



## NATIONAL WORKSHOP ON ROOFTOP SOLAR POWER

# 5 MW GANDHINAGAR PHOTOVOLTAIC ROOFTOP PROGRAMME

MNRE, NEW DELHI

7 June, 2016



# Outline



## 1. Ownership Models for Rooftop Solar



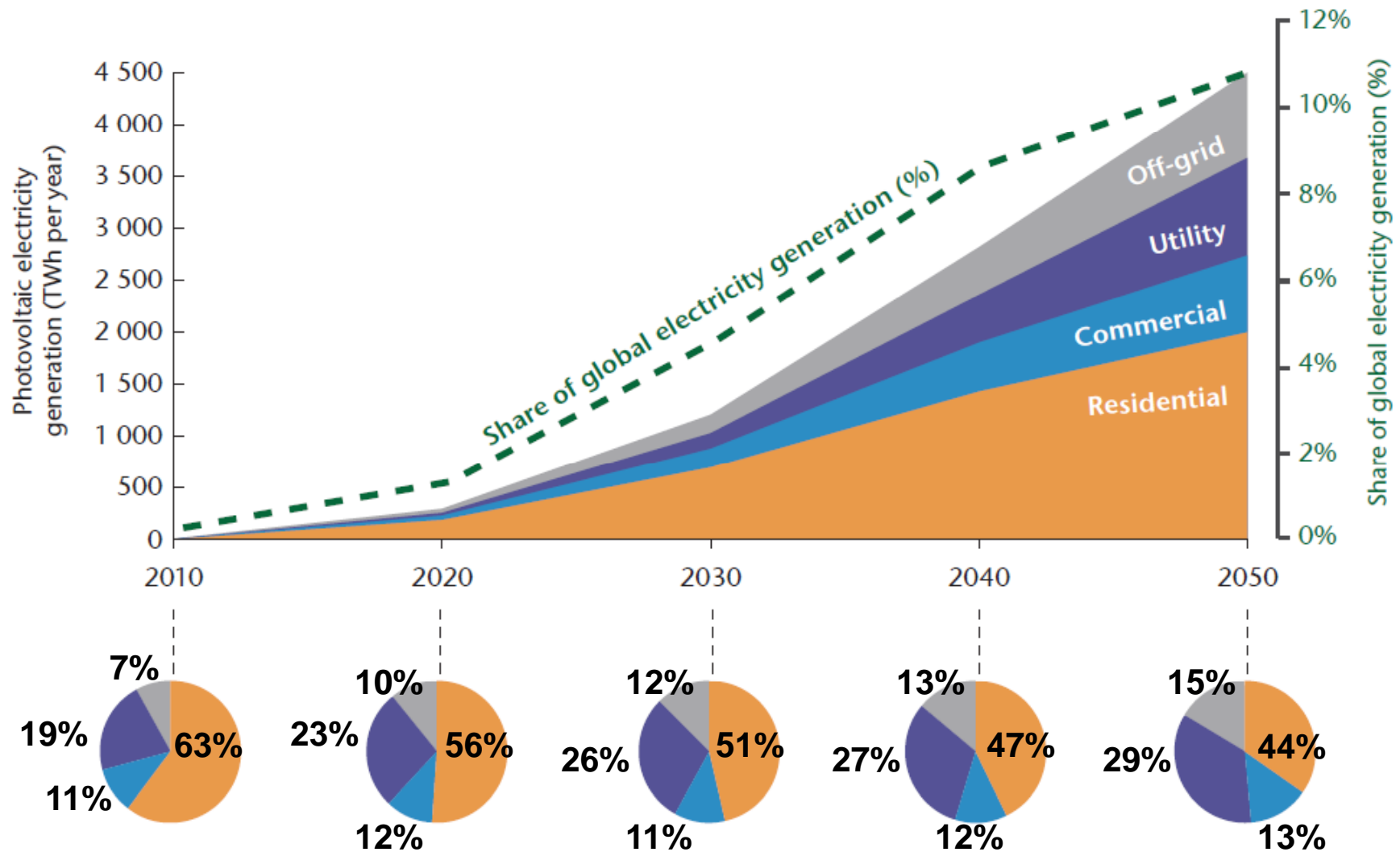
## 2. The 5 MW Gandhinagar Rooftop PV Programme



