IMA Research for Strategy

Solarising India

Commercial Feasibility Analysis and an Implementation Roadmap

IMA India

Disclaimer

This document has been prepared by International Market Assessment India Private Limited. It compares the 'true' cost of conventional energy with that of solar energy and builds a detailed commercial feasibility model to assess the suitability of solar power for rural India. The report also provides suggestions towards a policy framework as well as a subsidy strategy to achieve the above.

This report is not intended for decision making purposes. Whilst the information contained in the following pages is accurate to the best of our knowledge and belief, IMA India cannot assume any responsibility for the outcome of actions initiated, or decisions taken, as a result of this document. Moreover, IMA's assessment is based on conditions as they existed at the time of writing this report, and these may no longer be applicable consequent upon changes in political, economic or trade conditions within the Republic of India or elsewhere.

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I. About IMA India

What IMA Does…

- ***Undertakes in-depth market studies and opportunity assessments*** for individual companies: leveraging a full range of business and market research capabilities
- ***Provides ongoing market intelligence and risk assessments*** to country managers; offers research-based interpretations and top-level forecasts of the operating environment in India: economy, politics, key sectors, emerging business issues, etc
- ***Provides closed-door discussion platforms*** that enable focussed and high quality intellectual exchanges between senior executives on current and strategic business issues

Four Business Streams

- **Research and Advisory Services**
  - Proprietary studies for individual clients across issues and sectors
  - Leveraging a unique methodology comprising extensive desk analysis complemented by expert insights obtained from internal and external domain specialists
- **Peer Group Forums**
  - Membership-based executive briefing and research services: a platform for obtaining country intelligence and exposure to authoritative minds; access to top-level India research
  - An extensive corporate network: a forum for sharing experiences and learning from peers and pioneers
- **Conferences and Business Meetings**
  - Closed-door Roundtables for senior executives
  - Driven by research-based agendas and intense interaction
- **CFO Connect**: first-of-its-kind thought leadership journal for CFOs

II. The Economic Feasibility Model:
Conventional Power versus Solar Energy

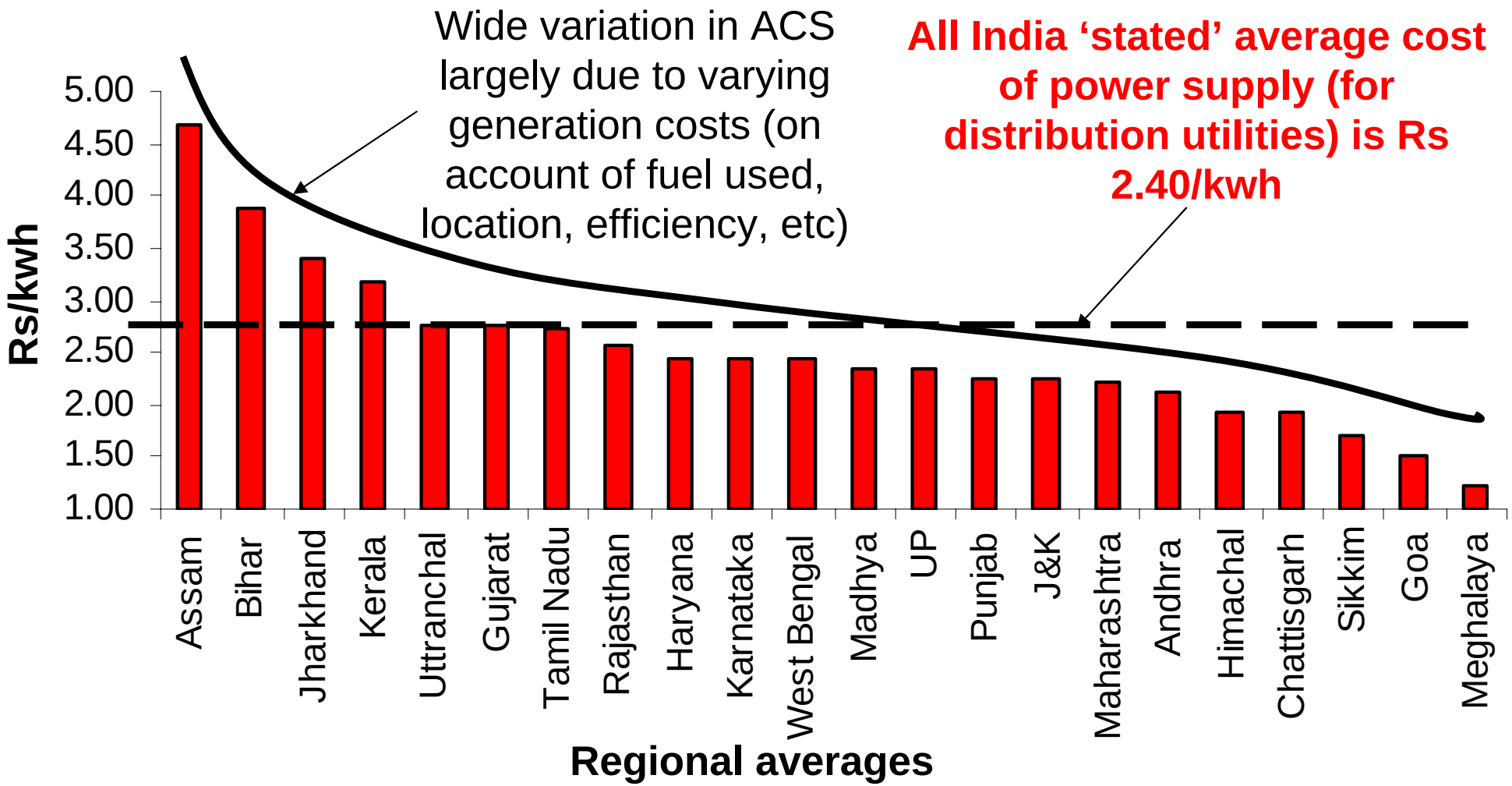
Approach

A ‘first principles’ approach…

- Estimate an average per unit ‘real’ cost of conventional power by taking into account all subsidies – direct and indirect – and other unaccounted costs across generation, transmission and distribution
- Identify/quantify additional ‘systemic’ costs – environmental, litigation, opportunity, subsidies on other conventional fuels, etc – to identify the ‘true economic delivered’ cost of conventional power
- Rural electrification economics – establish a relationship between the cost of delivered power and both the distance (of a village) from the grid and the population of the village
- Likewise, estimate the effective cost of solar energy and assess the economic viability and competitiveness of solar energy vis-à-vis conventional power

Estimating the true economic cost of delivered conventional power…

'Apparent' Average Cost of Supply (ACS)



Western average: Rs 2.35/kwh; Southern average: Rs 2.62/kwh; Northern average: Rs 2.12/kwh; North-Eastern average: Rs 3.45/kwh; Eastern region: Rs 2.63/kwh

Source: Ministry of Power, 2003-04

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Cost of power supply: industry estimates

Rs 1.80-2.45/kwh

Rs 2.20-3.05/kwh

Generation

Fixed costs* Rs 1.00-1.25/kwh

Fuel cost** Rs 0.80-1.20/kwh

Transmission/ wheeling charges
Rs 0.40-0.60/kwh

Distribution costs
Rs 0.60-0.90/kwh

Rs 2.80-3.95/kwh

Consumer

** includes all project and development costs, interest cost, depreciation, O&M, taxes, return on equity, etc*
*** includes cost of fuel used (i.e. coal) and freight charges*

Note: All costs are average industry estimates for thermal power and levelised over a period of 30 years

Subsidies and other 'black box' costs!

- **Generation**:
  - Capital equipment import duty exemption (applicable to mega power projects i.e. > 1,000 MW)
  - Interest rate subsidy to state and central utilities i.e. PFC offering near-PLR loans to un-credit-worthy SEBs
- **Transmission and distribution**:
  - Aggregate Technical and Commercial (A&TC) losses – including theft and pilferage and subsidies *(Recently, Planning Commission's Chairman Montek Singh Ahluwalia openly expressed his displeasure at the mounting losses of SEBs… estimated in excess of Rs 20,000 crores)*
- **Other/external costs**:
  - Conventional fuel subsidies
  - Opportunity cost of 'unmet' energy demand
  - Environmental externalities
  - Litigation cost
  - Cost of 'de-electrification'

Estimating the 'real' cost of supply

- Generation stage:
  - capital equipment import duty exemption (earlier 22.3%) is equivalent to a subsidy of Rs 0.08 paisa/kwh*
  - interest rate subsidy (25%) translates into an additional cost of Rs 0.06 paisa/kwh#
  - total unaccounted subsidies/costs at the generation stage: Rs 0.14/kwh
- Transmission: 50% AT&C losses – utilities 'collect' only half of the units purchased and put into the system
  - on account of agreements with states and ERCs, utilities are allowed to account for AT&C losses only in a phased manner, keeping the real cost and effective tariff low
  - Close to 25%* of the AT&C losses are currently 'unaccounted' i.e. not taken into consideration to derive the true cost of delivered power

** Industry/expert estimate*
 # IMA estimate

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Delivered cost: higher than it appears…

Rs 1.94-2.59/kwh

Rs 2.34-3.19/kwh

Generation

Fixed costs* Rs 1.00-1.25/kwh

Fuel cost** Rs 0.80-1.20/kwh

+ subsidy (Rs 0.14/kwh)

Transmission/ wheeling charges Rs 0.40-0.60/kwh

Distribution costs Rs 0.60-0.90/kwh

Rs 2.94-4.09/kwh

+ unaccounted AT&C losses

True delivered cost* Rs 3.67-5.11/kwh @25%

True delivered cost* Rs 4.41-6.13/kwh @50%

** The cost to consumer could be even higher in some cases as most states follow 'slab' pricing i.e. more the consumption, higher the per unit cost charged*

