



RE Technologies

Cost of Generation and Grid Parity



Presentation Structure

- Key parameters for determining cost of generation
- Concept & definition of Grid parity
- Restricted to Wind, Solar PV & Solar Thermal
- Growth, forecasts & potential
- Cost of generation & expected achievement of grid parity



Key Parameters for COG

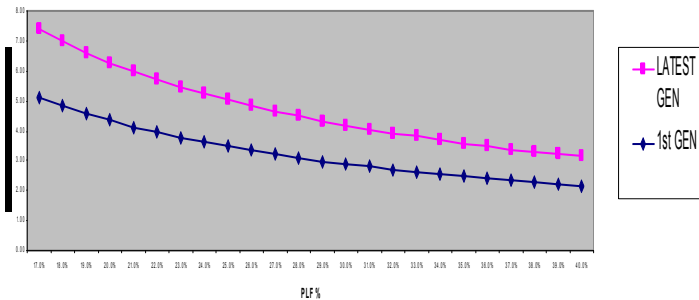
Cost mainly driven by Capital cost

- Interest on Debt financing
- Return on Equity
- Nil raw material cost
- Very low variable cost
- Resource availability & PLF



Cost per KWH & PLF%

PLF VS COST PER KWH





Comparison of Interest Burden

RE SECTOR	Int Burden Rs/kwh	% Incr
Benchmark Gas	0.43	100%
Coal based Thermal	0.48	113%
Biomass Project	0.88	206%
Small Hydro	1.34	315%
Wind MW Class	2.49	585%
Solar PV	8.15	1913%



Cost of Generation

- Impossible to indicate a precise cost per kwh specifically for a RE sector
- Cost depends on resource availability, capital cost & interest rates in the country where the project is installed
- Reliable costs can be determined only for a specific project site



Demand-Cost Relationship

- Cost inversely related to Demand for a Sunrise industry in its early lifecycle
- Volumes drive costs down due to economies of scale
- Large demand potential also drives innovation in technology driving costs further down
- Ex. Computer & Telecom Industry



Grid Parity Concepts

- Commonly accepted definition is when the price of RE equals the price paid to utility for a household.
- Typically used in Solar Rooftop applications
- Carbon penalty cost should be included in conventional power cost for determining grid parity



Grid Parity Concepts - 2

Large grid connected projects

- Cost of RE generation compared to peak load (expensive) conventional power
- Cost of RE generation compared to Base load least cost conventional power
- Cost of RE compared to average cost of conventional power
- Cost of RE compared to New Power station



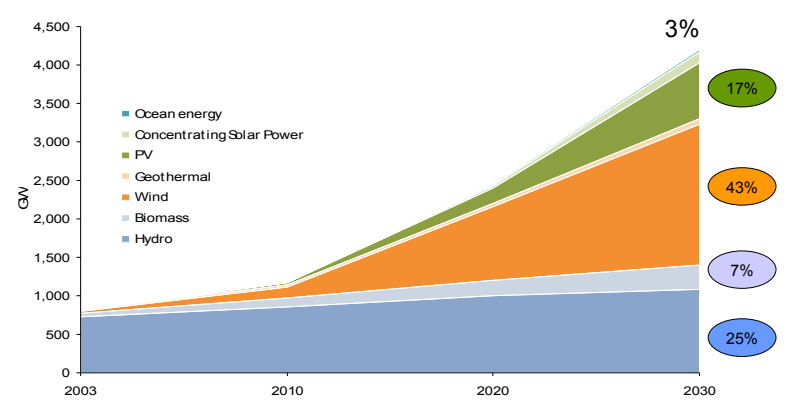
Grid Parity Concepts - 3

Off Grid Applications

- Cost of conventional power including per Kwh charges for building transmission infrastructure to site vs
- Cost of RE power installed on stand alone basis at the site