## 3. Expanding horizons



# Evolution of PV Generation w.r.t. End Use



Source: International Energy Agency (IEA)

# Evolution of Rooftop Solar PV Installations for Gujarat



## ➤ Model I: Capital cost borne by the Government

- Advantage:
  - Ease of implementation, and widely implemented.
- Challenges:
  - Ownership issues, and hence, maintenance suffers.
- Example: Most rooftop solar installations by various State Nodal Agencies (SNA).

## ➤ Model II: Public Private Partnership

- Advantage:
  - No upfront cost to Government/ Utility.
  - Generation-based incentive ensures long-term utilization.
  - Government interaction with limited number of credible Developers.
  - Standard quality and optimization of PV installations.
- Challenges:
  - Property owners unwilling to sign long-term lease agreements.
  - Incentives from solar generation not enough compared to real-estate lease.
- Example: 5 MW Gandhinagar Rooftop Solar Programme.

# Model III: Individual Ownership (Proposed in Current Rooftop Solar Policy)

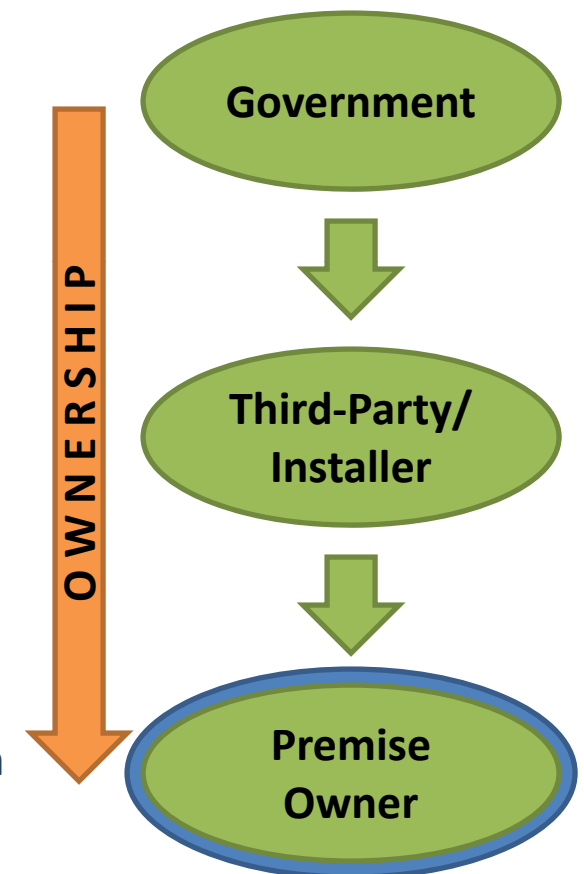


## ➤ Advantage:

- Equal opportunity to smaller rooftop owners.
- Ownership of individual is well-defined.
- Investors reap the direct benefit of electricity and also become energy aware/ efficient.
- Potential for widespread public deployment.
- Model successful globally.
- Other models (e.g. Third Party Ownership) are subsets.

## ➤ Challenge:

- Investment expected from someone who does not understand technology.
- Capital subsidies required to incentivize participation (under net-metering scheme).
- Direct dealing of DisComs directly with Customers.



