Experiences with Grid Integration of Wind Power in Sri Lanka

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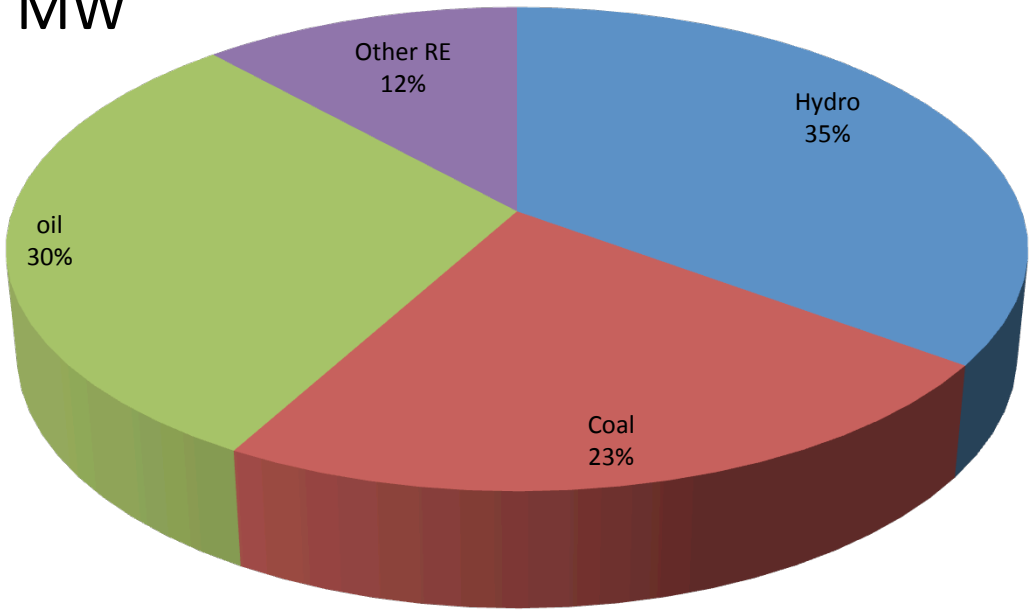
Present Capacity of the Power System

- Total Capacity 3928 MW
- Hydro 1377 MW - 35%
- Coal 900 MW - 23%
- Oil 1186 MW - 30%
- Other Renewable 465 MW - 12%

