Deloitte.

Rooftop Solar PV in India

Addressing Policy, Regulatory & Operational Barriers

February 2014

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Concept of Rooftop Solar – Benefits & Concerns

Solar Policy environment in India

- Government of India launched the Jawaharlal Nehru National Solar Mission (JNNSM) in 2009 to increase share of solar energy with following targets:

S. No	Application Segment	Target for Phase 1 (2010-13)	Target for Phase 2 (2013-17)	Target for Phase 3 (2017-22)
1	Solar Collectors	7 Million Sq meters	8 Million Sq meters	5 Million Sq meters
2	Off Grid Solar applications	200 MW	800 MW	1000 MW
3	Utility grid power, incl'ng roof top	1000 MW	3000 MW	16000 MW

- JNNSM also induced several states such as Gujarat, Karnataka & Rajasthan, to develop their own solar policies. Installed capacity has risen to approx 1 GW in 2 years with JNNSM & Gujarat Policy leading the way in capacity additions.
- JNNSM identified rooftop solar PV as one of the categories of solar projects.

"The Mission will encourage rooftop solar PV &other small solar power plants, connected to LV/11 KV grid, to replace conventional power and diesel-based generators. Operators of solar PV rooftop devices will also be eligible to receive the feed-in tariff fixed by the central level regulator….both on the solar power consumed by the operator and the solar power fed into the grid. "

- **Rooftop Solar PV has however gained little traction with most capacity additions being in the grid connected utility scale projects.**

Grid Connected Solar Energy Project Development

Grid-connected Solar Energy Project Deployment

Globally, grid-connected solar project development has followed 2 broad routes:

- **Utility driven solar project development:** Large MW-scale centralized solar projects developed to meet renewable purchase obligations (RPO) of the utilities – either developed by utilities themselves or by third parties for their procurement.

- **Customer driven solar project development:** Small-scale decentralized projects developed by electricity consumers on their own premises. Interest fueled by the declining cost of solar energy, fiscal incentives like feed in tariffs (FiT's), net metering and tax rebates, coupled with the increase in the cost of grid based conventional energy.

Several hybrids of the above routes have emerged in specific markets, depending on the regulations, market opportunities and role of intermediaries.

Roof top Solar Power – The Concept

The Concept

- Every building whether home, industry, institution or commercial establishment can generate some solar power by installing PV panels on the rooftop

Some Key Benefits

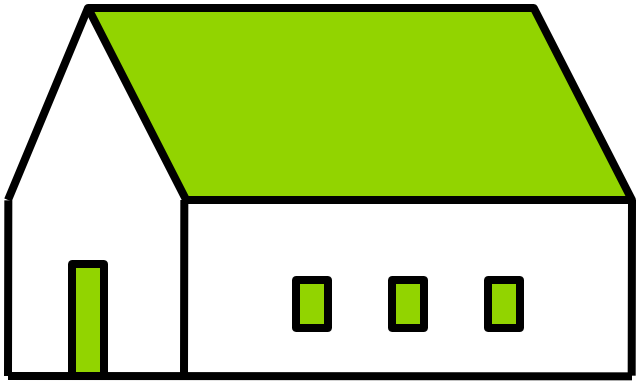
- Photovoltaic roof-top installations at the tail-end of the grid can enhance grid-stability and reduce losses
- Savings in land requirement and costs
- Savings in development of new transmission infrastructure
- Creation of value from under-utilized /unutilized rooftops
- Good choice for distributed power generation system

Gross Metered Rooftop solar

Photovoltaic Panel
(Approx. 1 - 5kW$_P$)

Grid-tied
inverter

Meter 2: Solar Electricity
Generation

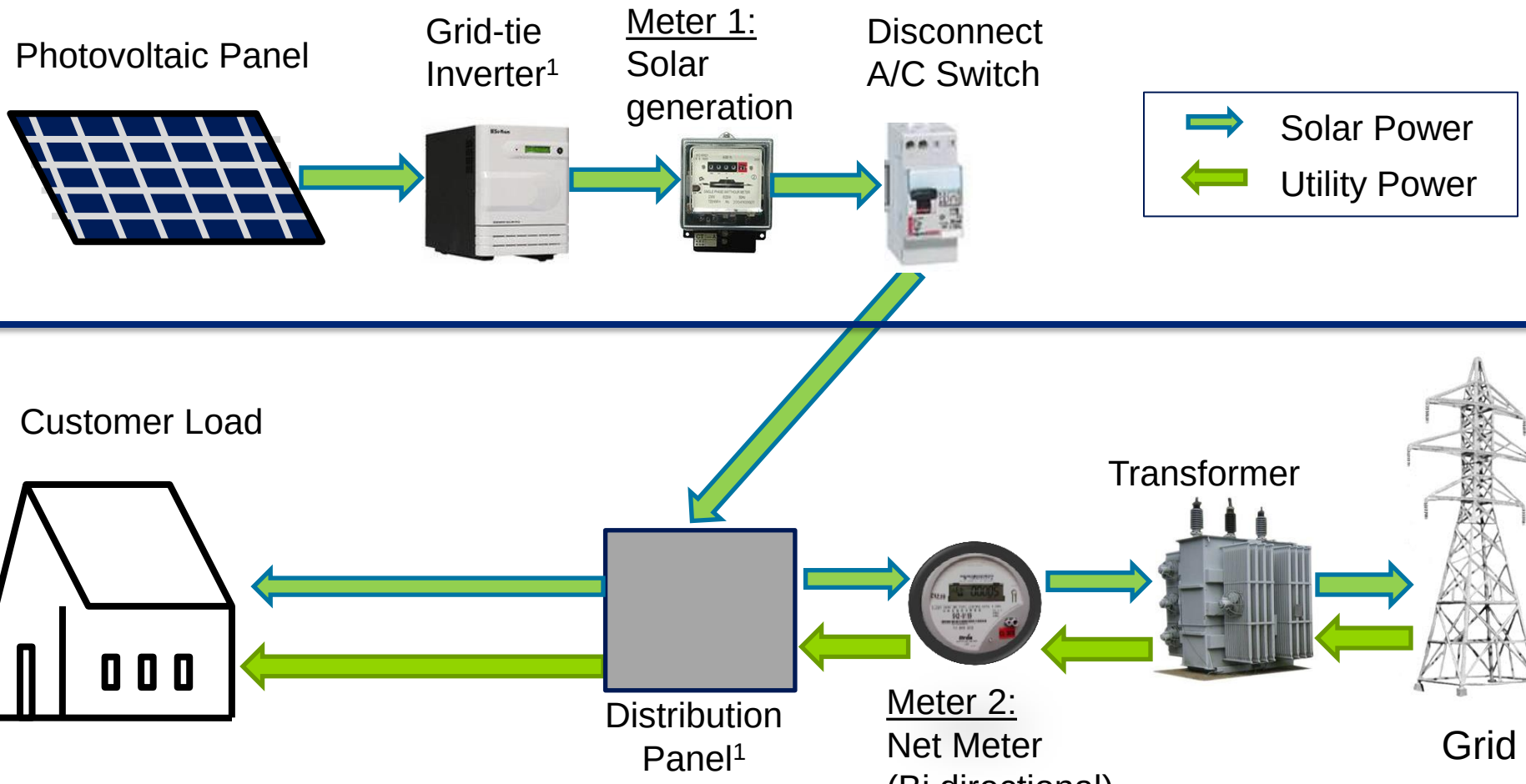


Meter 1: Conventional
Electricity Consumption

Transformer

Grid

Net-Metered Rooftop solar



1 – Option 2: Inverter with Consumer distribution panel.

Phases in rooftop market development

Key focus - demonstration PPP projects in India to:

- showcase technical & financial feasibility of rooftop solar PV.
- provide insights to policy makers to envisage implementation models and capacity targets.
- reveal implementation issues to move market towards self-replication phase.

Indian Pathway

Internationally

Proof of Concept Phase

E.g:

- Japan's Monitoring Programme for Residential PV Systems
- Germany's 1,000 rooftop programme

Market Transformation Phase

- Clearer policies, regulations, models & capacity targets
- Gross metering on PPP
- Net-metering guidelines for self-replication.

- Focus to build capacity in market
- Government or public agencies play an active role as market facilitator.
- E.g. Germany's 100,000 rooftop programme.