# 5 MW GANDHINAGAR ROOFTOP PROGRAMME

## *"Kilowatt Programme at a Megawatt-Scale"*



### ➤ Immediate Objectives:

- Achieve 5 MW on rooftops in Gandhinagar
- Promote even residential systems
- Encourage public investments (hence, PPP)
- (Govt. may only fund the viability gap)
- No Capital Subsidy
- (Hence, only generation-based incentive)



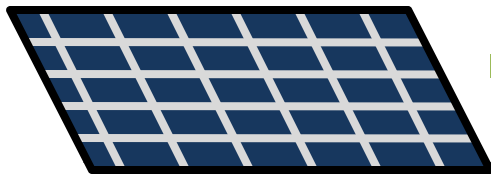
### ➤ Greater Objectives:

- Establish a benchmark for large-scale rooftop PV programmes
- Address all technical issues related to grid-connected rooftop PV
- Streamline administrative processes for implementation & approvals
- Encourage social participation



# Typical PV System Architecture

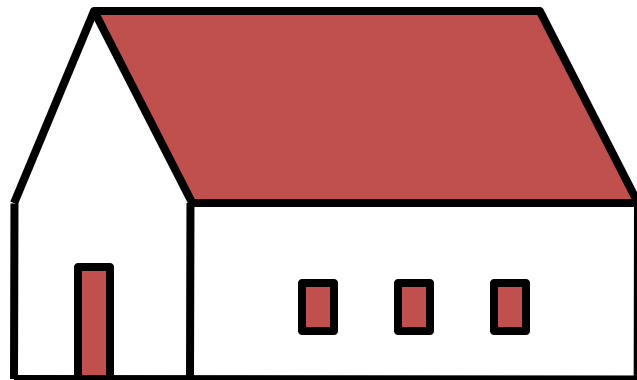
Photovoltaic Modules  
(Approx. 1 – 100 kW<sub>p</sub>)