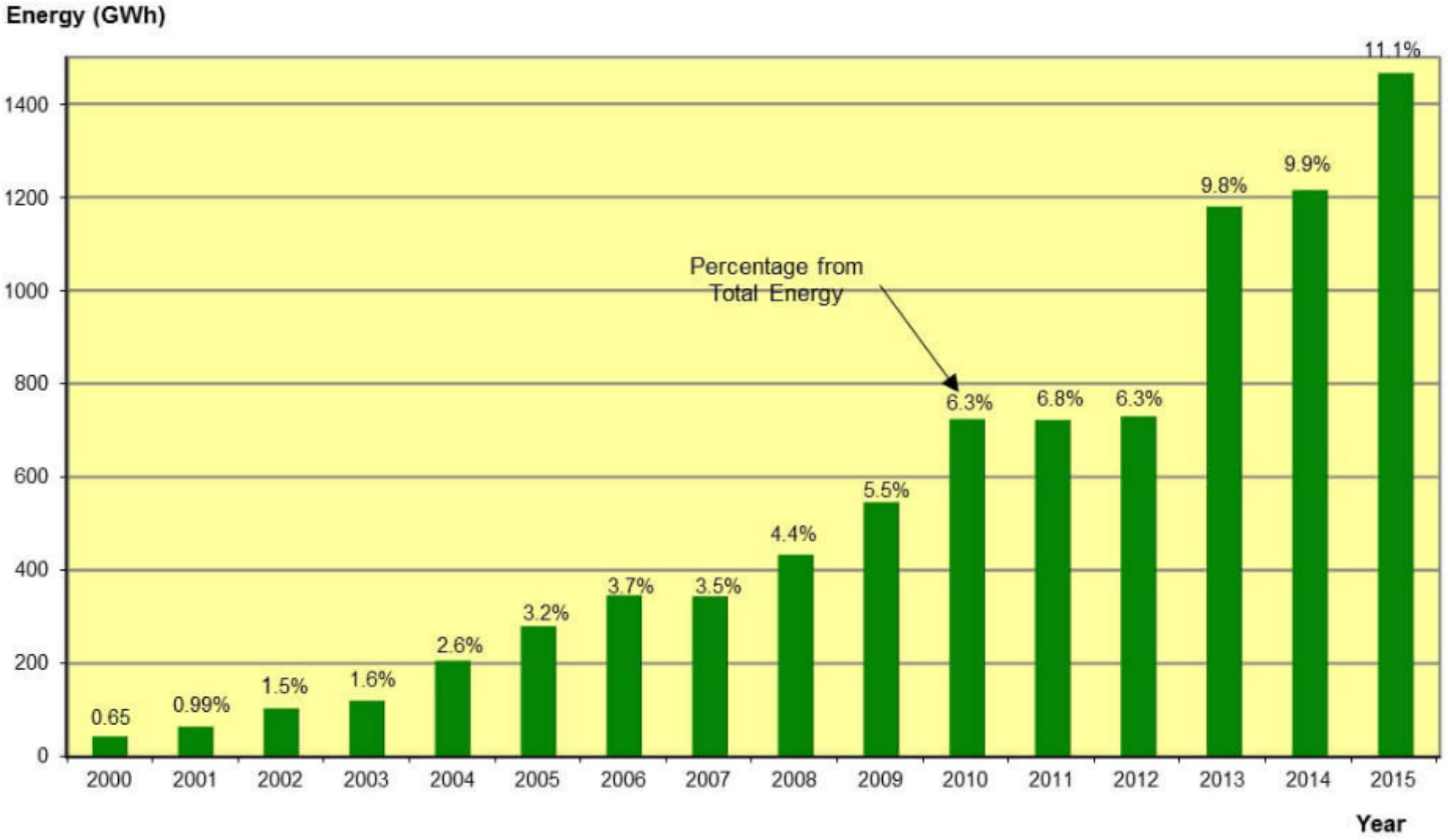
Peak Demand 2455 MW



Present Status of Development of Other Renewable Energy (as at 31st March 2016)

Project Type	No. of Projects	Capacity (MW)
Mini Hydro Power	158	315
Wind Power	15	129
Biomass-Agricultural & Industrial Waste Power	4	13
Biomass- Dendro Power	4	7
Solar Power	3	1.4
Total - Commissioned	**184**	**465**