Note: All costs are average industry estimates for thermal power and levelised over a period of 30 years

…and there are other costs too…

Conventional fuel subsidies

- Due to incomplete electrification, a large majority of the rural households (~ 80 million) use kerosene for lighting/heating purposes – the total under-recovery on account of subsidised kerosene is estimated in excess of Rs 11,500 crores/annum*
- Additionally, the use of subsidised diesel to run generators/pump sets is common (and on the rise) – however, due to the lack of any authentic data, only a broad estimate of the subsidy can be made in this context
  - In 2005-06, under-recoveries of the Oil Marketing Companies (OMCs) on petrol and diesel are estimated to be around Rs 20,000 crores** – in view of the volatile oil prices and the lack of an institutionalised petroleum pricing mechanism, this estimate – going forward – may vary widely e.g. under-recoveries in 2004-05 were only Rs 2,190 crores
  - In India, the ratio of diesel usage to petrol usage is about 7:1^ – this translates into an estimated diesel under-recovery of Rs 17,500 crores in 2005-06
  - Industry experts suggest that 10-20% of the diesel under-recovery can be attributed to generators, pump sets, etc – a conservative assumption of 10% translates into a Rs 1,750 crore diesel subsidy, which is a direct fall-out of un-electrification

Annual national spending on conventional fuel subsidies (Rs 13,200 crores) translates into a per unit subsidy of Rs 0.22 paise/kwh!

* assuming 10 litres per month per household with a subsidy of Rs 12/litre i.e. 80 mn x Rs 12/litres x 120 litres; ** Business Line, August 31, 2005

The opportunity cost of unmet energy demand

- Power shortages have a major impact on output and profitability in industry and agriculture
- A TERI/World Bank study estimates the opportunity cost of 'unserved' energy (poor quality, unreliable power or no power)
  - for the manufacturing sector to be in the range of Rs 5-22 per kwh
  - for the farm sector to be in the range of Rs 2-4 per kwh

Economically, the benefits of lighting an average rural household in India is in the range of Rs 15 to 20 per kWh… and there are a host of social benefits too!

The above estimates are basis a World Bank report - 'India: Power Sector Reform and the Poor' (2002) and a TERI report - Cost of Unserved Energy' (2001) for the states of Haryana & Karnataka. The TERI study uses three different methods – 'value of production loss', 'cost of alternative power generation' and 'willingness to pay for reliable power supply' – to arrive at these estimates.

Environmental impact

- Due to India's growing reliance on coal-based power, its CO_2 emissions have also grown rapidly over the past few years
  - Indian coal is characterised by a high ash content (building advanced coal washeries will have cost implications for the coal-based power)
  - estimates suggest 1.2 kg and 0.9 kg of CO_2 emissions per kwh of power produced using coal and oil, respectively
  - India is a signatory to the Kyoto Protocol and while under no 'pressing' timeline to reduce its CO_2 emissions (like developed nations), it has an immediate opportunity to capitalise on developed countries' commitments
- Additional externalities associated with mining, water use, social dislocation, health effects, fly ash disposal, etc

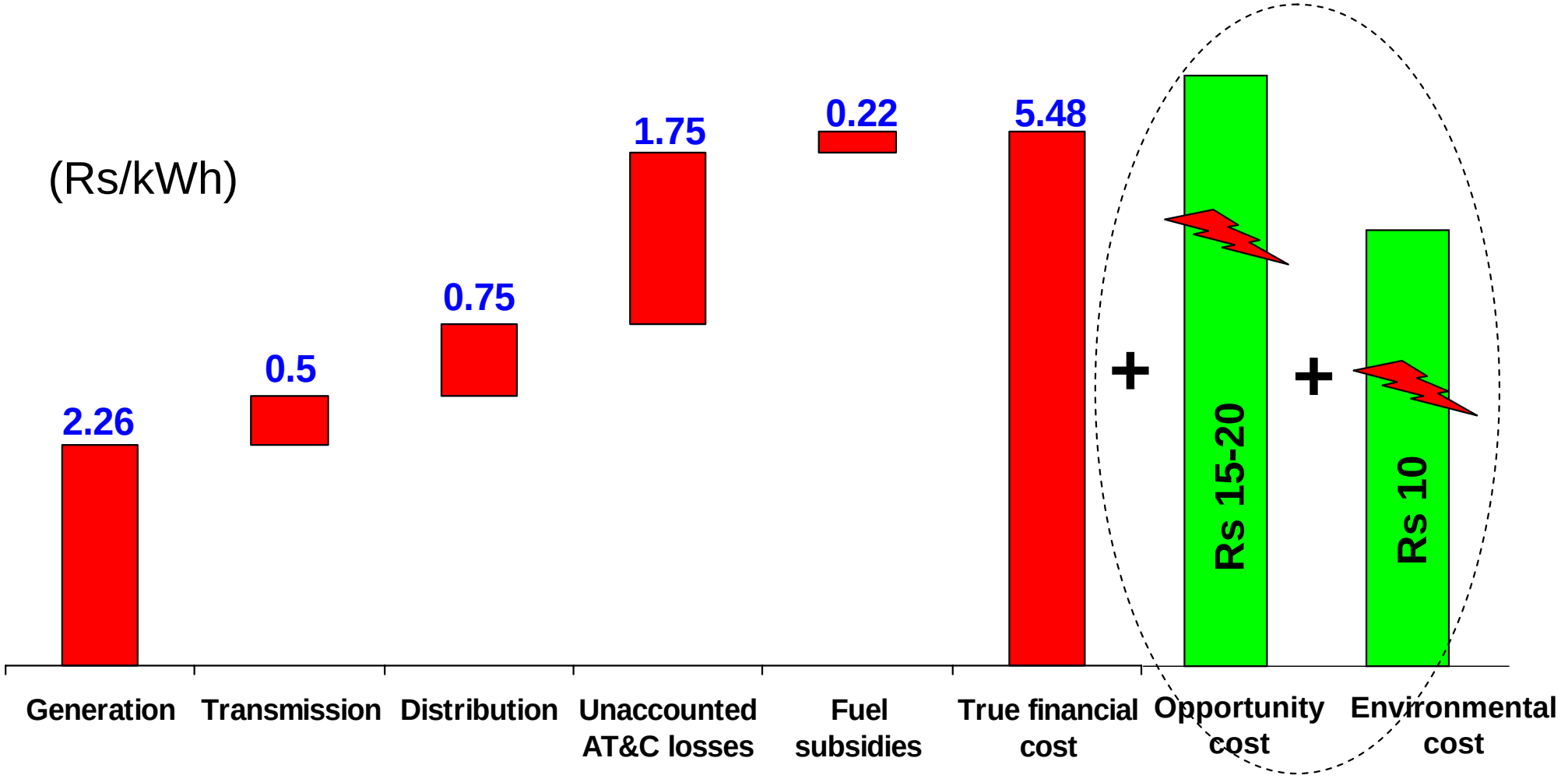
If environmental impact costs are factored in – the price of conventional electricity (produced from coal) would double!

* Source: ExternE Project, European Commission, 2005; www.externe.info

Other costs

- **Cost of litigation**
  - Several public sector projects in India, especially in the power sector, have been marred with public interest litigations (PILs) on environmental and other grounds
  - This delays on-the-ground implementation and undermines projects' profitability
- **Cost of de-electrification**
  - In villages where power supply does not reach despite being connected to the grid, theft of poles, wires and even transformers have been reported
  - The phenomenon of de-electrification further strains the financial viability of state utilities

The true cost of conventional power…



Note: The above are 'average' per unit cost estimates based on IMA India's desk research and interactions with industry experts and players

Conventional versus solar – urban areas

- Industry estimates suggest the average per unit cost of solar energy is Rs 15-20/kwh* – this is mainly on account of high capital costs
- At a macro level and in terms of pure financial costs, solar energy seems 'unfeasibly' high – 3-4 times higher than even the 'true' cost of conventional power i.e. Rs 5/kwh

However, when economic costs (environmental, opportunity, other systemic subsidies, etc) are accounted for, the picture changes dramatically… conventional power is not as cheap as people think!