RE generation Forecasts



WIND PROJECTS

Cost of Generation & Grid parity

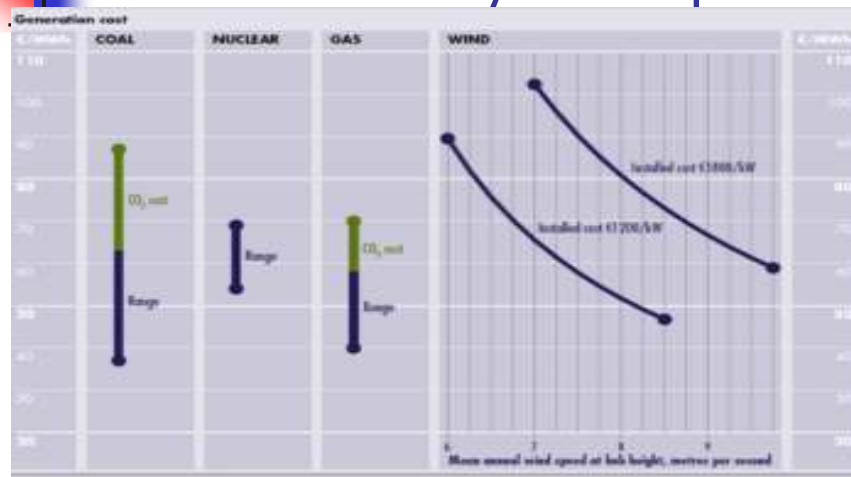


Wind cap additions-global

Scenario	Capacity Additions, GW							
	2020			2030			2050	
	Cumulative		Annual	Cumulative		Annual	Cumulative	Annual
	Global	India		Global	India			
Reference	352	20	24	496	27	30	679	36.6
Moderate	709	69	82	1420	142	84	1834	100.0
Advanced	1081	138	143	2375	235	165	3498	165.0



Wind Grid Parity - Europe



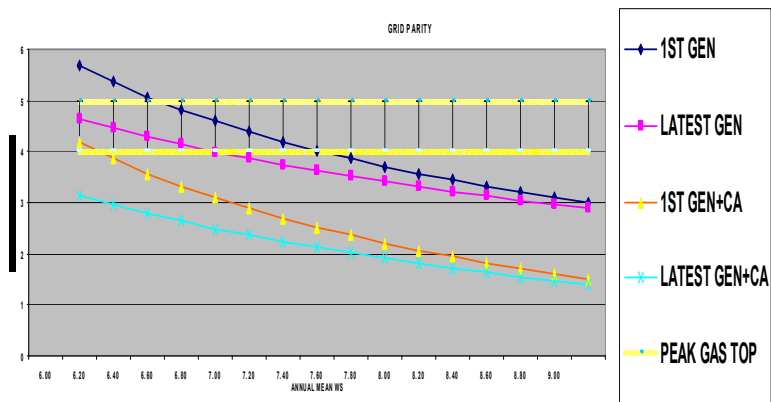


Wind Grid Parity - India

- Based on Turbine Technology
- Wind regime – mean a/l wind speeds
- Comparison to Peak Demand, combined cycle gas and coal based conventional power projects
- Carbon advantage to be factored



Wind Grid Parity Calculation





Wind Grid Parity Results

WITHOUT FACTORING CARBON ADVANTAGE
Annual Mean wind speed-m/s to achieve Grid Parity

TECHNOLOGY	1ST GEN. WEG		2ND GEN WEG	
	TOP END	LOW END	TOP END	LOW END
PEAK GAS	6.6	7.6	<6.2	7.0
CC GAS	7.4	9.0	6.8	8.6
IMPORT COAL	8.0	NA	7.6	8.8
DOMESTIC COAL	9.0	NA	8.8	NA