Mature Self-Replication Phase

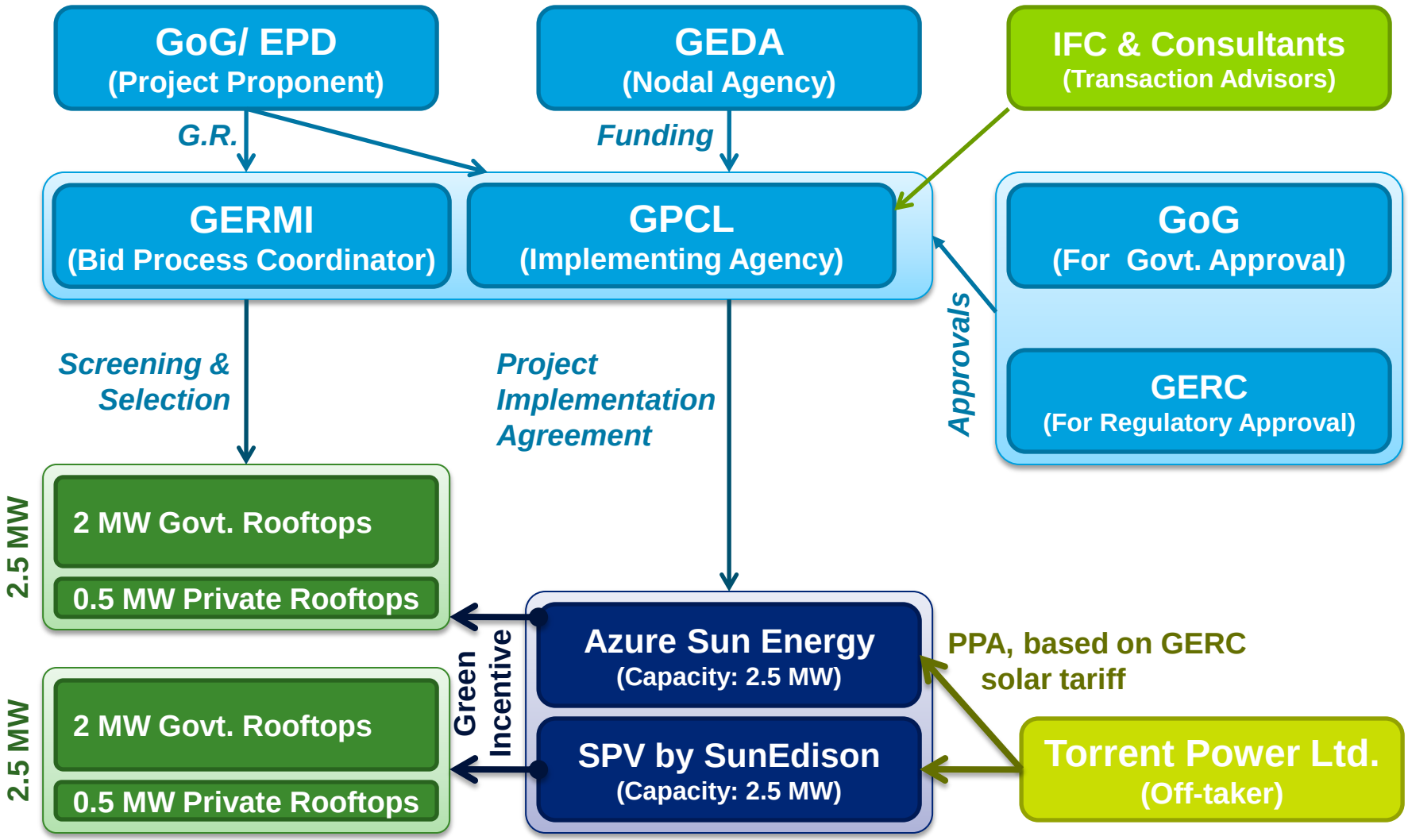
- Self-replicating Net Metering facilitated by enabling regulations & incentives
- Self-replicating Gross Metering facilitated by GBI & capacity targets

- e.g. Japan, Germany & US
- New implementation models emerge which drive the market towards greater efficiency
- Government inputs are minimal with focus on providing a facilitating regulatory environment

Experience in Other Countries

Key components for development of rooftop solar PV programmes	Germany	Japan	California
Incentive structures	• FIT, periodically updated	• Capital subsidy, Renewable Purchase Obligation	• Capital subsidy , tax credits, rebates
Long-term project viability	• Long-term FIT guarantee • Public participation in enhancing financing • Streamlined interconnection & permitting processes	• Soft financing • Streamlined interconnection and administrative approval processes	• Emergence of third-party service providers who take on the risks associated with the development and performance of the system
Metering arrangements	• Gross metering till now • Piloting net metering	• Net metering	• Net metering
Implementation (business) models	• Income from preferential tariff	• Savings in electricity bill	• Savings in electricity bill for rooftop owners • Lease payments and tax benefits to project developer or owner
Reasons for Programme Structure	• FiT's (gross metering) to encourage solar project development independent of the captive load of the consumers	• Higher retail tariffs & promotion of captive consumption were the key factors for choice of net metering	• Use of the net metering mechanism allowed regulators to facilitate the development of decentralised solar systems without significant cooperation from electricity utilities

Gandhinagar – Rooftop PPP based on Gross Metering



Concerns with Rooftop PV

Two Significant Classes of Concern

- Technical: Grid-integration challenge with likelihood of
  - Reversal of power flows across the LT network.
  - Breach of voltage regulations with tail-end generation feed
  - Erratic behavior of LV protection systems

- Commercial: Utility likely to have certain valid long-term concerns
  - Loss of consumers / reduction in revenue in net-metering / captive operation
  - Regulators don't often factor in / compensate for the cost of grid support provided to distributed generators

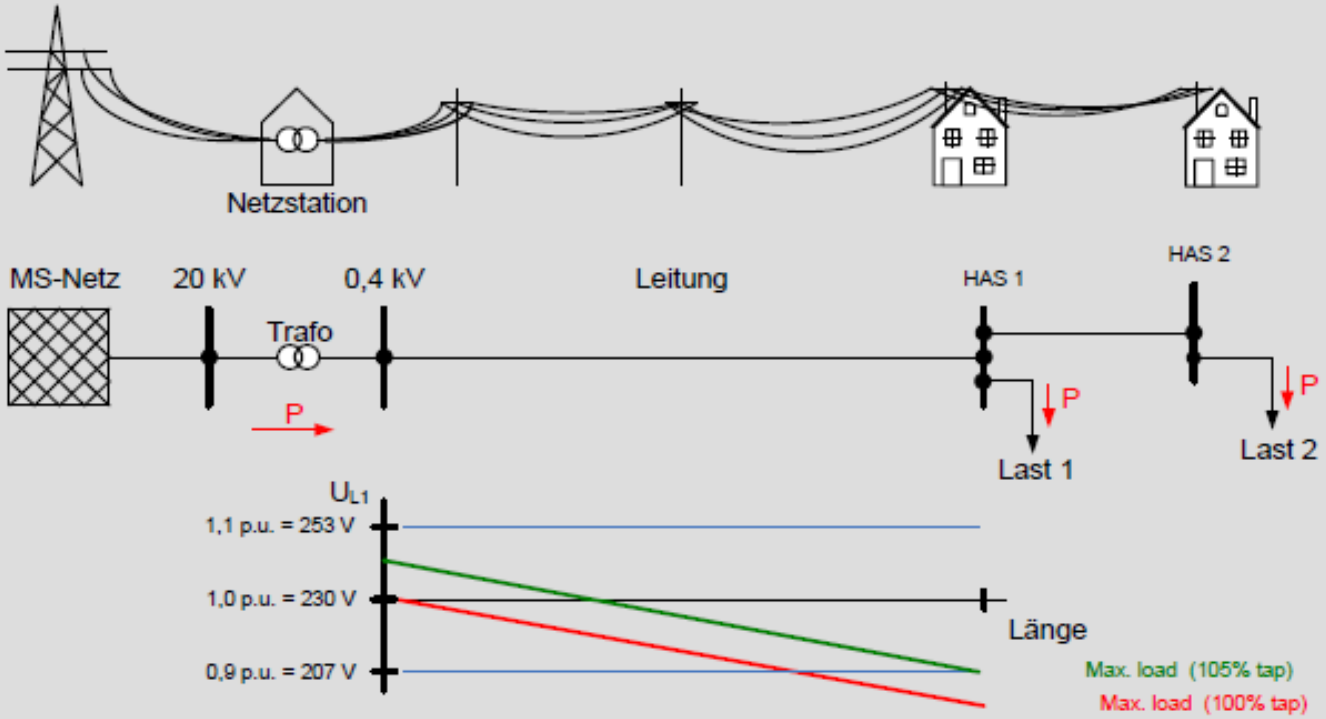
V Support - addressed through Inverter standards in Germany ..1

