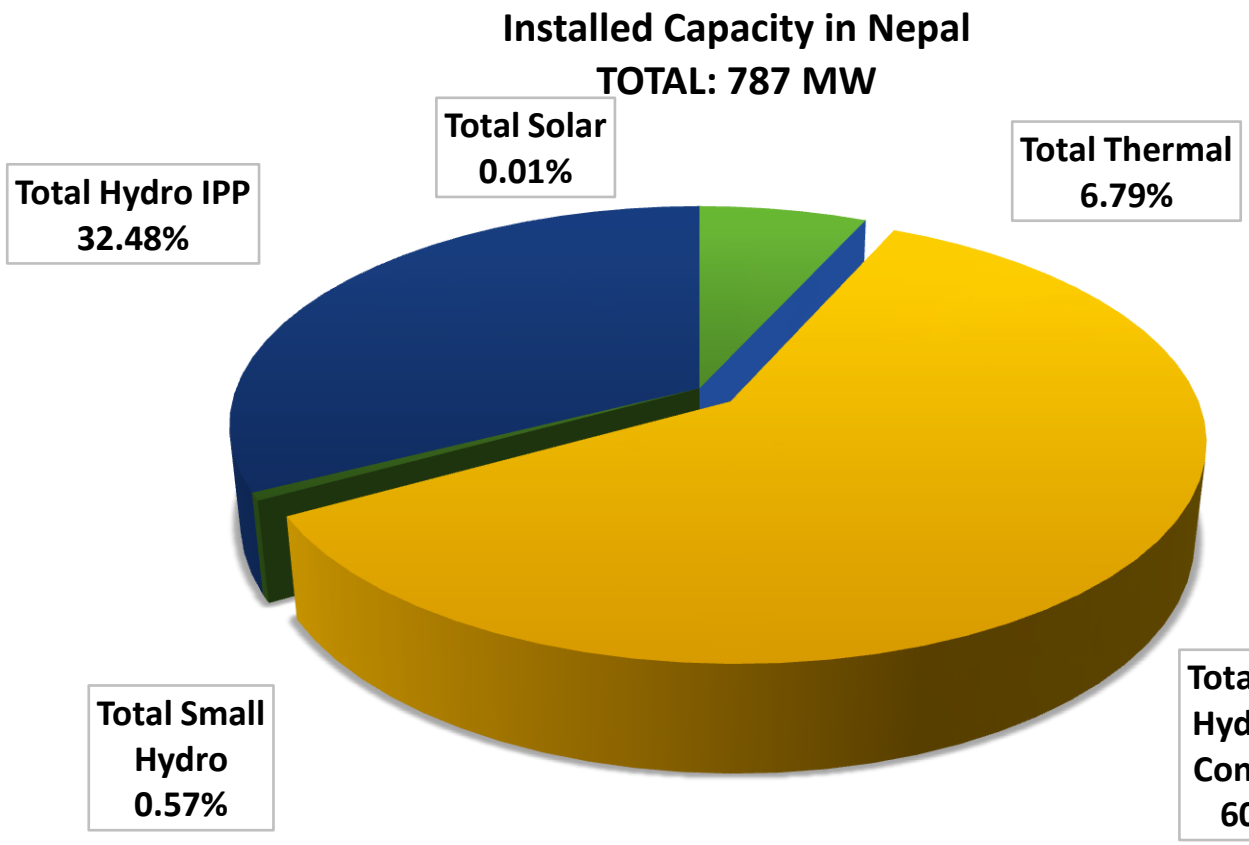
Power Sector Overview

- Installed Capacity : 787 MW
- Access to Electricity#: 76.3% (World Bank, 2012)

*Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

#Access to electricity is the percentage of population with access to electricity.

Nepal - Capacity Dominated by Hydro

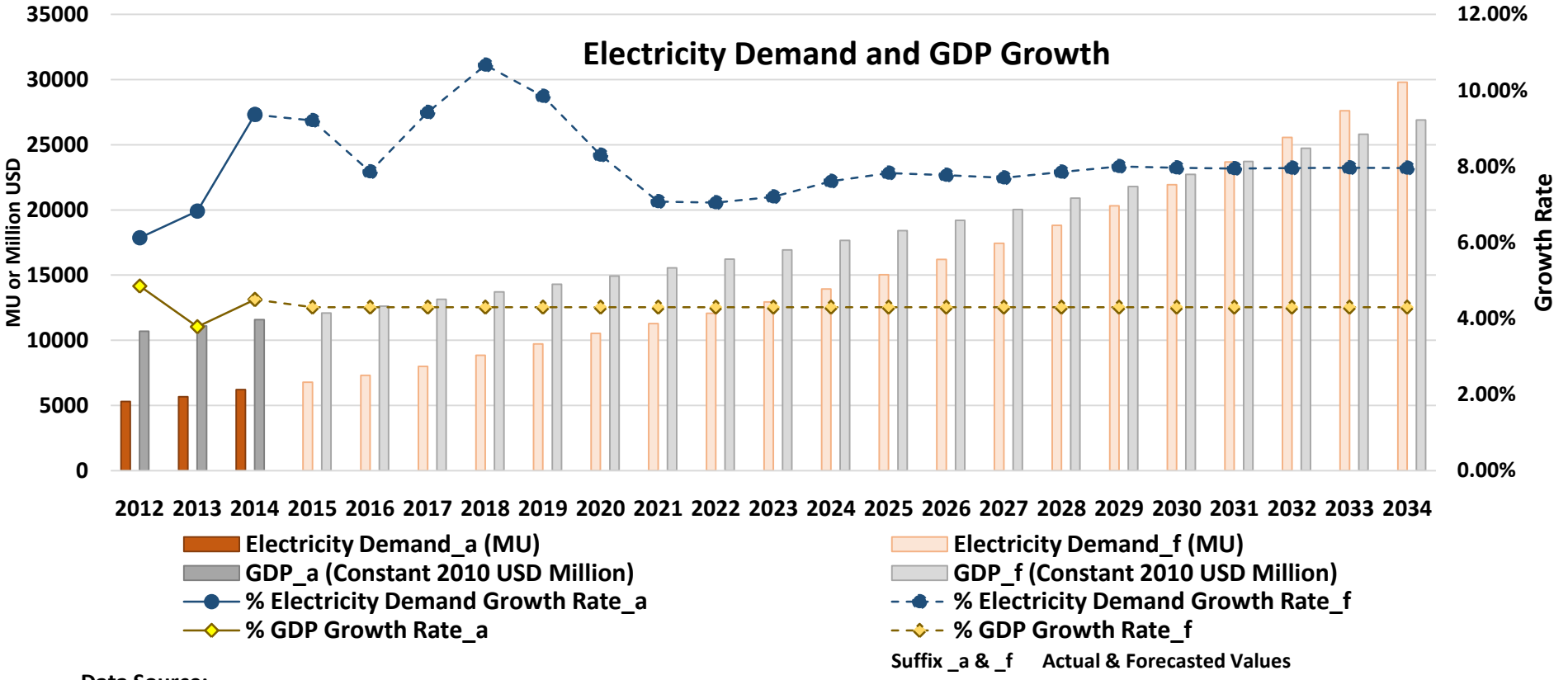


Type	Capacity (MW)
Solar	0.1
Hydro IPP	255.6
Small Hydro	4.5
Thermal	53.4
Major Hydro	473.4

As on 31st May 2015

Source: Nepal Electricity Authority

Nepal – GDP & Electricity Demand Growth



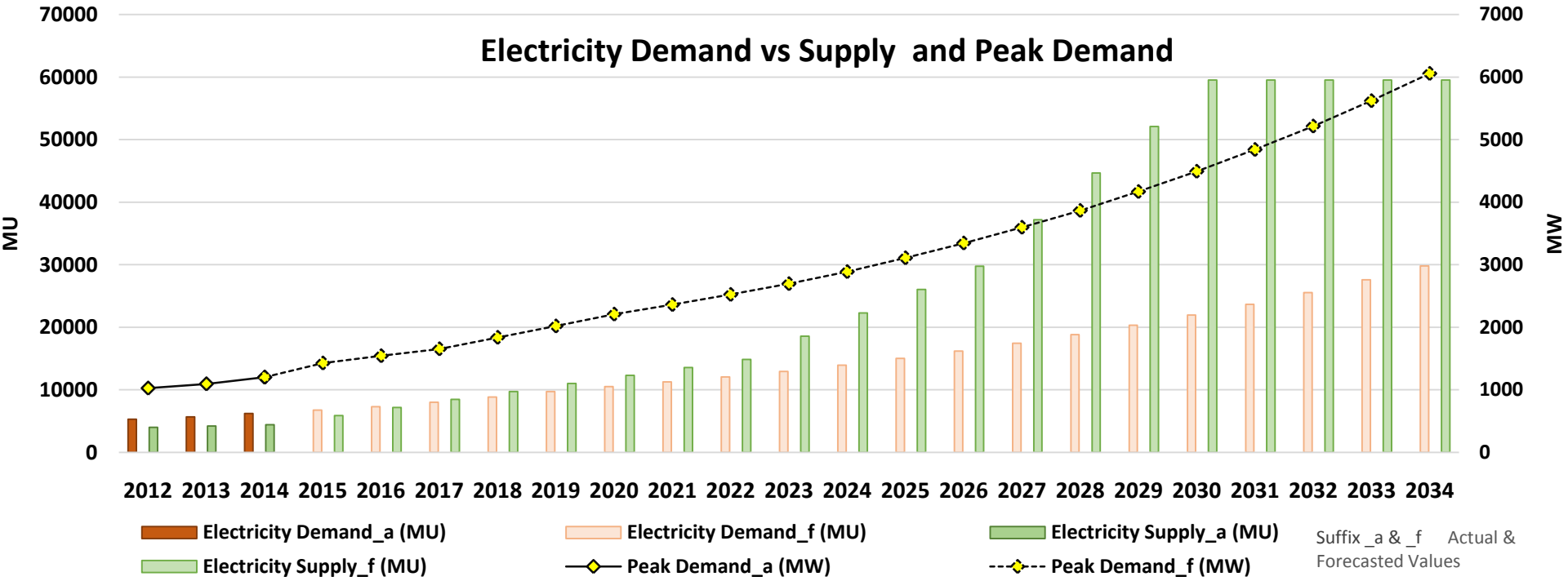
Data Source:

GDP (absolute value & growth rate)		Electricity Demand	
Till 2014	2015 Onwards	Till 2033	2034
The World Bank	The World Bank forecast; growth rate kept constant 2016 onwards	Nepal Electricity Authority Annual Report 2014	Estimated using 5-yr CAGR

Key Points:

- Nepal has very high electricity shortages
- Unrestricted Demand data for past 3 years has been used to forecast future demand

Nepal – Electricity Demand vs Supply & Peak Demand



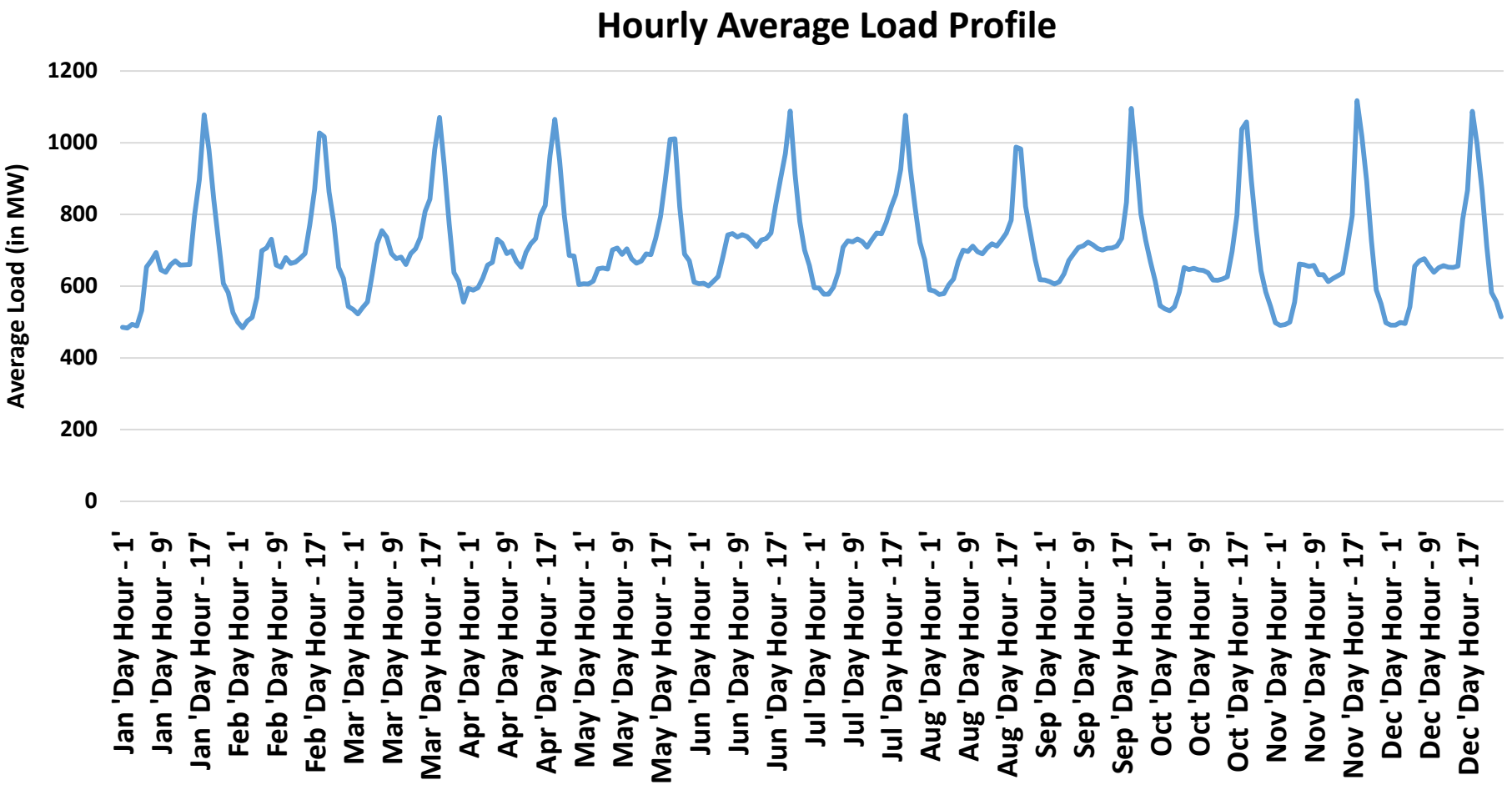
Data Source:

Electricity Demand		Electricity Supply		Peak Demand	
Till 2033	2034	Till 2030	2034	Till 2033	2034
NEA Annual Report 2014	Estimated using 5-yr CAGR	Based on expected capacity additions (10,000 MW Hydro by 2030)	Assumed to remain constant up to 2034	NEA Annual Report 2014	Estimated using 5-yr CAGR

- Power exchange between India and Nepal takes place in three modes:
  - Power under River Treaty (~40 MW)
  - Border Town Exchange Program (~50 MW)
  - Commercial Power Trading with PTC India during Dry season
- Nepal is currently importing ~150 MW from India through medium term arrangements (Nepal's 18% electricity supply)

