



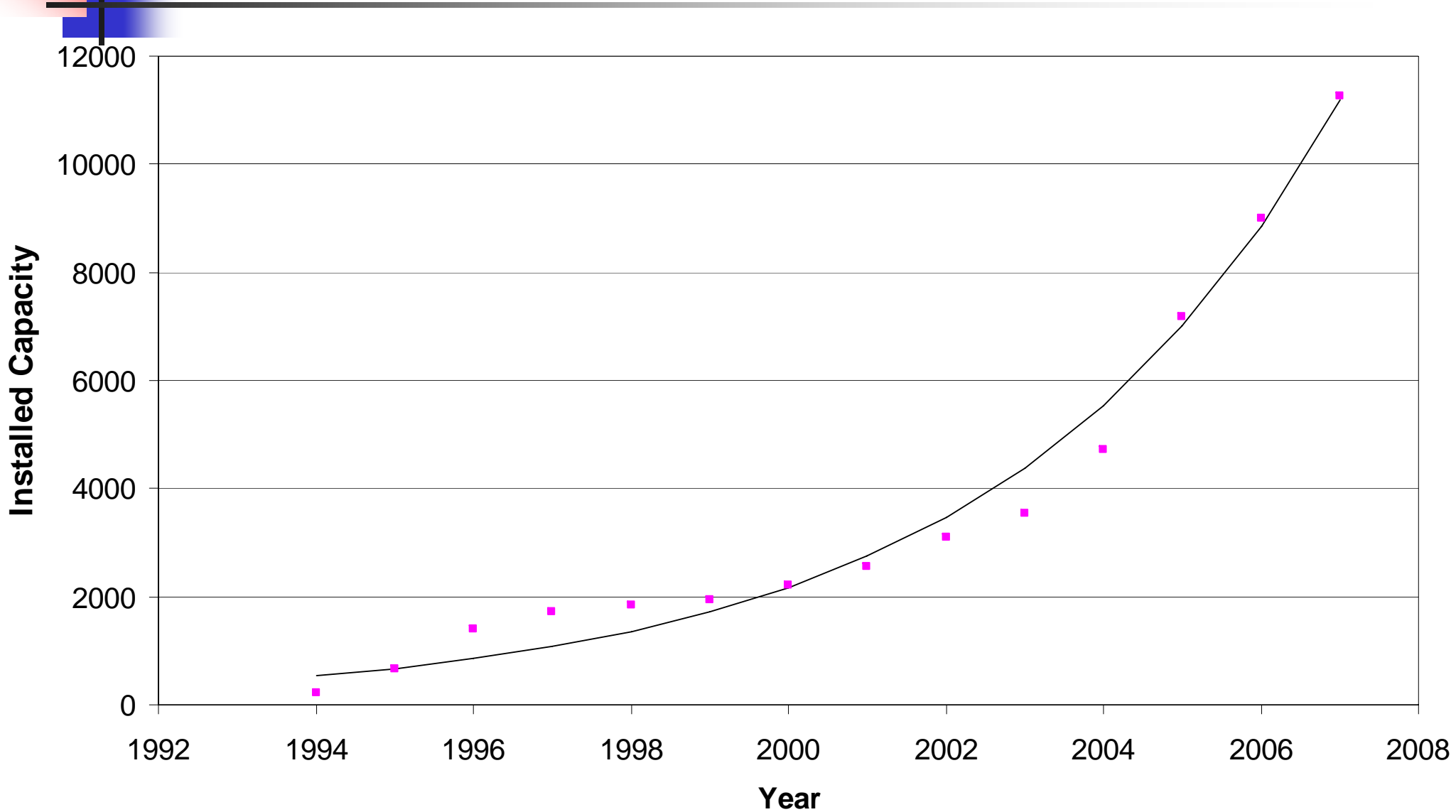
Promoting Renewable Energy in Maharashtra

Department of Energy Science and Engineering
IIT Bombay



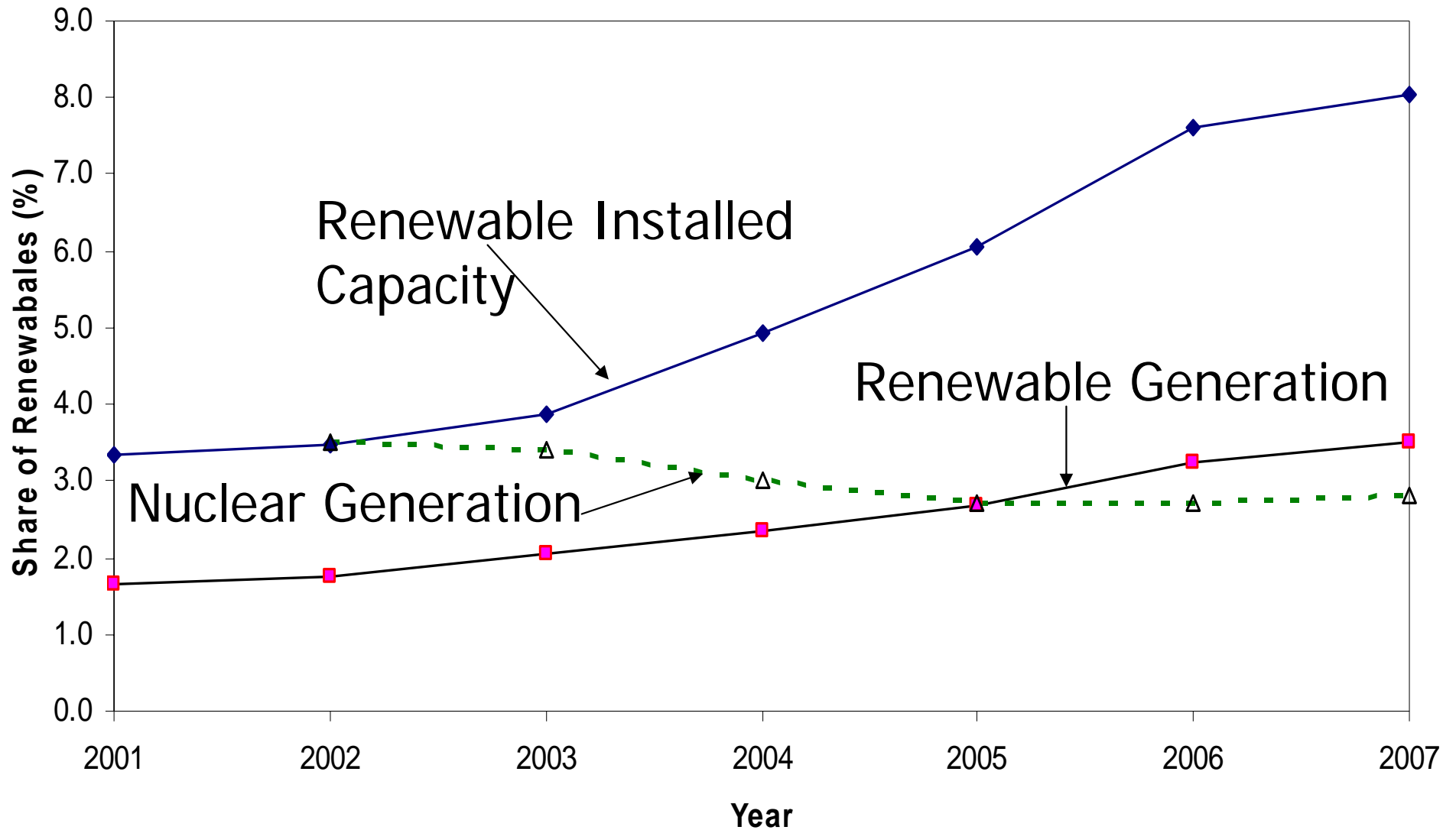


India-Renewable Installed Capacity trend





India-Renewable Share in Power





Renewable Energy (2008) Installed Capacity

	India	Maharashtra
Wind Power	9.66 GW	1.95 GW
Small Hydro	2.0 GW	0.2 GW
Biomass Power	8.0 GW	0.35 GW
Solar PV (grid)	3 MW	0
Geothermal Power	0	0
Solar Thermal Power (CSP)	0	0
Total renewable power	13 GW	2.5 GW
Solar Water heater	1.7 GW (th) (2.4 million m ²)	Not known

Source: REN21 Renewables Global Status Report-2009 Update



India Renewable installed capacity and generation

	Installed Capacity* (MW)	Estimated Capacity factor	Estimated Generation (GWh)
Wind	7845	14%	9621
Biomass Power	606	70%	3185
Biomass Gasifier	86	60%	527
Bagasse Cogeneration	720	60%	3784
Small Hydro	2046	40%	7169
Waste to Energy	55	50%	241
Solar PV	2.74	20%	5
Total	11360	25%	24380

*as on Jan 1, 2008



Maharashtra Renewable installed capacity and generation

	Installed Capacity (MW)	Estimated Capacity factor	Estimated Generation (GWh)
Wind	1948	14%	2389
Biomass Power	95	70%	582
Bagasse Cogeneration	262	60%	1377
Small Hydro	211	40%	924
Waste to Energy	6.1	50%	37.4
Solar PV	-	20%	-
Total	2522	25%	5310

*in 2009



Solar resource



- Area 26.8 km x 26.8 km Nagpur district
- Solar insolation 1800 kWh/m²/year
- 20% capacity factor, plant efficiency 20%
- 150000 MU annual generation



Renewable Energy Issues

- Energy Security
- Energy Access
- Local and Global Emissions
- **Marginal to Mainstream**
- Incentives for Investors/ Technology Developers
- Impact on cost of supply to consumers
- Long term – capability development
- Employment potential
- Level playing field between technologies