E.g. of Germany (Source: Dr.Bernd Engel's (SMA) presentation at IEA PVPS Programme)

> Objective: To support the voltage criterion in accordance with EN 50160 ($U_N \pm 10$ %)

> Example: Compensation for the voltage drop in the cabling:

stationary adjustment to the transformation ratio at the transformer on the grid statior

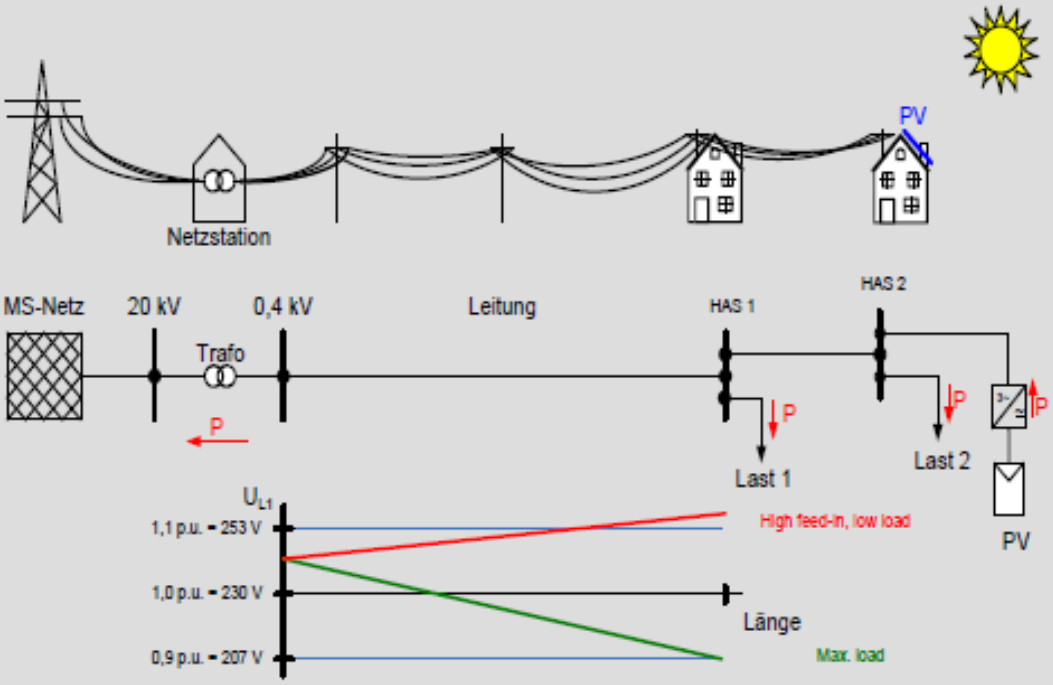


Until now, the distribution grid was designed for consumption

V Support - addressed through Inverter standards in Germany ..2

E.g. of Germany (Source: Dr.Bernd Engel's (SMA) presentation at IEA PVPS Programme)

> Example: PV plant installation: In the low load hours before lunch, a **power flow reversal** occurs. **Violation of the voltage criterion** in accordance with EN 50160

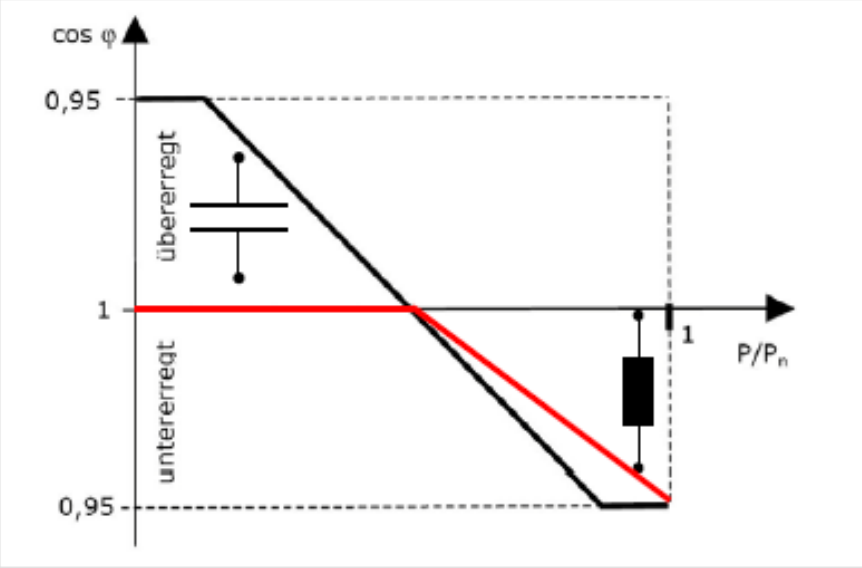


- Voltage Problems were previously associated with costly grid development involving increased amounts of copper, new cables and more powerful transformers.

V Support - addressed through Inverter standards in Germany ..3

E.g. of Germany (Source: Dr.Bernd Engel's (SMA) presentation at IEA PVPS Programme)

Supporting Voltage through Reactive Power Supply



Source: PV plants in the medium-voltage grid BDEW (German Association of Energy and Water Industries), drafted April 2008

>> By supporting the voltage in the inverter, the capacity of the low-voltage grid can potentially be tripled
(source: Federal Ministry for Environment, Nature Conservation and Nuclear Safety project PV-EMS)

> New grid connection directives:

PV plants must make their **reactive power** available during normal operation

> Grid operator specifies Q_{Set}, $\cos\varphi_{Set}$ or $\cos\varphi(P),Q(U)$ characteristics

> **MV guidelines:** Operate with a shift factor ranging from
$\cos\varphi = 0.95_{inductive}$ to $0.95_{capacitive}$