** Assuming a Rs 17,550 solar home system (80W) used for 5 hours a day and depreciated over a period of 15 years at a discount rate of 8% results into a per unit cost of Rs 15/kwh*

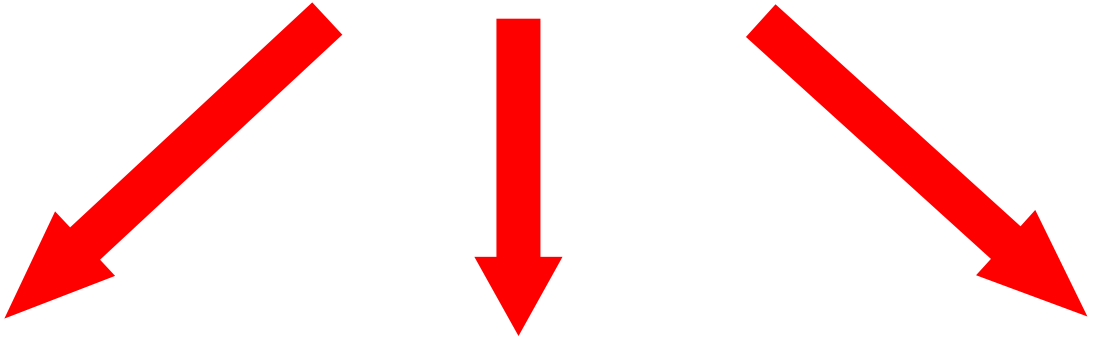
Conventional versus solar – rural areas

- In areas where a sub-transmission and distribution network is not present or not economical, a different model is needed i.e. in large parts of rural India, particularly remote and 'difficult' locations
- The delivered cost of conventional power needs to be separately computed for these areas
- This then would be compared to the cost of solar energy solutions to determine the feasibility of each alternative

Rural electrification economics

Viability of electrifying a village* with conventional power

Key determinants



- Distance from the grid
- Location of the village (the cost is higher in case of hilly areas, forests, etc)
- Number of households in the village

**Electrifying a village typically involves: laying an 11 kVA line, installing a transformer of 25/50/100 kVA capacity (depending upon the village population), laying a low tension distribution line in the village and laying distribution lines to households, internal wiring, fixtures, etc*

Grid extension costs: estimates/assumptions

Capital costs

- Cost of laying a 11KV line from a 33KV grid point: Rs 2.0 lac per km
- Cost of setting up a transformer and laying a low tension distribution line in the village: Rs 0.5 lac (25 kVA); Rs 0.75 lac (50 kVA); Rs 1.25 lac (100 kVA); Rs 2.00 lac (200 kVA)
- Cost of laying a distribution line to each household, internal wiring, fixtures, etc: Rs 1,500/household
- All capital costs have been depreciated over a period of 20 years at a discount rate of 8%

Annual O&M costs

- O&M costs have been assumed to be 2.5% of the total capital cost

Peak and average load

- Peak load has been assumed on the basis of the number of households in the village (i.e. 200-300 VA per household) and average load has been assumed to be 20% of the peak load

Cost of conventional power:

- The average cost of power at grid point has been assumed at Rs 3/kwh

The above cost estimates are based on IMA India's interactions with industry experts and hold true in the current operating environment. However, in view of the rising cost of steel, copper, aluminum, etc, these estimates may not hold in the future.

Distance-wise cost of extending grid: villages with population < 500 (219,595 villages)

Distance from the grid	Annualised capital cost (Rs)	O&M cost (Rs)	Total annual cost (Rs)	Cost of extending grid (Rs/kwh)	Cost of delivered power (Rs/kwh)
5	119,167	2,979	122,146	2.79	5.79
10	221,019	5,525	226,545	5.17	8.17
15	322,872	8,072	330,943	7.56	10.56
20	424,724	10,618	435,342	9.94	12.94
25	**526,576**	**13,164**	**539,740**	**12.32**	**15.32**
30	628,428	15,711	644,139	14.71	17.71
35	730,280	18,257	748,537	17.09	20.09
40	832,133	20,803	852,936	19.47	22.47
45	933,985	23,350	957,334	21.86	24.86
50	1,035,837	25,896	1,061,733	24.24	27.24
100	2,054,359	51,359	2,105,718	48.08	51.08
500	10,202,536	255,063	10,457,599	238.76	241.76

Peak load has been assumed at 25 KW and average load at 5 KW; average number of households (80)

Distance-wise cost of extending grid: villages with population between 500-1,000 (144,817 villages)

Distance from the grid	Annualised capital cost (Rs)	O&M cost (Rs)	Total annual cost (Rs)	Cost of extending grid (Rs/kwh)	Cost of delivered power (Rs/kwh)
5	127,825	3,196	131,020	1.50	4.50
10	229,677	5,742	235,419	2.69	5.69
15	331,529	8,288	339,817	3.88	6.88
20	433,381	10,835	444,216	5.07	8.07
25	535,233	13,381	548,614	6.26	9.26
30	637,086	15,927	653,013	7.45	10.45
35	738,938	18,473	757,411	8.65	11.65
40	840,790	21,020	861,810	9.84	12.84
45	942,642	23,566	966,208	11.03	14.03
50	**1,044,494**	**26,112**	**1,070,607**	**12.22**	**15.22**
100	2,063,016	51,575	2,114,592	24.14	27.14
500	10,211,193	255,280	10,466,473	119.48	122.48

Peak load has been assumed at 50 KW and average load at 10 KW; average number of households: 120

Distance-wise cost of extending grid: villages with population between 1,000-2,000 (129,662 villages)

Distance from the grid	Annualised capital cost (Rs)	O&M cost (Rs)	Total annual cost (Rs)	Cost of extending grid (Rs/kwh)	Cost of delivered power (Rs/kwh)
5	151,251	3,781	155,032	0.88	3.88
10	253,103	6,328	259,430	1.48	4.48
15	354,955	8,874	363,829	2.08	5.08
20	456,807	11,420	468,227	2.67	5.67
25	558,659	13,966	572,626	3.27	6.27
30	660,512	16,513	677,024	3.86	6.86
35	762,364	19,059	781,423	4.46	7.46
40	864,216	21,605	885,821	5.06	8.06
45	966,068	24,152	990,220	5.65	8.65
50	1,067,920	26,698	1,094,618	6.25	9.25
100	**2,086,442**	**52,161**	**2,138,604**	**12.21**	**15.21**
500	10,234,619	255,865	10,490,485	59.88	62.88

Peak load has been assumed at 100 KW and average load at 20 KW; average number of households: 240

Distance-wise cost of extending grid: villages with population between 2,000-5,000 (80,313 villages)

Distance from the grid	Annualised capital cost (Rs)	O&M cost (Rs)	Total annual cost (Rs)	Cost of extending grid (Rs/kwh)	Cost of delivered power (Rs/kwh)
15	402,316	10,058	412,374	1.18	4.18
20	504,168	12,604	516,773	1.47	4.47
25	606,021	15,151	621,171	1.77	4.77
30	707,873	17,697	725,570	2.07	5.07
35	809,725	20,243	829,968	2.37	5.37
40	911,577	22,789	934,367	2.67	5.67
45	1,013,429	25,336	1,038,765	2.96	5.96
50	1,115,282	27,882	1,143,164	3.26	6.26
100	2,133,804	53,345	2,187,149	6.24	9.24
150	3,152,326	78,808	3,231,134	9.22	12.22
200	**4,170,848**	**104,271**	**4,275,119**	**12.20**	**15.20**
500	10,281,980	257,050	10,539,030	30.08	33.08

Peak load has been assumed at 200 KW and average load at 40 KW; average number of households: 500