Grid-tied  
inverter



Meter 2: Solar Electricity  
Generation



Meter 1: Conventional  
Electricity Consumption



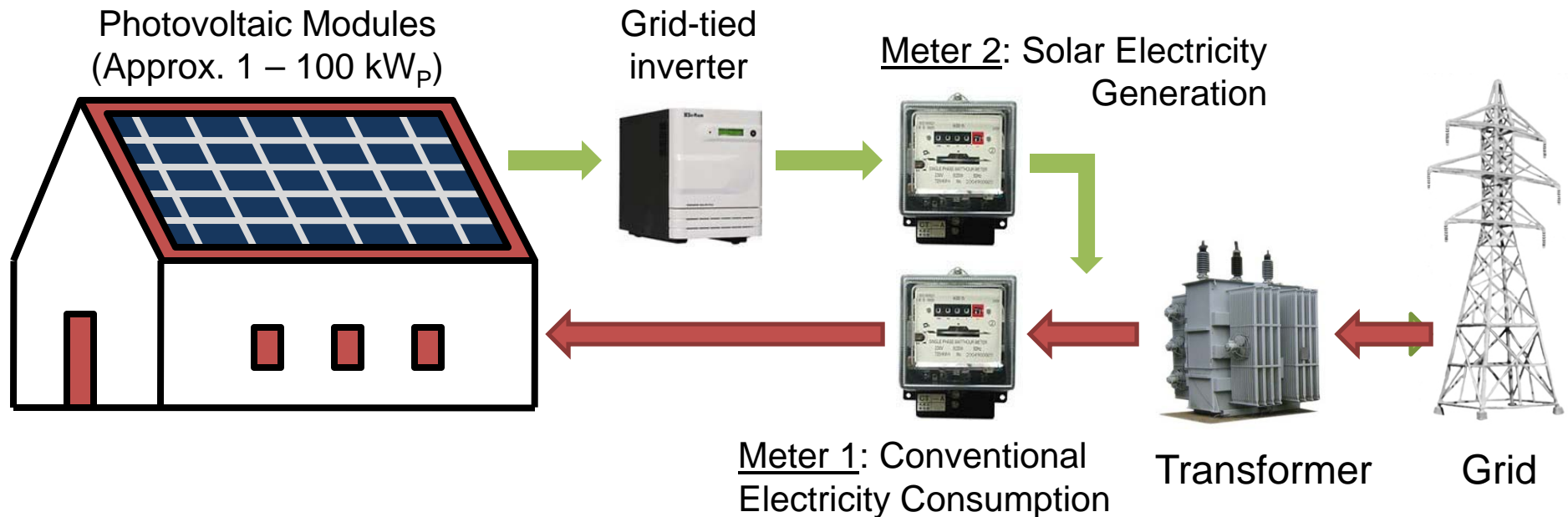
Transformer



Grid

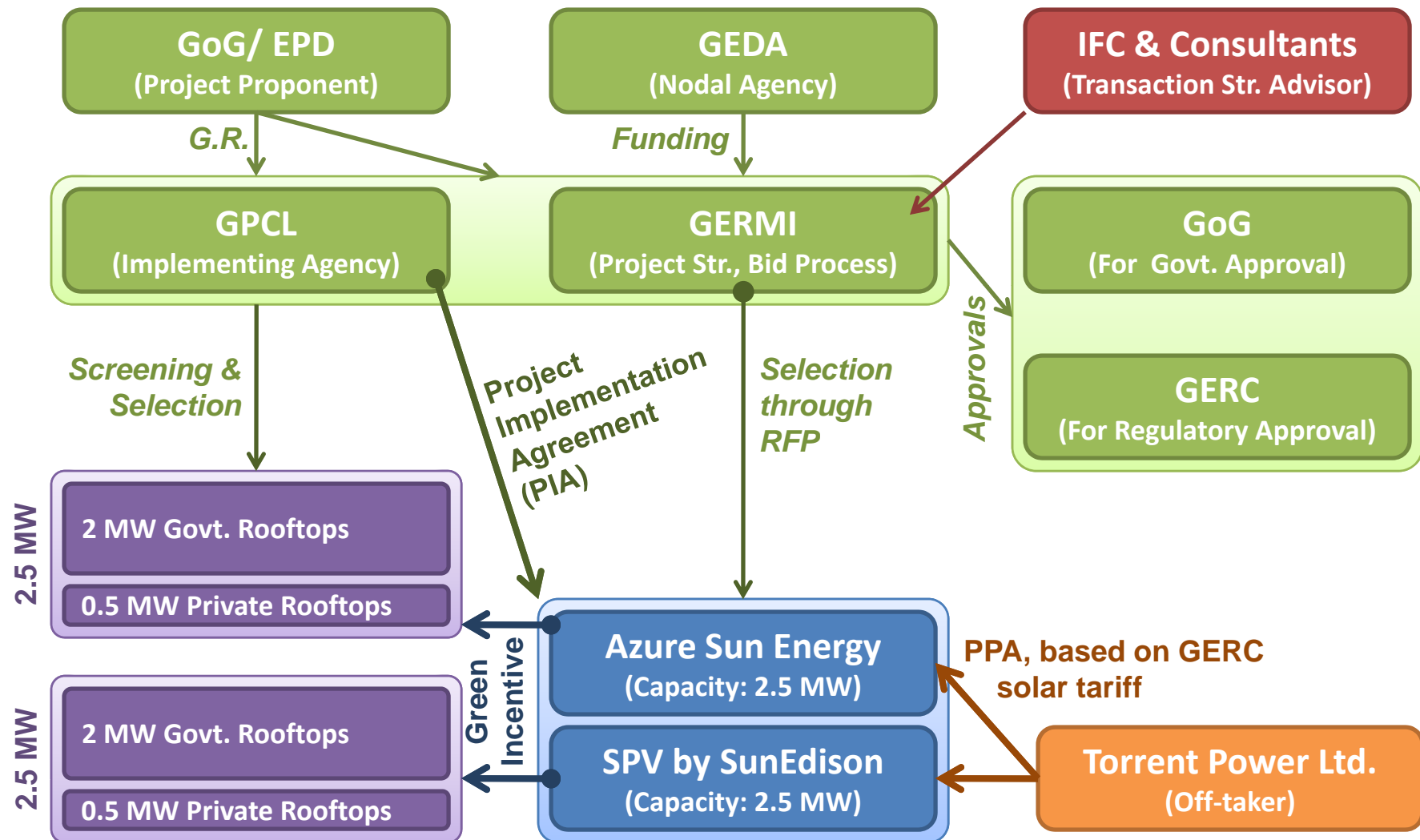
# Advantages of PV System Architecture

- Relatively simple to install, operate and maintain.
- Most popular and globally accepted configuration.
- Disadvantage: No availability when grid is down.