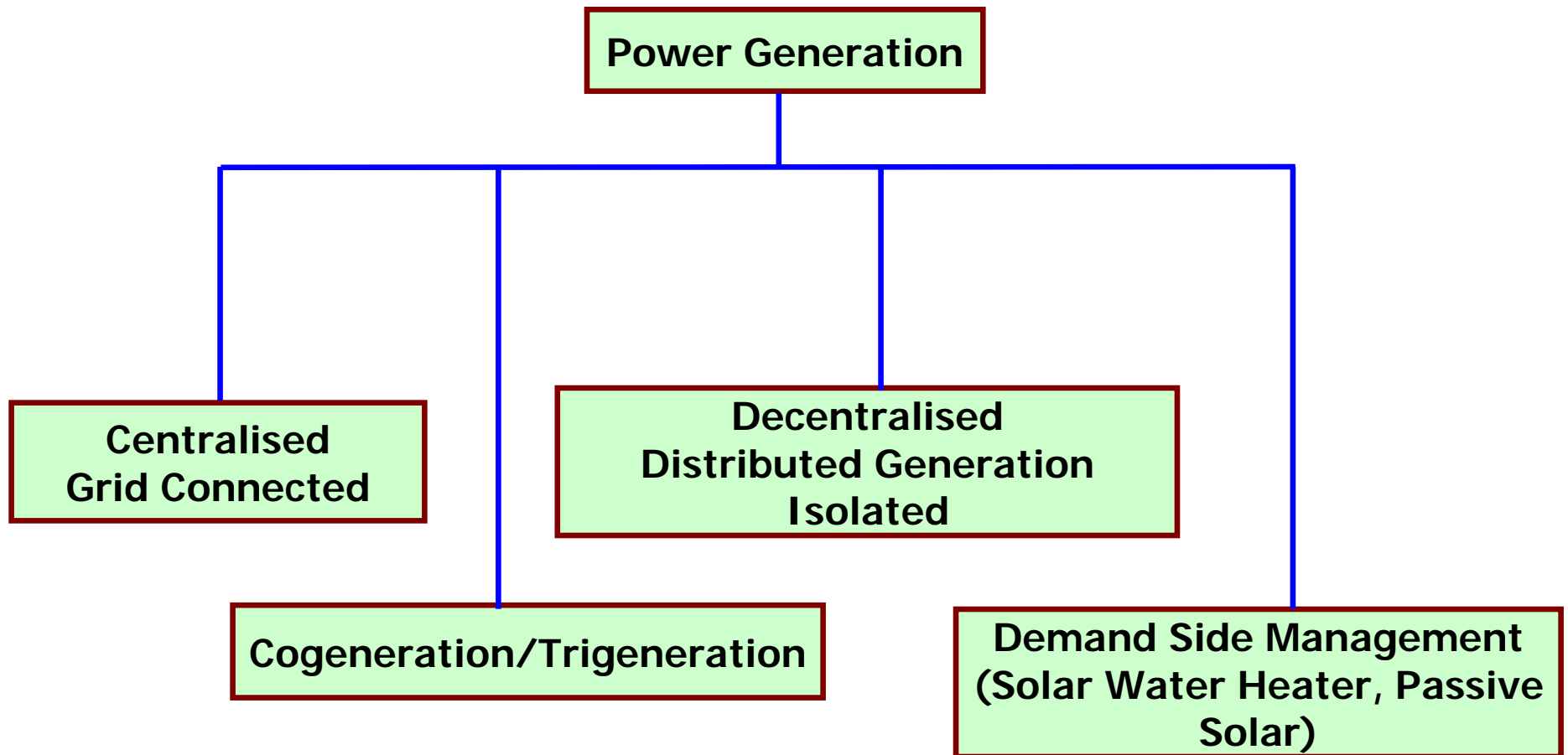


Renewable Energy Policies

- Capital Subsidy
- Tax Benefits (accelerated depreciation)
- Preferential Tariffs (feed-in) – technology differentiated, performance based incentives
- Renewable Portfolio Standards
- Renewable Energy Certificates



Power Generation Options





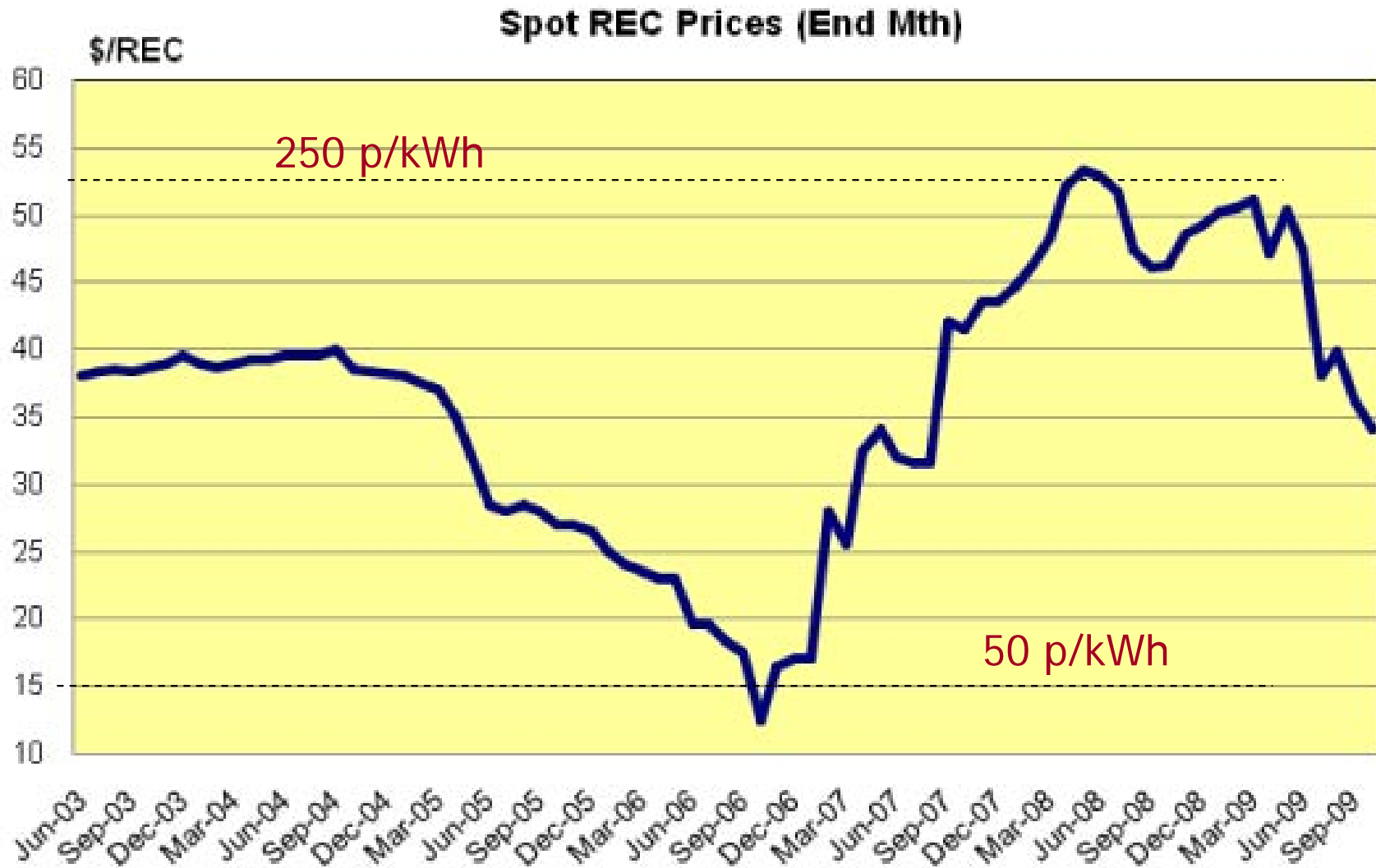
Renewable Energy Certificates

- #1 Does it provide “stable” signals to investors?
- #2 Does it promote renewable energy in the state?
- #3 How do we differentiate between different technologies ? Do we have multiplication factors based on technology type/ status?
- #4 How do we prevent gaming? Can we ensure validation? Monitoring and verification?
- #5 Can we extend to smaller grid connected systems? (e.g BIPV)
- #6 Solar Water Heaters as “Deemed Generation”?