III. Solar versus Conventional Power:

Possible scenarios

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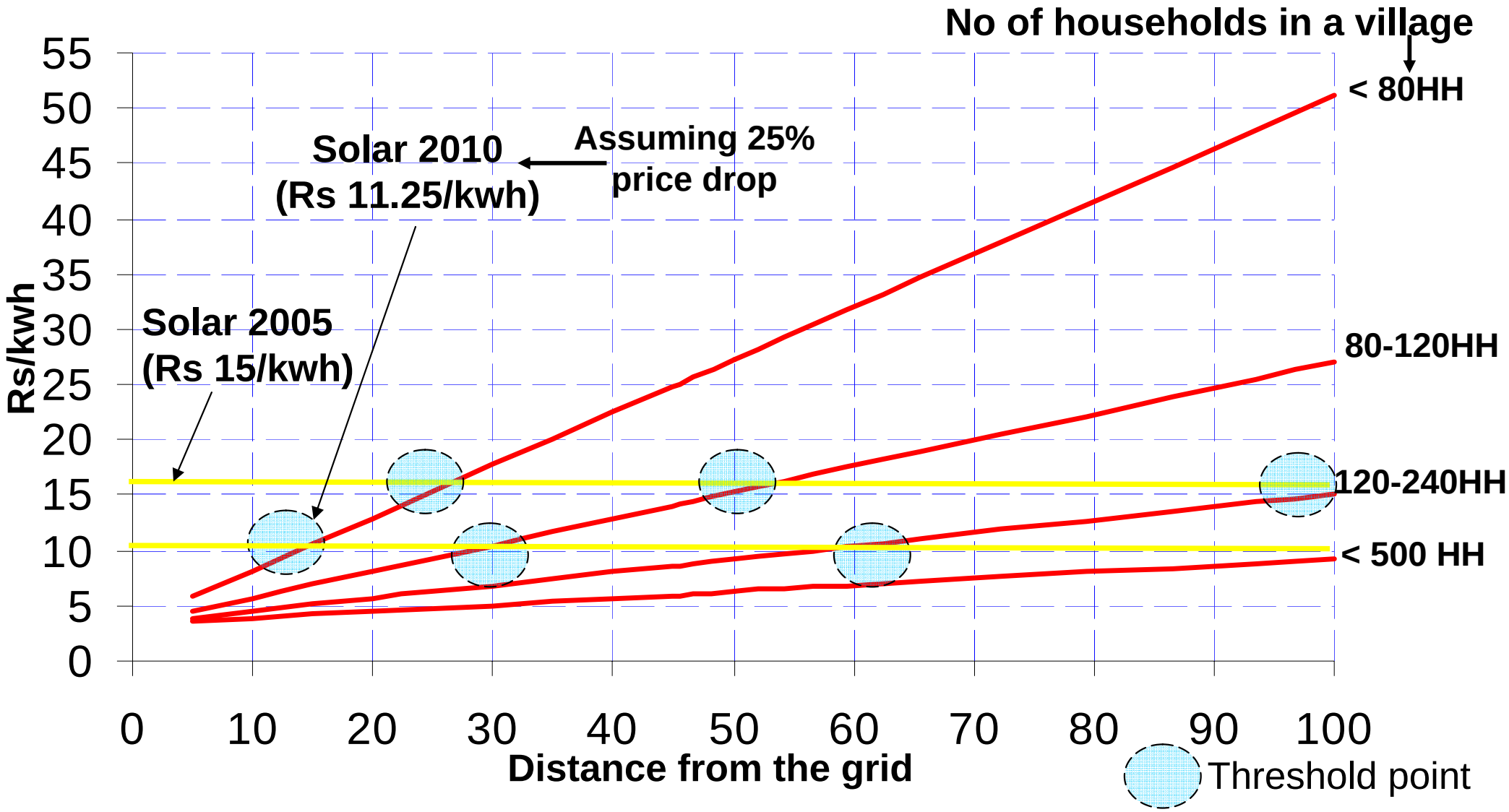
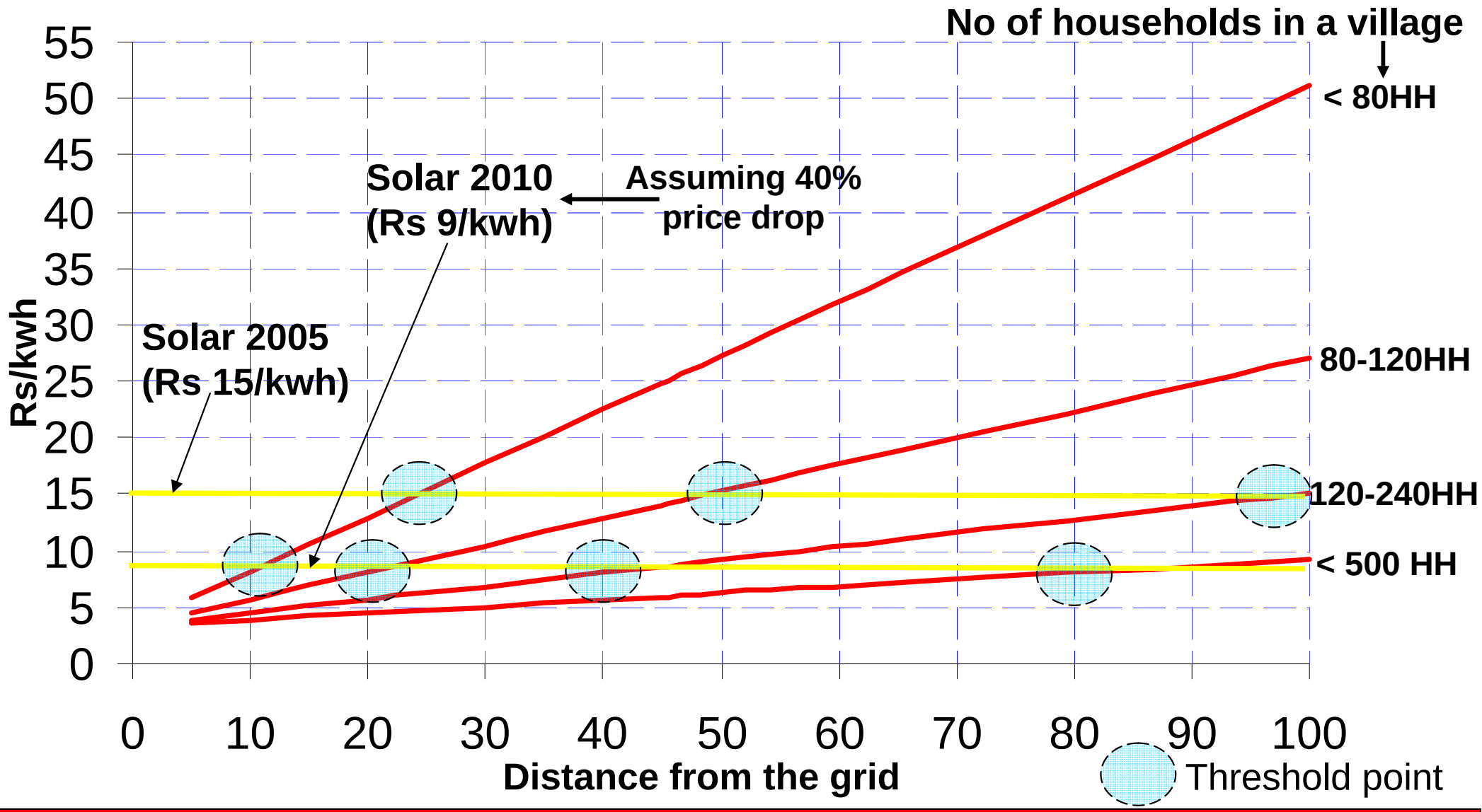
Solar versus conventional power: comparison

Current per unit solar cost of Rs 15/kwh with an expected price drop of 25% by 2010



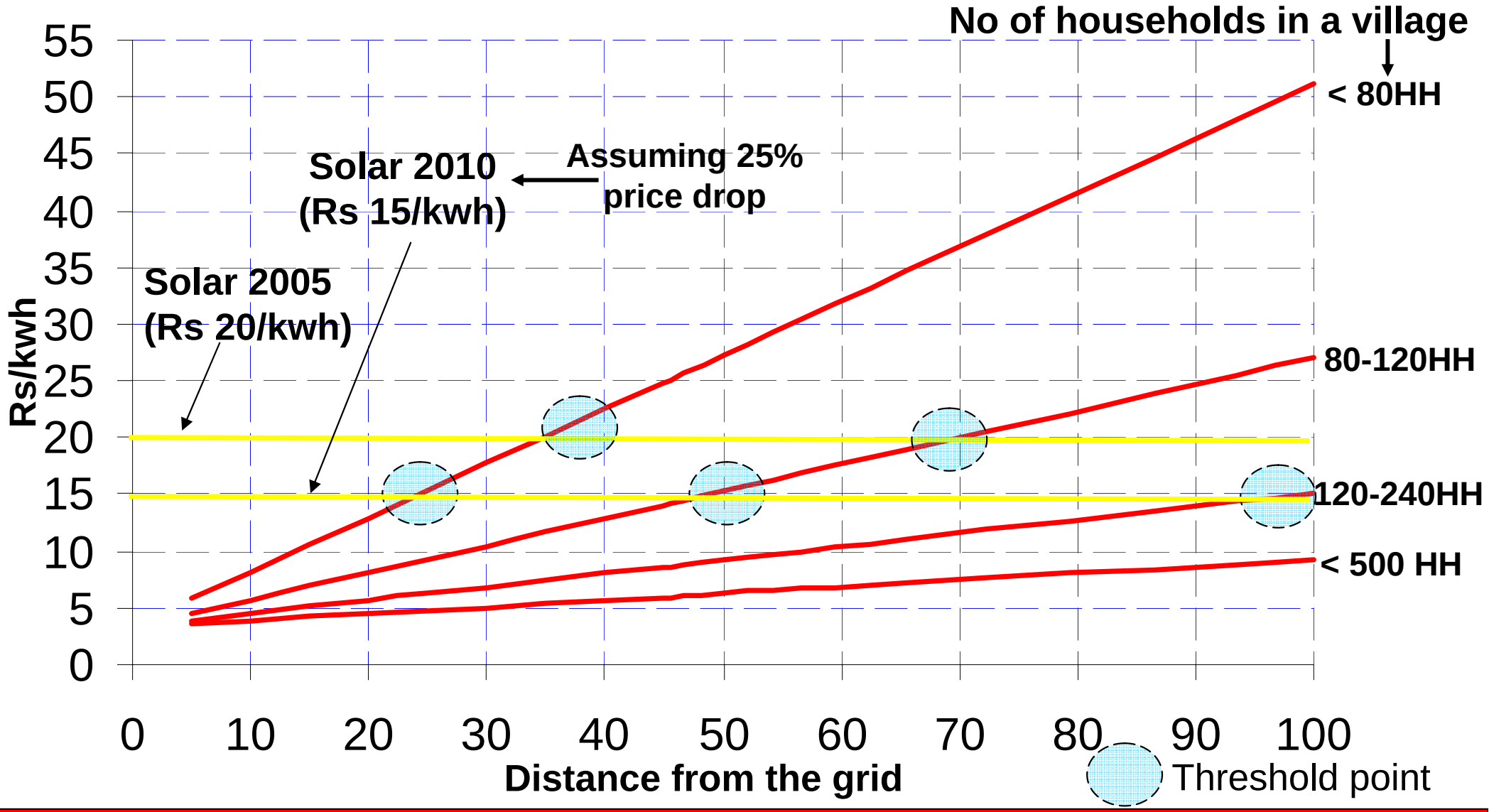
Solar versus conventional power: comparison

Current per unit solar cost of Rs 15/kwh with an expected price drop of 40% by 2010