Assumptions (Brief Overview) – Unconstrained Case

Nepal Load Profile 2014



Data Source: Nepal Electricity Authority and ICF Analysis

Nepal – Firm Capacity Additions

Capacity type	Size (MW)	Online year
Hydro	215	2016
Hydro	215	2017
Hydro	215	2018
Hydro	215	2019
Hydro	215	2020

Data Source: Nepal Electricity Authority and ICF Analysis

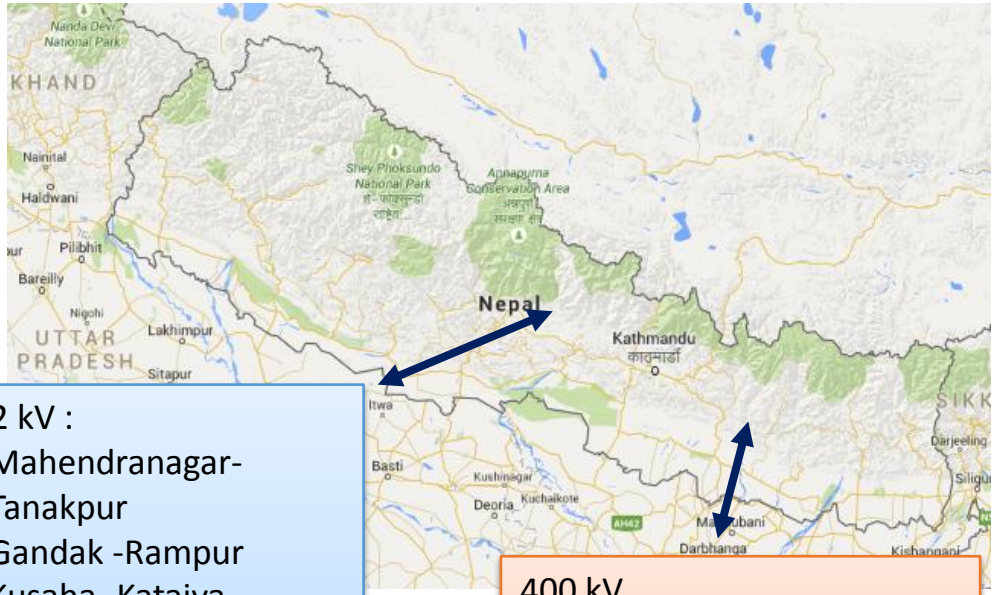
Nepal – Monthly Capacity Factor

Month	Average CF (%)
Jan	39%
Feb	34%
Mar	34%
Apr	39%
May	64%
Jun	100%
Jul	100%
Aug	100%
Sep	73%
Oct	58%
Nov	54%
Dec	47%
Annual Average	62%

Data Source: Nepal Electricity Authority and ICF Analysis

Transmission Links

- Existing links:
  - 132 kV : Mahendranagar-Tanakpur; Gandak –Rampur; Kusaha- Kataiya
  - 33 kV : Kataiya- Rajbiraqj; Raxual-Birgunj; Sitamadhi-Jaleswor; Nepalgunj-Nanpara; Jayanagar-Siraha
- Future links (400 kV)
  - Dhalkebar- Muzzafarpur
  - Duhabi- Jogbani
  - Bardaghat- Gorakhpur



132 kV :
- Mahendranagar-Tanakpur
- Gandak -Rampur
- Kusaha- Kataiya

33 kV :
- Kataiya- Rajbiraqj
- Raxual- Birgunj
- Sitamadhi-Jaleswor
- Nepalgunj-Nanpara
- Jayanagar-Siraha

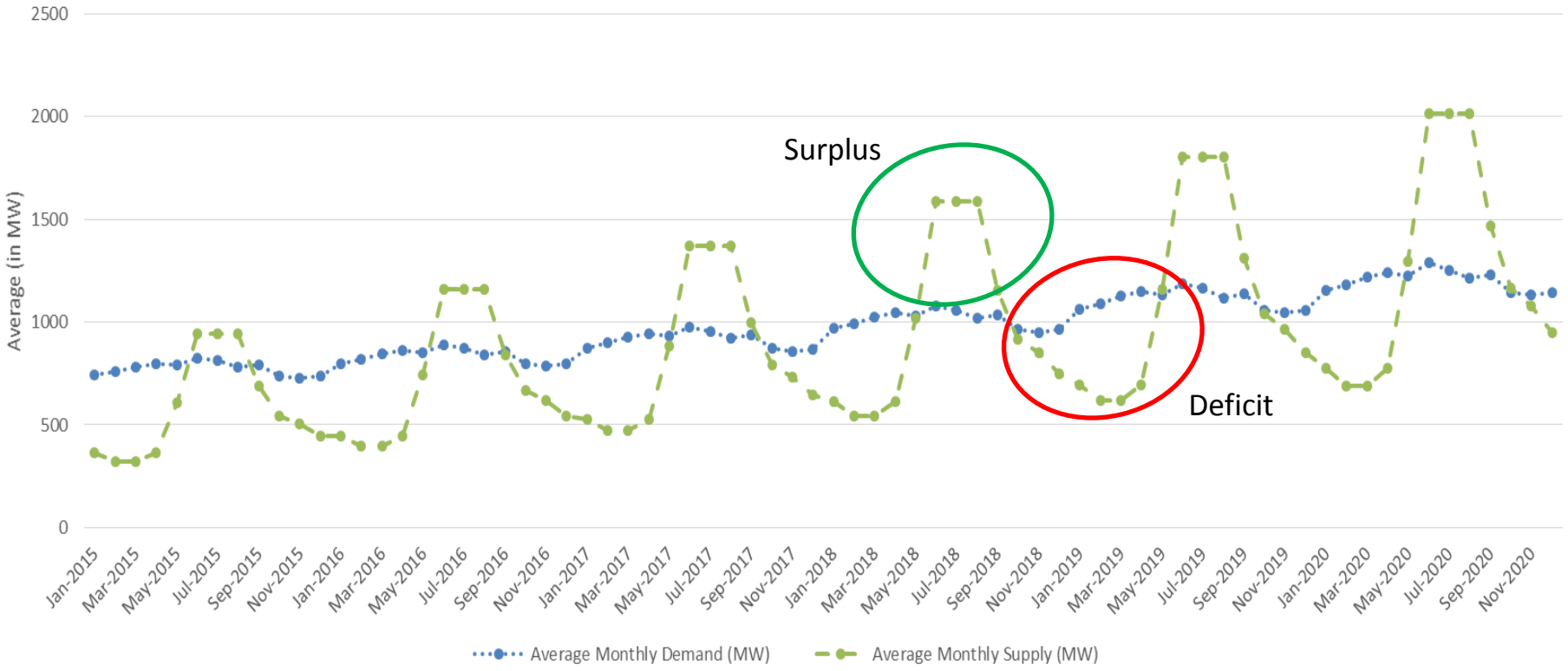
400 kV
- Dhalkebar- Muzzafarpur (Under cons.)
- Duhabi- Jogbani (Identified and Proposed)
- Bardaghat- Gorakhpur (Planned)

For the current unconstrained transmission case, no transmission constraint between Nepal and neighboring countries is considered

Source: ICF Research, 2015

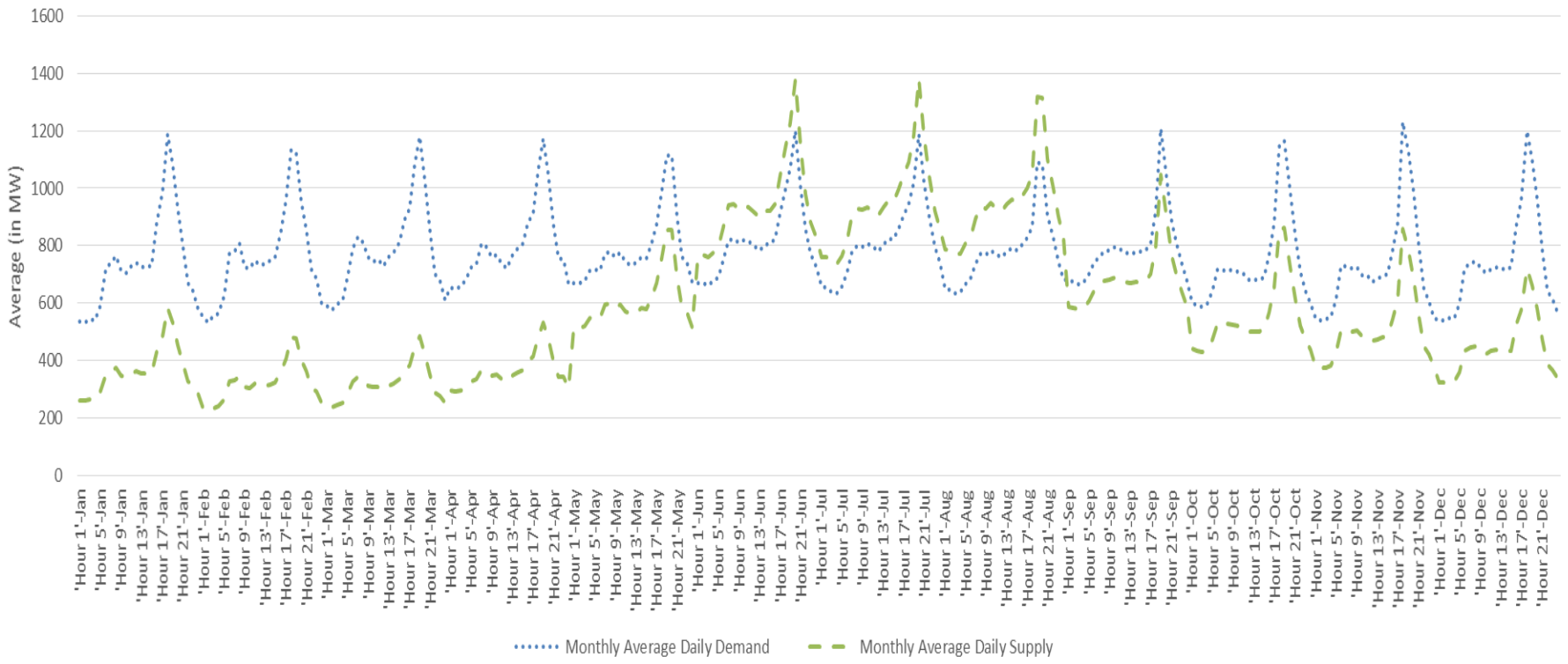
Results – Unconstrained Case

Nepal Average Monthly Electricity Supply Demand 2015-2020



Source: ICF Analysis

Nepal Monthly Average Daily Electricity Supply Demand 2015



Source: ICF Analysis

Nepal Import/Export Summary

Nepal	Annual Average (Export) - MW	Annual (Export) - BUs
2015	-190	-1.66
2016	-119	-1.04
2017	-63	-0.56
2018	-28	-0.24
2019	5	0.05
2020	45	0.39
2021	458	4.01
2022	862	7.55
2023	1,257	11.0
2024	1,640	14.4
2025	2,010	17.6
2026	2,372	20.8
2027	2,724	23.9
2028	3,063	26.8
2029	3,386	29.7
2030	3,696	32.4
2031	3,497	30.6
2032	3,282	28.7
2033	3,049	26.7
2034	3,049	26.7

Nepal	Daily Peak (Export) - MW	Daily Peak (Import) - MW	Monthly Peak (Export) - MW	Monthly Peak (Import) - MW
2015	279	699	232	693
2016	515	682	443	676
2017	725	693	632	685
2018	906	732	796	723
2019	1,084	774	956	764
2020	1,273	806	1,130	795

- In the near term (i.e. 2015 to 2020), annual average net import by Nepal is expected to decline although the country will still substantially import during lean months
- In the medium-term to long-term, it has been estimated that Nepal holds potential to export ~3,000 MW of power annually

Source: ICF Analysis

Summary of Findings

- Nepal, a net importer till 2018 and then net exporter
- Nepal exports primarily in wet season of May to September
- Even though Nepal is expected to become a net exporter by 2020, it is estimated that Nepal may still need to import in dry months of Jan to April and Oct to Dec
- In near term (i.e. 2015 to 2020), a transmission link of ~1,500 MW may be required to meet import/export potential

4 INDIA

India: Macroeconomic Overview

General Overview (Source: World Bank, 2014)

- Political System : Federal Parliamentary Constitutional Republic
- Land Area* : 3,287,590 km^2
- Population : 1.2 billion
- GDP : 2.1 trillion (current $)
- Real GDP / Capita : 1630.8 (current $)

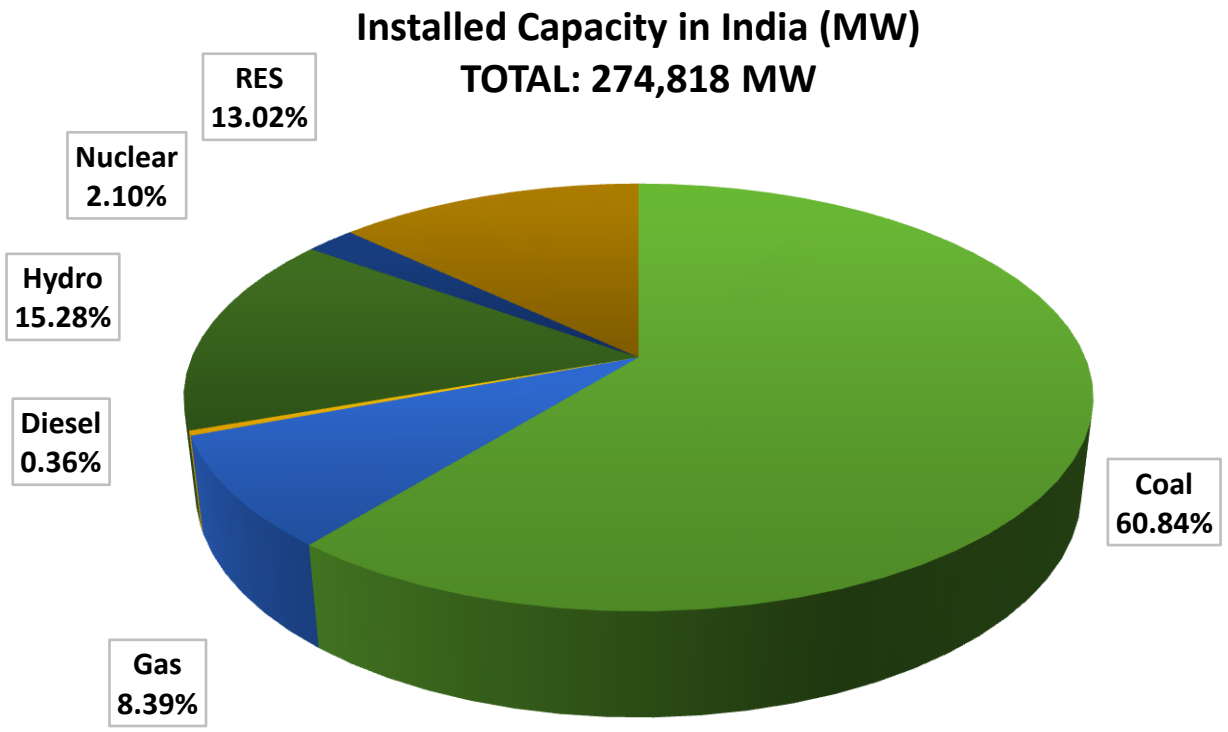
Power Sector Overview

- Installed Capacity : 274,818 MW
- Access to Electricity#: 78.7% (World Bank, 2012)

*Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

#Access to electricity is the percentage of population with access to electricity.