Annual Energy Contribution from ORE



2014 Sri Lankan Transmission System with Wind Development Zones

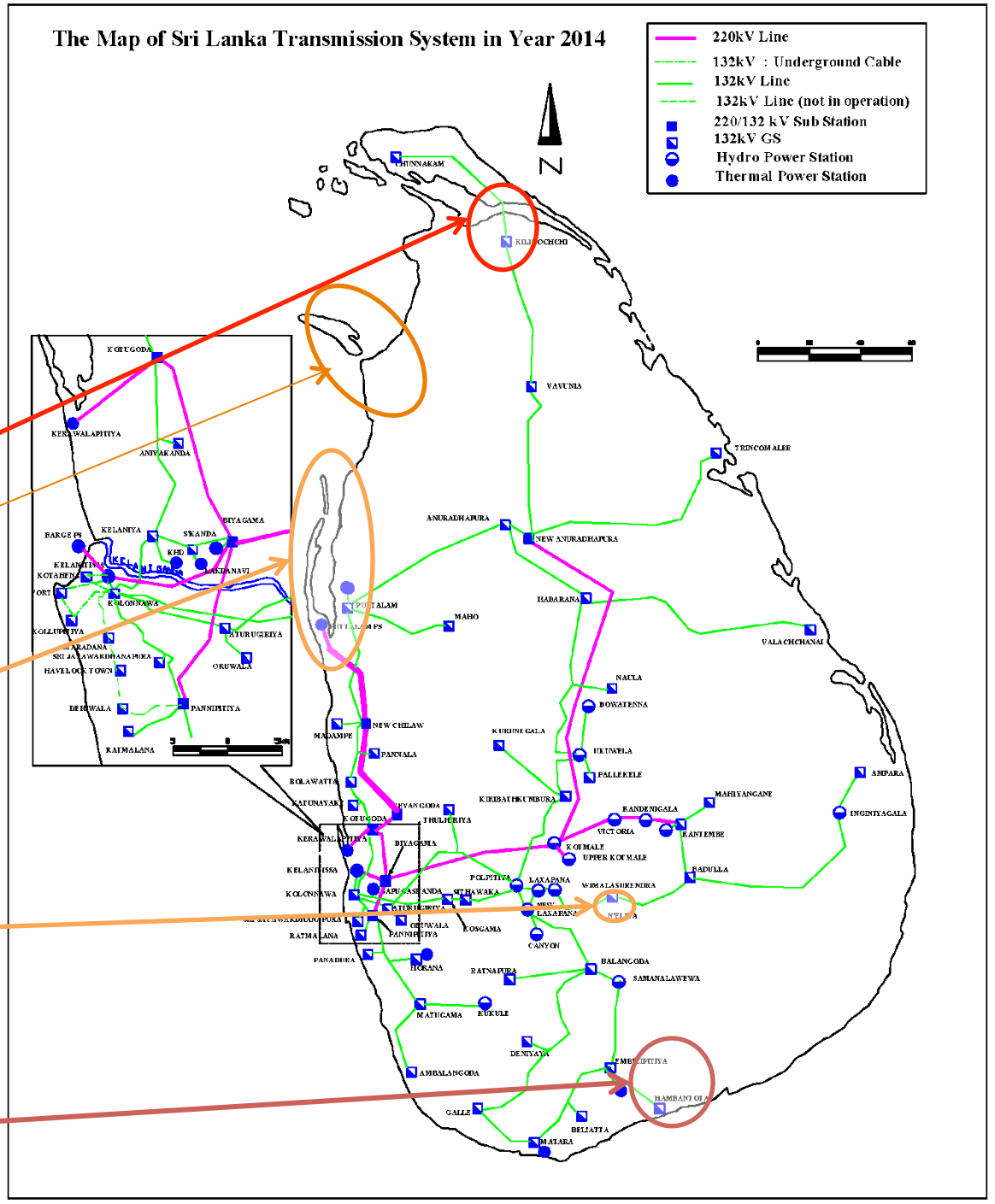
Kilinochchi Wind

Mannar

Puttalam

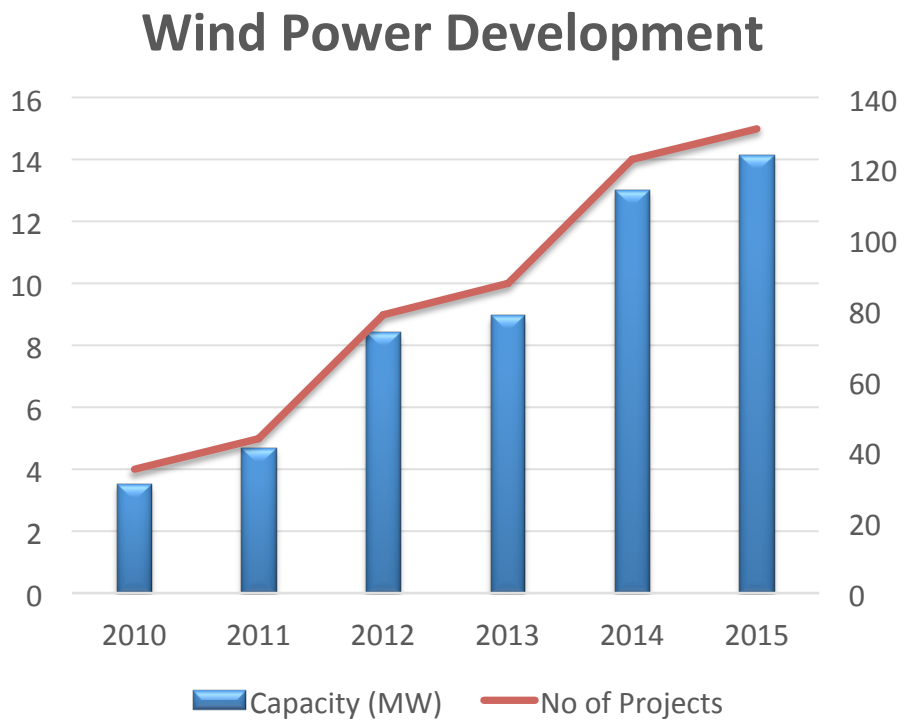
Ambewela

Hambanthota

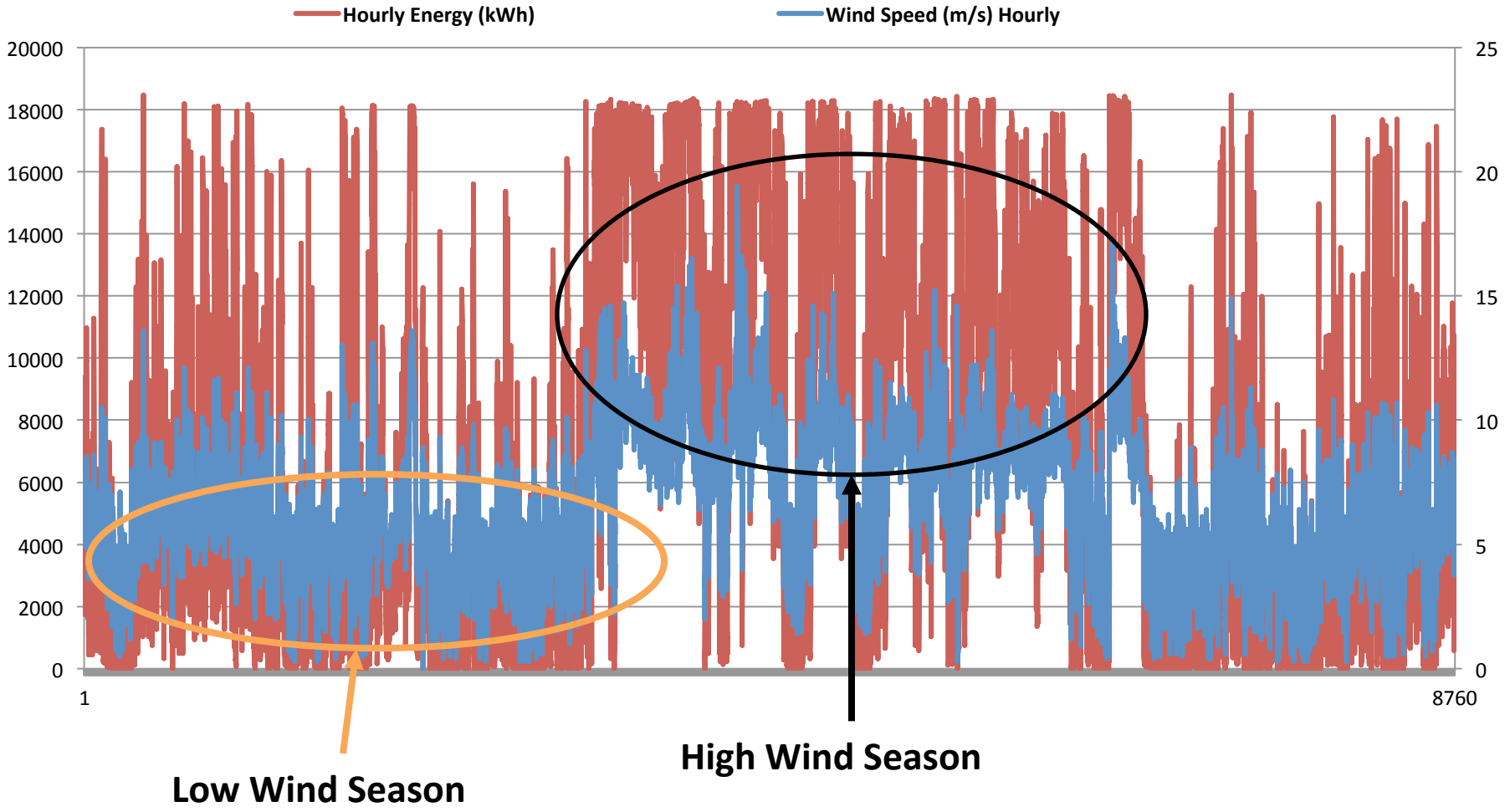


Existing Wind Power Plants

Project Name	Location	Capacity (MW)
Hambanthota WPP	Hambanthota	3
Mampuri WPP	Puttalam	10
Seguwanthivu WPP	Puttalam	10
Vidathamunai WPP	Puttalam	10
Wilpita WPP	Balangoda	0.85
Nirmalapura WPP	Puttalam	10
Ambewela WPP	Nuwara Eliya	3
Madurankuliya WPP	Puttalam	10
Uppudaluwa WPP	Puttalam	10
Kalpitiya WPP	Puttalam	9.8
Erubukkudal WPP	Puttalam	4.8
Mampuri WPP - II	Puttalam	10
Mampuri WPP - III	Puttalam	10
Puloppalai WPP	Kilinochchi	10
Vallimunai WPP	Kilinochchi	10
Musalpitti WPP	Puttalam	10
Total		**129**