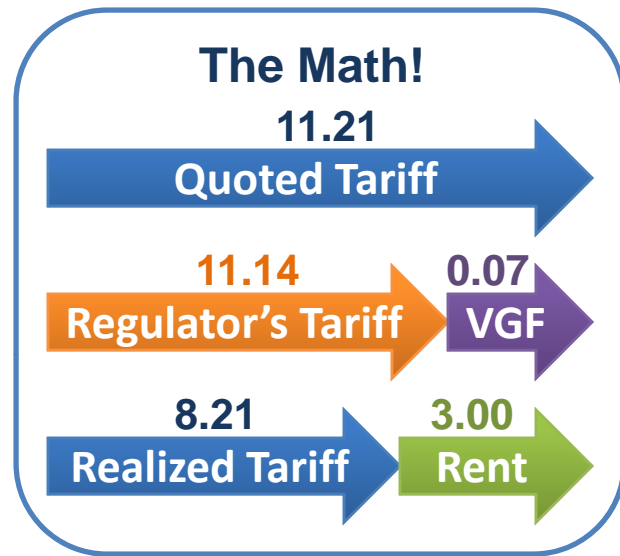




# Transaction Structure among Stakeholders



# 5 MW Gandhinagar Rooftop Solar Programme



**Awards:**

- Top 10 deals of Asia-Pacific (2012) by Infrastructure Journal
- Earth Care Award-2015

Power Purchase Agreement (PPA)  
Tariff determined by Regulator



Project Implementation  
Agreement (PIA)



Rooftop Lease Agreement  
@ Rs. 3/- per kWh



# Green Incentive: Aid to Roof-owners



- 'Green Incentive' is the minimum generation-based incentive for participating Roof-owners specified by GoG.
- Advantages:
  - Encourage awareness and participation among roof-owners.
  - Will be correlated to home-owner's electricity bill.
  - Should not be compared to 'constant' (or 'dead') lease rental.

Plot Size (Sq. m.)	Built-up Area (60%)	Typical Solar Area (30%)	Typical PV Capacity (kW)	Monthly Generation (kWh)	Green Incentive (Rs.)		
					@ Rs. 2/ kWh	@ Rs. 3/ kWh	@ Rs. 4/ kWh
50	30	9	1	135	270	405	540
70	42	12.6	1.5	202.5	405	607.5	810
81	48.6	14.58	2	270	540	810	1080
90	54	16.2	3	405	810	1215	1620
135	81	24.3	4	540	1080	1620	2160
200	120	36	6	810	1620	2430	3240
250	150	45	7	945	1890	2835	3780
330	198	59.4	8	1080	2160	3240	4320

# Capacity Split



## Azure Power

## SunEdison

Sector	No. of Installations	Net Capacity	Sector	No. of Installations	Net Capacity
Government	21	2,001 kW	Government	17	1,685 kW
Residential	161	501 kW	Residential	113	501 kW
<b>Total</b>	<b>182</b>	<b>2,502 kW</b>	<b>Total</b>	<b>130</b>	<b>2,186 kW</b>

## TOTAL

Sector	No. of Installations	Net Capacity
Government	38	3,686 kW
Residential	274	1,002 kW
<b>Total</b>	<b>312</b>	<b>4,688 kW</b>