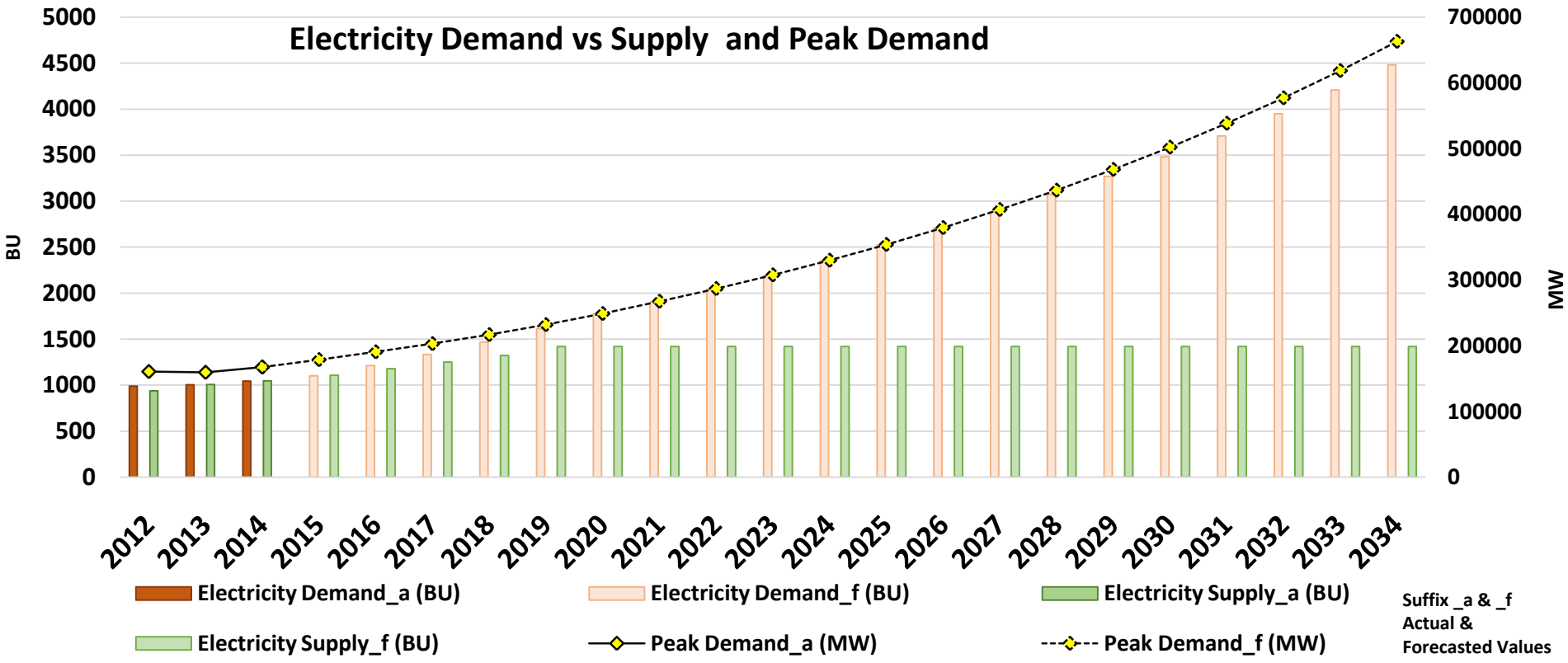
India – Capacity Dominated by Coal, Hydro and Renewables



Type	Capacity (MW)
Coal	167,208
Hydro	41,997
Diesel	994
Gas	23,062
Nuclear	5,780
RES	35,777

Source: CEA, India June'15 Monthly Report

India – Electricity Demand vs Supply & Peak Demand

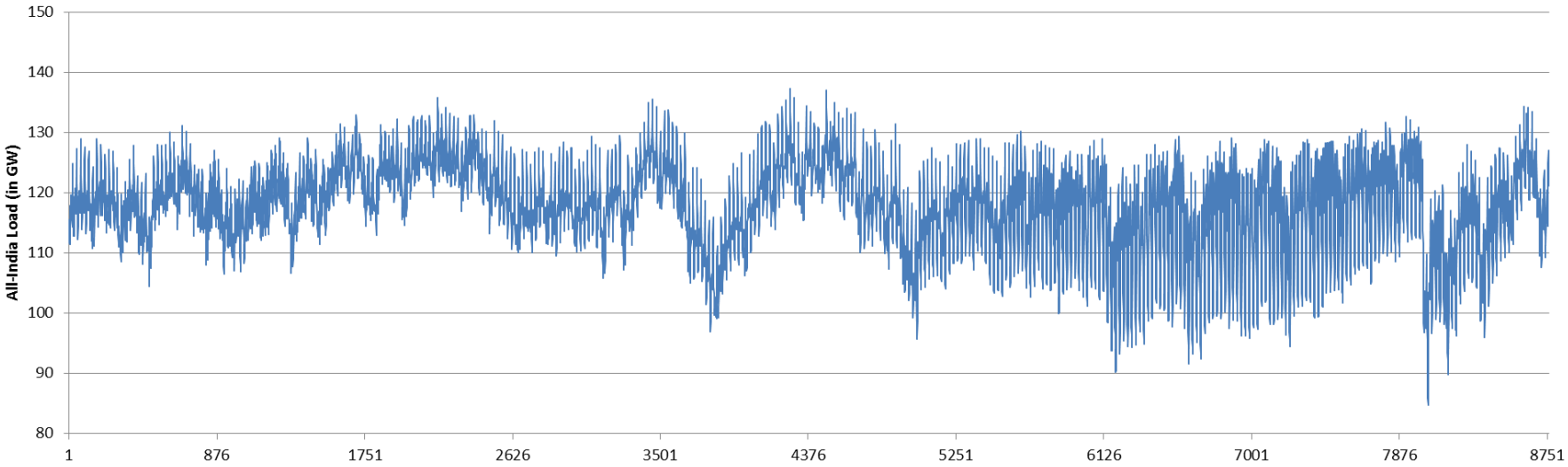


Electricity Demand		Electricity Supply		Peak Demand	
Till 2013	From 2014	Till 2013	From 2014	Till 2013	From 2014
Central Electricity Authority, India	ICF Analysis	Central Electricity Authority, India	ICF Analysis	Central Electricity Authority, India	ICF Analysis

Details on electricity shortages in India and its impact on Demand

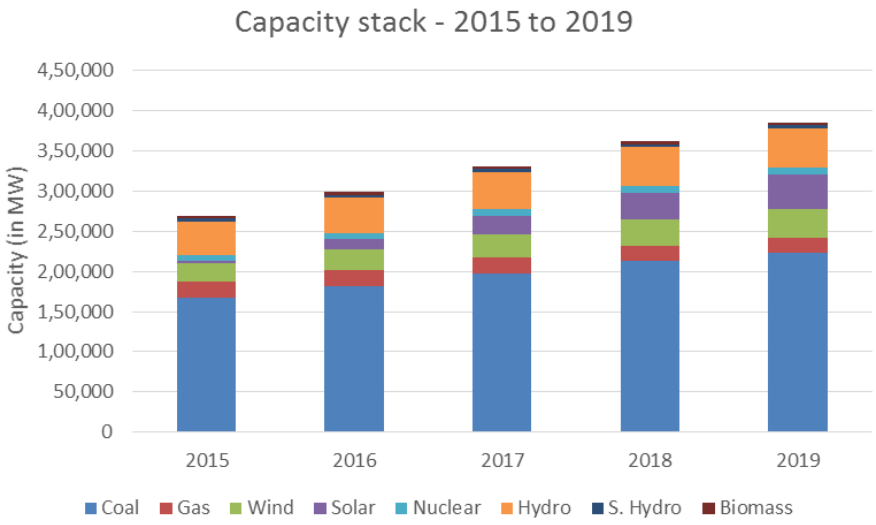
Assumptions (Brief Overview) – Unconstrained Case

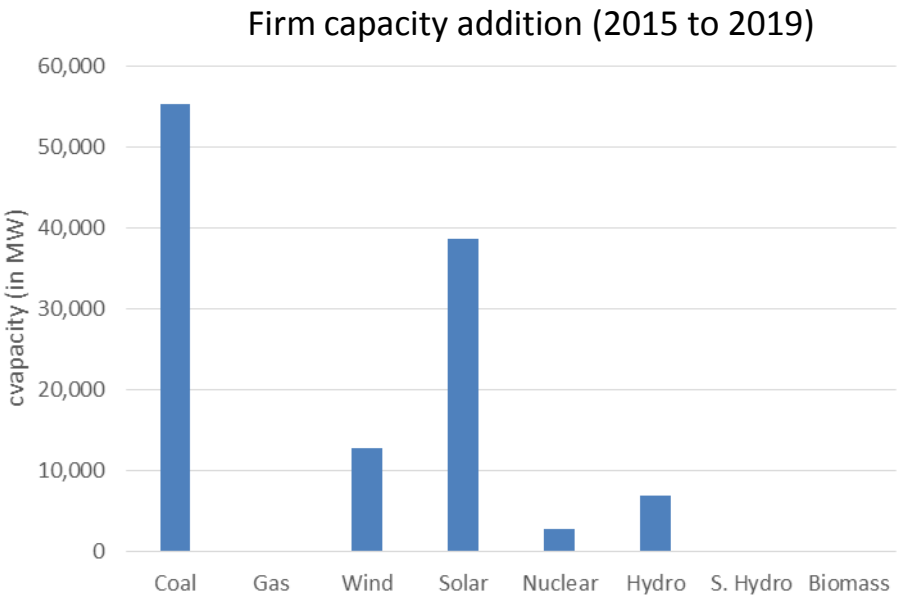
India – Load Profile FY15



Data Source: NLDC, India - 2015

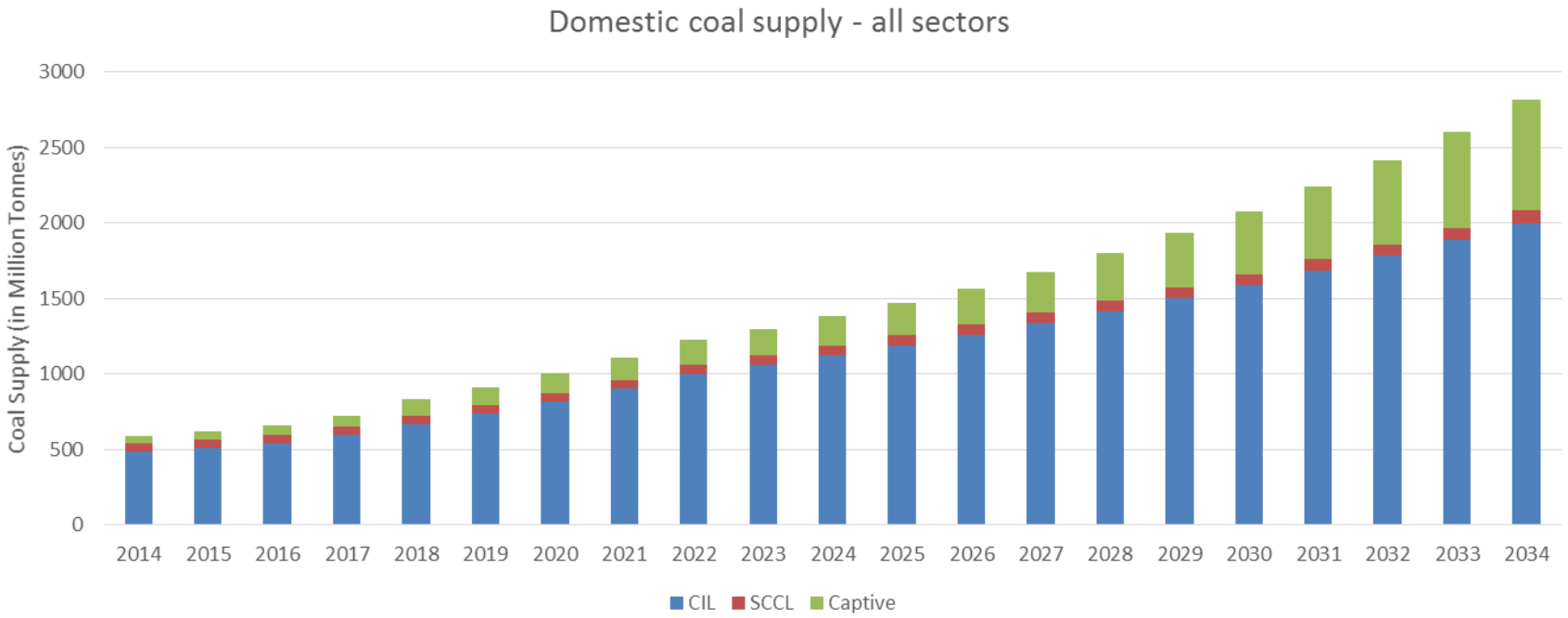
Firm Capacity Additions till 2019





Data Source: ICF Research and Central Electricity Authority, India

Domestic Coal Supply



- 1000 MT CIL production by 2022, increase up to 2000 MT by 2034

Data Source: ICF Research and Ministry of Power

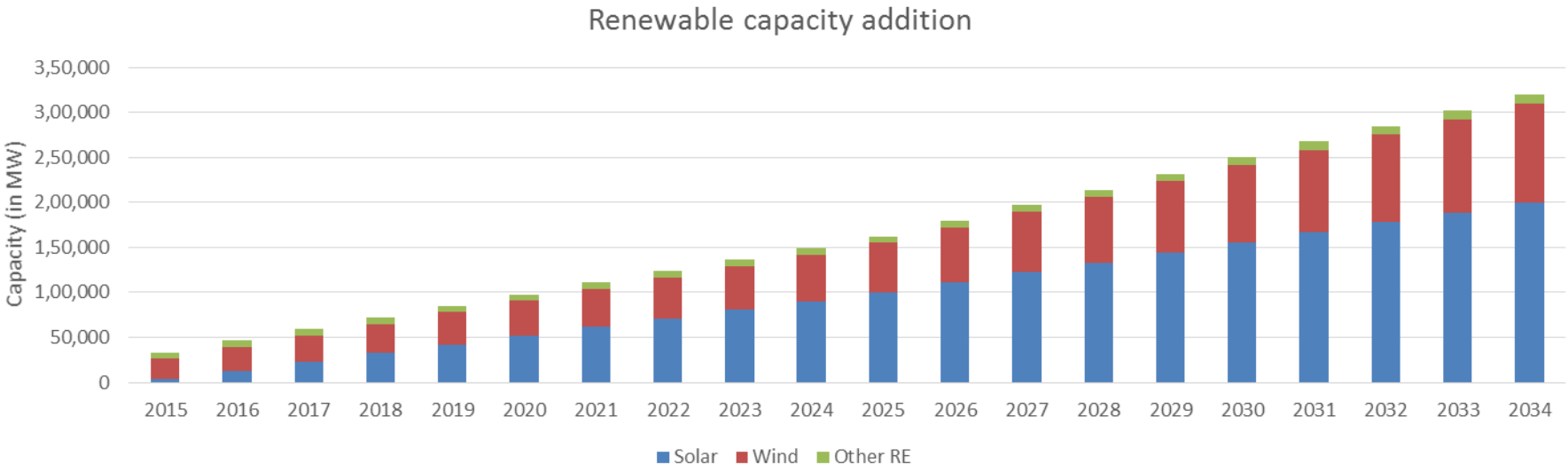
Domestic Coal Prices

CIL Notified Run of Mine Prices (INR/Tonne)			
Grade	**GCV Range**	**CIL Subsideries excluding WCL**	**WCL**
G1	Above 7000	*	*
G2	6701 to 7000	5,226	5,226
G3	6401 to 6700	4,174	4,174
G4	6101 to 6400	3,745	3,745
G5	5801 to 6100	3,004	3,004
G6	5501 to 5800	1,717	1,888
G7	5201 to 5500	1,502	1,652
G8	4901 to 5200	1,341	1,481
G9	4601 to 4900	1,041	1,148
G10	4301 to 4600	923	1,009
G11	4001 to 4300	751	826
G12	3701 to 4000	708	783
G13	3401 to 3700	655	719
G14	3101 to 3400	590	655
G15	2801 to 3100	547	601
G16	2501 to 2800	483	537
G17	2201 to 2500	429	472
* For GCV exceeding 7000kcal/kg, price shall increase by 150 per tonne for increase in GCV by every 100kcal/kg			
Notified on May 2013			