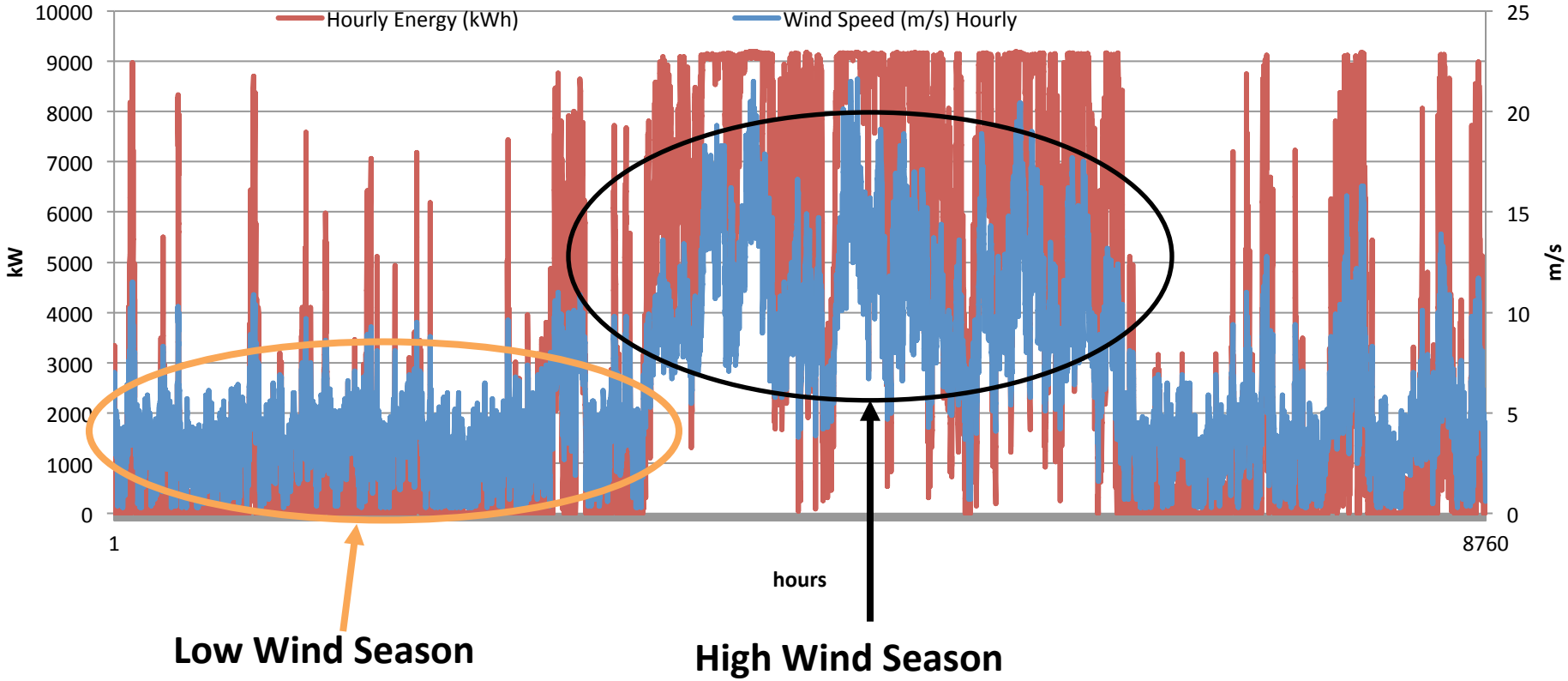


Wind Speed and Energy Variation at Puttalam (20MW)



Capacity Factor : 31.4%

Wind Speed and Energy Variation in Hill Country (10MW)