# PV Installation in Gandhinagar

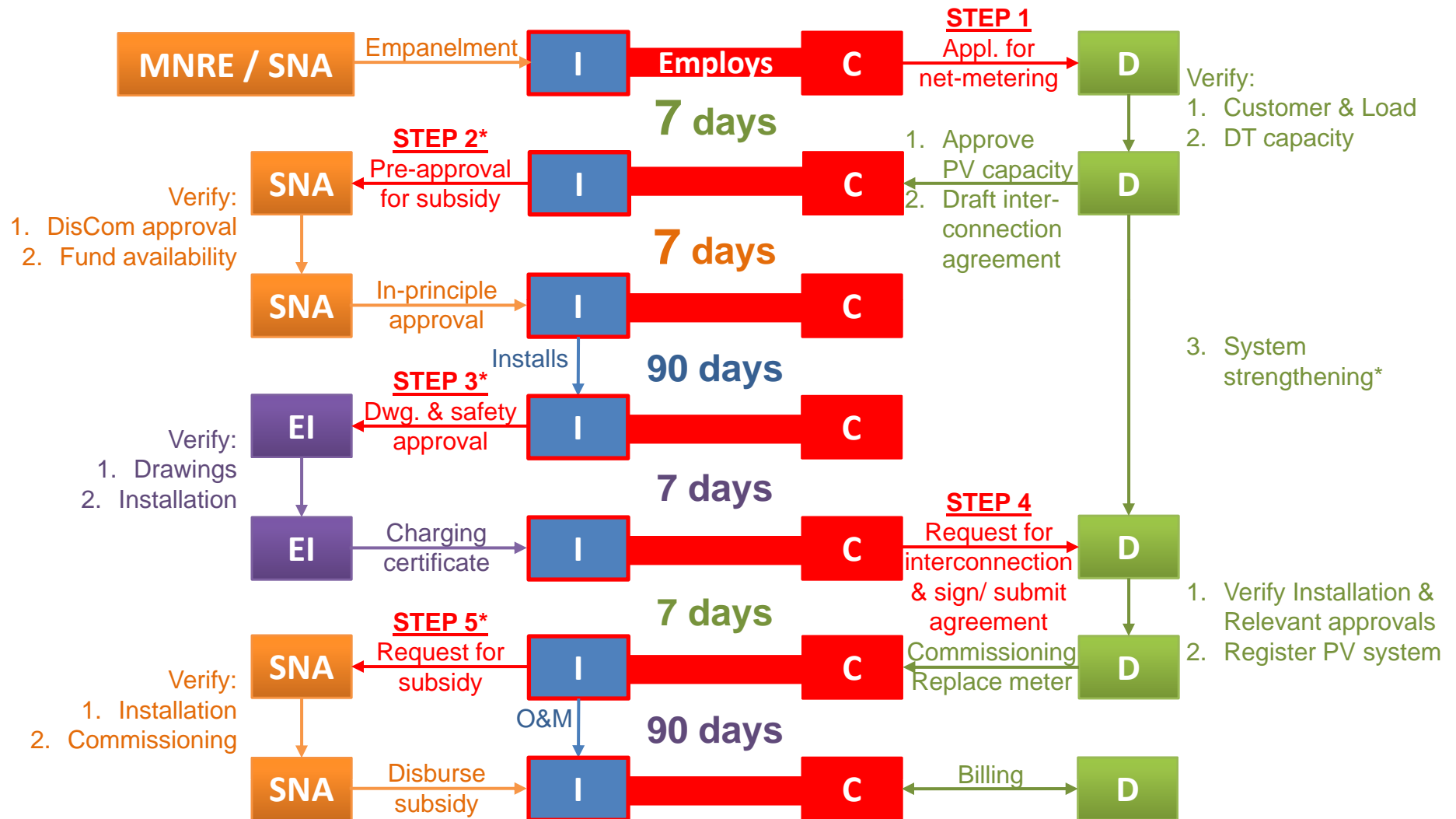


# Several Initiatives Thereafter...



- Replication in several cities within and outside Gujarat.
- Acceptance and inclusion in national and state-level policies.
- Installer Certification: National Certification Programme for Rooftop Solar Photovoltaic Installer
- Best Practices Manual for Implementation of State-Level Rooftop Solar Photovoltaic Programmes in India
- Advisory to several other rooftop PV programmes
- More business models:
  - Microgrid approach
  - Solar agriculture cooperative
- **STREAMLINING OF APPROVAL AND INSPECTION PROCEDURES**