SCCL Notified Run of Mine Prices (INR/Tonne)		
Grade	**GCV Range**	**SCCL Coal Prices**
G1	Above 7000	4680.0
G2	6701 to 7000	4,480
G3	6401 to 6700	4,390
G4	6101 to 6400	4,340
G5	5801 to 6100	4,320
G6	5501 to 5800	2,720
G7	5201 to 5500	2,120
G8	4901 to 5200	1,960
G9	4601 to 4900	1,730
G10	4301 to 4600	1,610
G11	4001 to 4300	1,300
G12	3701 to 4000	1,050
G13	3401 to 3700	800
G14	3101 to 3400	710
G15	2801 to 3100	590
G16	2501 to 2800	550
G17	2201 to 2500	490
*Prices notified in 2014 INR		

Data Source: ICF Research, Coal India Limited and Ministry of Power, India

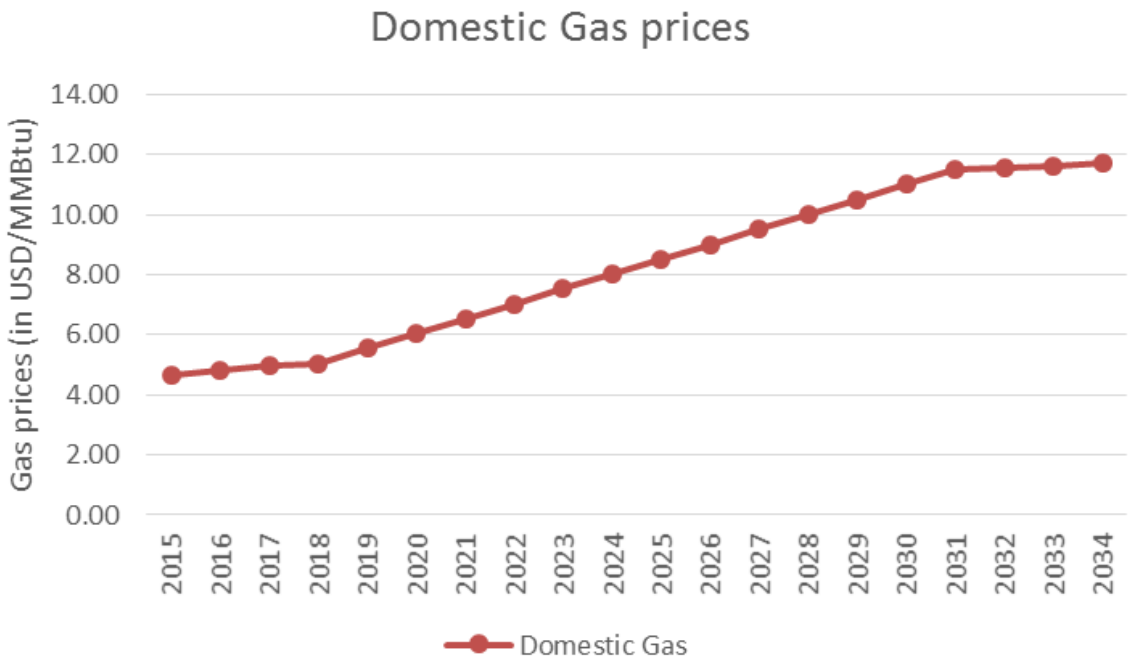
Renewable Capacity Addition Targets



- 100 GW solar capacity addition by 2025, increases up to 200 GW by 2034

Data Source: ICF Research and Ministry of New & Renewable Energy, India - 2015

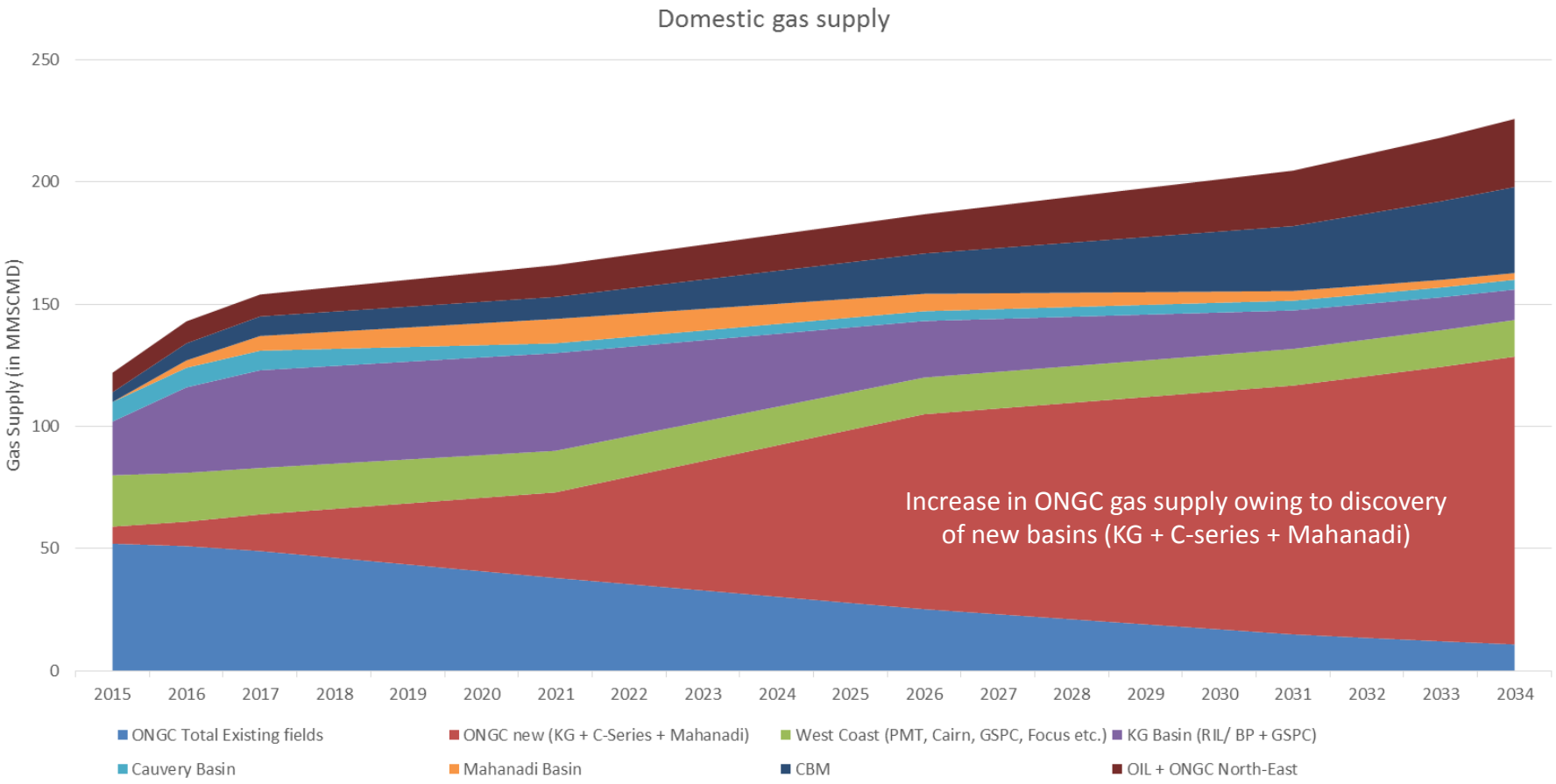
Domestic Gas Prices, Gradually Linking to LNG Prices



- 2015-18: Based on current formula proposed by GoI
- 2019-30: Gradual increase to link gas prices to LNG prices
- 2030 onwards: Link to LNG prices at 15% discount

Data Source: ICF Assumptions

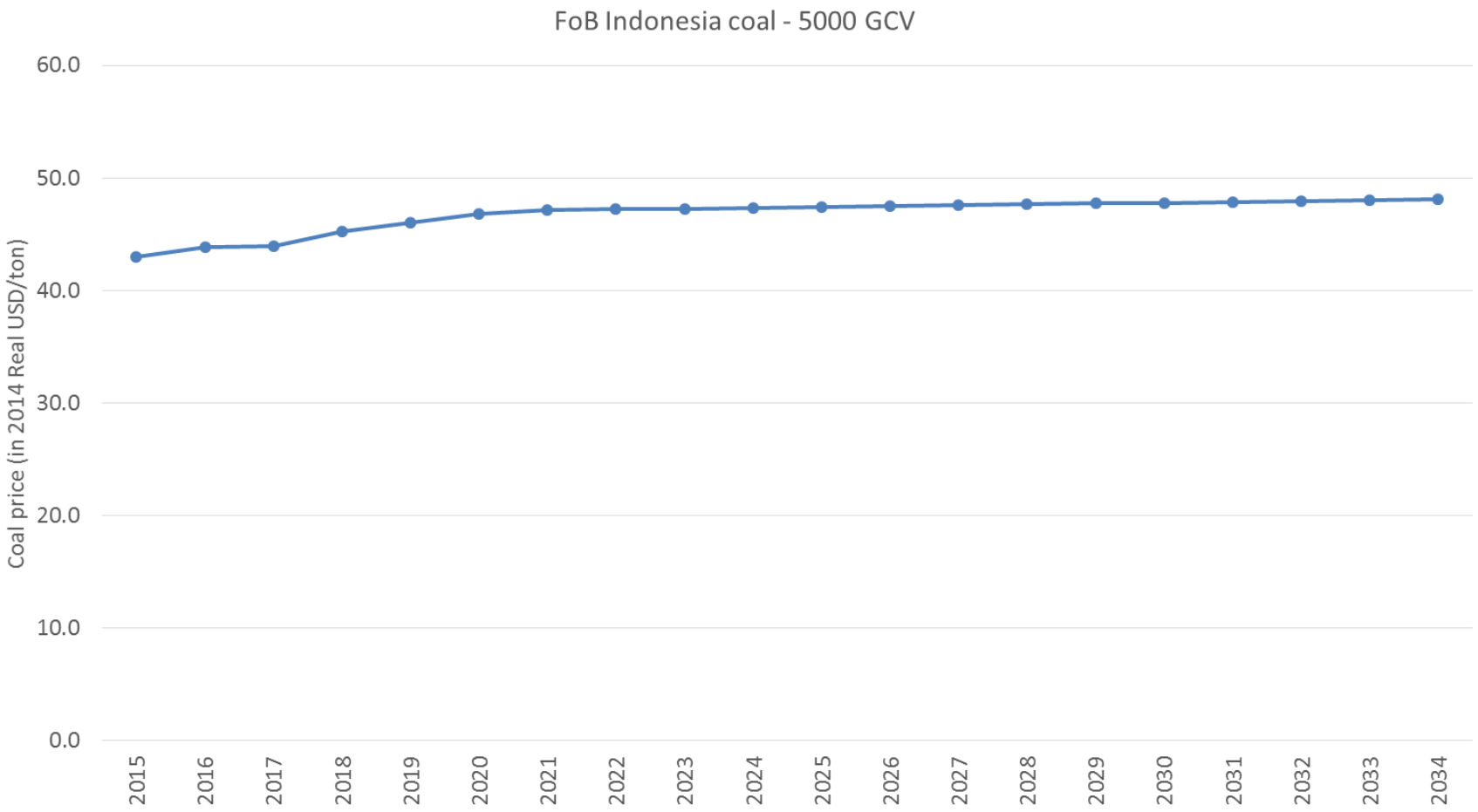
Domestic Gas Supply – All Sectors



- Of the total supply, 35% is assumed to be available for power sector in all the years