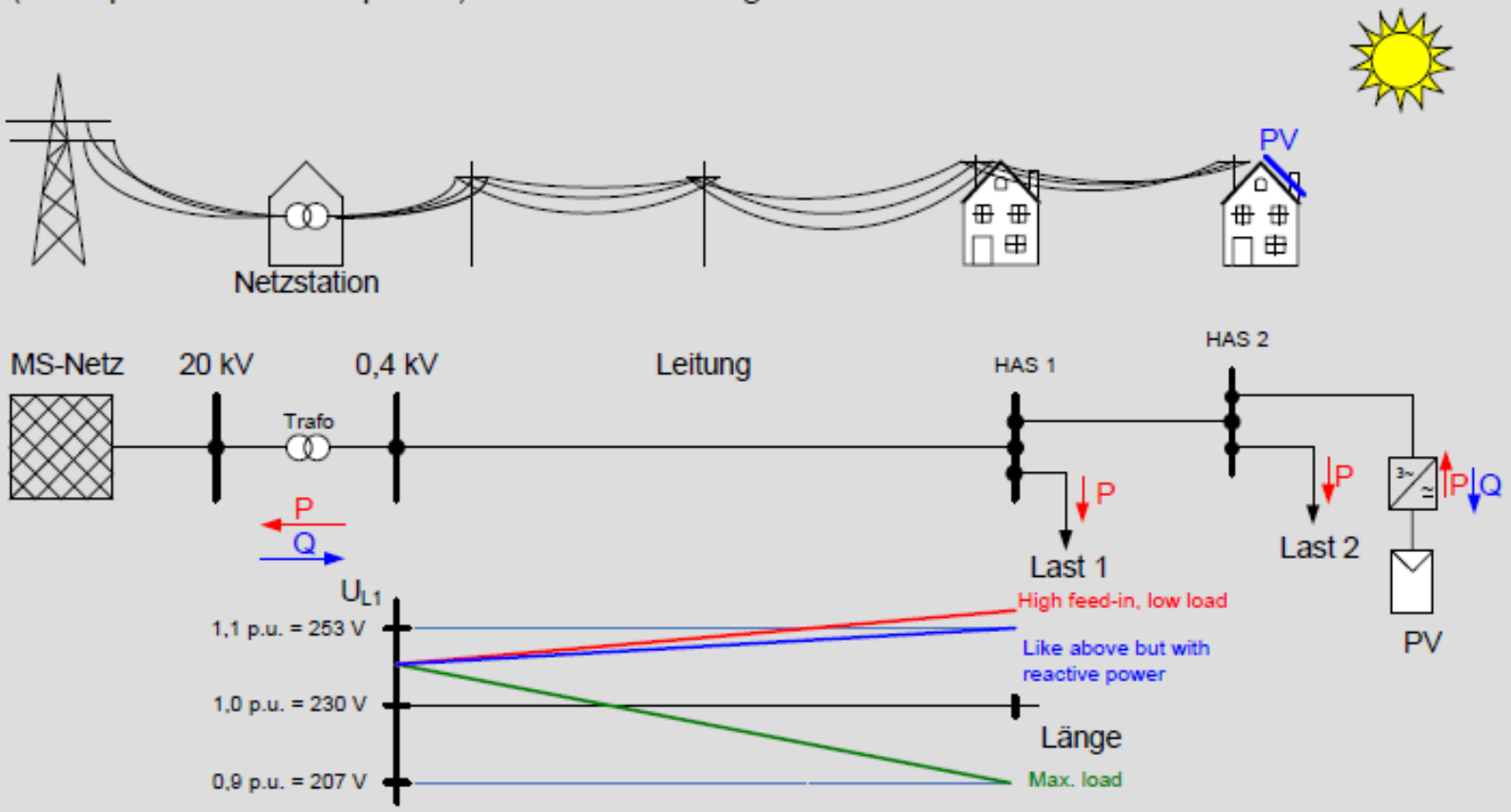
> **LV directives**: Operate with a shift factor ranging from
$\cos\varphi = 0.90_{inductive}$ to $0.90_{capacitive}$

V Support - addressed through Inverter standards in Germany ..4

E.g. of Germany (Source: Dr.Bernd Engel's (SMA) presentation at IEA PVPS Programme)

Supporting Voltage through Reactive Power Supply

> Example: **Inductive/underexcited operation of the PV inverter** (absorption of reactive power) reduces the voltage boost



Voltage Support & Avoiding Power Flow Reversal – The Future!

1. Reactive (non-unity pf) operation of Inverters connected to LV Grid

2. Introduce dynamic compensation on the LV Grid with intelligent sub-stations

3. Provide for on-line auto-tap changing transformers in LV grid

4. Move towards mesh/loop distribution systems instead of radial systems

Commercial Concerns

- Utilities need to exploit their advantages & play in the rooftop solar value chain rather than be passive recipients of power
  - Several utilities in US, Germany and Australia offer to supply solar deployment / lease schemes to their consumers

- Grid integration of distributed generation is no longer an exception to the rule.
  - Regulators need to consider the business case for deep pricing of network upgrades (including smarter DMS) and factor them into their tariff policies

Enabling Net Metering concept in India

Key Action Points

Key Enabling Regulatory Actions

A. Net metering regulations – Permitting provisions	
Definition of net-metering	• Self owned/third party owned facilities
Define permitting capacity limits for Individual Projects	• Individual capacity • Maximum capacity eligible for net-metering
Define Electricity generation limits	• Sale to utility by net metered – charges to apply?
Level of overall/local grid penetration	• Impact on utility's system; avoiding reverse flows
B. RPO/Tariff Guidelines	
Renewable Purchase Obligation/REC framework	• Deemed RPO for utilities • Issuance of RECs for small capacity projects
Tariff settlement framework	• Self consumption • Excess injection into the grid
Applicability of Other charges	• Open Access charges, CSS, wheeling charge, banking, etc.

Key Enabling Regulatory Actions

C. Metering	
Meter Specifications and Standards	• Availability of LT bi-directional meters • Adequacy of existing standards. • CEA defined standards
D. Energy Accounting	
Meter data compilation	• Roles and responsibilities
Settlement Period	• Define the accounting period • Carry forward energy • Sale of energy to Discoms
E. Commercial Arrangements	
TOD Settlement	• Settlement to be in line with existing framework
REC framework	• Changes in REC regulations for net metering

1. Eligible Consumer Definition

Discussion Points

- Permit third party ownership
  - waiving open-access or supply (without license) implications
- Qualification for open access (eligibility requirements)
  - Not allowed below 1 MW by SERCs
  - these consumers are liable to pay wheeling charges, cross-subsidy surcharge and additional surcharge (if applicable)

Model Net-metering Guidelines

1. 'Eligible consumer' means a consumer of distribution licensee, who uses a ***rooftop solar electrical generation*** facility ***installed in the consumer premises***, primarily to offset part or all of the consumer's own electrical requirements, given that such facility can be ***self-owned or third party owned;***
2. Exemption from banking, wheeling & cross-subsidy charges for such consumers

2. Defining permitting capacity limits & connection voltage for individual project capacities

Discussion Points

- Address boundary conditions/ constraints presented by service line capacities
- Standard connection voltage ranges may require changes to Distribution Codes – easier to address by linking to respective state distribution codes
- Who bears the cost of infrastructure up-grade, if required, at distribution level and who should bear the cost of such upgrade?

Model Net-metering Guideline

1. Define Individual project capacities to be allowed : shall be linked to connected consumer load (kW) and connection voltage levels (Single/ Three Phase) - ***aligned to respective State's Electricity Supply Code as applicable for loads.***
2. Define maximum capacity size for each rooftop project - **proposed to be capped at *1 MW for single metering point (for discussion)*** to qualify under net-metering

Covered under State Regulation/ Codes

- Consumer load revision guidelines : Developer to bear costs of service line upgrade if higher than existing service line capacity is sought to be evacuated.

3. Permitting limits on individual projects' generation & Tariff settlement

Discussion Points

- Should excess injection into the grid be recognized for commercial settlement as sale of electricity to utility – if so what should be the settlement mechanism and price ? – retail tariff, APPC, avoided cost?
  - Increases the complexity of energy accounting, contracting arrangements & pricing
- Whether to have cap on PLF - Impact on the overall quantum of subsidy/ incentives – impact on Government
- Settlement period to be defined

Model Net-metering Guideline

1. Proposed limit for commercial settlement of electricity : ***Generation as 90% of the total consumption in a financial year***
2. ***Any excess injection (above 90%)*** at the end of financial year to be considered ***as free energy***
3. No carry forward of energy allowed to next financial year
4. PLF of the project not to exceed 22% on annual basis

Reference Case – Energy Accounting under Net-metering

Month	Generation (kWh)	Consumption (kWh)	Net Electricity (kWh)	Effective Bill (kWh)
April	150	160	10	10
May	150	180	30	30
June	150	20	-130	-130
July	150	260	110	-20
August	150	100	-50	-70
September	150	260	110	40
October	150	140	-10	-10
November	150	200	50	40
December	150	220	70	70
January	150	100	-50	-50
February	150	250	100	50
March	150	0	-150	-150
Yearly Total	1800	1890	90	
Annual Generation as a % of Consumption		95%		

- Monthly accounting required, previous month credit (if any) to be accounted
- Generation as a % of consumption to be calculated at the end of Financial Year

4. Level of grid penetration (i)

Discussion Points

Overall Cap : Driven by consideration of Utility's loss of revenue; overall variability of generation & grid stability; cost of up-gradation

Local level cap

- Distribution system configuration not geared for reverse flow of power – can impact grid stability beyond a limit
- Diversity of consumers at feeder / DTR level can assist in accommodating generation up to a limit without reversal in the network
- HVDS may require separate considerations as diversity is low (e.g., can be excluded in Phase 1 until effect of reversal of power flows are examined on HVDS transformers)

Model Net-metering Guideline

1. Define Overall Cap: SERC to decide in capacity terms or % of demand of the Discom
2. Define local Level Cap : Define limits for connecting solar rooftop projects - DTR capacity ~ say 10% - 15% of capacity in Phase 1
3. Discoms to update DTR level capacity available regularly – display on website

4. Level of grid penetration (ii)

Other Initiatives required

Phase 2

CEA to define limits based on study

Phase 3

In the long term, the distribution utilities may be directed to undertake appropriate network architecture / infrastructure upgrades : Ring / meshed architecture, auto-tap changing transformers, etc.