#1

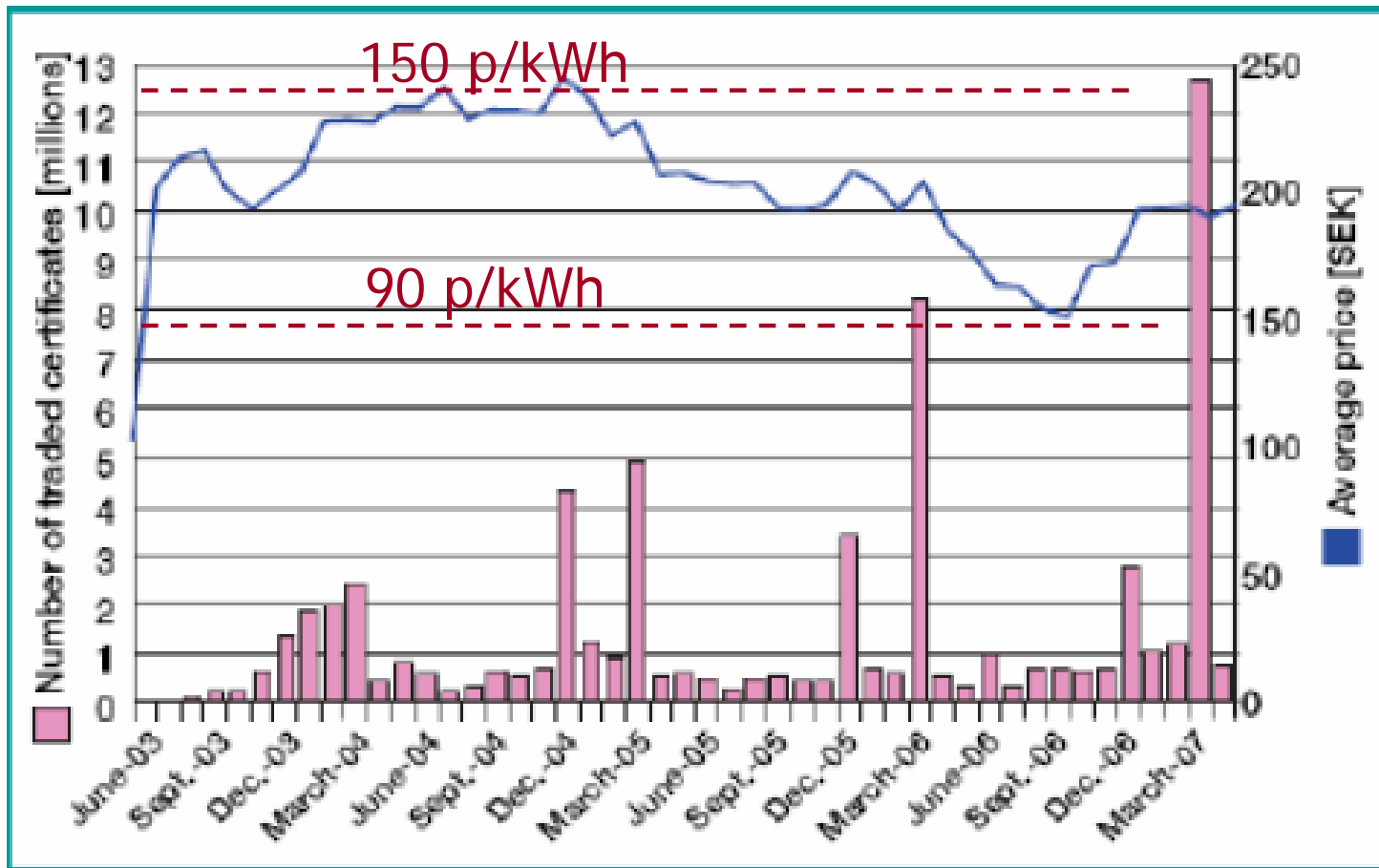
Variability in REC price (Australia)





#1

Variability in REC price (Sweden)

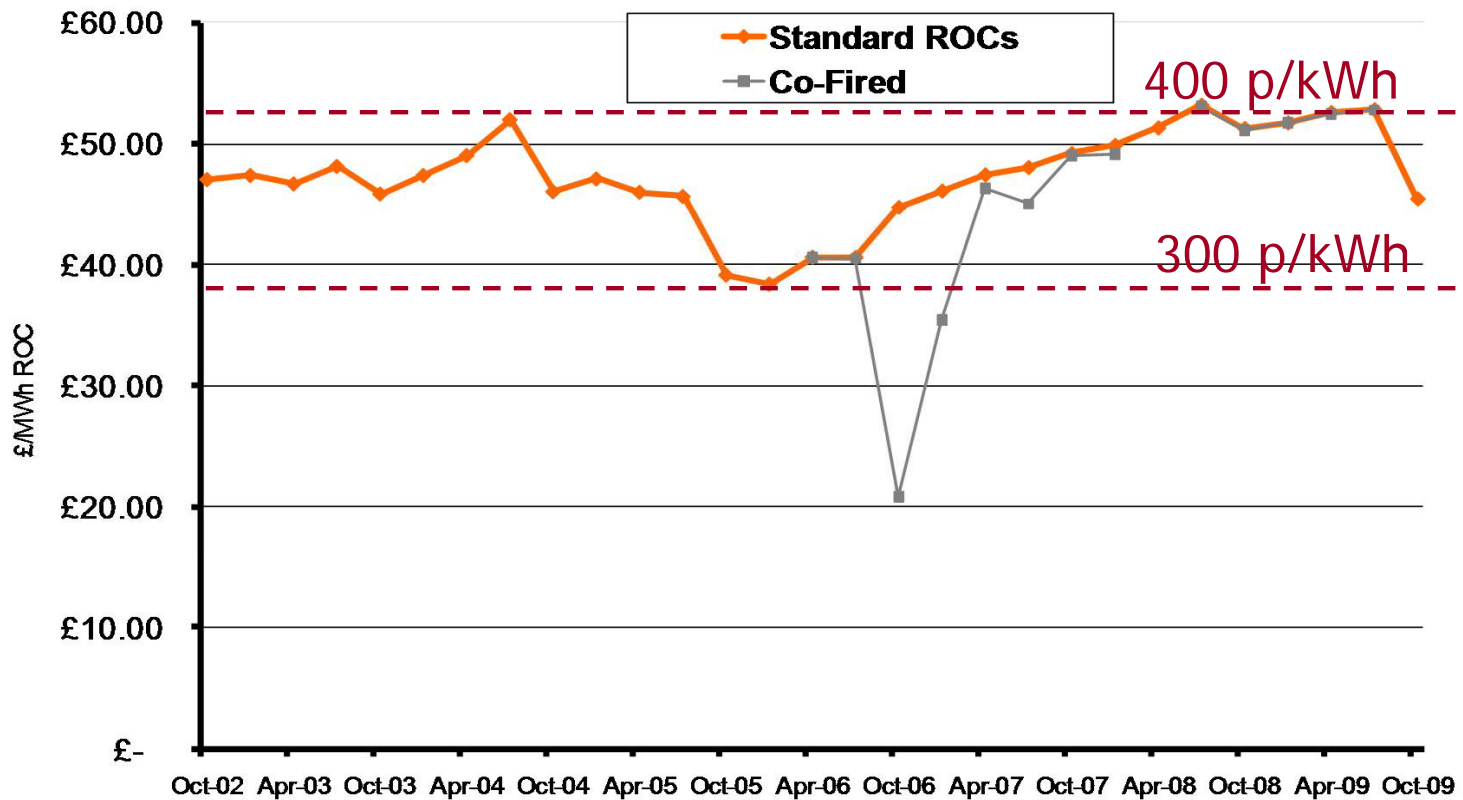


Source: InfralineEnergy Report on REC - October 2009



#1

Variability of ROCs in UK



Source: <http://www.e-roc.co.uk/trackrecord.htm>



#1

Sample REC rates

	UK	AUSTRALIA	SWEDEN	ITALY
Price Range of REC (\$/MWh)	63-86	11 – 49	14.6 – 36.4	123 – 195
Rs/kWh	2.9 – 4.0	0.5 – 2.3	0.7 – 1.7	5.7 – 9.0
Multiplication Factor Based on Technology	YES	YES	NA	YES
Starting year	2002	2001	2003	2001
Penalty/Buyout \$/MWh	65	27	-	-

+ Instantaneous values

Source: <http://www.e-roc.co.uk/trackrecord.htm>

InfralineEnergy Report on REC - October 2009

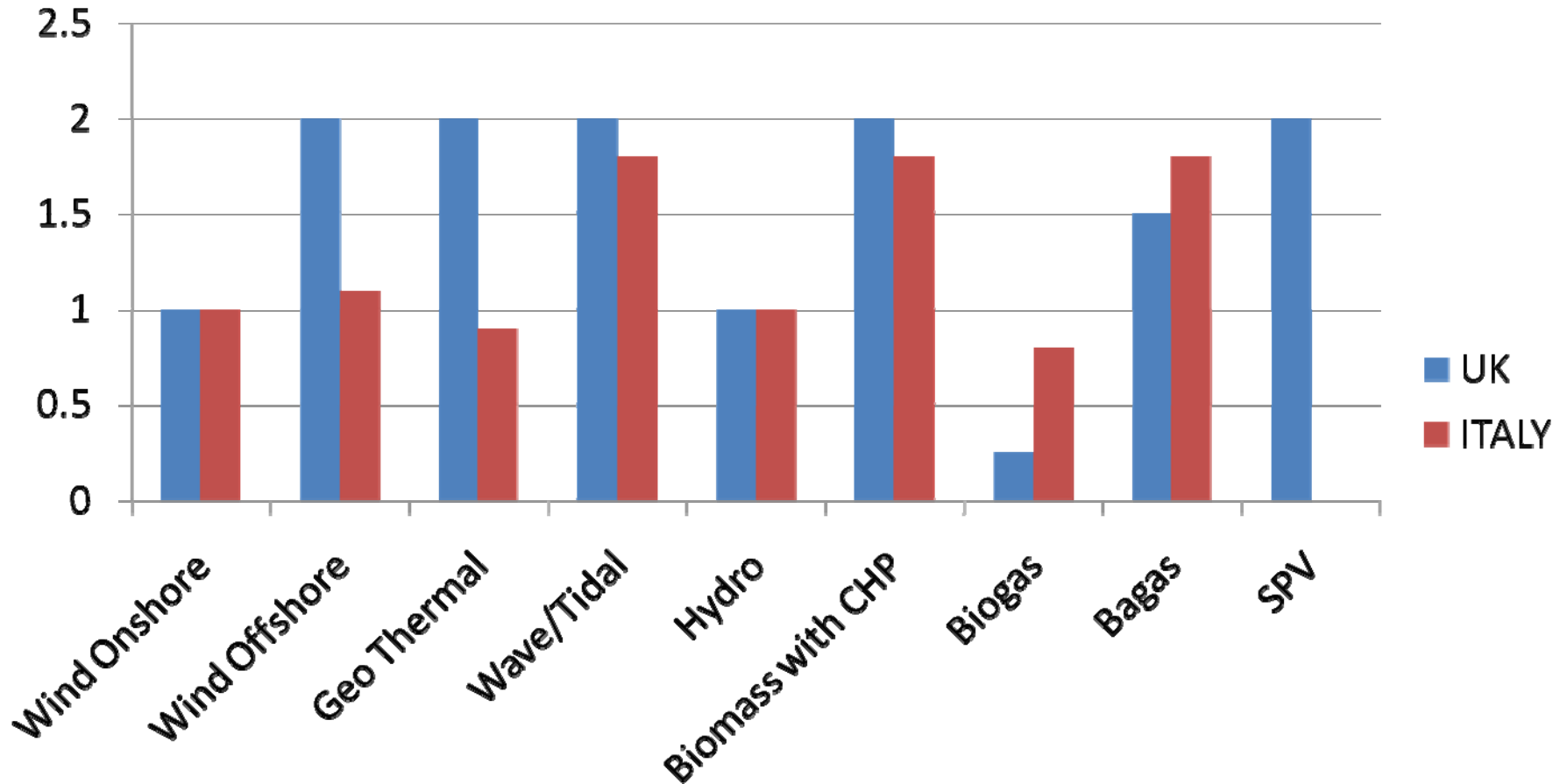
<http://www.greenenergytrading.com.au/how-are-recs-priced.html>