Data Source: ICF Assumptions

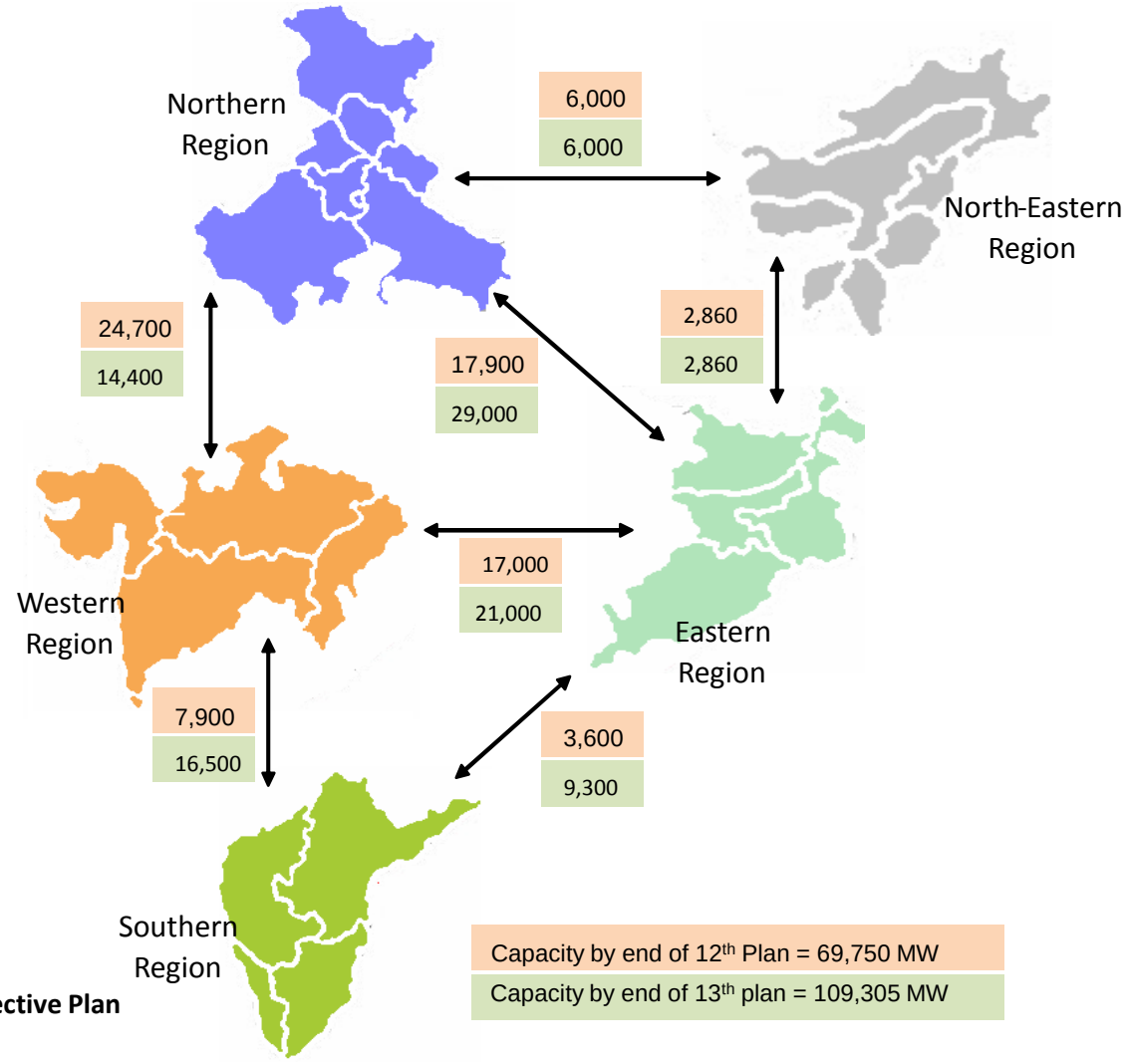
Imported Coal Prices



Data Source: ICF Assumptions

Transmission Links

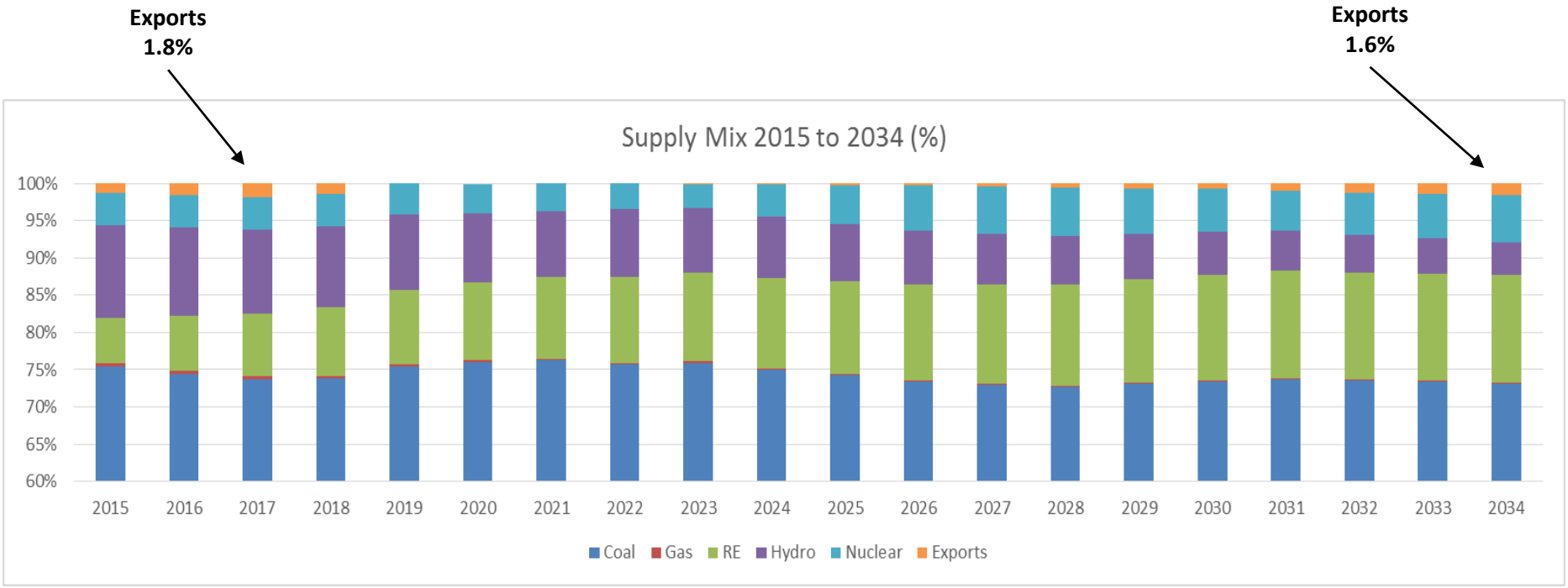
- Map shows, intra-country transmission constraints modeled for India
- For the current unconstrained transmission case, no transmission constraint between India and neighbouring countries is considered



Data Source:
Central Electricity Authority's Transmission Prospective Plan
ICF Assumption

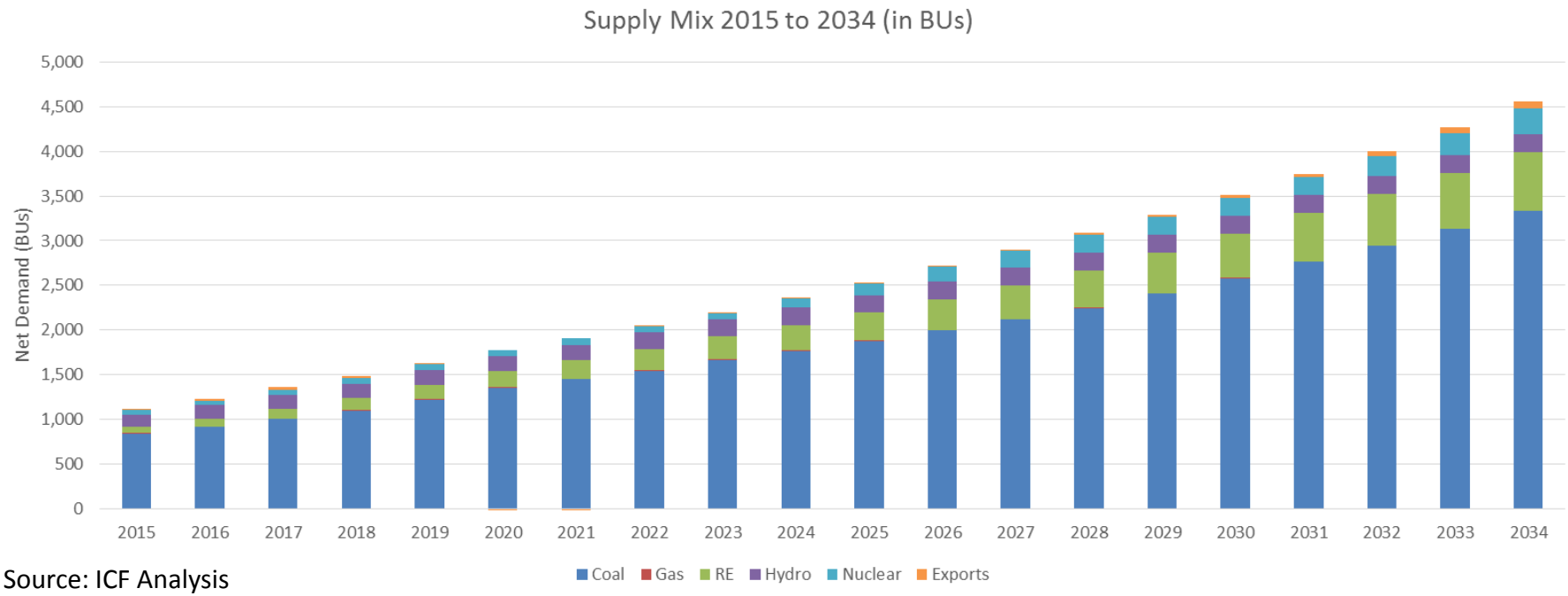
Results – Unconstrained Case

India – Supply Mix



Source: ICF Analysis

India – Supply Mix (in BUs)



Source: ICF Analysis

India – Trade in BUs

Source: ICF Analysis

in BUs	Internal Demand - India	Import from Bangladesh	Import from Bhutan	Import from Nepal	Total Import - India	Total Trade as % of India's Internal demand	Net Generation Required (India)
2015	1,102	-19.2	6.01	-1.66	-14.9	-1.3%	1,117
2016	1,213	-23.8	5.73	-1.04	-19.1	-1.6%	1,232
2017	1,334	-29.4	5.43	-0.56	-24.5	-1.8%	1,359
2018	1,468	-35.3	14.8	-0.24	-20.8	-1.4%	1,489
2019	1,616	-21.4	20.7	0.05	-0.65	-0.0%	1,617
2020	1,778	-18.8	20.3	0.39	1.91	0.1%	1,776
2021	1,904	-24.1	20.6	4.01	0.56	0.0%	1,904
2022	2,043	-29.4	21.0	7.55	-0.90	0.0%	2,044
2023	2,192	-34.7	21.2	11.0	-2.45	-0.1%	2,194
2024	2,352	-40.0	21.5	14.4	-4.12	-0.2%	2,356
2025	2,524	-45.3	21.8	17.6	-5.93	-0.2%	2,530
2026	2,709	-52.4	22.0	20.8	-9.62	-0.4%	2,719
2027	2,885	-59.4	22.2	23.9	-13.4	-0.5%	2,898
2028	3,072	-66.5	22.3	26.8	-17.4	-0.6%	3,089
2029	3,271	-73.6	22.4	29.7	-21.5	-0.7%	3,292
2030	3,483	-80.6	22.4	32.4	-25.8	-0.7%	3,509
2031	3,709	-90.0	21.7	30.6	-37.7	-1.0%	3,747
2032	3,950	-99.4	21.0	28.7	-49.7	-1.3%	4,000
2033	4,207	-108.8	20.1	26.7	-62.0	-1.5%	4,269
2034	4,480	-118.2	19.3	26.7	-72.2	-1.6%	4,552

- In the near term (i.e. 2015 to 2020), annual average electricity import from Bhutan and Nepal is expected to rise while export to Bangladesh will fall in 2019 due to capacity additions in Bangladesh
- In the medium-term to long-term, India is expected to remain a net exporter of power to Bangladesh while increasing its imports from Nepal and Bhutan

Summary of Findings

- India, a net exporter of power
- India to remain a predominantly coal-based economy
- Coal to continue to account for nearly 72% of total electricity requirement
- Increasing importance of RE capacity – by 2034, RE generation to account for ~14% of total generation (up from 6% in 2015)
- Total export (in MUs) as percentage of India's internal demand is quite small (i.e. at 1.8% in 2017)
- In near term (i.e. 2015 to 2020), total exports peak in 2017 (at 24.5 BUs)
- India does not need to set-up additional capacity to meet the additional requirement to export to neighboring countries, since the overall requirement is quite small as compared to Indian grid
- Improvement in capacity factor of coal plants by ~1% - 2% would be sufficient to meet the growing export demands in near term

5 SRI LANKA

Sri Lanka – Macroeconomic Overview

General Overview (Source: World Bank, 2015)

- Political System : Unitary Semi-Presidential Constitutional Republic
- Land Area* : 62,710 km^2
- Population : 20.64 million
- GDP : 74.9 billion (current $)
- Real GDP / Capita : 3631.0 (current $)

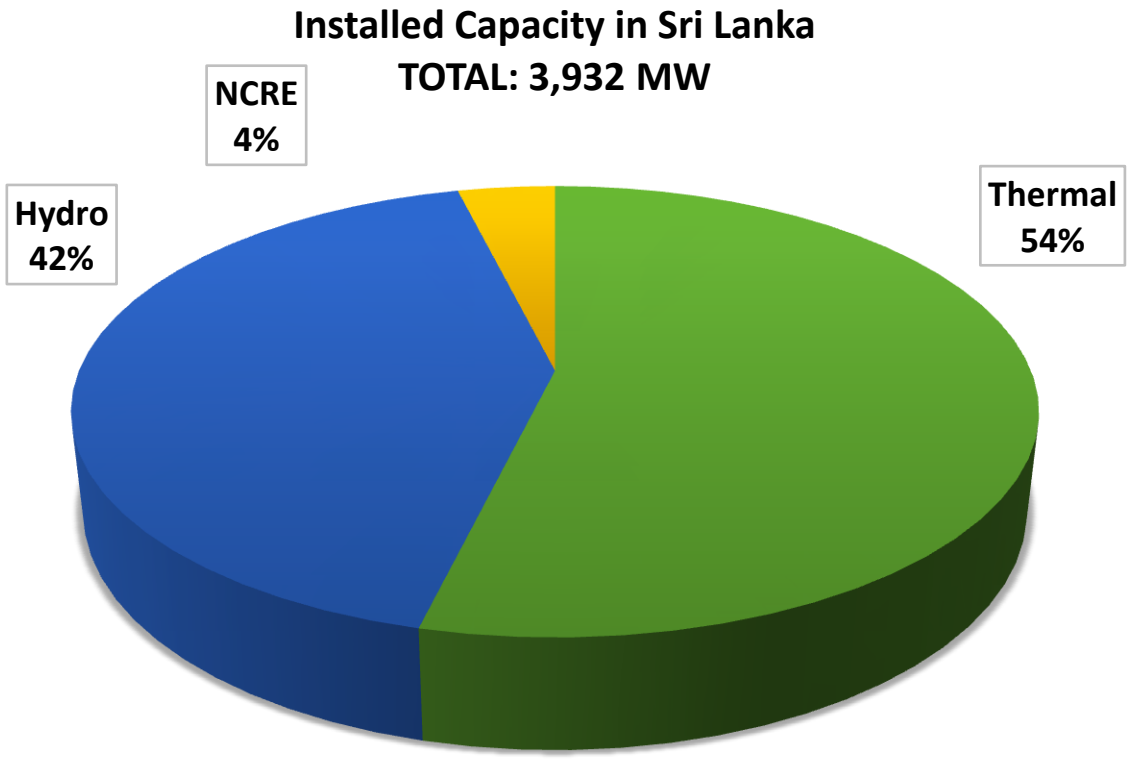
Power Sector Overview

- Installed Capacity : 3,932 MW
- Access to Electricity#: 88.66% (World Bank, 2012)

*Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

#Access to electricity is the percentage of population with access to electricity.