5. Solar Renewable Purchase Obligation (RPO) (i)

Discussion Points

- Solar RPO targets fixed by State Regulators
- Definition of obligated entities

Types of Captive Consumers

Category 1	• Defined as Obligated Entity under State RPO Regulation – generally for captive capacity of 1 MW and above (e.g. industrial consumers) • May like to claim Solar RPO through self-consumption from net-metered based rooftop solar project
Category 2	• Not defined as Obligated Entity under State RPO Regulation – generally for captive capacity less than 1 MW and other consumers • This form of captive consumption not covered under RPO framework currently • ***Discoms can be given benefit of deemed RPO under this category*** – This will encourage Utilities to facilitate implementation of small capacity net-metering based rooftop solar

Solar Renewable Purchase Obligation (RPO) (ii)

Discussion Points

- If Deemed RPO allowed for net-metering systems, such consumers (generator) cannot get benefit of RECs
  - will result in double accounting of same electricity
- In case excess injection is allowed for commercial settlement, issues will revolve around :
  - Need to demarcate capacity under net-metering and sale to utility - Utility may sign PPA for a defined capacity to have clarity to meet Solar RPO target
    - Segregating capacity for sale to utility will be gross metering rather than any form of net-metering
  - No defined RPO target for rooftop solar separately – may not be a preferred option for utilities over ground mounted solar

Model Net-metering Guideline

1. **Allow Deemed RPO for utilities** against the electricity consumption from net-metering based solar rooftop - **only against self-consumption by consumers not defined as obligated entities**

6. Renewable Energy Certificate (REC)

Discussion Points

- Small projects not under REC framework - not having adequate energy accounting systems in place
- Net-metering projects would be more of captive consumption – will need banking exemption and hence will not qualify under current REC regulation eligibility criteria

Proposed Action

REC Regulation

1. Allow small capacity size projects to participate under REC mechanism
2. No changes in REC eligibility Condition
   - Only eligible projects can claim REC benefit
   - Given the fact that net-metered based projects need to be necessarily exempted from banking & wheeling/open access charges – ***such projects may not qualify for REC benefit***

7. Time Of Day(TOD) settlement

Discussion Points

- Commercial settlement across periods for the banked energy & energy accounting
  - Whether the excess energy generated by the solar installation and exported to the grid during a particular time period can be used to net energy imported in other time period in TOD regime?
- Availability of TOD meters across consumer categories : TOD metering done in most States for HT/ commercial consumer levels - LT level consumers not covered under TOD metering in general

Model Net-metering Guideline

- Commercial settlement to be mapped as per the State Regulation on TOD periods : peak to peak, off-peak to off-peak, etc.
- Consumer to pay the differential tariff across periods (if applicable)
  - Will safeguard commercial interest of utility & in line with existing regulatory framework

8. Metering requirements (i)

Discussion Points

- Process of meter reading for generation & consumption
  - Whether Joint meter reading is required for Net metered systems?
  - Whether utility will recognize all the meters (in case of 2/3 meter systems) for commercial settlement
- Minimum features required for net metering?
  - Metering standards; Requirement for Backup stand by, check meters
  - Bi-directional meters for LT Level are currently not available in India
- Do all meters need to be at utility voltage level? Case of solar generation and consumption at auxiliary voltage

Proposed Action:

Model Net-metering Guideline

1. Meter reading to be taken by utility only & accepted for commercial settlement

8. Metering requirements (ii)

Proposed Action :

Modifications in Supply Code

Position & sealing of Solar Meter will be guided by the same provisions as applicable to consumer meter in Supply Code.

Acceptance of net-meters for commercial settlement

- Net-meter should be downloadable (i.e. Meter Reading instrument (MRI) compliant or wireless equipment for recording meter readings)
  - If bills are prepared on the basis of MRI downloads or if meter reading is taken on the basis of remote meter-reading and the consumer wishes to have a record of the reading taken, he shall be allowed so by the licensee.
- Installation of bi-directional meters at LT level
- Main Solar Meters shall be of 0.2s class accuracy and with facility for recording meter readings using Meter Reading Instrument (MRI).
- Solar Check meters shall be mandatory for rooftop solar installations having capacity more than 20 kW.
  - For installations size of less than and equal to 20 kW, the solar Check meters would be optional.

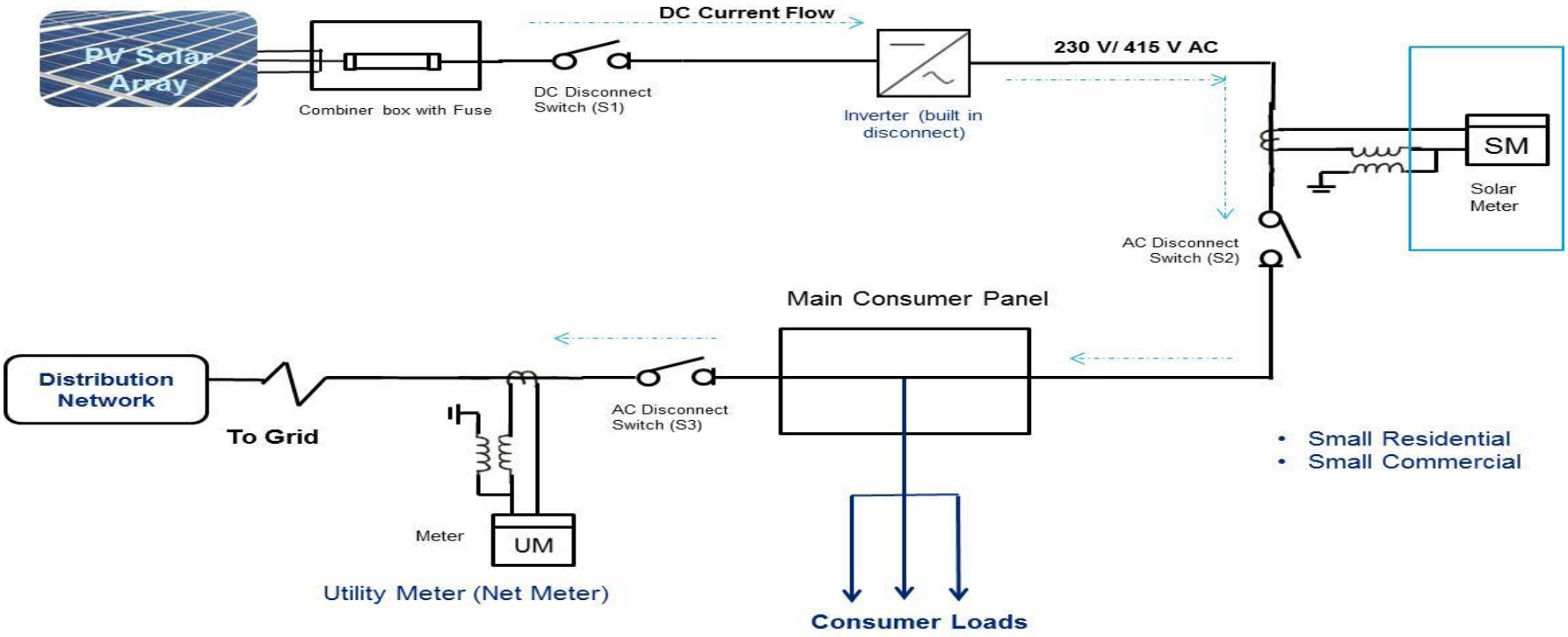
Metering Configurations

Proposed Metering Arrangement - Net-metering

- 2 Meter Configuration
  - without Storage
  - with Storage

Net metering w/o storage backup:

2 Meter Configuration : 230 V Single Phase/ 415 V 3 Phase Connection

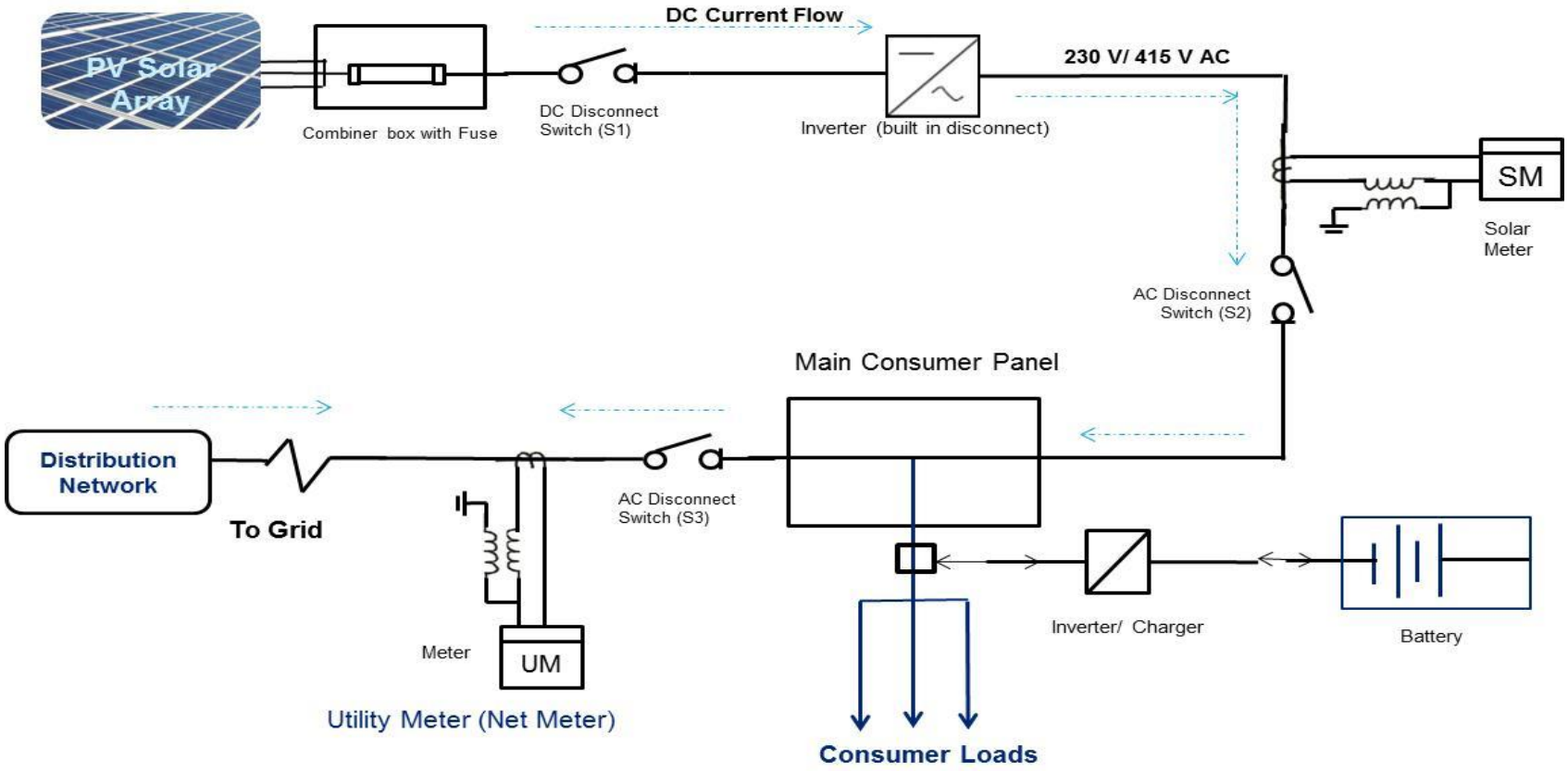


Key observations

- Two meter configuration is most optimal configuration – allows discrete measurement of both solar and utility power
- The presence of the solar meter allows use of generation based incentives like REC/ GBI etc.
- Key issues – 1) Acceptability of solar meter as a commercial meter; 2) placement of the solar meter – should it be next to the main utility meter or next to the solar inverter; 3) need for a solar check meter; 4) **Need for an easily accessible external AC disconnect switch**

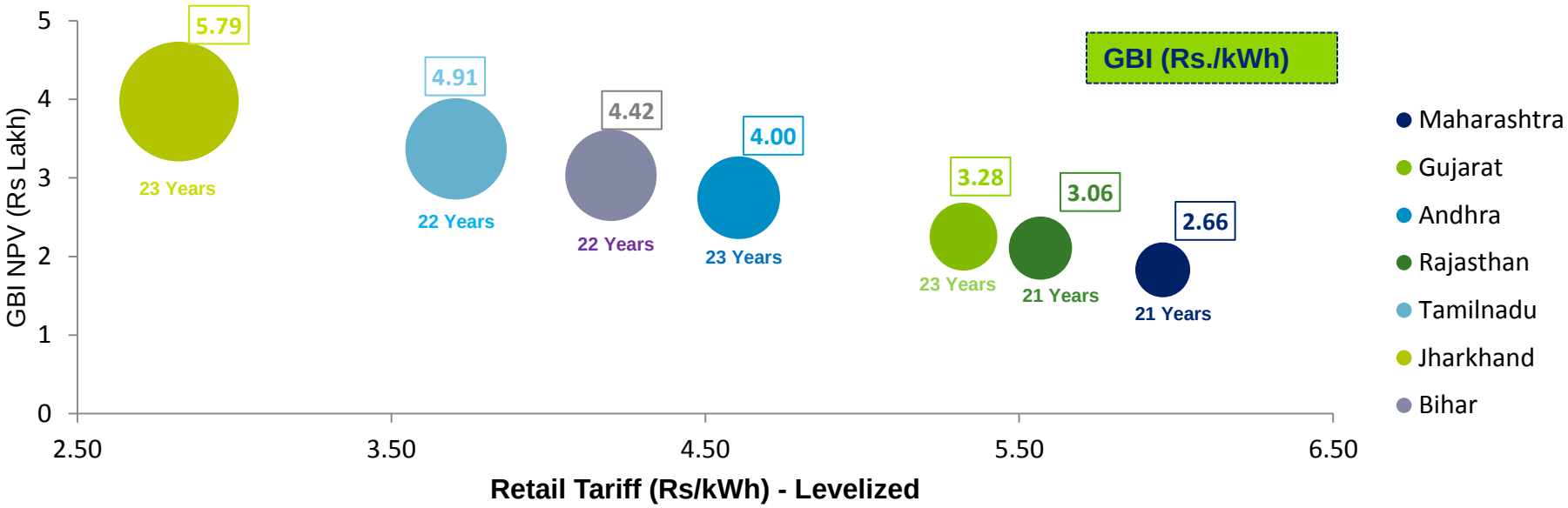
Net metering with storage backup

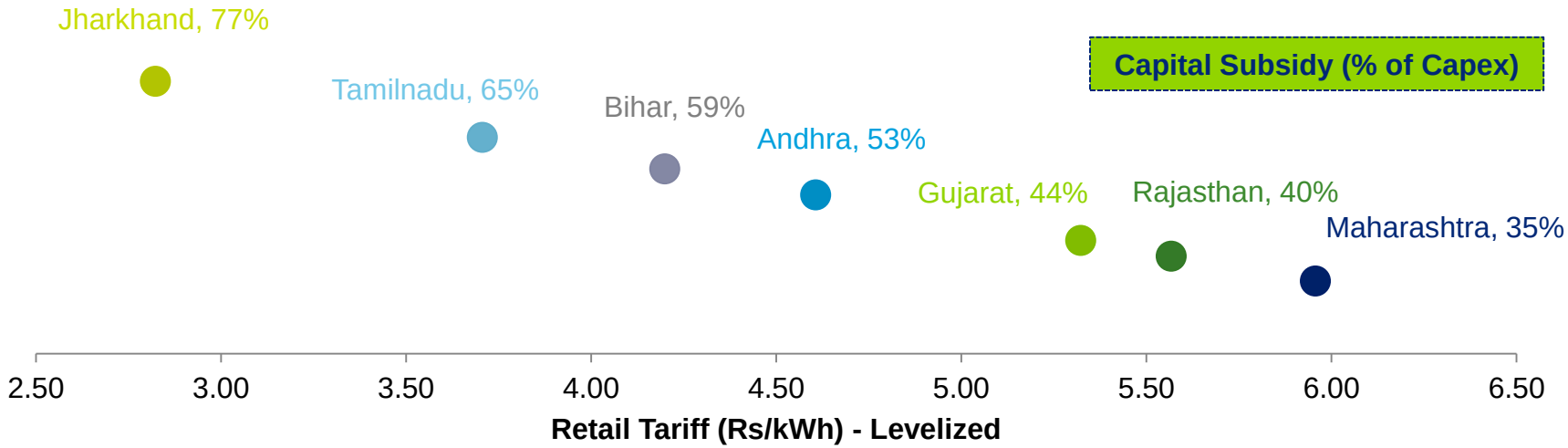
2 Meter Configuration : 230 V Single Phase/ 415 V Three Phase Connection