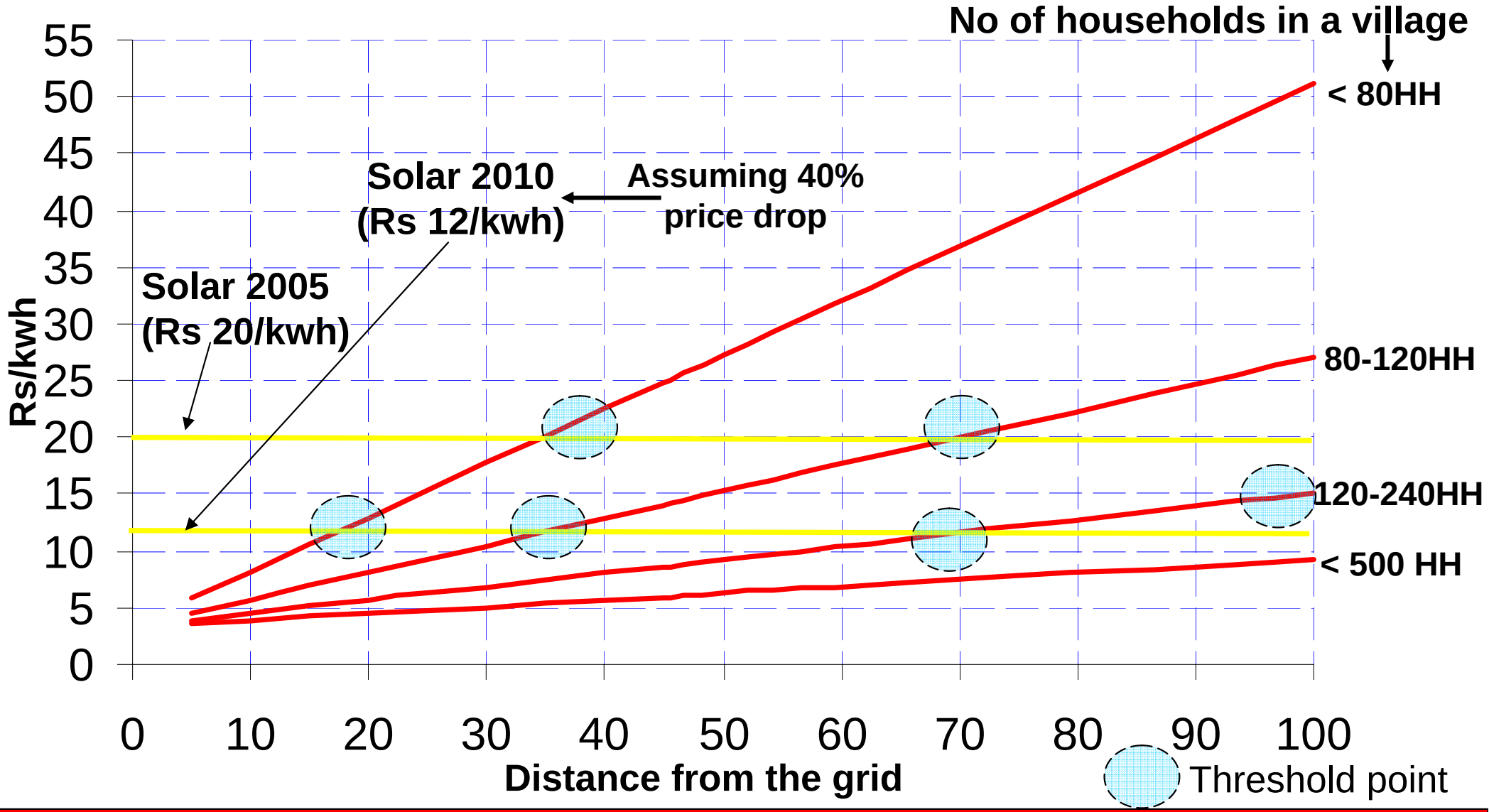
Solar versus conventional power: comparison

Current per unit solar cost of Rs 20/kwh with an expected price drop of 25% by 2010



Solar versus conventional power: comparison

Current per unit solar cost of Rs 20/kwh with an expected price drop of 40% by 2010



Conclusions

With current solar power cost: Rs 15/kwh

With a per unit cost of Rs 15/kwh, solar energy is more economical vis-à-vis conventional power, for villages with a population…

- Less than 500 people and located more than 25 kms away from the grid
- Between 500-1,000 and located 50 kms away from the grid
- Between 1,000-2,000 and located 100 kms away from the grid

In case of a 25% price drop, solar energy would become economical vis-à-vis conventional power, for villages with a population…

- Less than 500 people and located more than 16 kms away from the grid
- Between 500-1,000 and located 34 kms away from the grid
- Between 1,000-2,000 and located 68 kms away from the grid
- Between 2,000-5,000 and located 100 kms away from the grid

In case of a 40% price drop, solar energy would become economical vis-à-vis conventional power, for villages with a population…

- Less than 500 people and located more than 10 kms away from the grid
- Between 500-1,000 and located 20 kms away from the grid
- Between 1,000-2,000 and located 40 kms away from the grid
- Between 2,000-5,000 and located 80 kms away from the grid

Conclusions

With current solar power cost: Rs 20/kwh

With a per unit cost of Rs 20/kwh, solar energy is more economical vis-à-vis conventional power, for villages with a population…

- Less than 500 people and located more than 35 kms away from the grid
- Between 500-1,000 and located 70 kms away from the grid

In case of a 25% price drop, solar energy would become economical vis-à-vis conventional power

- Less than 500 people and located more than 24 kms away from the grid
- Between 500-1,000 and located 48 kms away from the grid
- Between 1,000-2,000 and located 100 kms away from the grid

In case of a 40% price drop scenario, solar energy would become economical vis-à-vis conventional power

- Less than 500 people and located more than 18 kms away from the grid
- Between 500-1,000 and located 35 kms away from the grid
- Between 1,000-2,000 and located 70 kms away from the grid

IV. Constraints to the growth of solar energy in India and suggested measures

Enormous potential… but where is the growth?

- India is possibly the only country in the world to have an exclusive Ministry for non-conventional energy resources… *yet renewable energy accounts for only 3% of the total installed power capacity*
- India has one of the largest solar energy programmes in the world… *but solar energy accounts for only 0.2% of total electricity production*
- Countries like Japan and Germany are adding more capacities annually than India's total cumulative solar PV capacity… even emerging economies like Thailand, Korea, China, etc have launched ambitious solar programmes

Clearly, there is an urgent need to revisit the current policy and regulatory framework to realise the true potential of solar energy in India

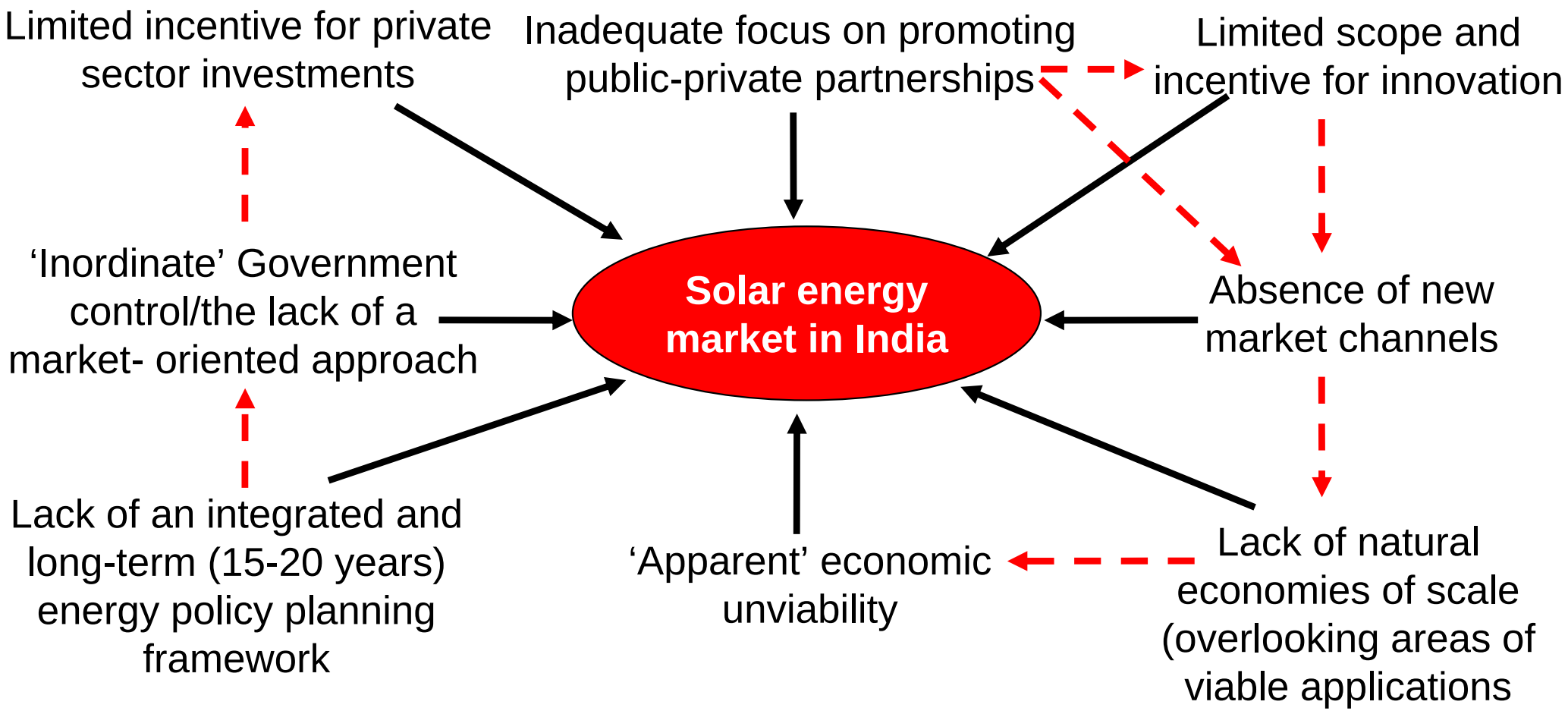
Key constraints

- **'Un-integrated' Government intervention**
  - The absence of an 'integrated' and 'long-term' (15-20 years) energy policy planning and monitoring framework… no binding targets, supportive reform, etc
  - Encouraging 'capacity creation' as against 'adoption and generation' of solar energy... no natural economies of scale, resulting in a market completely dependent on the Government
  - Government distribution through heavy capital subsidy… little focus on maintenance, training, repair, etc
  - Solar energy relevant and important only in the context of rural electrification… limited effort to tap the 'environmentally-conscious' urban consumer
  - Viewed as a 'nice-to-do' social cause as against a 'strategic' activity

Key constraints (2)