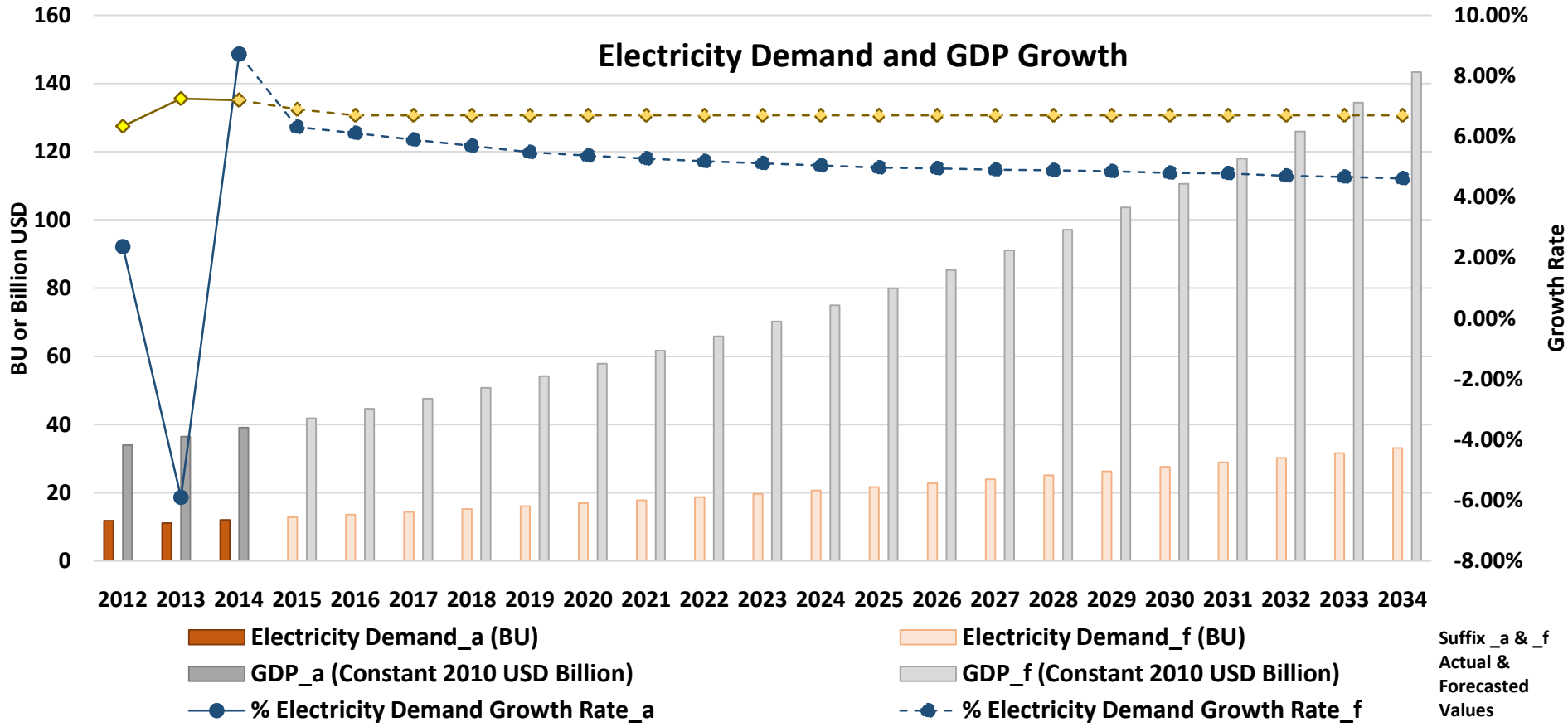
Sri Lanka – Capacity Mix Dominated by Hydro and Thermal



Type	Capacity (MW)
Thermal	2,115
NCRE	152
Hydro	1,665

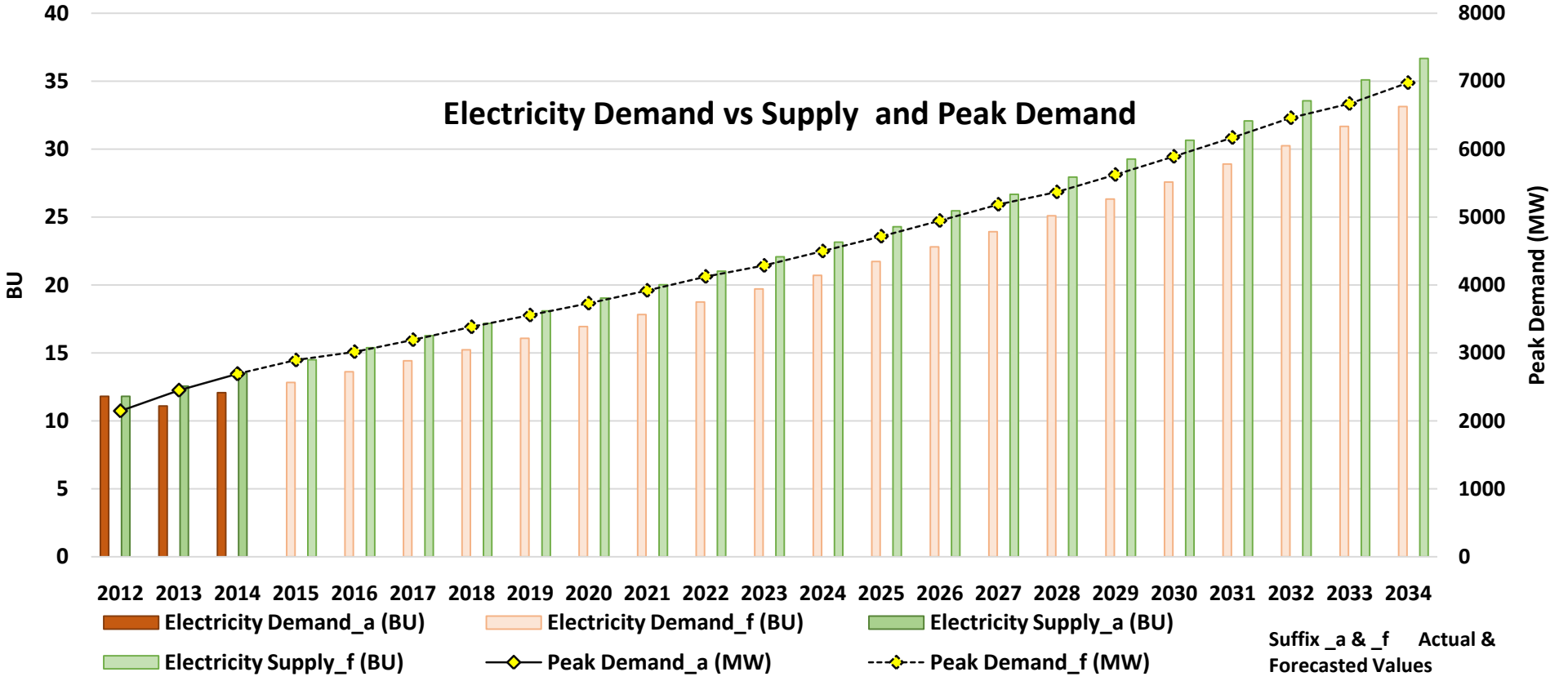
NCRE: Non-Conventional Renewable Energy
Source: Ceylon Electricity Board

Sri Lanka – GDP & Electricity Demand Growth



GDP (absolute value & growth rate)		Electricity Demand
Till 2014	2015 Onwards	Till 2034
The World Bank	The World Bank forecast; growth rate kept constant 2017 onwards	LTGEP, Ceylon Electricity Board

Sri Lanka – Electricity Demand vs Supply & Peak Demand

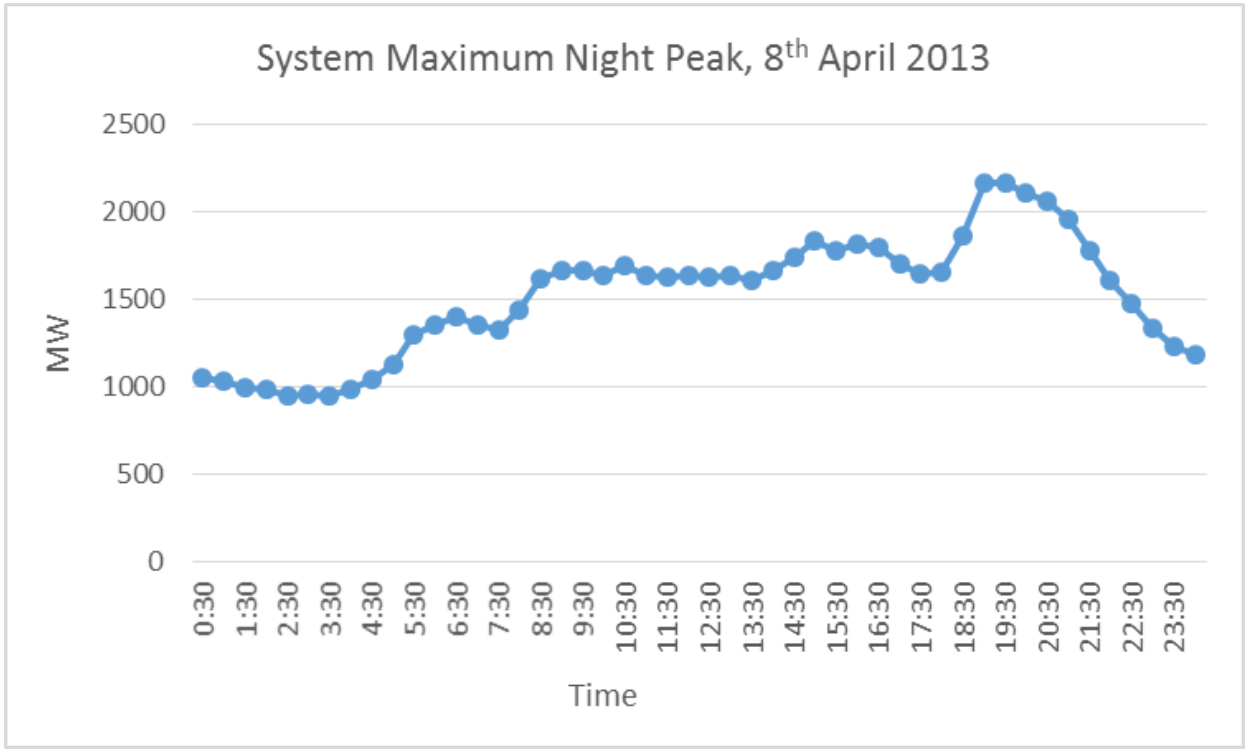


Data Source: LTGEP – Long Term Generation Expansion Plan

Electricity Demand	Electricity Supply	Peak Demand
Till 2034	Till 2034	Till 2034
LTGEP, Ceylon Electricity Board	LTGEP, Ceylon Electricity Board	LTGEP, Ceylon Electricity Board

Sri Lanka – Full System Load 2012-2013

- 24 hour load profile for a system maximum night peak in 2013 as available is shown below



Data Source: Sri Lanka Sustainable Energy Authority

6 PAKISTAN

Pakistan – Macroeconomic Overview

General Overview (Source: World Bank, 2015)

- Political System : Federal Parliamentary Republic
- Land Area* : 770,800 km^2
- Population : 185.1 million
- GDP : 246.9 billion (current $)
- Real GDP / Capita : 1333.5 (current $)

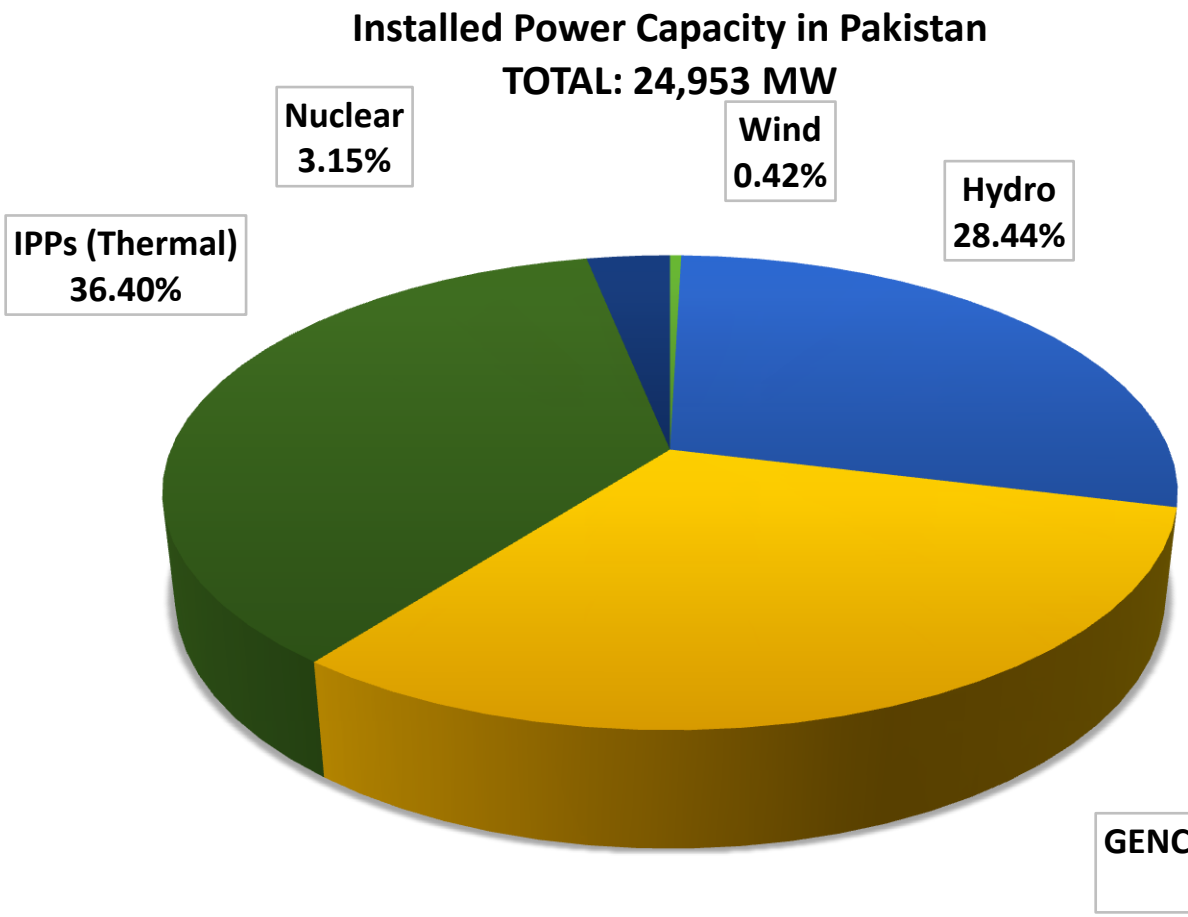
Power Sector Overview

- Installed Capacity : 24,953 MW
- Access to Electricity#: 93.6% (World Bank, 2012)

*Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

#Access to electricity is the percentage of population with access to electricity.