Renewable Energy Country Profiles, Report – February 2008.



#3

Multiplication Factor

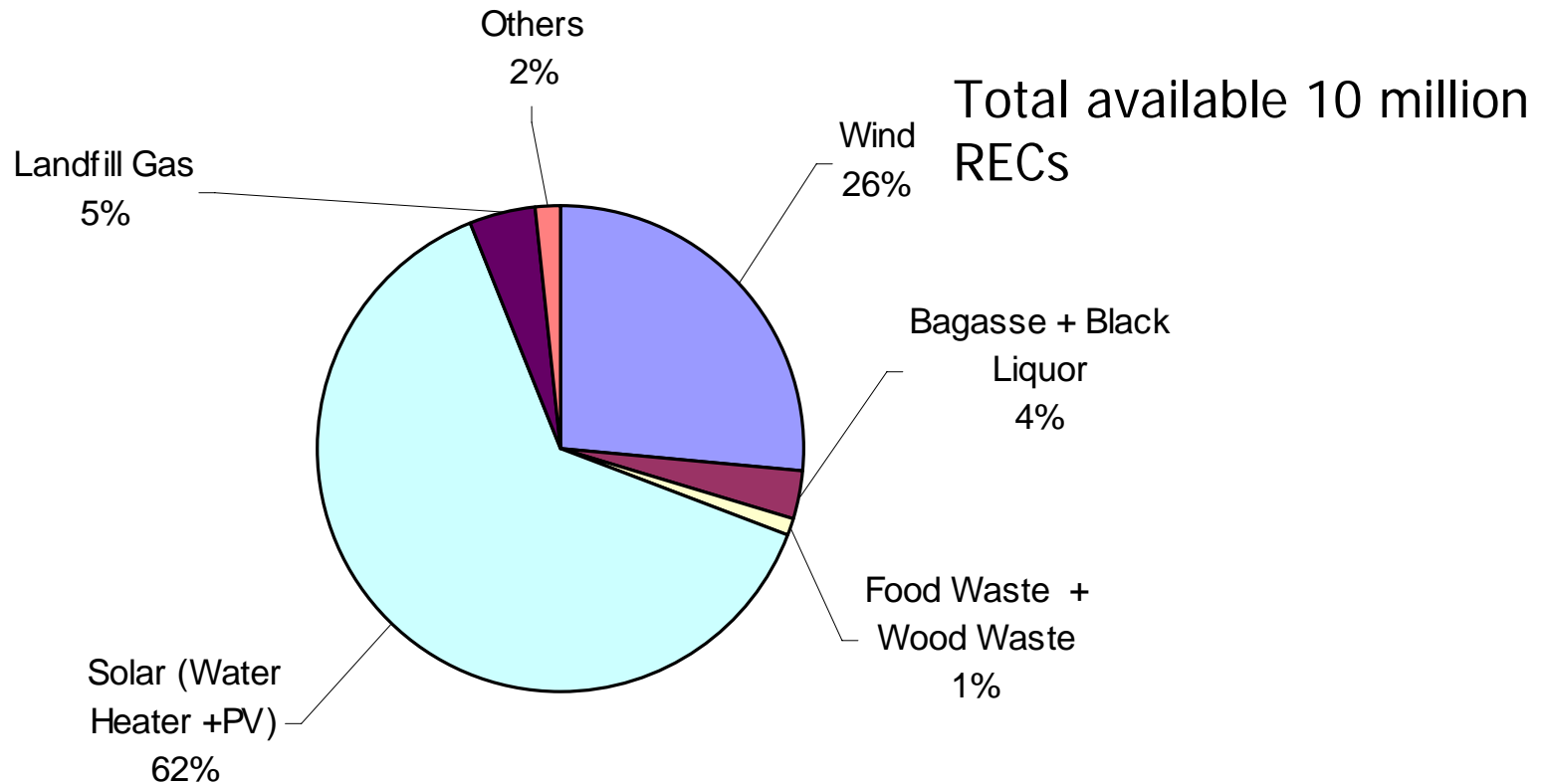


Source: Renewable Energy Country Profiles, Report – February 2008.
The UK Renewable Energy Strategy July 2009