- **Limited scope for innovation**
  - Government sets the standards/specs… producers have no direct interface with end-users resulting in limited scope for product improvement and enhancement
  - Existing market framework stifles 'quality' competition, product innovation and development of new market channels
- **Inadequate focus on promoting public-private partnerships**
  - Limited scope for sharing technology, knowledge, etc
  - Independent measures undertaken by private entities (mainly NGOs) remain limited to village/district-level
- **The myth that the cost of solar energy is 'prohibitively' higher than conventional electricity**
  - Inadequate policy focus to determine parameters that impact 'real' costs of conventional power; need for paradigm shift

The vicious cycle… stifling solar energy growth

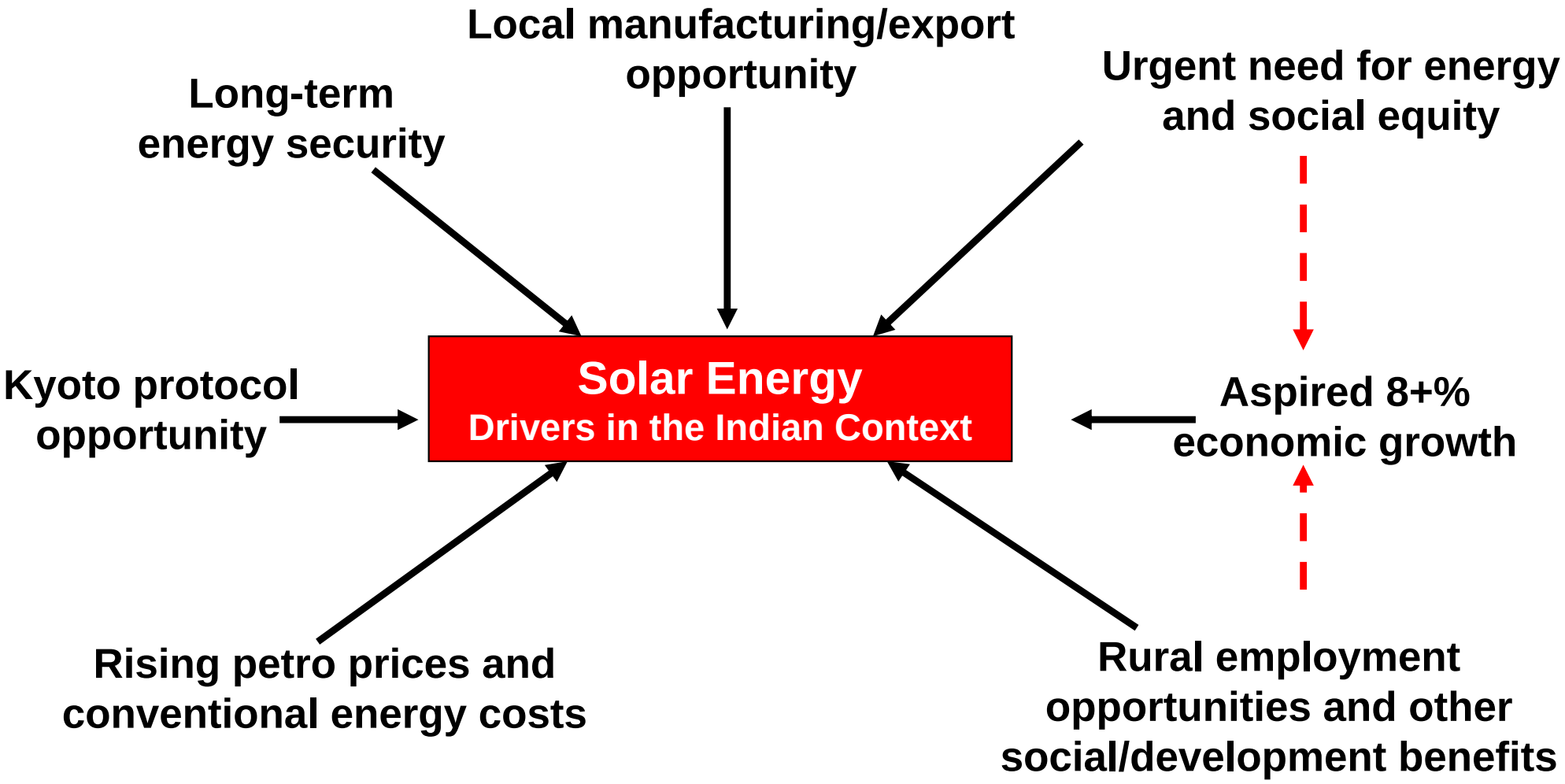


Need for an 'integrated' and 'long-term' (15-20 years) policy as against piece-meal measures

Drawing from international experience

- The international experience with solar energy offers important policy insights for India
- Solar energy has grown rapidly in developed countries like Germany, Japan, USA, Spain, etc and emerging economies like China, Korea, Thailand, etc due to innovative new policies that **rewarded consumers** (urban and rural, household and industrial) **for the use of solar energy** – rather than merely subsidising the purchase of solar modules (not sustainable and growth-inducing)
- The essential elements of these policies have been:
  - An 'integrated' and 'long-term' (15-20 years) approach
  - Binding and serious targets
  - Fiscal and other incentives to generate and use solar energy with the objective of creating natural economies of scale
  - Free electricity markets; availability of the grid to absorb excess solar energy produced

India's case is even stronger!



More than enough reason for solarising India!

Policy recommendations for India

The Government must consider **encouraging 'generation and adoption' as against only 'capacity creation'** – so that natural economies of scale could emerge

- adopt a mix of short term policies (aimed at correcting the skew caused by previous policies) and long term policies (aimed at developing a consistent strategy towards solar energy adoption)
- adopt a distinct approach towards urban and rural markets
- follow the guiding principle of leveraging India's strengths to adopt solar energy for its inherent benefits – not as an 'allied' activity undertaken for 'social' reasons

The guiding principles…

- Solar energy **should not be approached only as the 'poor man's' source of energy**, but as an internationally emerging, convenient and decentralised new source of energy for all users
- A **unified national approach** to solar energy development as an alternative, or supplement, to conventional energy is crucial
- Solar energy **should be viewed as a strategic tool** in the context of **India's long-term energy security** and the need to leverage the **opportunity under the carbon trading mechanism of the 'Kyoto protocol'**
- The Government should **promote public-private partnerships** to **encourage innovation and technology advancement**
- Given India's huge solar energy potential and R&D strengths in electronics, engineering, etc, the Government should aim to **develop India as a global solar PV manufacturing hub** and, equally, **promote solar hybrid energy systems** – this will help achieve economies of scale, an overall development of the renewable energy market and bring down solar energy prices

Policy recommendations
'Correcting the skew' in rural India

- Re-orient subsidy mechanisms to encourage ongoing consumption of solar energy, not just (one-time) generation e.g. replace pure capital subsidies with a mix of capital and tariff/maintenance subsidies
- Create a greater role (and responsibility) for the private sector i.e. encourage competition and direct customer interface; this will help to drive down prices and bring in innovative delivery mechanisms as companies look to capture market share i.e. creating a market-mechanism as against price-prescription mechanism
- Encourage the adoption and use of solar PV water pumping systems through capital subsidy and maintenance support
- Promote post-sale service as an income generating/employment opportunity for the local population

Policy recommendations: Rural India (2)

- Prioritise areas suitable for solar energy programmes – this should include a mix of
  - Remote and difficult villages (for whom conventional energy sources are expensive/impossible to provide vis-à-vis solar energy – see preceding economic feasibility analysis)
  - main-stream villages (for whom solar energy can become a reliable supplement to erratic conventional power supply)
- Government should play the role of a facilitator, not only that of a procurer i.e. it should
  - formulate guidelines and standards (in terms of product standards, maintenance services, repair facilities, user training) to ensure 'orderly involvement' of the private sector - existing international standards can be adopted in this context
  - provide information support and awareness to villagers
  - Endorse credible private players and NGOs to encourage accountability

Policy recommendations: Urban India

- Adapt successful models of other countries to encourage urban citizens to purchase solar energy (to supplement conventional power) – as well as successful models in India itself
- Create awareness and publicity about (the benefits of) solar energy – set guidelines and standards to protect consumer interests i.e. play the role of a facilitator and ombudsman
- Leverage the higher awareness levels and environment-consciousness of urban citizens to promote solar energy as a 'desirable and sustainable' option

Setting 'showcase' stories by exhorting and incentivising large corporate houses could set a direction for the whole country!