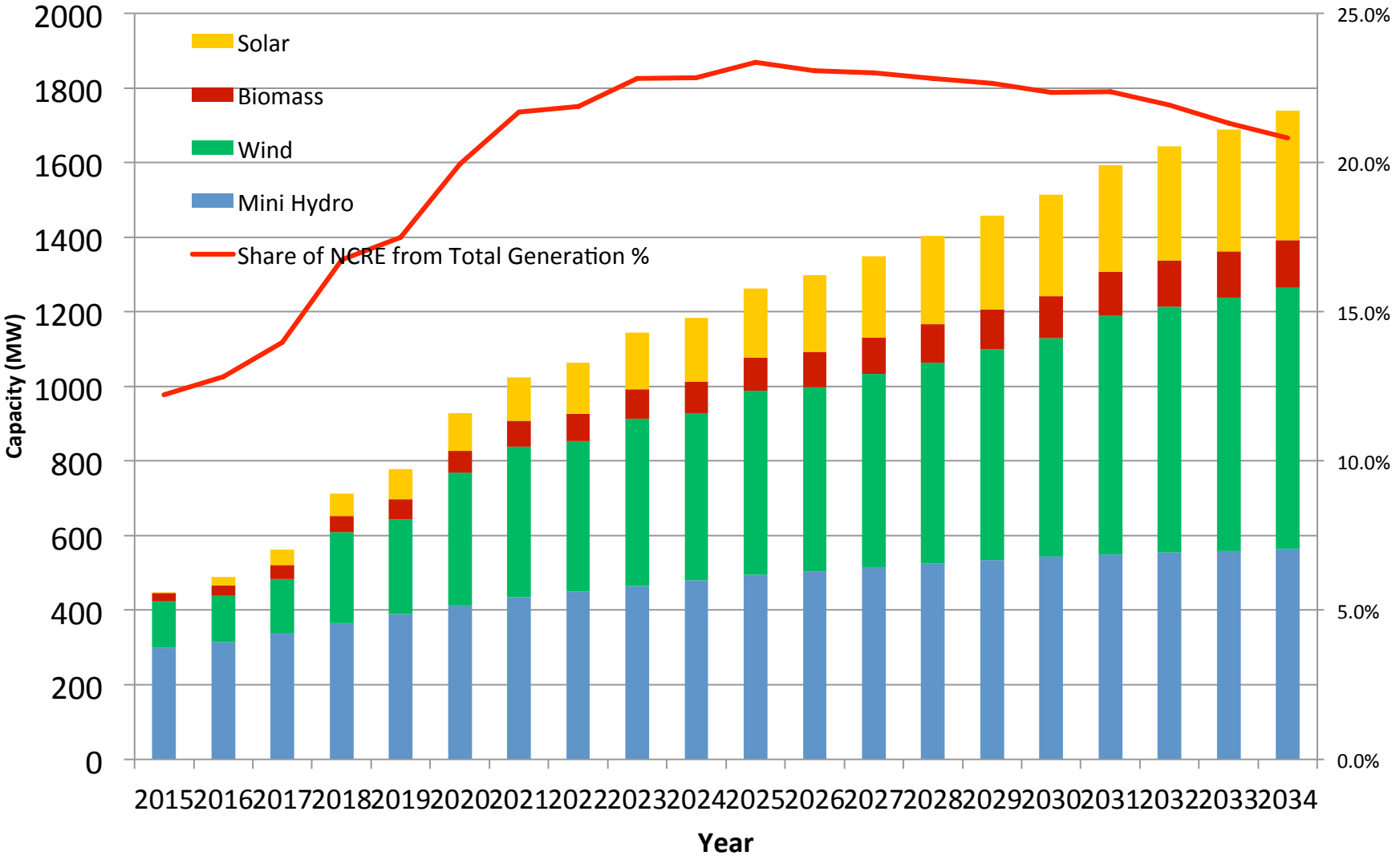


Capacity Factor : 25.9%

Renewable Energy Integration Studies

- System studies are being revised in order to identify the system impacts on integration of intermittent renewable energy sources and to identify the necessary transmission network improvement including the financial and economic implications.

Development Plan of Other Renewable Energy Power Plants



Present Grid Connection Code

- **Controls**
  - The wind farm shall provide the controlling facility to limit the variation of the wind farm by incorporating necessary controls to individual wind turbines
  - The ramp rate will be defined for the grid substation and shall not exceed **10 MW/minute**