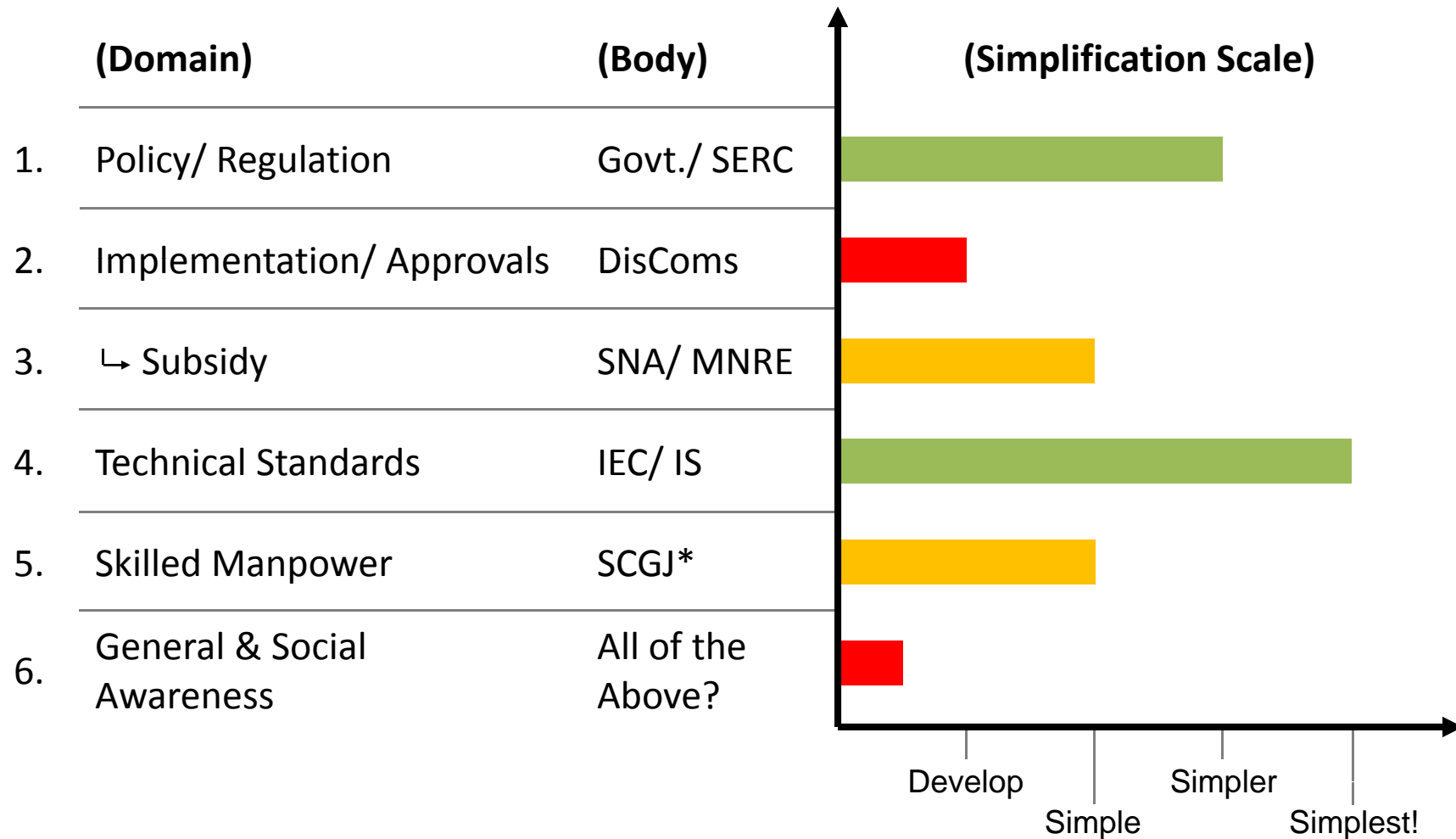
# Sample Administrative Process for RTPV