Policy recommendations: Urban India (2)

- Offer incentives in the form of income/sales tax exemption on expenditure on solar energy – but otherwise allow economics to be determined by market forces i.e. do not subsidise
- Encourage solarised buildings/structures i.e. residential, offices, petrol pumps, schools, parks, etc (solar water heating systems, lighting, etc)
- Promote 'pooled' expenditures – e.g. by groups of households, resident's welfare associations, builders and developers to bring down the per-unit cost for individual households and create scope for economies of scale *(global experience suggests that costs fall by 20% when capacity doubles)*

Policy recommendations: Urban India (3)

- Also extract learnings from other 'voluntary' initiatives such as rainwater harvesting in major cities, which function on similar principles
- Mandate Oil Marketing Companies (OMCs) to solarise roofs of at least 5% of their petrol-pumps… offer supporting tax exemptions and depreciation benefits; offer CDM auditing and carbon credit monetising assistance, etc
- Encourage the adoption of solar water heating/lighting systems among urban population at the individual citizen-level… offer property tax credits (compensate state Governments, if required)

Longer term policy recommendations

- Introduce **wheeling and banking for solar energy** (as for wind energy) – to promote large plants with greater economies of scale in sunny areas
- **Set and guarantee favourable tariffs for grid feed-in by solar IPPs**
- **Incentivise and reward industrial users** to adopt solar energy (e.g. as in wind energy) by way of tax exemption, depreciation, etc
- **Foster new models of bank financing** for solar entrepreneurs and users e.g. include solar energy under 'priority sector lending' for banks
- Leverage the **opportunity under the carbon trading** mechanism of the Kyoto protocol – a USD 150 billion opportunity globally

Policy recommendations: long term (2)

- Promote the development and adoption of solar-hybrid energy systems – an orderly development of the renewable energy market in the country
- Encourage domestic R&D and manufacturing through tax breaks and other incentives – leverage India's strengths to develop the country as an export hub for PV cells
  - India has significant strengths in electronics and hi-tech R&D
  - Most of the world's largest electronics companies are using India's R&D expertise to develop high-end applications for global markets

Above all, work towards an integrated approach towards the replacement/supplementing of conventional energy by renewable energy – requires close coordination between several Ministries (Power, Petroleum and Natural Gas and Non-conventional Energy Sources)

Conceptual delivery model… empowering people

- Encourage an Energy Service Agent (ESA) in every village
- ESAs to act as a three-way interface between the service provider, villagers and the Government(s)
- ESAs to coordinate electrification and other activities i.e. maintenance, collection of charges, disbursement of credit, etc
- ESAs to be responsible for the individual consumer (rural household) accountability and the quality of service rendered by the service provider
- ESAs to also educate and train villagers on the efficient usage of electricity and other related areas

V. Solarising Rural India: An implementation roadmap

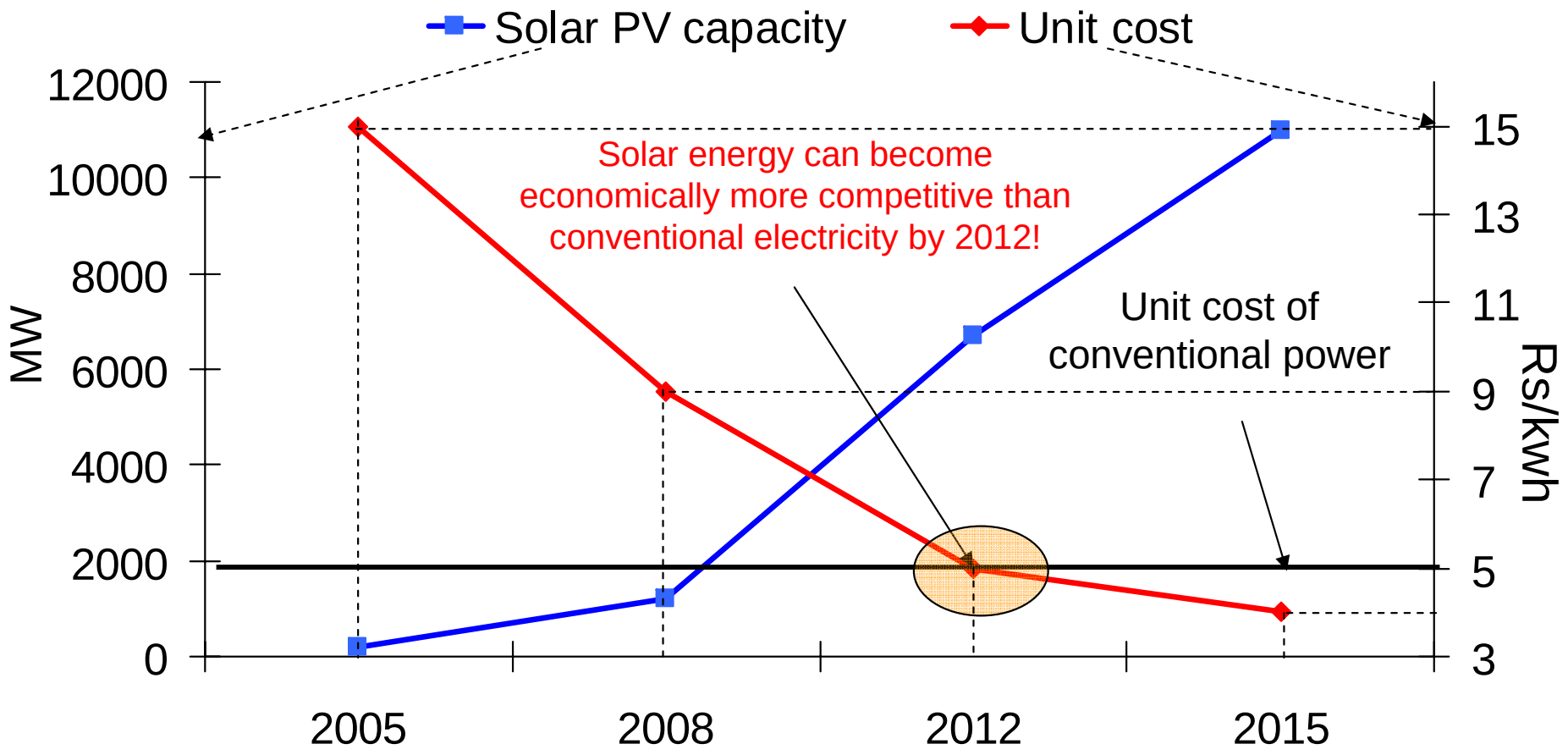
Solarising rural India: the potential

Some assumptions…

- A Solar Home System (a 80 Wp solar PV module) for every un-electrified rural household
  - Two CFL lights of 9W each, one fan or portable TV
- 1 kW of solar module/plant per 200 rural households for community lighting and related purposes
- Solarising un-electrified water pumps (there are an estimated 7 million pump sets that still needs to be energised) with a 700 W solar PV plant/module (~ 1 HP)

Basis our assumptions, the total potential for solar in the context of un-electrified villages could exceed 11,000 MW

Economies of scale will further drive the growth!



Global experience suggests that costs fall by 20% when capacity doubles… initial momentum can make the sector self-sustaining!

Solarising rural India: the roadmap

Targeting to solarise all villages with population less than 500 and villages in remote/difficult locations, by 2020 i.e. approximately 250,000* villages/27.7 million households *(this essentially includes un-electrified villages and other villages, though stated as electrified, where the extended grid is economically unviable)*

- Phase I-Mission mode (2006-2010)**:** 7.3 million rural households **in villages of population between 1000-2000 at a distance of more than 100 km from the grid**
- Phase II (2011-2015)**:** 10.3 million rural households **in villages of population between 500-1000 at a distance of more than 50 km from the grid**
- Phase III (2016-2020)**:** 10.1 million rural households **in villages of population less than 500 at a distance of more than 25 km from the grid**

** Total villages with population between 1000-2000, 500-1000, 0-500: 129,000, 144,000, 219,000 respectively; assumed average population: 1500, 750, 350 respectively; assumed household size: 5.3 individuals; assumed 20%, 50%, 70% villages are located more than 100 km, 50 km, 25 km respectively from the grid*

Solarising Rural India: Phase I (2006-2010)

Phase I-Mission mode (2006-2010): 7.3 million rural households in villages of population between 1000-2000 at a distance of more than 100 km from the grid

- a 80 Wp SHS for every household (two CFL lights of 9W each for 4-5 hours a day, one small fan or small portable TV)
- 1 kW solar PV plant per 200 households for community and street lighting and related purposes (i.e. 36,500 plants)
- estimated cost: Rs 10,422 crores^ (over 5 years) i.e. Rs 2,084 crore per annum

Subsidy outlay with 75% subsidy: Rs 7,800 crore i.e. Rs 1,560 crore per annum

^ Expecting the economies of scale effect, the average cost of a SHS, a CFL bulb and a 1kW SPV plant is assumed at Rs 12,500, Rs 100 and Rs 3,00,000 respectively

Solarising Rural India: Phase II (2011-2015)

Phase II (2011-2015): 10.3 million rural households in villages of population between 500-1000 at a distance of more than 50 km from the grid

- a 80 Wp SHS for every household (two CFL lights of 9W each for 4-5 hours a day, one small fan or small portable TV)
- 1 kW solar PV plant per 200 households for community and street lighting and related purposes (i.e. 51,500 plants)
- estimated cost: Rs 11,640 crores^ (over 5 years) i.e. Rs 2,328 crore per annum

Subsidy outlay with 50% subsidy: Rs 5,820 crore i.e. Rs 1,164 crore per annum

^ Expecting the economies of scale effect, the average cost of a SHS, a CFL bulb and a 1kW SPV plant is assumed at Rs 10,000, Rs 80 and Rs 2,40,000 respectively

Solarising Rural India: Phase III (2016-2020)