- **Protection**

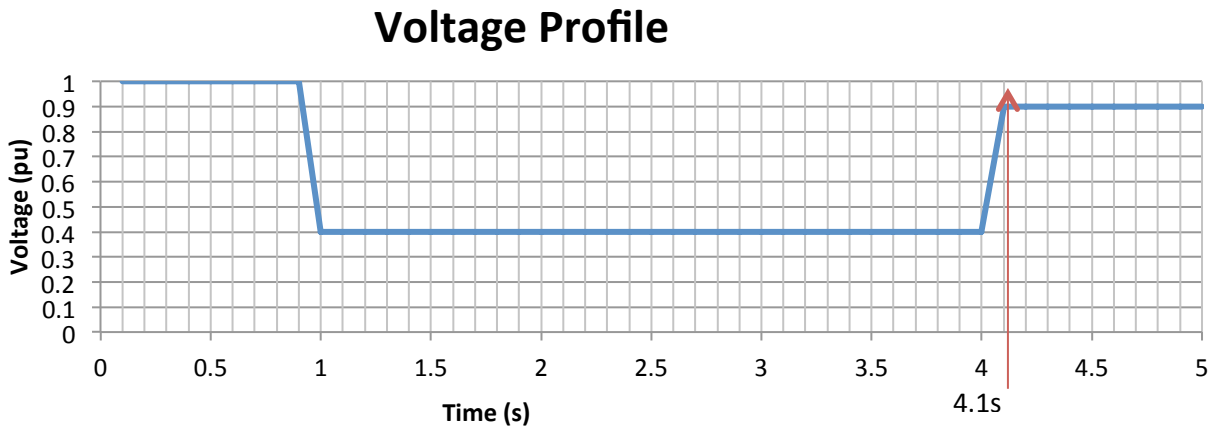
- Frequency Requirement (47-52Hz)
  - Over Frequency: 1.04pu -Continuously
  - Under Frequency: 0.94pu -Continuously

- Voltage Requirement
  - Over Voltage: 1.1pu – Continuously
    >1.1pu, 1 sec – Should remain connected to the grid for 1 second and trip
  - Under Voltage: <0.9pu, 3sec – If LVRT capability applicable, Should remain connected to the grid for 3 seconds and trip
  - Otherwise: <0.9pu, 1sec – Should remain connected for 1 second and trip

Present Grid Connection Code Cont.

- Power Factor and Reactive Power Support
  - Wind Farm shall operate in the range of 0.98 leading to Unity Power Factor
  - Reactive power support range is 0.80 lagging to 0.95 leading

- Low Voltage Ride Through (LVRT) Capability
  - If the grid voltage at the point of interconnection reduces to 40% of the nominal voltage and remain at 40% of the nominal voltage for a period less than 100ms and then recover to a voltage of 90% or higher within 3 seconds, the wind farm shall remain connected to the grid. If voltage during the disturbance reduces below the aforesaid voltage profile, wind farm shall trip



Present Grid Connection Code Cont.

- **Power Quality**
  - Harmonics
    - Relevant emission limits as per IEC 61800-3 is given below

Harmonic Order	Odd Harmonic Current (% of I rated)	Even Harmonic Current (% of I rated)
n <11	4.0	1.0
11≤n<17	2.0	0.5
17≤n<23	1.5	0.4
23≤n<35	0.6	0.2
35≤n<50	0.3	0.1
THD ≤ 5% (for n=40)		

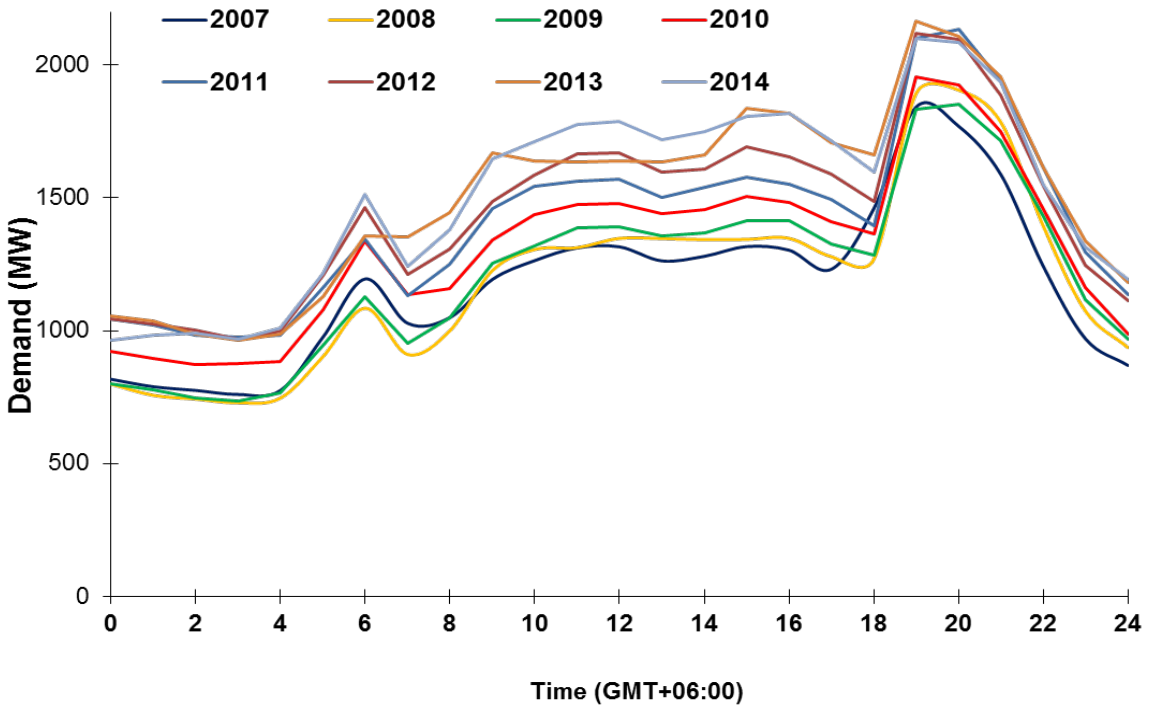
  - Flicker
    - Flicker emission for continuous and switching operation should be within the limits given in IEC 60868, IEC 61400-21 and IEC 61000-3-7