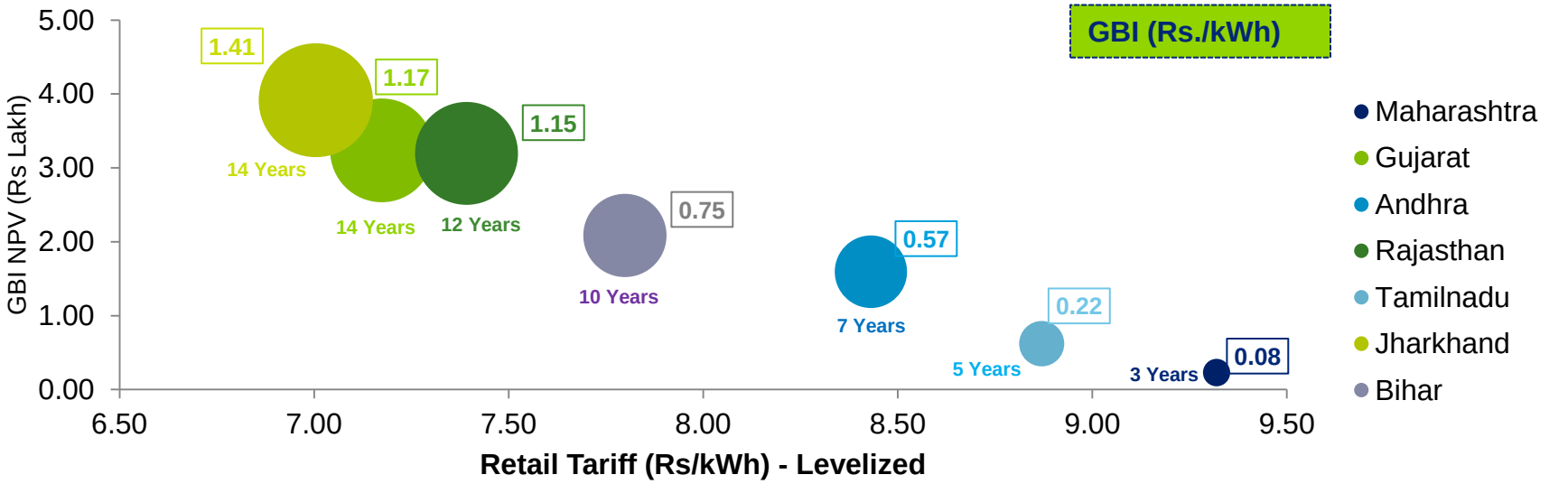
GBI/ Capital Subsidy Requirements for Net Metered Systems

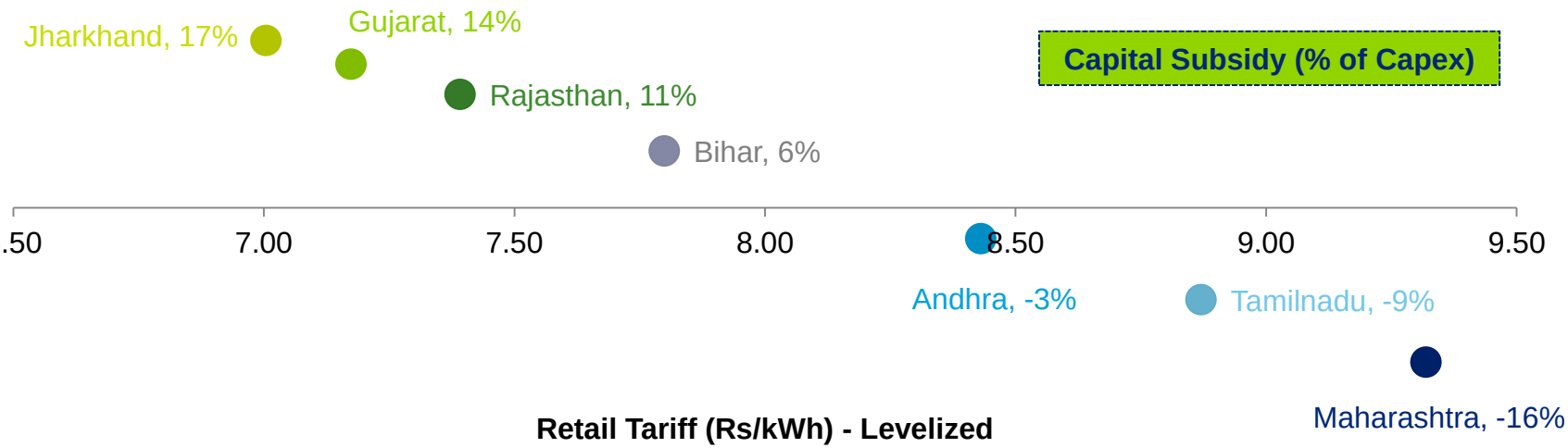
Residential Consumers (5kWp System)