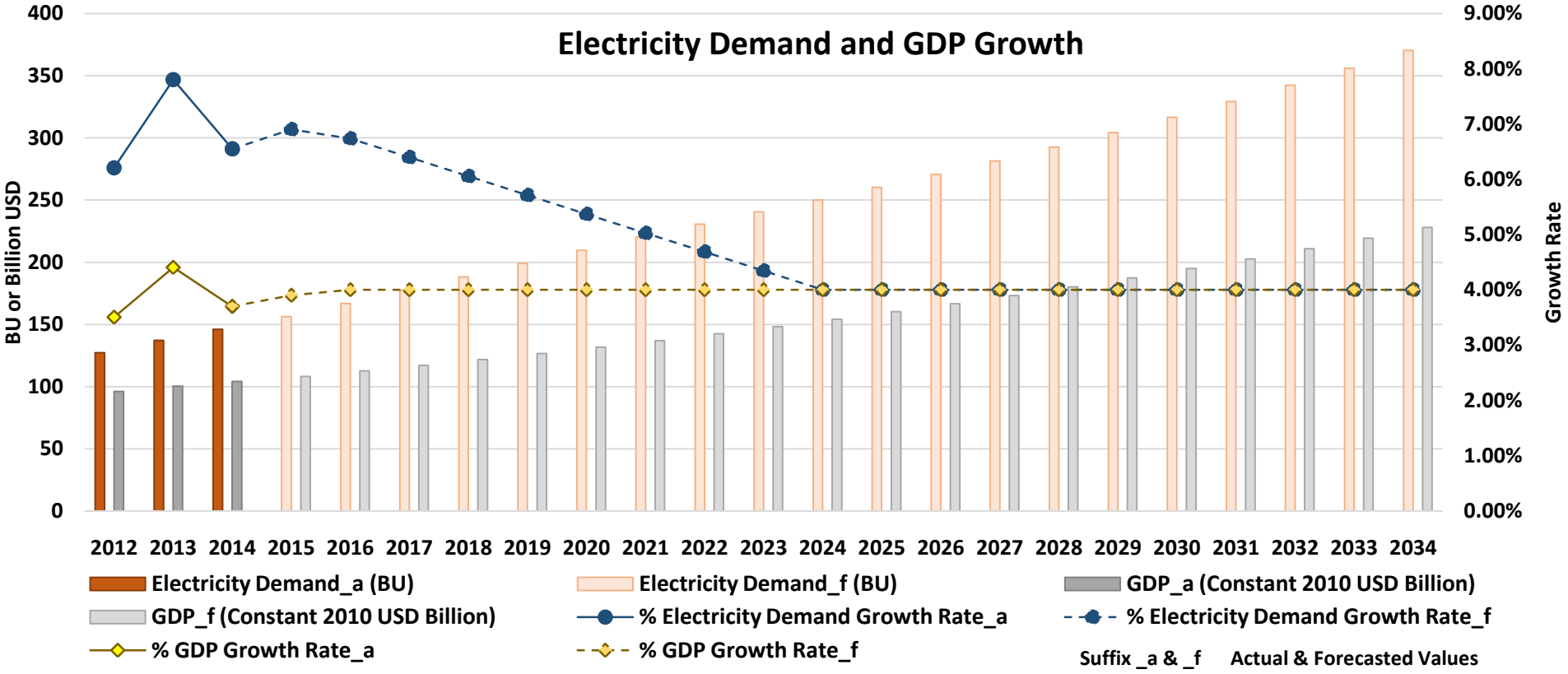
Pakistan – Diverse Capacity Mix but Predominantly Thermal



Type	Capacity (MW)
GENCOs	7,880
IPPs	9,083
Wind	106
Hydro	7,097

Source: National Transmission & Despatch Company (NTDC), Pakistan

Pakistan – GDP & Electricity Demand Growth



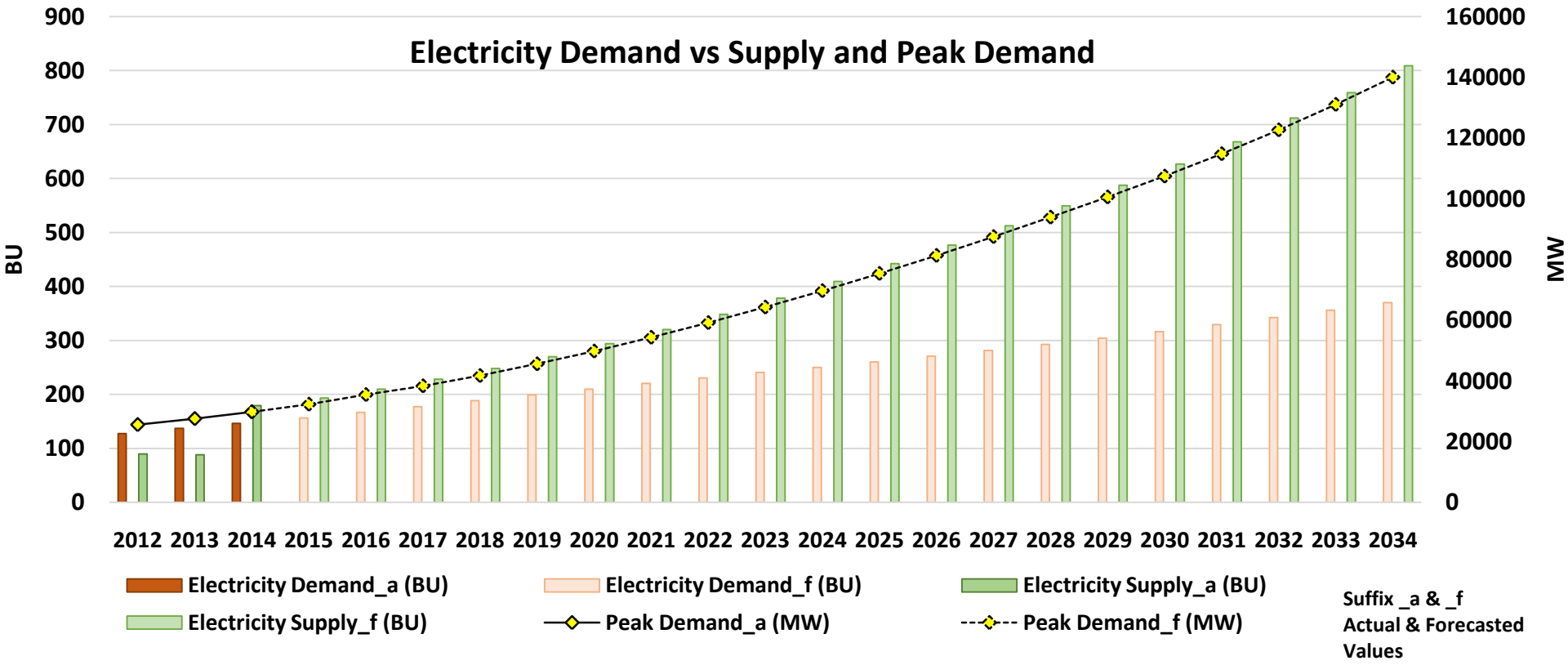
Data Source:

GDP (absolute value & growth rate)		Electricity Demand	
Till 2014	2015 Onwards	Till 2010	2011 - 2034
The World Bank	The World Bank forecast; growth rate kept constant 2016 onwards	Power System Statistics 2012-13, National Transmission and Despatch Company	ICF Analysis

Key Points:

- Electricity demand in Pakistan follows an asymmetric pattern.
- The demand has strongly been influenced by GDP during high growth period 1999-2006

Pakistan – Electricity Demand vs Supply & Peak Demand



Data Source:

Electricity Demand		Electricity Supply	Peak Demand
Till 2010	2011 - 2034	2012 - 2034	2012 - 2034
Power System Statistics 2012-13, National Transmission and Despatch Company	ICF Analysis	National Power System Expansion Plan (NPSEP)	National Power System Expansion Plan

Key Points:

Pakistan has been facing ~25% electricity shortages for many year and these are expected to persist in future too.

7 AFGHANISTAN

Afghanistan – Macroeconomic Overview

General Overview (Source: World Bank, 2015)

- Political System : Unitary Presidential Republic
- Land Area* : 652,860 km^2
- Population : 31.28 million
- GDP : 20.8 billion (current $)
- Real GDP / Capita : 666.3 (current $)

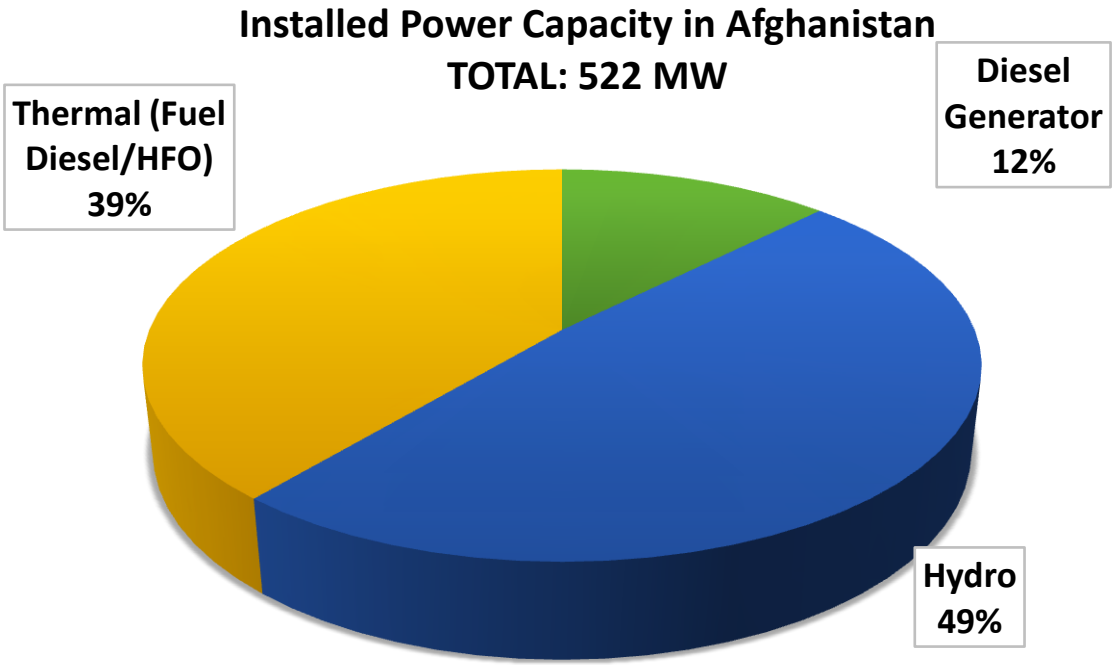
Power Sector Overview

- Installed Capacity : 522 MW
- Access to Electricity#: 43% (World Bank, 2012)

*Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

#Access to electricity is the percentage of population with access to electricity.

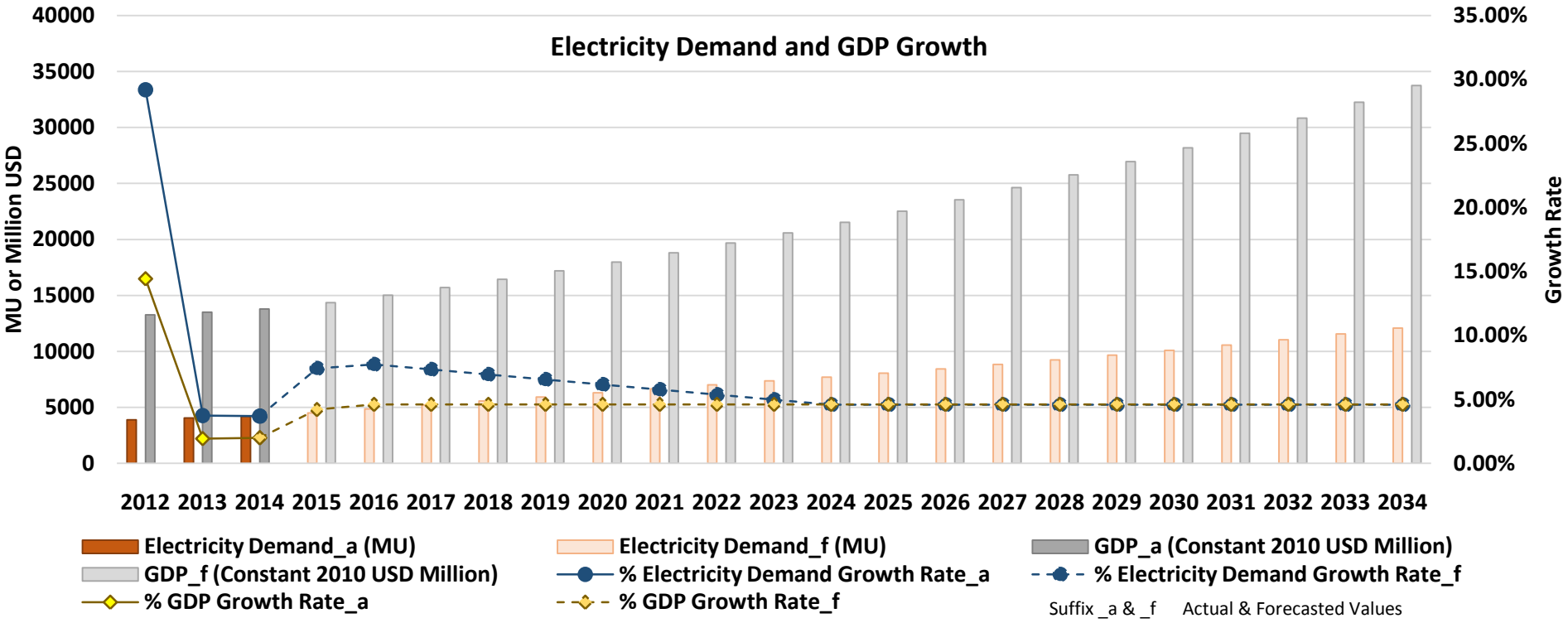
Afghanistan – Capacity Mix



Type	Capacity (MW)
Diesel Generator	65
Hydro	254
Thermal (HFO/Fuel Diesel)	203

Source: Da Afghanistan Breshna Sherkat (DABS), Afghanistan

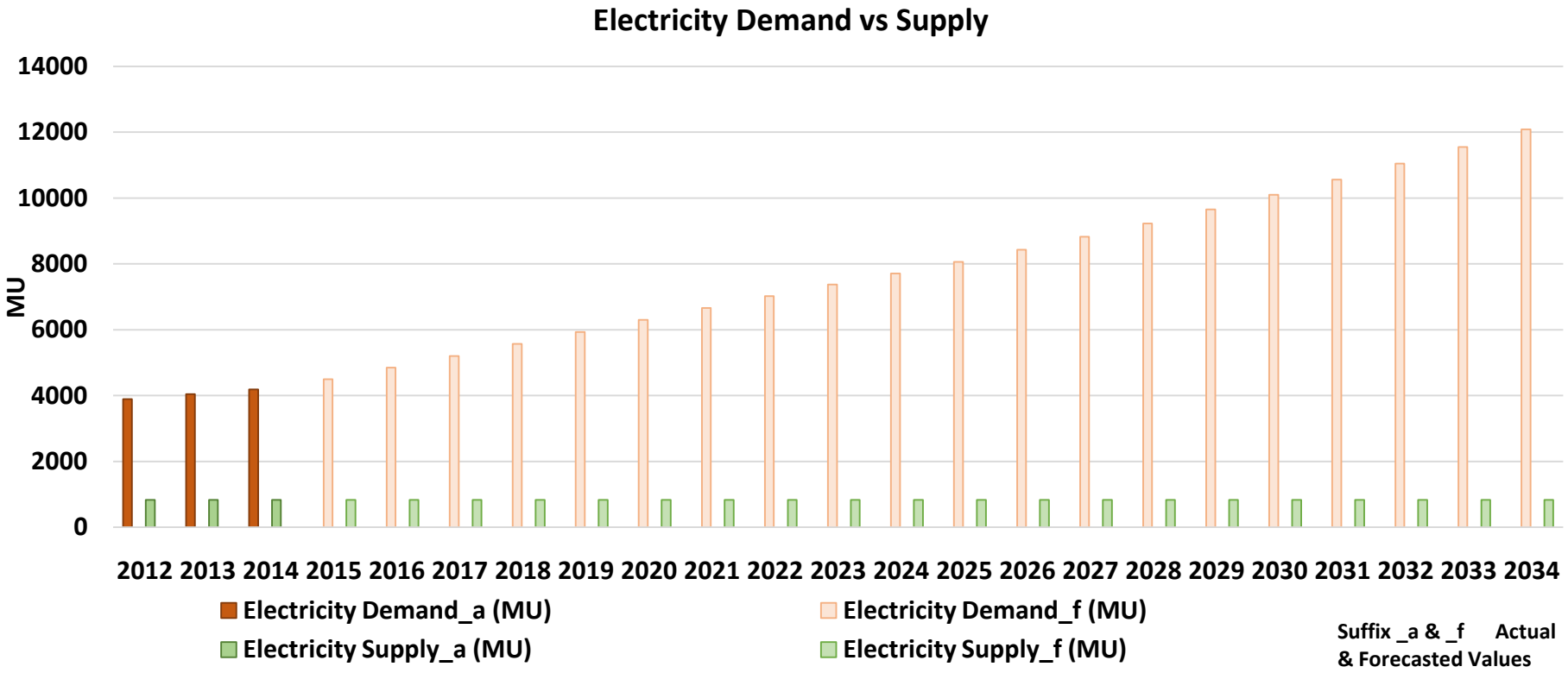
Afghanistan – GDP & Electricity Demand Growth