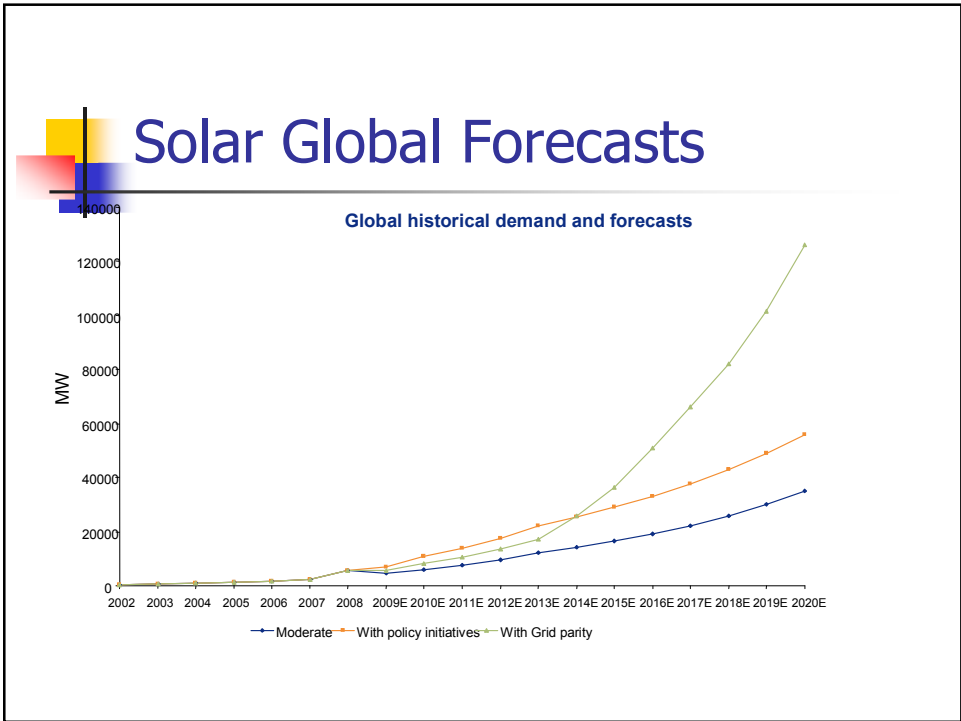
Wind Grid Parity Results-2

FACTORING CARBON ADVANTAGE
Annual Mean wind speed-m/s to achieve Grid Parity

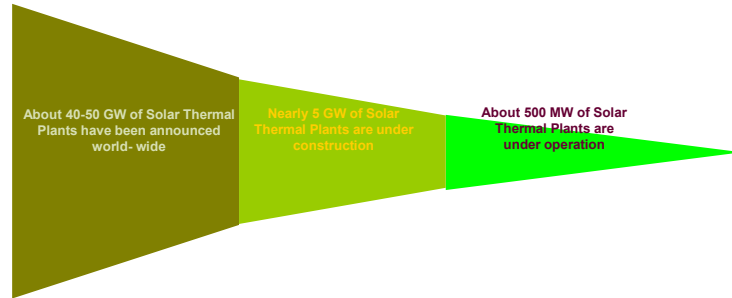
TECHNOLOGY	1ST GEN. WEG		2ND GEN WEG	
	TOP END	LOW END	TOP END	LOW END
PEAK GAS	<6.2	<6.2	<6.2	<6.2
CC GAS	6.2	7.0	<6.2	6.2
IMPORTED COAL	6.6	7.0	<6.2	6.4
DOMESTIC COAL	7.0	7.4	6.2	6.8

Solar Thermal Projects

Cost of Generation & Grid parity



Global Solar Capacity Addition

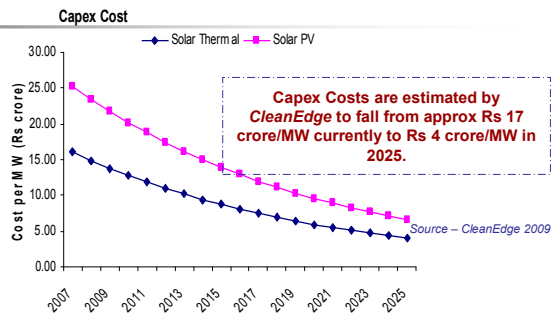


COSTS OF SOLAR POWER

Cost Trends – Capex per MW

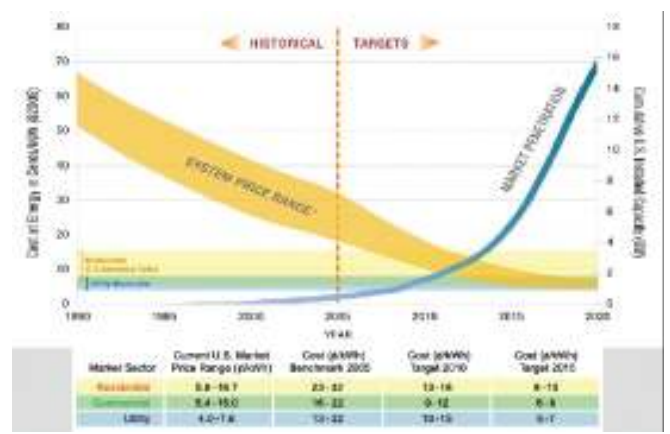
Capital cost of a recently proposed plant in Bikaner, Rajasthan is estimated to be around Rs. 15 crores/MW

- Indigenization, economies of scale and improvement in efficiencies are expected to bring down the cost of power from solar thermal



1. Storage System – CSP plants with heat storage system will increase PLF and lead to lower generation costs & higher reliability
2. Hybridization Possibilities - CSP plants can be integrated with conventional steam or combined cycle power plants