#5,6

Available REC's in Australia in 2009 for Trade

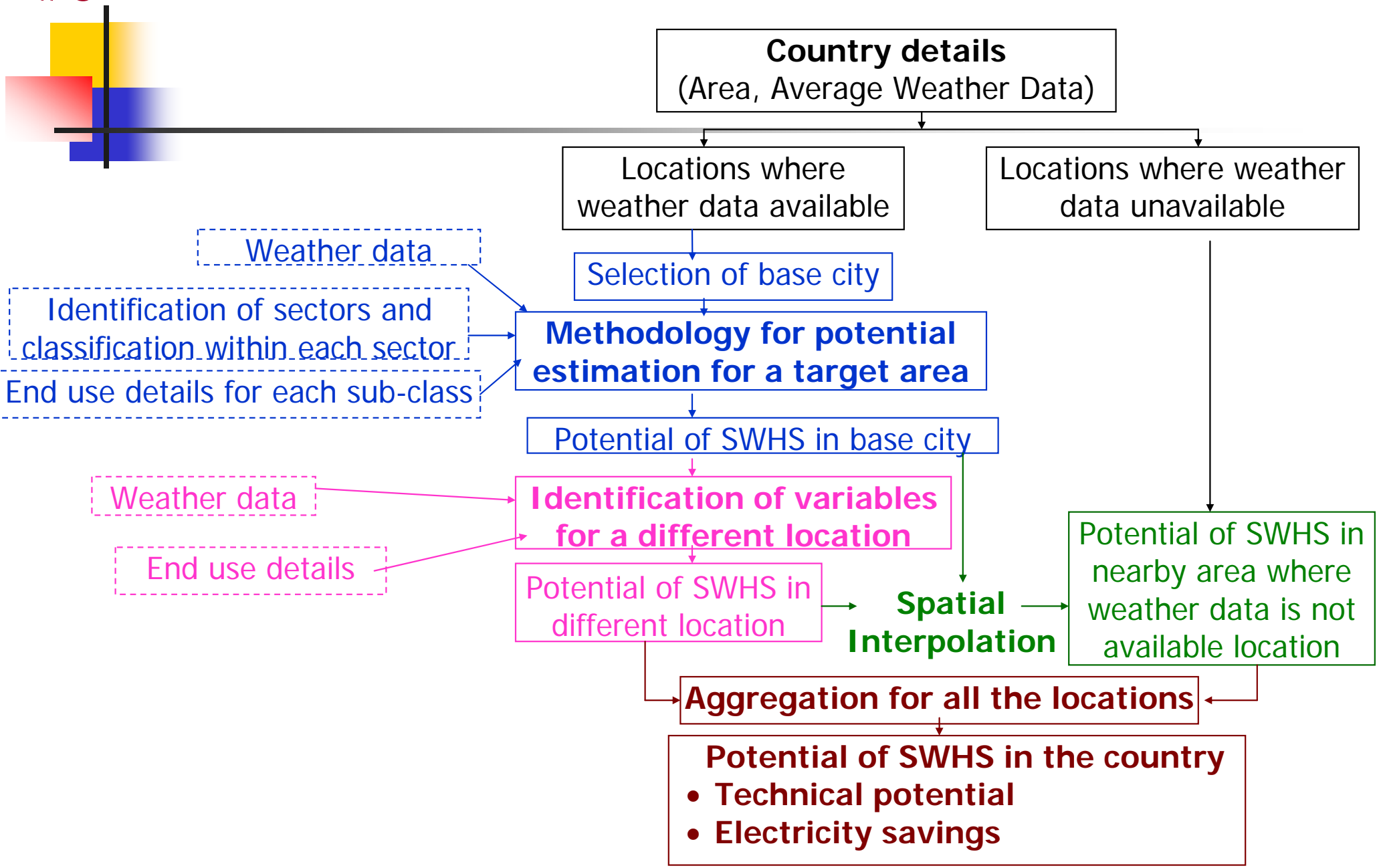


Source: <https://www.rec-registry.gov.au/getSearchPublicRecHoldings.shtml>



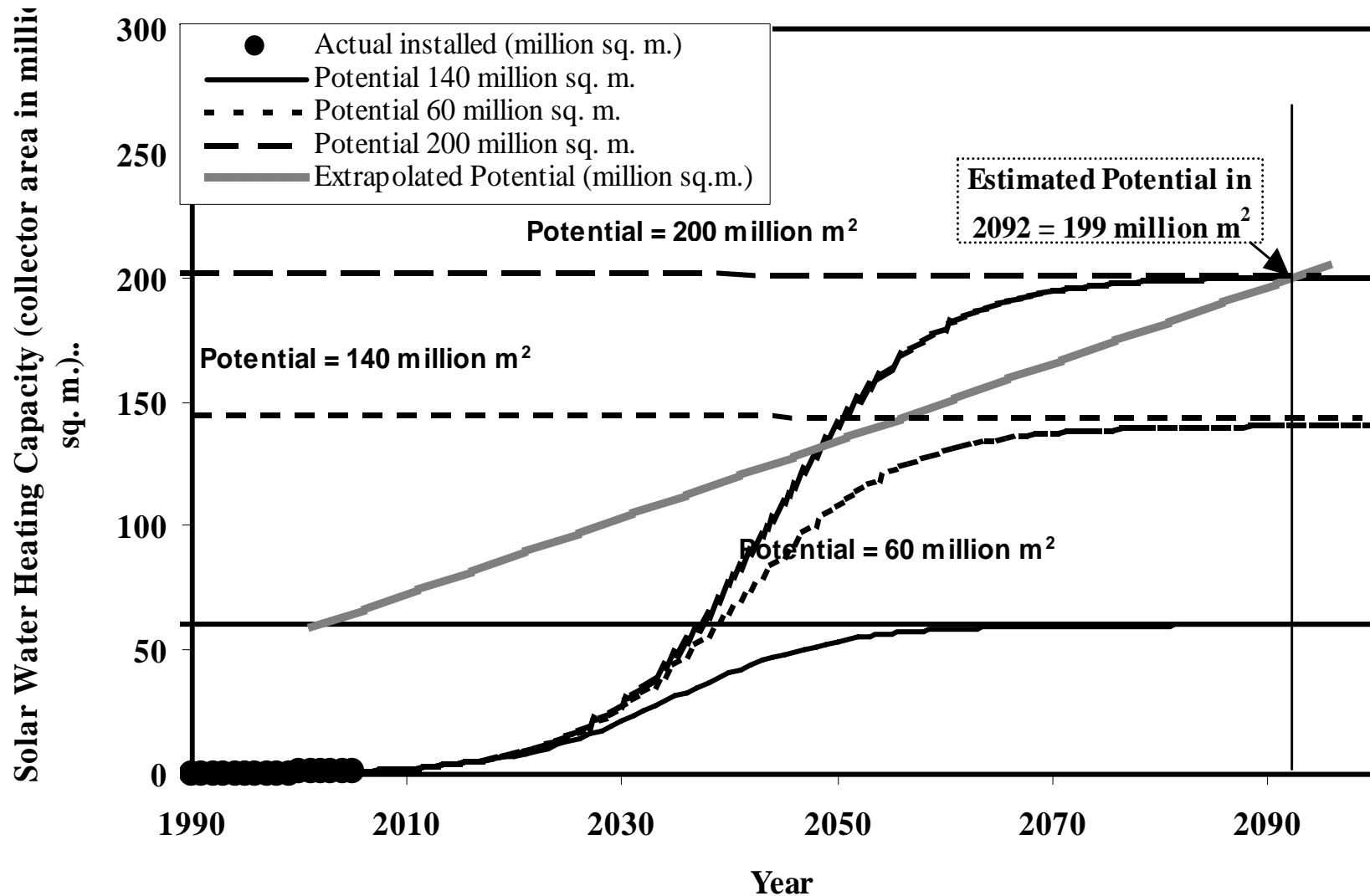
#6

Framework for Potential Estimation of Solar Water Heating Systems in a Country





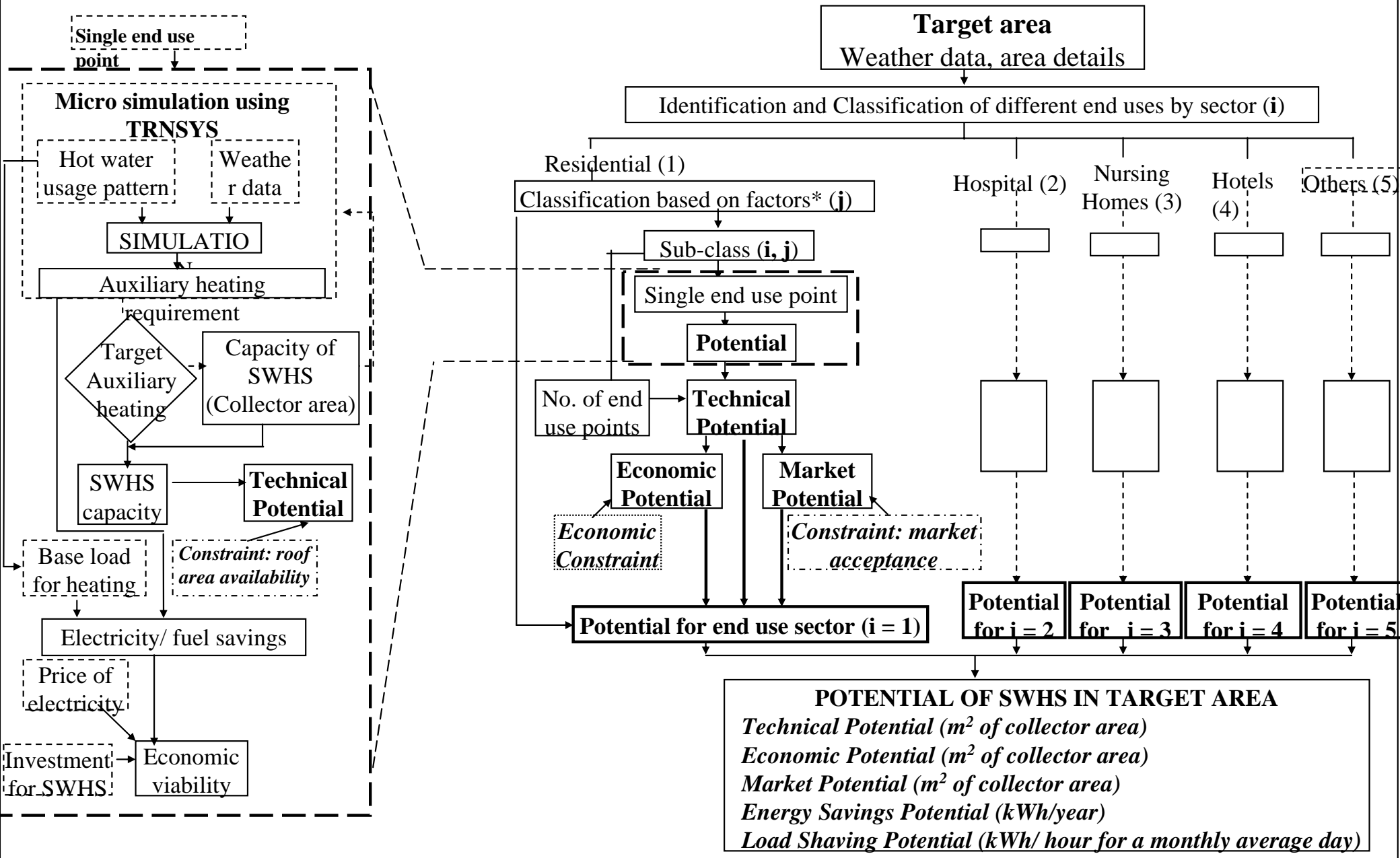
Diffusion of SWH





Model for Potential Estimation of Target Area

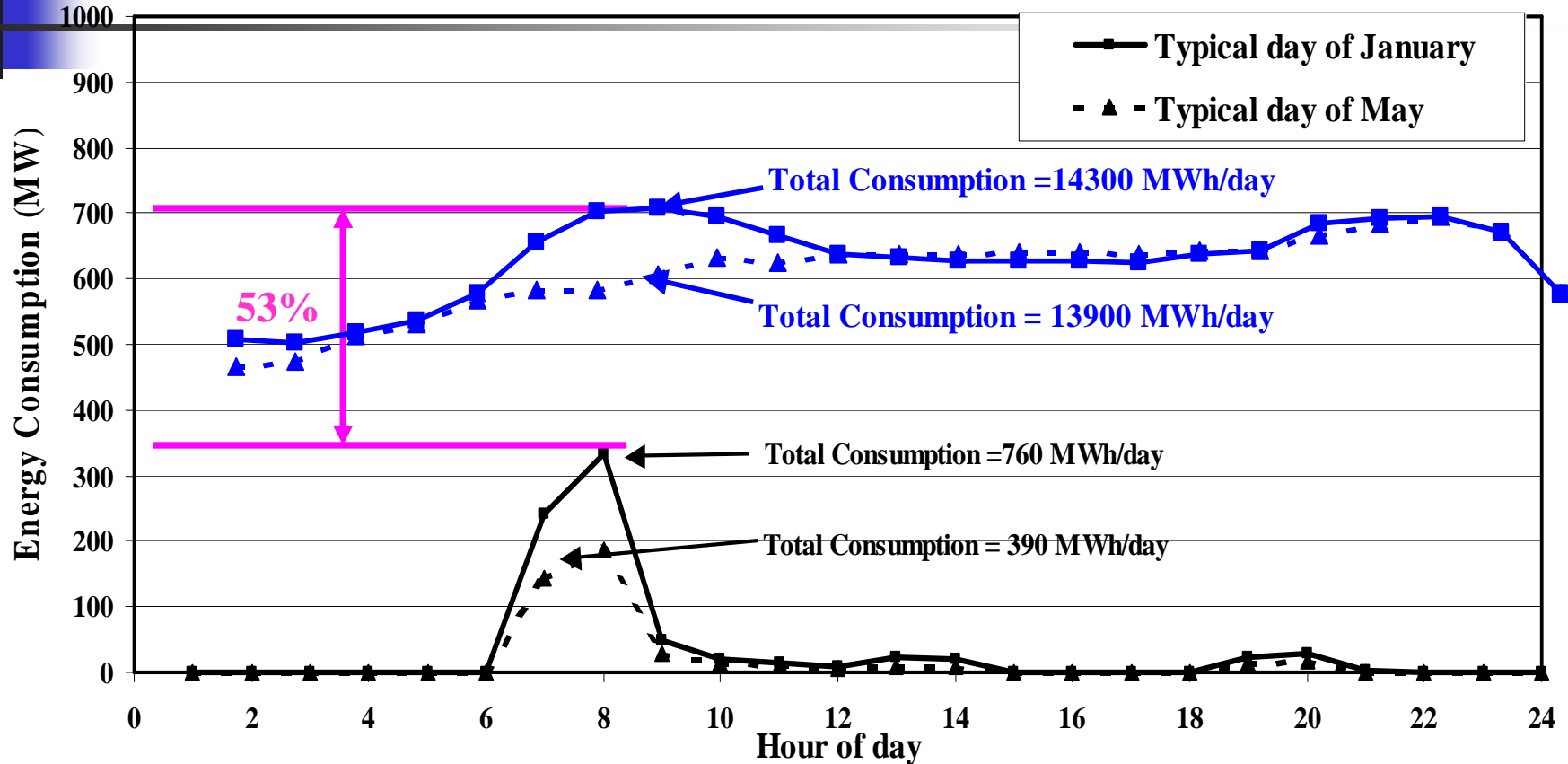
#6



* Factors affecting the adoption/sizing of solar water heating systems



Load Curve Representing Energy Requirement for Water Heating



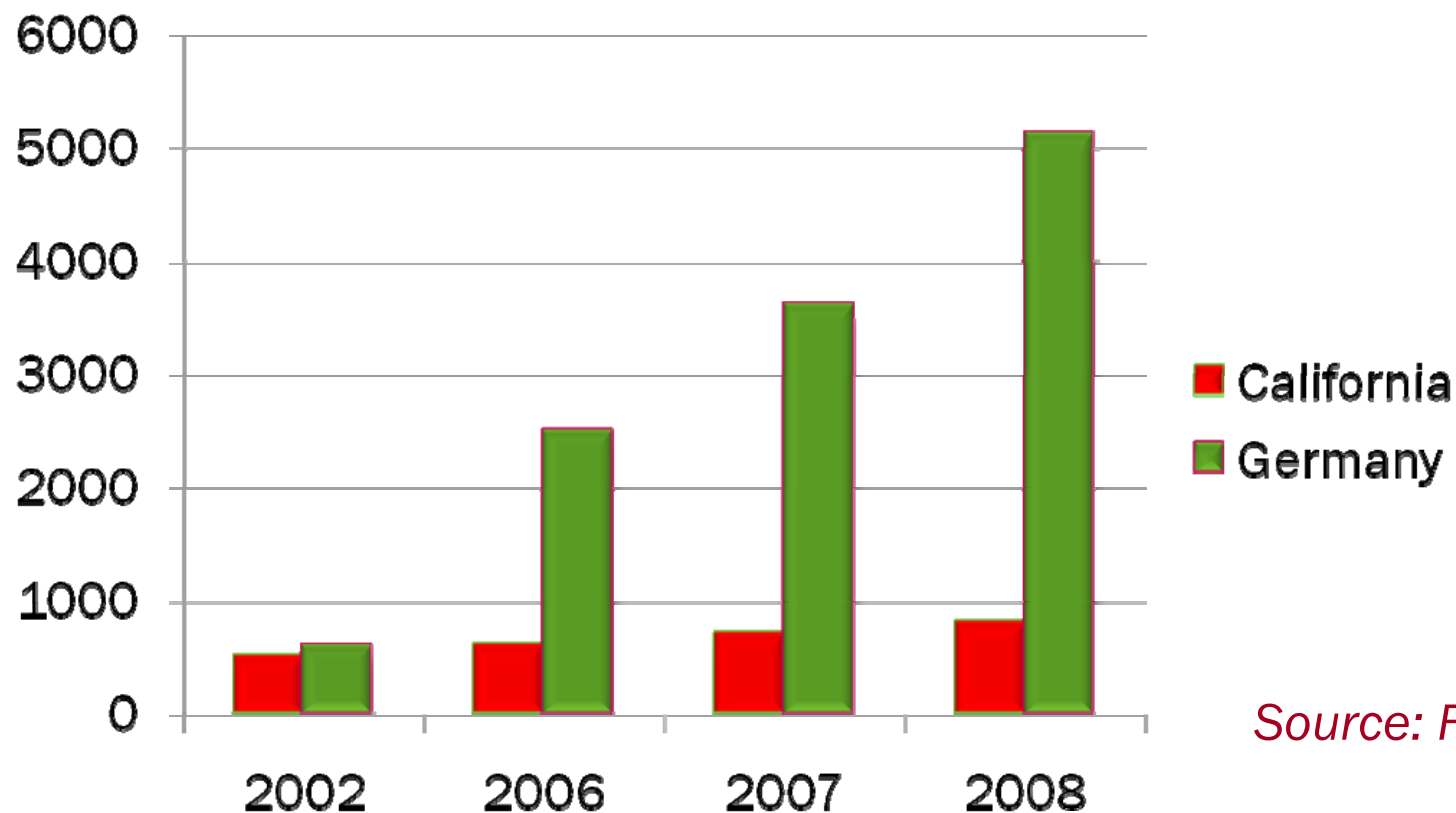
■ Total Electricity Consumption of Pune

■ Electricity Consumption for water heating of Pune



RECs (California) Vs FiT (Germany) Comparison