Data Source:

GDP (absolute value & growth rate)		Electricity Demand	
Till 2014	2015 Onwards	Till 2012	2013 Onwards
The World Bank	The World Bank forecast; growth rate kept constant beyond 2016	U.S. Energy Information Administration - EIA	ICF Analysis

Afghanistan – Electricity Demand vs Supply & Peak Demand



Data Source:

Electricity Demand		Electricity Supply	Peak Demand
Till 2012	2013 Onwards	Till 2034	NA
U.S. Energy Information Administration - EIA	ICF Analysis	2012 supply assumed to be constant till 2034	NA

- Supply is assumed to be constant due to unavailability of any estimates
- Demand is projected as per ICF's methodology
- Peak demand projections also unavailable

8 MALDIVES

Maldives – Macroeconomic Overview

General Overview (Source: World Bank, 2014)

- Political System : Unitary Presidential Constitutional Republic
- Land Area* : 300 km^2
- Population : 351,600
- GDP : 3.0 billion (current $)
- Real GDP / Capita : 8624.8 (current $)

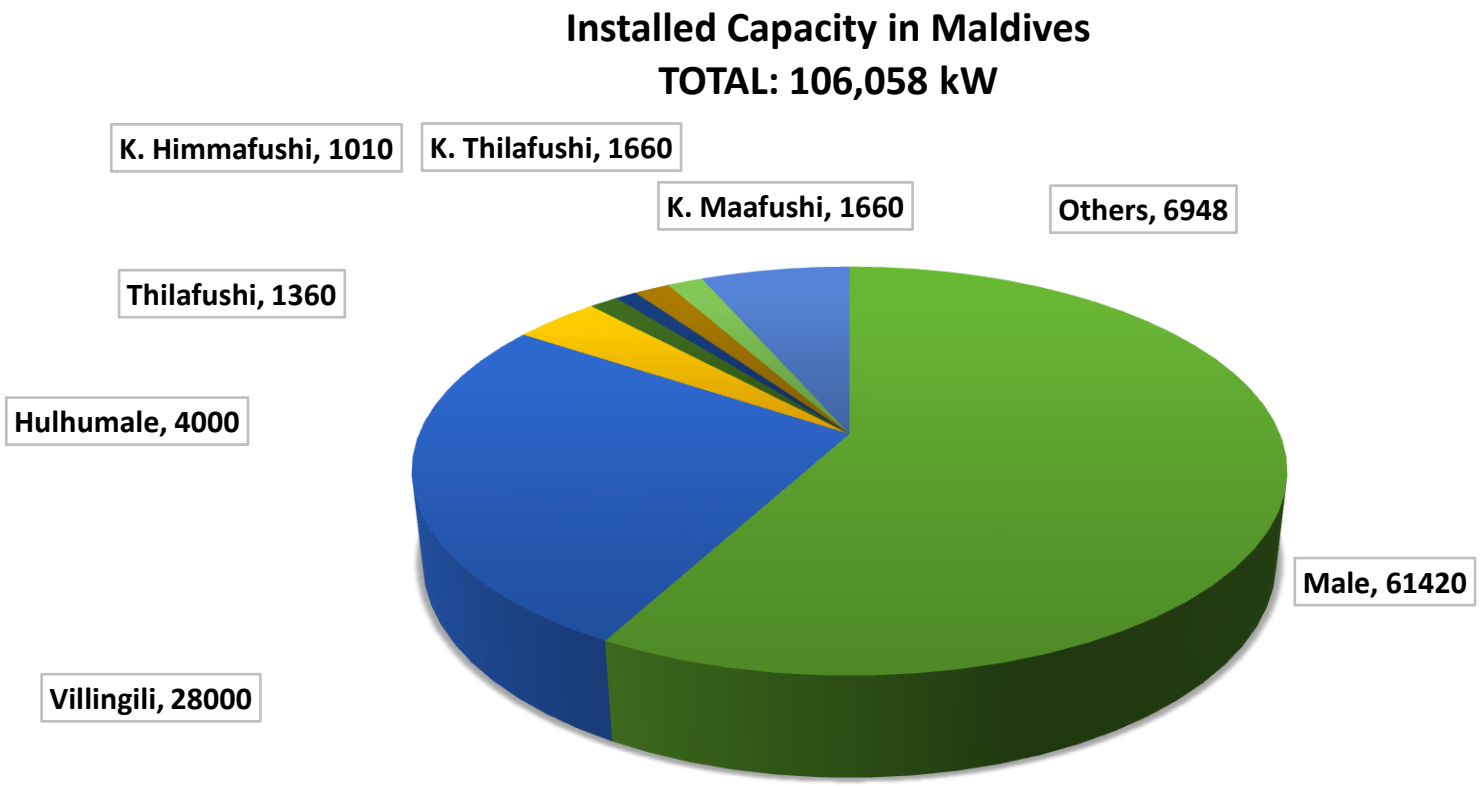
Power Sector Overview

- Installed Capacity : 106.058 MW
- Access to Electricity#: 100% (World Bank, 2012)

*Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

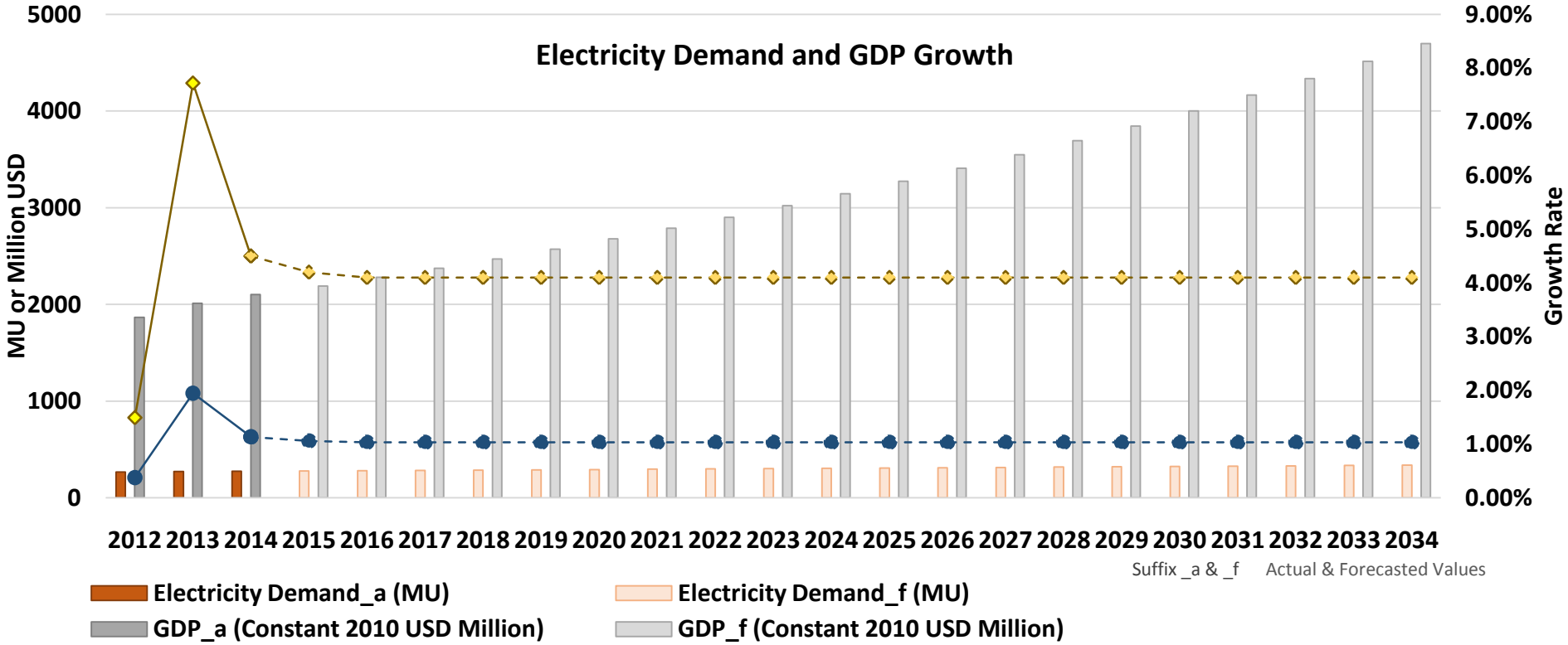
#Access to electricity is the percentage of population with access to electricity.

Maldives – Only Diesel-based Capacity



Source: State Electricity Company Limited (STELCO), Maldives

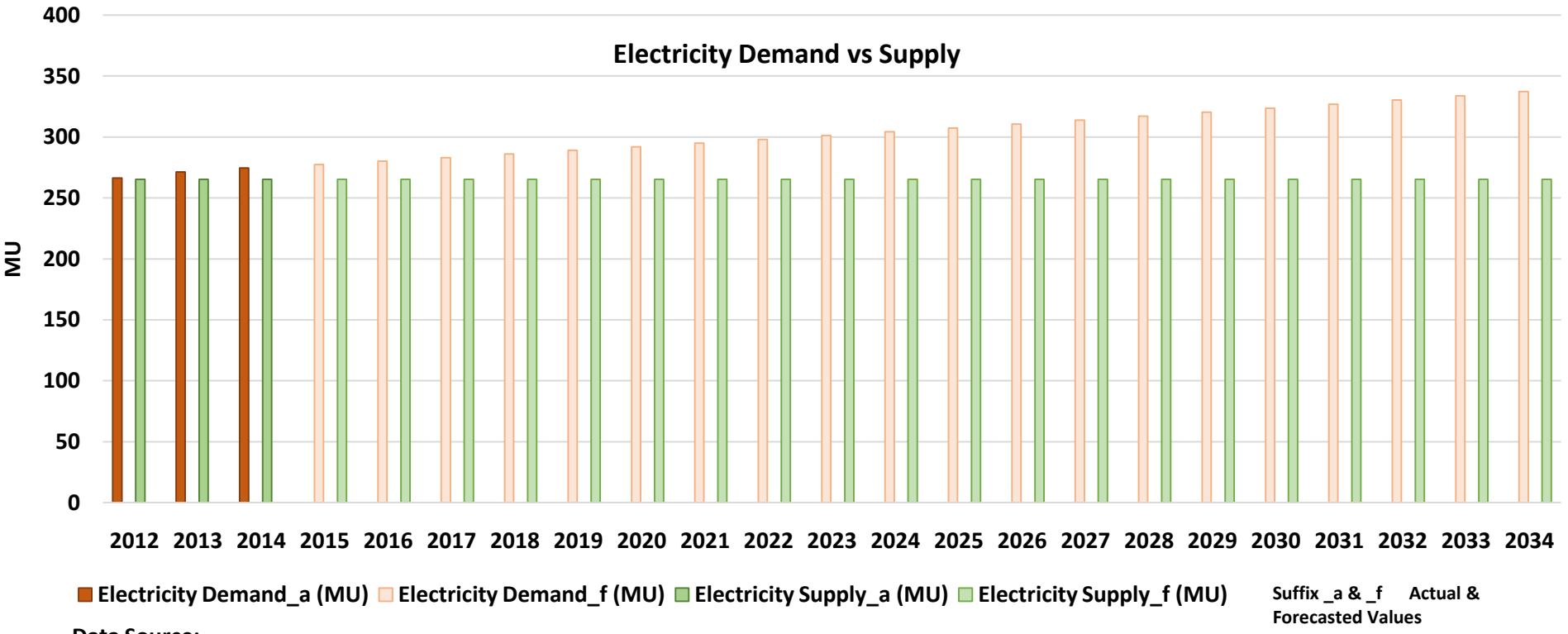
Maldives – GDP & Electricity Demand Growth



Data Source:

GDP (absolute value & growth rate)		Electricity Demand	
Till 2014	2015 Onwards	Till 2013	From 2014
The World Bank	The World Bank forecast; growth rate kept constant beyond 2016	U.S. Energy Information Administration - EIA	ICF Analysis

Maldives – Electricity Demand vs Supply & Peak Demand



Data Source:

Electricity Demand		Electricity Supply	Peak Demand
Till 2013	From 2014	Till 2034	NA
U.S. Energy Information Administration - EIA	ICF Analysis	2013 supply assumed to be constant till 2034	NA

Key Points:

- 27 Islands, 27 power systems with overall installed capacity of ~62 MW
- No substantial generation capacity addition expected in future year

Conclusions: Demand – Supply Scenario for South Asian Nations

Summary of Modeling Results

- Summary of trade potential estimation

Year	Bangladesh		Bhutan		Nepal		India	
	Demand (BUs)	Net Export (BUs)	Demand (BUs)	Net Export (BUs)	Demand (BUs)	Net Export (BUs)	Demand (BUs)	Net Export (BUs)
2015	56	-19	2	6	7	-2	1,102	15
2020	80	-19	4	20	10	0.4	1,778	-2
2025	110	-45	6	22	15	18	2,524	6
2030	148	-81	9	22	22	32	3,483	26
2034	189	-118	12	19	30	27	4,480	72

- Annual regional cross border electricity trade potential:
  - Near term (2015-2020): ~27 BU to ~39 BU
  - Long term (2021 onwards): ~49 BU to ~164 BU

Conclusions – Regional CBET Potential

- Bangladesh
  - To increasingly depend on imports from India instead of power from expensive FO/HSD units
  - Share of imports expected to fall in 2019 due to imported coal-based capacity addition plans
  - Imports and coal-based capacity to meet base load requirement, whereas gas capacity based on domestic gas to be used as mid-merit or for meeting peaking load
- Bhutan
  - Exporter to India in all seasons which are expected to increase with capacity additions
  - RTC exports throughout the year with heavy exports during wet season
- India
  - To emerge as a net exporter of power and will continue to remain a predominantly coal-based economy
  - Does not need to set up additional capacity to meet the additional requirement to export to neighboring countries; improvement in capacity factor of coal plants by ~1% - 2% would be sufficient
- Nepal:
  - Net importer from India till 2018 and then likely to become a net exporter
  - RTC imports during deficit season and RTC exports during surplus season
- Coal-based generation capacity remains on the margin for the system and any capacity having lower price would receive priority for dispatch

Way Forward

- Review of results by respective task force members in next two weeks
- ICF to review the feedback received and incorporate changes, if any
- Proposed scenarios and sensitivity analysis:
  - **Capacity Addition Scenario**: Evaluate impact of realistic vis-à-vis current capacity additions plans of Bangladesh
  - **Imported Coal Price Scenario**: Evaluate impact of higher prices of imported coal (increase over a 3-4 year period)
  - **Increased Renewable Capacity Scenario**: Evaluate impact of revised RE capacity additions plans in respective countries
  - **Transmission Constraints Scenario**: Evaluate impact of constraints on inter-country transmission flow capacities