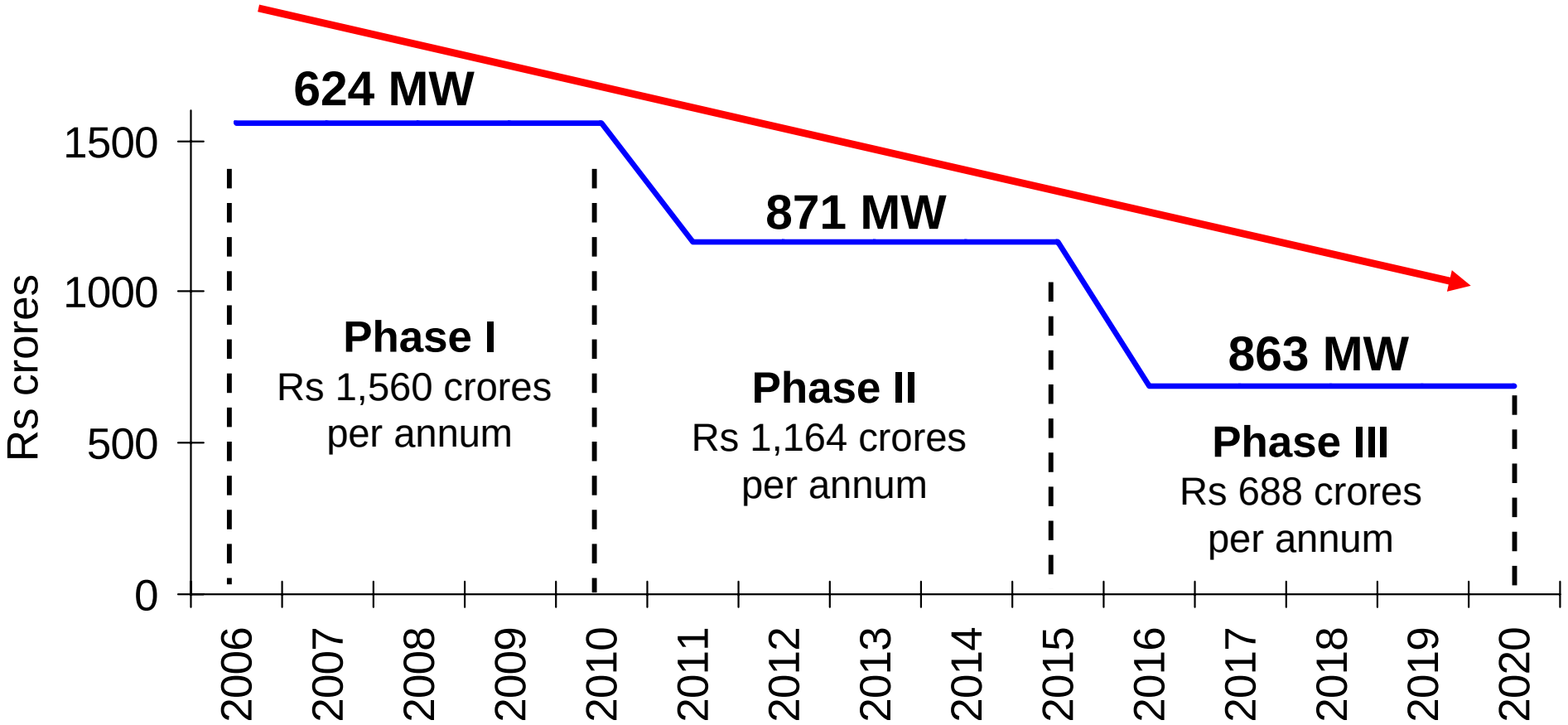
Phase III (2016-2020): 10.1 million rural households in villages of population less than 500 at a distance of more than 25 km from the grid

- a 80 Wp SHS for every household (two CFL lights of 9W each for 4-5 hours a day, one small fan or small portable TV)
- 1 kW solar PV plant per 100 households for community and street lighting and related purposes (i.e. 10,100 plants)
- estimated cost: Rs 11,471 crores^ (over 5 years) i.e. Rs 2,294 crore per annum

Subsidy outlay with 30% subsidy: Rs 3,440 crore i.e. Rs 688 crore per annum

^ Expecting the economies of scale effect, the average cost of a SHS, a CFL bulb and a 1kW SPV plant is assumed at Rs 9,000, Rs 70 and Rs 2,16,000 respectively

Solarising rural India: the subsidy outlay



Appears too ambitious…?

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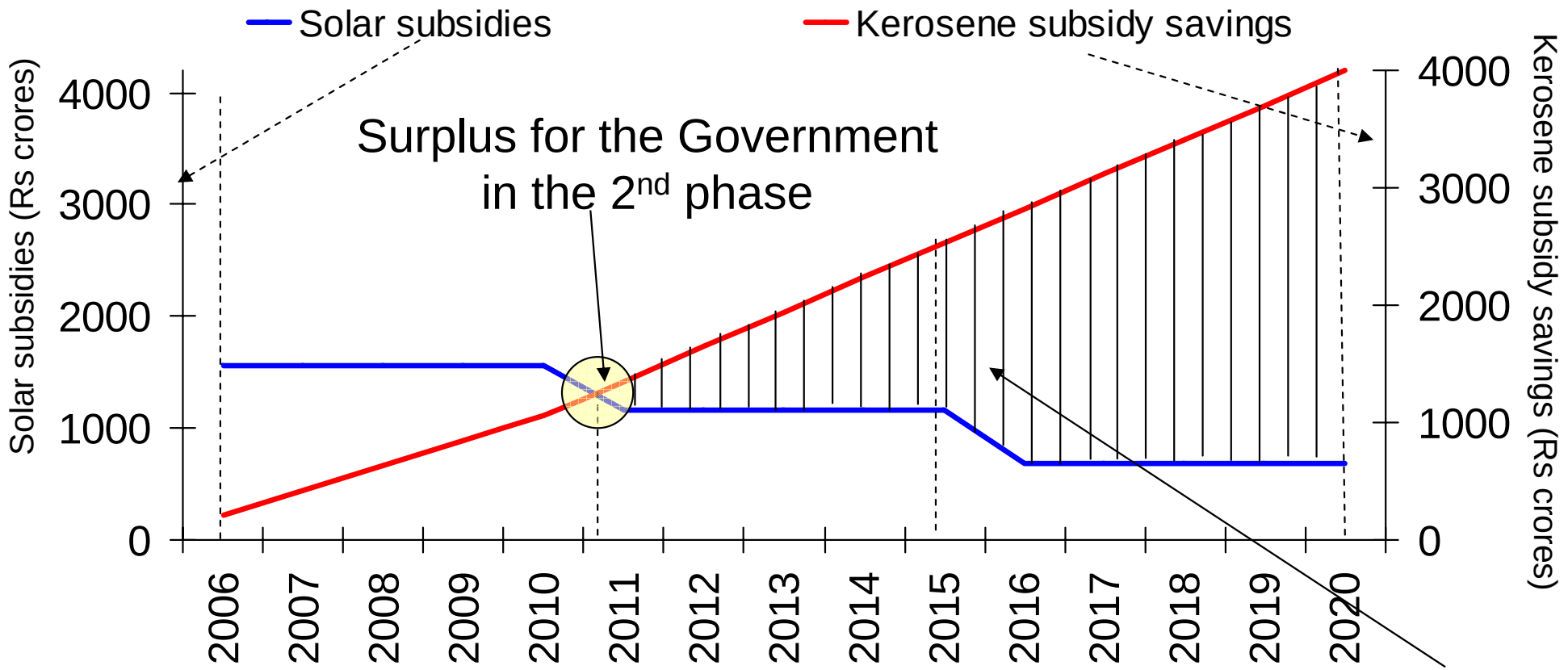
Kerosene subsidy savings…

…surplus for the Government by 2011



Kerosene subsidy savings*:

- Phase I: Rs 211 crore per annum (for 7.3 million households)
- Phase II: Rs 506 crore per annum (additional 10.3 million households)
- Phase III: Rs 798 crore per annum (additional 10.1 million households)

*Assuming a consumption of 10 litres/month/household, subsidised @Rs 12 litre

Funding mechanisms

- **Rural Energy Equity Central Cess**:
  - 2 paisa per unit of conventional power generated (also applicable to captive power plants that wish to feed their surplus power to the grid)
  - Expected mop-up ~ Rs 1,100 crores per annum *(likely in increase as utilities add capacities)*
- **Solarising Rural India Bonds**:
  - 5-10 year tax-free bonds with coupon rate of 6-9% to collect up to Rs 1,000 crore; of this a certain proportion to be compulsorily subscribed by conventional power companies according to the following principle
    - each company to invest a minimum of 1-2% of average net profits of last three years (1% for companies with revenues below Rs 500 crore and 2% for companies with revenues above Rs 500 crore); optionally, the coupon rate can be reduced by 1% for these subscriptions
  - Expected mop-up ~ Rs 400-500 crores

Funding mechanisms (2)

- **Savings on account of lower kerosene subsidies**
  - solarising rural households will help the Government eliminate kerosene subsidies in the long-run
  - basis our assumptions, the Government could see a surplus (after adjusting for solar subsidies) by 2011
- **States' contribution**:
  - Encourage beneficiary states to contribute a total of Rs 1,000 crores (over 5 years) – on the lines of APDRP
- **Monetising carbon credits**
  - the average price of one carbon credit is around USD 5 (likely to go up as the market develops)
  - Solarising India programme has the potential to generate in excess of Rs 100 crores/annum* from carbon credits (a conservative estimate)

*estimated on the basis of per tonne CO_2 not emitted into the environment as a result of the solar energy

Funding mechanisms (3)

- **Foster new models of bank financing for solar entrepreneurs and users**
  - including renewable energy funding under priority sector lending
  - leverage the rural infrastructure created by industry
  - facilitating micro-credit/financing to ESAs

In summary… funding subsidy outlay

	Subsidy* ***(Rs crore)***	**Funding*** ***(Rs crore)***	**Key funding measures**
Phase I (2006-10)	Rs 1,560	>Rs 1,600	Rural Energy Equity Cess^, Solarising Rural India Bonds, Kerosene subsidy savings, states' contribution
Phase II (2011-15)	Rs 1,164	> Rs 1,200	Rural Energy Equity Cess (could be reduced to 50%), Kerosene subsidy savings, states' contribution
Phase III (2016-20)	Rs 688	> Rs 700	Kerosene subsidy savings

** per annum*
^ 2 paisa per unit

IMA Research for Strategy

IMA India

107 Time Square, Sushant Lok I, Block B

Gurgaon 122002, Haryana, India

Tel: +91 124 4591 200 Fax: +91 124 4591 250