- California enjoys 50% more sunshine
- But Germany installed 10 times solar than California



Source: FiT for America



Feed in tariffs Vs REC's

	Price Variability	Incentive to Investor	Market Driven	Trade across states	Comments
Feed in Tariff	Low	High	No	Exchange Possible	Within State development Differentiation between technologies
Renewable Energy Certificate	High	Medium (Uncertain)	High	High	Gaming possible



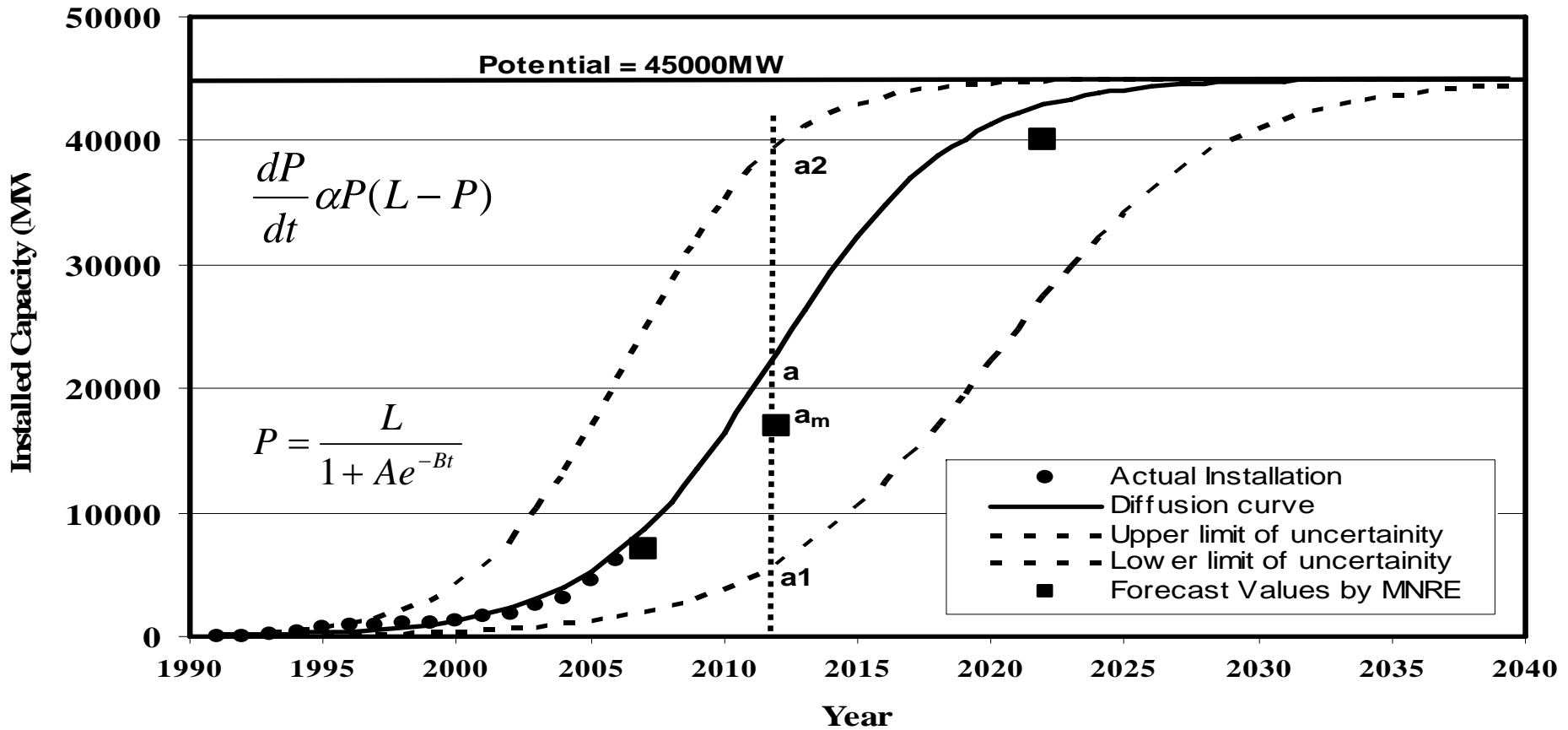
Mainstreaming of renewables

- #1 Technology Development and Research challenge -Cost Reduction challenge
- #2 System Integration/ System Planning challenge – Need for better methods for potential estimation, Impact on rest of grid
- #3 Sustainability- Land, Water, Materials, Emissions