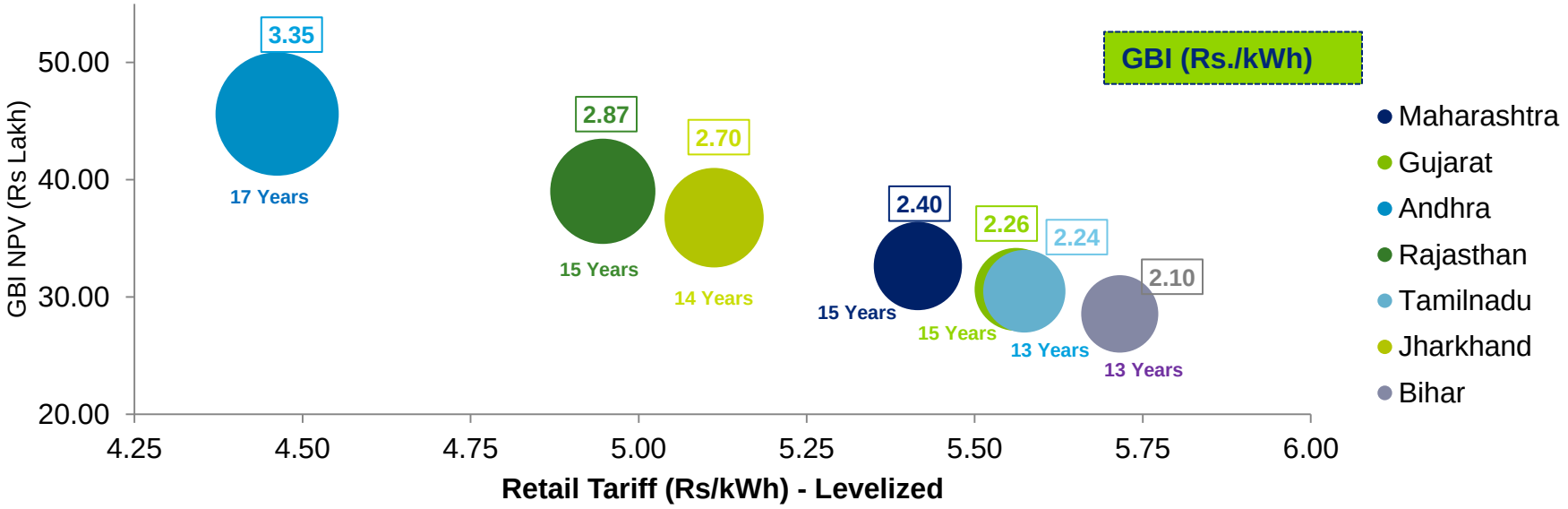


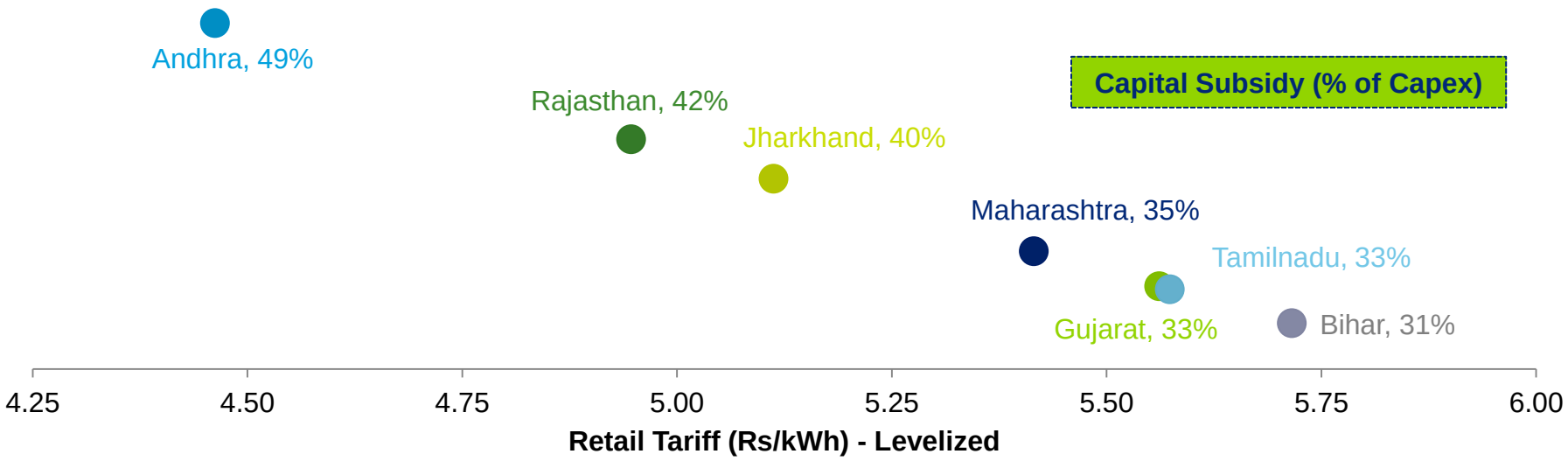
Commercial Consumers (20kWp System)





Industrial Consumers (100kWp System)





Status of Policy & Regulations

Net-metering Policy & Regulatory review……(i)

	Key parameter	Andhra Pradesh Policy on net metering for solar (2013)	Tamil Nadu Draft Order on net-metering (2013)/ Solar Energy Policy 2012	Karnataka KERC Solar Tariff Order (Oct. 2013)	West Bengal WBERC RE Regulations 2010	FOR Draft Model FOR Regulation
1	**Eligible consumers**	Allowed only for 3 Phase service consumers. Single Phase consumers are not eligible	Domestic & Commercial	Systems connected to LT grid	Only for institutional consumers like government departments, academic institutions, etc.	All consumer categories
2	**Project capacity limit at consumer level**	-	-	1 MW	2-100 kW	Maximum installed capacity shall not exceed 1 MW
3	**Local level limits**	Should not exceed 50% of transformer (DTR's) rated capacity	-	-	-	should not exceed 15% peak capacity of Distribution transformer
4	**Third party ownership allowed**	-	-	-	-	Allowed - more from perspective of exemptions of charges applicable on third party sale

Draft – Under discussion

Net-metering Policy & Regulatory review……(ii)

	Key parameter	Andhra Pradesh : Policy on net metering for solar (2013)	Tamil Nadu : Draft Order on net-metering (2013)/ Solar Energy Policy 2012	Karnataka : KERC Solar Tariff Order (Oct. 2013)	West Bengal : WBERC RE Regulations 2010	FOR : Draft Model FOR Regulation
5	**Excess generation**	Allowed – no limit defined	Generation capped commercially at 200 % consumption for a year	Allowed – no limit defined	Only up-to 90% of annual electricity consumption	Only up-to 90% of annual electricity consumption
6	**Commercial settlement**	Net export of energy value @ pooled cost decided by APERC Payment of pooled cost will be made effective for a period of 7 years from the date of commissioning.	Excess at end of settlement period @ 75% of solar tariff. No carry forward to the next settlement period	Net energy pumped into the grid shall be billed @ rooftop solar tariff	No payment for excess injected electricity	No payment for excess injected electricity. No carry forward to next settlement period.
7	**Settlement period**	Settlement of registered surplus energy will be carried out on a half yearly basis	12 month period from August – July.	Billing period	Financial year	Financial year

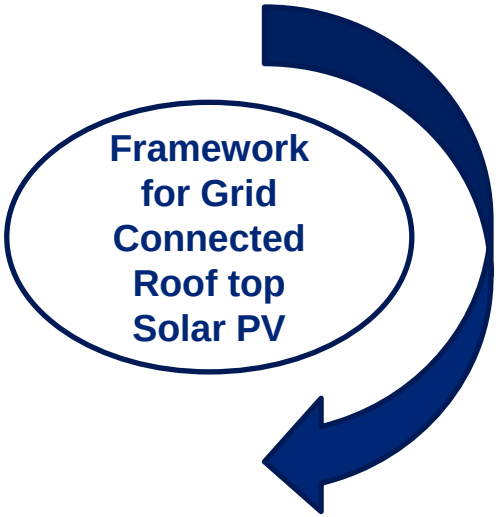
Draft – Under discussion

Net-metering Policy & Regulatory review……(iii)

	Key parameter	Andhra Pradesh : Policy on net metering for solar (2013)	Tamil Nadu : Draft Order on net-metering (2013)/ Solar Energy Policy 2012	Karnataka : KERC Solar Tariff Order (Oct. 2013)	West Bengal : WBERC RE Regulations 2010	FOR : Draft Model FOR Regulation
8	**Interconnection arrangement**		< 10 KWp : 240V; 10 kWp to < 15 kWp : 240/415 V; 15 to 100 kWP : 415 V; > 100 kWp : 11 kV	1 kW to 5 kW – single phase 230 volts 5 kW to 50 kW – 3 phase 415 Volts 50 kW to 1 MW – 11 kV line.	Allowed at Low Voltage or Medium Voltage, or 6 KV or 11 KV - as considered suitable by licensee & developer	As per State Supply Code provisions for providing consumer connections
9	**Metering arrangement**	Single bi-directional	Two meters : One for solar generation & bi-directional	-	Two meter arrangement or single bi-directional meter	Two meter arrangement : Bi-directional meter & Solar meter
10	**Banking, wheeling & cross-subsidy charges**	-	-	Exemption for solar projects	Higher value of : either 1/3 of wheeling charges calculated as per Tariff Regulations or cost of 7.5% of the energy fed to the grid	Exemption (also applicable on third party owned systems)
11	**Incentives**	20% GoAP subsidy of capital cost up to 3 KW capacity in domestic sector only	GBI of Rs. 2/kWh for first two years, Rs. 1/kWh for next two & Rs. 0.5/kWh for tnext 2 years (domestic consumers)	-	-	-

Draft – Under discussion

SECI - Implementation of Grid connected Roof Top Solar PV System Scheme in Selected Cities/States in India (Phase –II)



Competitive Bidding on project cost

Subsidy - 30% of the quoted project cost

- **Project Capacity limit**: 100-500 kW; **Total Capacity limit for bidder** : 250kW – 2 MW
- Bidders will be selected by the final project cost they offer @ Rs. /W basis
- **If the project is implemented in RESCO mode, maximum chargeable tariff is up to Rs. 6.00/kWh**
- Minimum CUF of 15% to be maintained for a period of 2 years for release of performance related subsidy
- Subsidy to be released in three installments:
  1. 20% after commissioning and acceptance
  2. 5% at the end of 1 year of O&M period, from date of commissioning
  3. 5% at the end of 2 years of O&M