Generation Expansion Plan 2015- 2034

YEAR	RENEWABLE ADDITIONS	THERMAL ADDITIONS
2015	-	60MW Barge Power Plant
2016	-	-
2017	35MW Broadlands HPP 120MW Uma Oya HPP	-
2018	**100MW Mannar Wind Park Phase I**	2x35MW Gas Turbine
2019*	-	1x35MW Gas Turbine
2020	31 MW Moragolla HPP 15MW Thalpitigala HPP **100MW Mannar Wind Park Phase II**	2x250MW Coal Power Plants Trincomalee Power Company Limited
2021	**50MW Mannar Wind Park Phase II**	-
2022	20MW Seethawaka HPP 20MW Gin Ganga HPP **50MW Mannar Wind Park Phase III**	2x300MW New Coal Plant – Trincomalee -2
2023	**25MW Mannar Wind Park Phase III**	163 MW Combined Cycle Plant
2024	**25MW Mannar Wind Park Phase III**	1x300MW New Coal plant
2025	1x200MW PSPP **25MW Mannar Wind Park Phase III**	-
2026	2x200MW PSPP	-

Power System at Present

- Installed capacity - 3923 MW
- Peak Demand - 2455 MW
- Off peak Demand - 950 MW



Power System at Present Cont.

- Grid is small and isolated.
- Power system is operating with less spinning reserve and also less reserve capacity.
- System frequency is controlled mostly by hydro generators response time of which is not sufficient to respond for a major system disturbance .
- Automatic Governor Controls are not in place at present.
- System inertia is low. Mostly system survives with under frequency load shedding scheme in case of a disturbance.

Issues Related to Wind Power Integration

- To deal with Intermittency of wind power generation, additional spinning reserves are required.
- Capacity of transmission infrastructure in wind rich areas is limited.
- Wind power is available mostly during minimum load condition when major power contribution is from coal. Therefore, wind power has to be integrated de-loading cheap coal power generation.
- Wind power is also available mostly during wet season when hydro power generation is high. Therefore, wind power has to be accommodated de-loading cheap generation from hydro power plants during low demand condition.

Issues Related to Wind Power Integration Cont.

- Inertia contribution from wind power plants to the system is very small.
- Power quality issues
- Environmental and social issues are encountered in implementing wind power.
- At present, generation from wind power plants is not curtailed as per the Standard Power Purchase Agreements signed with CEB. However, in the future, wind generation will have to be curtailed during low demand condition to maintain system stability and overcome other operational issues.

Measures under consideration to facilitate grid integration of wind power

- Develop wind plants as parks and introduce wind forecasting systems to deal with intermittency.
- Improve off peak demand by implementing DSM measures.
- Improve the system inertia, by implementing planned major generation according to the Long term Generation Expansion Plan.
- Generators with fast response such as gas turbines, combined cycle should be installed.
- Required to invest on new transmission infrastructure to transmit power from North and North Western to demand centres.
- Power quality issues will be addressed complying with grid code.
- Feasibility of connecting Sri Lankan Electricity Grid with Indian Electricity Grid is also under consideration which will definitely improve the reliability and stability of the system.

Thank You

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