Diffusion Curves for wind energy

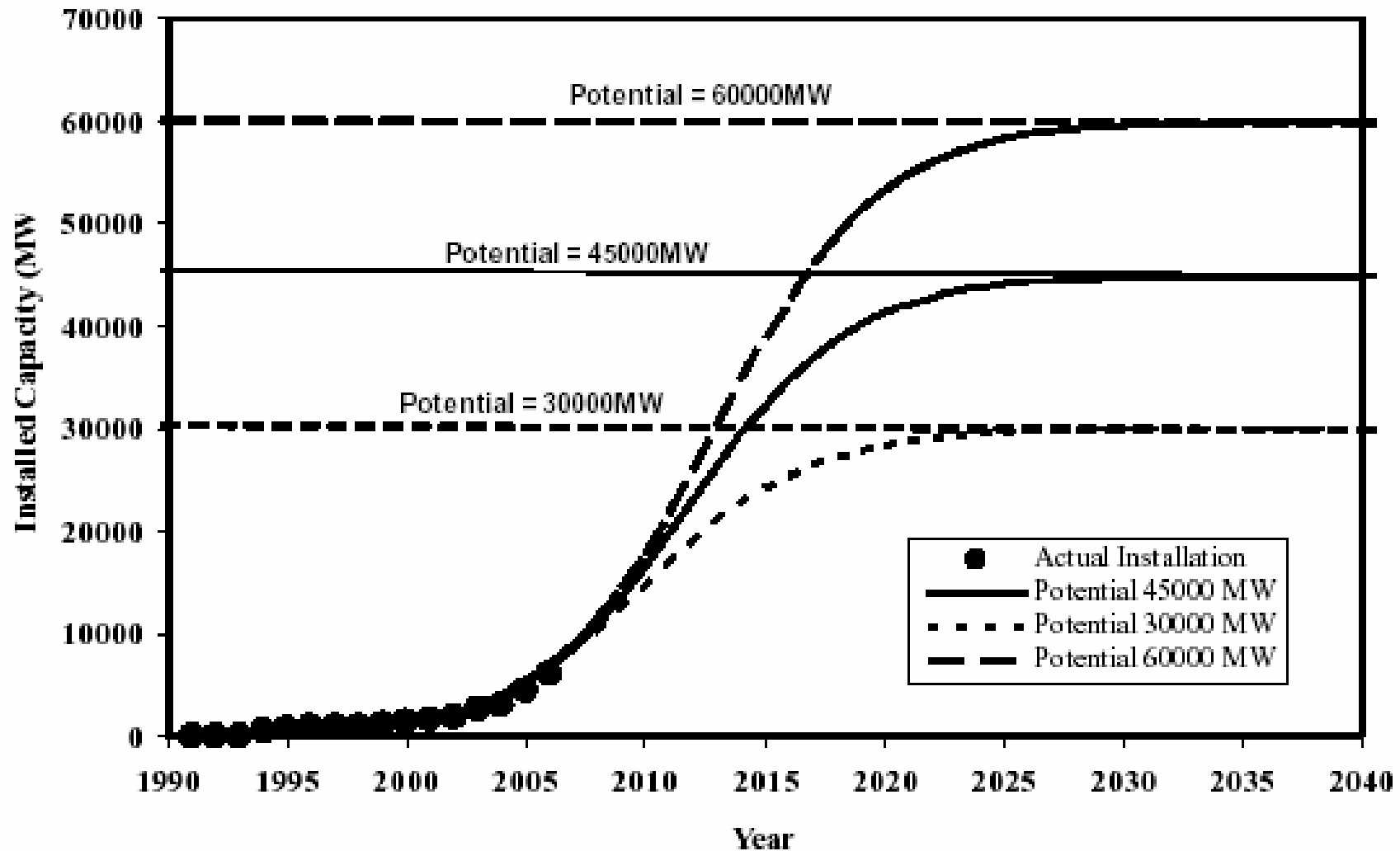
#2



Year	Projection by MNRE	Projection by diffusion curve	Values in the uncertainty limit of 5%	
			Lower limit	Higher limit
2007	7000	8700	2000	24800
2012	17500	23000	5800	39600
2022	40000	42900	27400	44800



Wind Diffusion





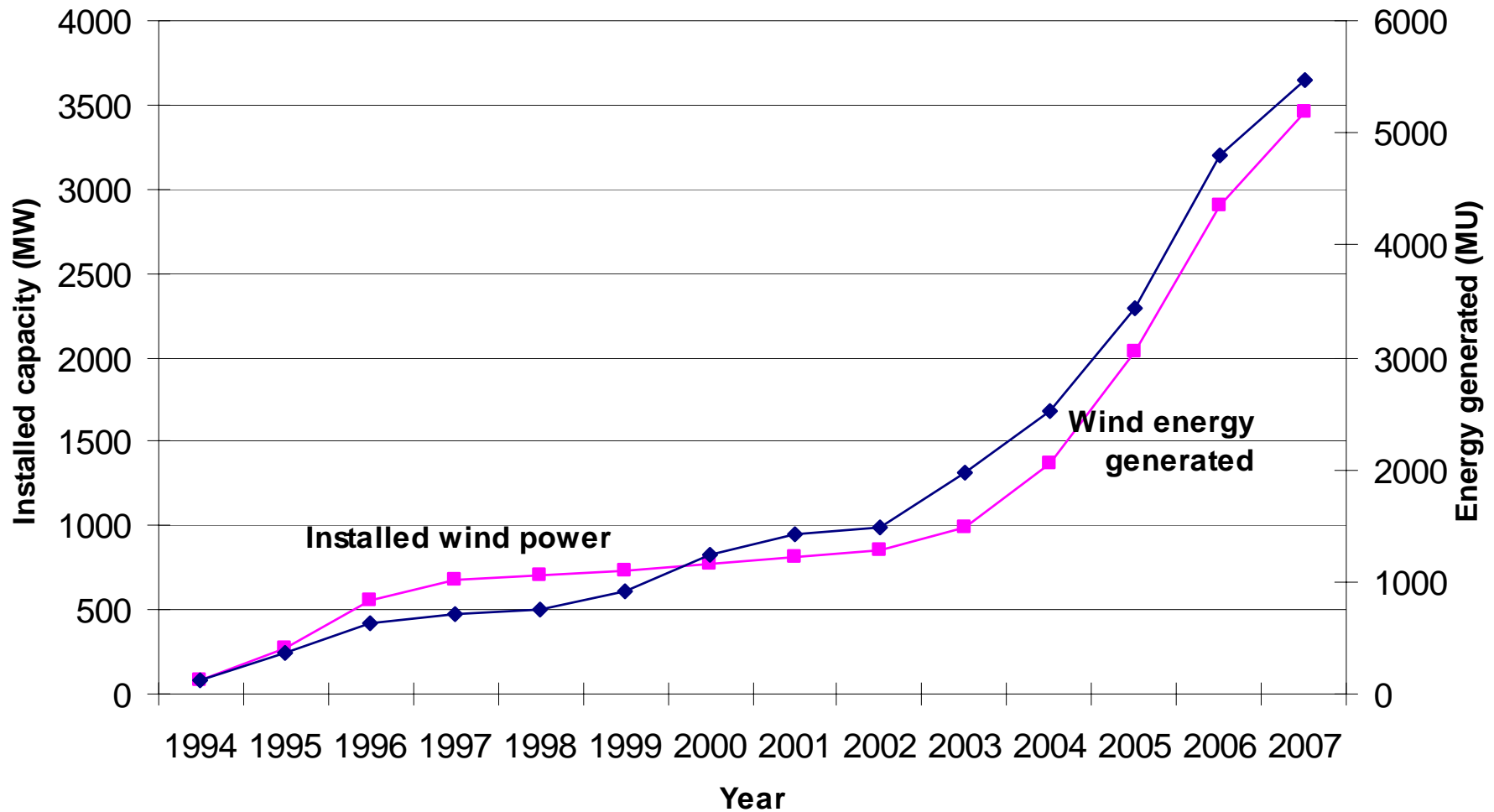
Tamil Nadu – Grid Details

#2

Source	Installed capacity (MW)	Annual Energy generated (MU)	Annual average capacity factor (%)
Coal	2970	21230	81.6
Gas	424	1945	52.4
Hydro	2187	6290	32.8
Firm central share [#]	2825	17785	71.9
Wind (state + private)	3856	5270	18.6
Other renewables (solar PV, biomass and Bagasse based cogeneration)	556	1220	25.1
Independent power projects (coal, lignite, diesel or gas based)	1180	6360	61.5
Assistance from other regional grids	519	2280	50.1
Total	14517	63370	49.8