Grid Parity – Solar Thermal



SOLAR PV PROJECTS

Cost of Generation & Grid parity

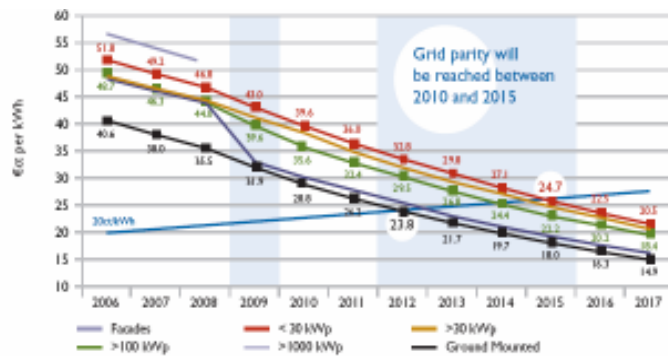
Rooftop Solar PV Costs

Table 4.1: Expected PV generation costs for roof-top systems at different locations

	Sunshine hours	2007	2010	2020	2030
Berlin	900	0.44 €	0.35 €	0.20 €	0.13 €
Paris	1,000	0.39 €	0.31 €	0.18 €	0.12 €
Washington	1,200	0.33 €	0.26 €	0.15 €	0.10 €
Hong Kong	1,300	0.30 €	0.24 €	0.14 €	0.09 €
Sydney/Buenos Aires/ Bombay/Madrid	1,400	0.28 €	0.22 €	0.13 €	0.08 €
Bangkok	1,600	0.25 €	0.20 €	0.11 €	0.07 €
Los Angeles/Dubai	1,800	0.22 €	0.17 €	0.10 €	0.07 €

Note: The calculation method has been changed from the previous edition of 'Solar Generation'.

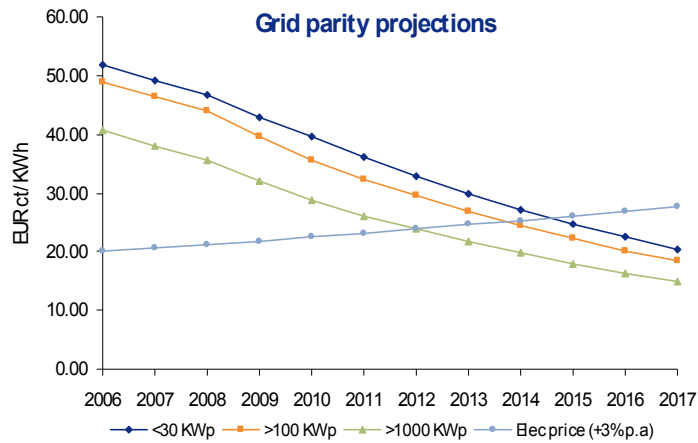
Solar PV FIT Grid Parity



Source: Gerhard Stryi-Hipp, Fraunhofer Institute for Solar

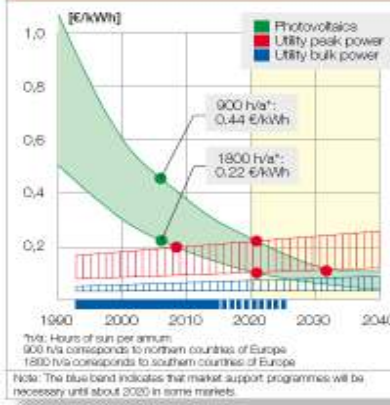


Solar PV Grid Parity



Solar PV grid parity

Figure 4.1: Development of utility prices and PV generation costs



NATIONAL SOLAR MISSION: PROPOSED ROADMAP

Target – 20,000 MW by 2020

Application segment	Phase I (2010-13)	Phase II (2013-17)	Phase III (2017-22)
Utility grid power, including roof top	1,000 -2,000 MW	4,000 – 10,000 MW	20,000 MW
Off grid solar applications	200 MW	1,000 MW	2,000 Mw

CERC Norms for Tariff

Solar PV	Unit	Solar Thermal	Solar PV
Capacity Utilization Factor	%	23%	19%
Useful Life	Years	25	25
Capital Cost per MW	Rs Lakh	1300	1700
O&M Expenses per MW	Rs Lakh	13	9
O&M Escalation	%	5.72%	5.72%
Depreciation Rate	%	7%	7%
Loan Tenure	Years	10	10
Interest	%	13.50%	13.50%
Debt	%	70%	70%
Return on Equity (up to 10th Year)	%	19%	19%
Return on Equity (From 11th Year)	%	24%	24%
Levelised Tariff	Rs per unit	14	19



Solar Mission Targets

- Manufacturing capacity targets
- 4000-5000 MW by 2017
- Grid tariff parity by 2020
- Parity with coal based generation by 2030
- One million rooftops by 2020



Concluding Observations

- Grid parity an important consideration
- But not the sole objective for RE capacity additions
- Other compelling reasons to rapidly increase RE contribution to the Energy mix to meet climate change deadlines



RE Generation Costs & Grid Parity

THANK YOU