**LEGEND:** C:Customer, I:Installer, D:DisCom, SNA:State Nodal Agency, EI:Electrical/ 3<sup>rd</sup> Party Inspector, \*If applicable



# Conclusion: Develop... Simplify... Simplify... Simplify!



\*Skill Council for Green Jobs



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## BACKUP SLIDES



# Advantages of Rooftop Solar PV

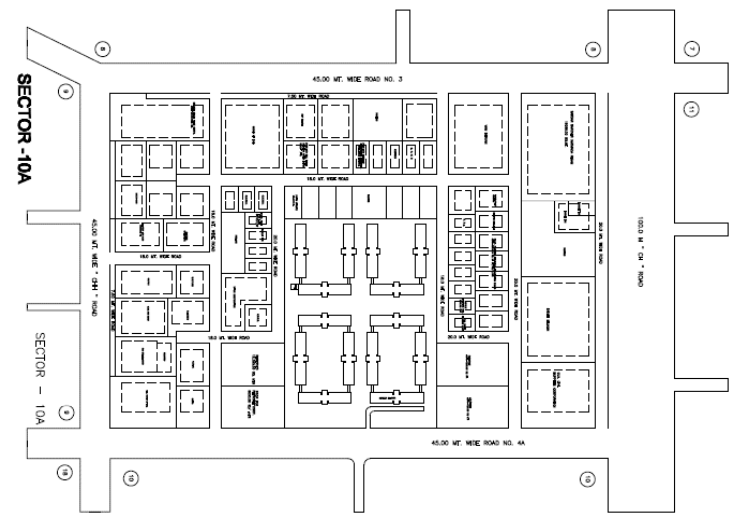


- Social
  - Opportunity for consumer participation and investment
  - Higher employment generation and entrepreneurship options
  
- Technical
  - Low distribution losses
  - Last-mile support to grid stability, w.r.t. voltage & reactive power support
  - Creates case for smart grids
  
- Administrative
  - Widely accepted, Saves space
  - Lowest time to commission → technical and administrative
  - Lower investment in distribution infrastructure (for lower penetrations)
  - Can improve distribution grid capacity





# Gandhinagar PV Potential Estimation



# Sector-wise Rooftop PV Potential of Gandhinagar



Sector	Household Rooftop (m <sup>2</sup> )	Commercial/ Public/ Government (m <sup>2</sup> )
1	49,043	
2	67,818	
3	33,112	
4	26,377	
5	20,572	
6	31,121	
7	52,042	
8	56,811	16,867
9	11,814	11,467
10		69,263
11	1,023	23,444
12	15,502	13,252
13	36,118	13,755
14	10,124	9,642
15		34,678
16	8,100	11,889
17	2,331	9,968
18		
19	32,383	
20	27,795	21,722
21	29,294	20,123
22	67,390	7,141
23	33,034	26,151
24	30,672	2,144
25	26,999	
26	22,597	
27	42,269	3,914
28	50,127	
29	55,547	
30	24,723	



Available “fraction” of net “shadow-free” area.

Sector	Household Rooftop (m <sup>2</sup> )	Commercial/ Public/ Government (m <sup>2</sup> )
Sub-Total (m <sup>2</sup> ):	864,736	295,420
Equivalent MW:	86.47	29.54
Acceptance Rate:	5%	33%
<b>Net Capacity (MW):</b>	<b>4.32</b>	<b>9.75</b>
<b>TOTAL (MW):</b>	<b>14.07</b>	