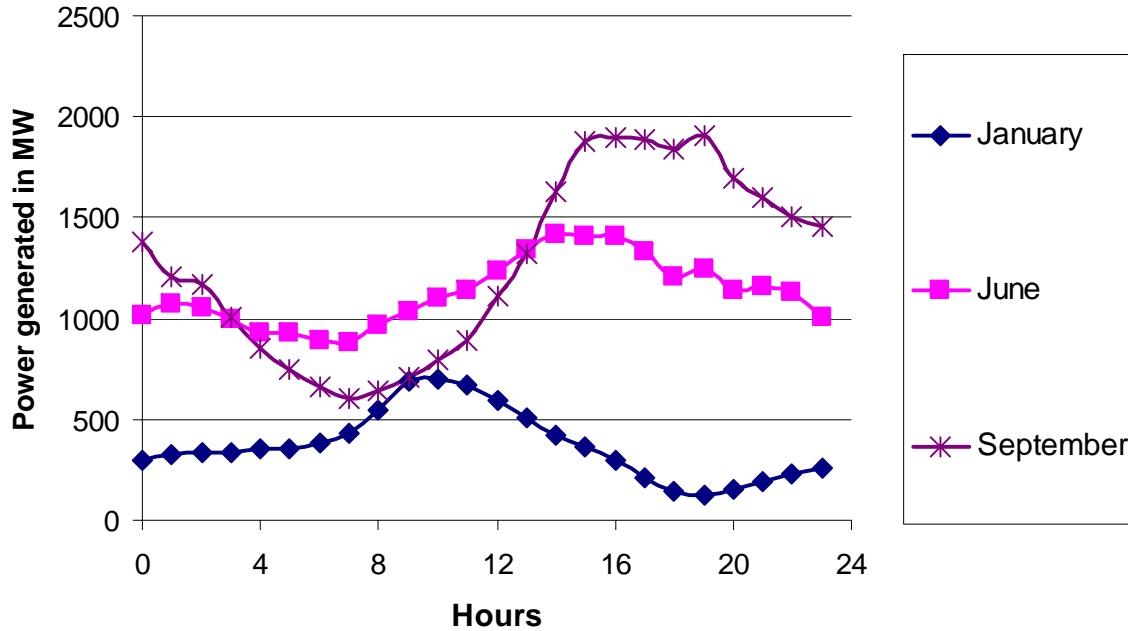


TN – Installed wind power and wind energy generated

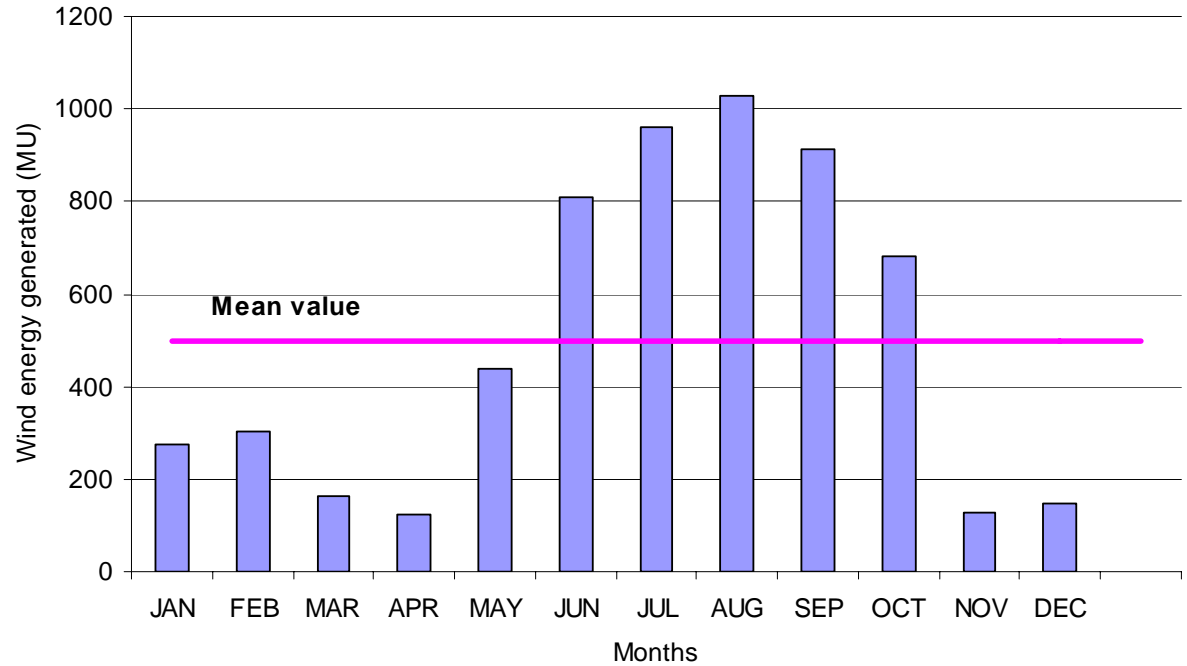




Hourly variation of wind power

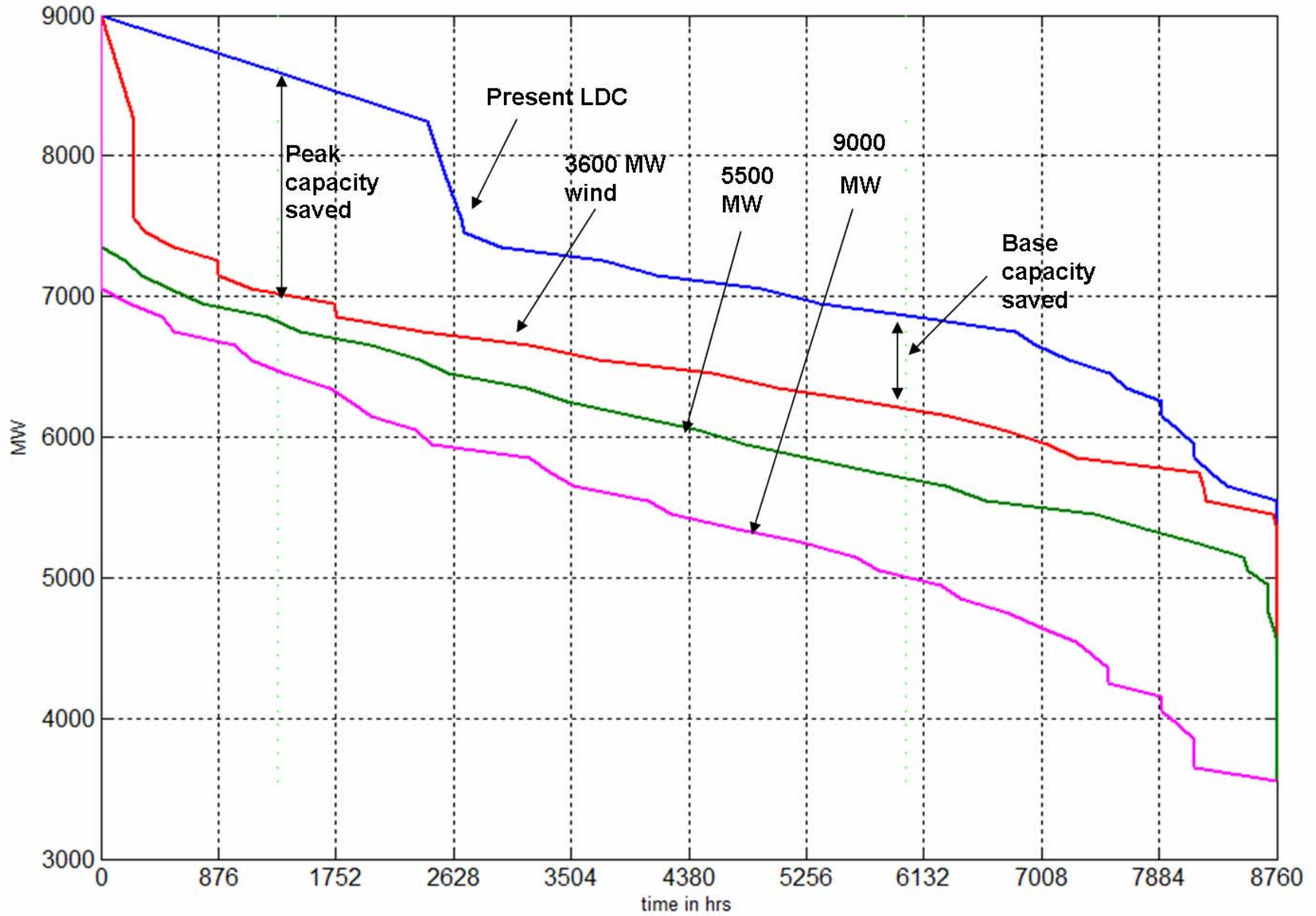


Monthly variation of wind energy generated





Impacts on LDC

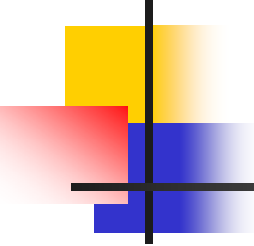




Summing up

- Long term – capability development, employment potential for Maharashtra
- Level playing field between technologies – New technologies, cofiring, hybrids, technologies at different stages of development
- Local and Global Emissions
- Sustainability – Area, materials, water
- Marginal to Mainstream – System integration and planning issues, need for new methodologies
- Policies to foster cost effective renewable for future



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Thank you



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