Economics and Finance of Rootop (distributed) and other PV

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Rahul Tongia, Ph.D.
Fellow, Brookings India
Adj. Professor, Carnegie Mellon University
Tech. Advisor, Smart Grid Task Force, Govt. of India
Founding Advisor, India Smart Grid Forum (ISGF)

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3 Types of Solar PV

Type

1. Standalone
   a. Flashlight/lantern
   b. Solar Home System
2. Grid Interactive distribued (aka "rooftop")
   FINE PRINT: MINIGRIDS?
3. Solar Farm

Benchmark cost or reference

1. (If not darkness)
   a. Candle/kerosene
   b. [a] plus niches (diesel)
2. Consumer tariffs (prices)??
3. Lowest alternative supply source

Nuances of Economics and Finance

- Standalone systems
  - Willingness to pay is highly variable, including by volume
  - First few units people can per a lot (per unit)
  - Total monthly cost is key
- Rooftop systems
  - Are they expected to consume all or do they send back into the grid? Does "when" matter?
  - Is this a comparison of consumer RETAIL tariffs versus generation costs? Is that apples to apples?
- Grid Scale
  - Most calculations only examine Levelized Cost of Energy (LCOE)
  - What about system-level costs? Time of Day?

India's Example of Solar Plans and Ambitions

- 100 GW of solar by 2022
  - 40 GW Rooftop aka behind the meter
  - 60 GW Grid-scale

(add in other and it's 175 GW by 2022, = ~25% CAGR!)

- Where is "rooftop"?
  - Estimated 3.3 GW as of December 2018

Why is rooftop "behind schedule"?

- Grid-scale can be pushed top-down
  - Bids, RPOs, etc.
  - Rs. 2.44/kWh used to be a benchmark (we'll come back to this)
- Rooftop needs consumer buy-in
  - Aside – Germany and California solar is mostly rooftop or edge-based
  - Consumer value depends on THEIR prices
    - BUT that is retail prices
    - May have distortions

Rooftop Challenges

- Fragmented market
- Quality concerns
- Lower PLF/CUF
  - Cleaning is a major issue, as is urban pollution
- Other risks
  - Vagaries of what neighbors do (shading)
  - Municipal limitations on design (e.g., stilts)
    - Consumers lose an “empty roof”

MiniGrid Economics Issues

- Will the “real” grid come and disrupt?
- In some countries, it’s a household aka last mile challenge
- Most costs are fixed costs
  - Sizing it right is tough
- “Cheap solar” doesn’t cut it
  - Backup (battery) and fixed infra (wiring/metering) costs dominate
- For low monthly usage, per kWh costs WILL be high
  - Same is true for the regular grid

What's holding it back?

- Fundamental Economics?
- Fundamental technicals – roofspace?
- Policies and frameworks?
  - Technical
  - Pricing
- Human capacity?
- Finance?
- Awareness and behaviour?

- Maybe it's a bit of all of the above – the *ecosystem*

History of Net Metering

- One of the first legislations was the Public Utility Regulatory Policy Act (PURPA) 1978 in USA
  - Made utilities buy back power at their avoided cost
- State to state variations are policies exist in USA (like India) on how to handle net metering (size requirements, prices, etc.)

Net metering is a loose term: There are many types of "Net Metering"

- Differences include
  - Is this for gross or net feed-in?
    - The more a consumer uses in-house, the less they can feed-in
  - At what tariff (rate) are they paid?

- What these mean, technologically?
  - What type(s) of meters are installed?
  - Where do you install the meter(s)?
  - What flows does it measure, and at what rate?

Simplest world: Meter spins backwards

- Means consumer gets paid only equal to their *marginal* tariff
  - Varies a lot by consumer type and size/scale
    - A small home would be paid far less than a large/commercial consumer
- Are they consuming any power in-house?
  - The more one uses in-house, the better (from a losses perspective)
- Does this make sense?
  - Consumer: Is this enough?
  - Utility: Can I afford to pay so?
    - Usually the largest/richest consumers are the ones to go in for such schemes

Will they have a battery?

- If there is no battery, all the power must be used up immediately
  - IF grid connected, can handle all loads, but then GRID MUST BE ON
  - IF not grid-connected, then is there enough load in the house (esp. in the middle of the day)?
- All consumers who pay for such systems would want back-up power
  - This implies a battery
  - BUT, most grid-tie inverters (today) cannot feed a home during power outages (safety design)
    - Other risk – can a consumer game the system via a battery?
      - If GBI > tariff plus battery losses, then what is to stop them from charging it via the grid?
- Battery raises costs by 70-90%, perhaps more (efficiency losses plus investment)

Fundamental Qs for Net Metering

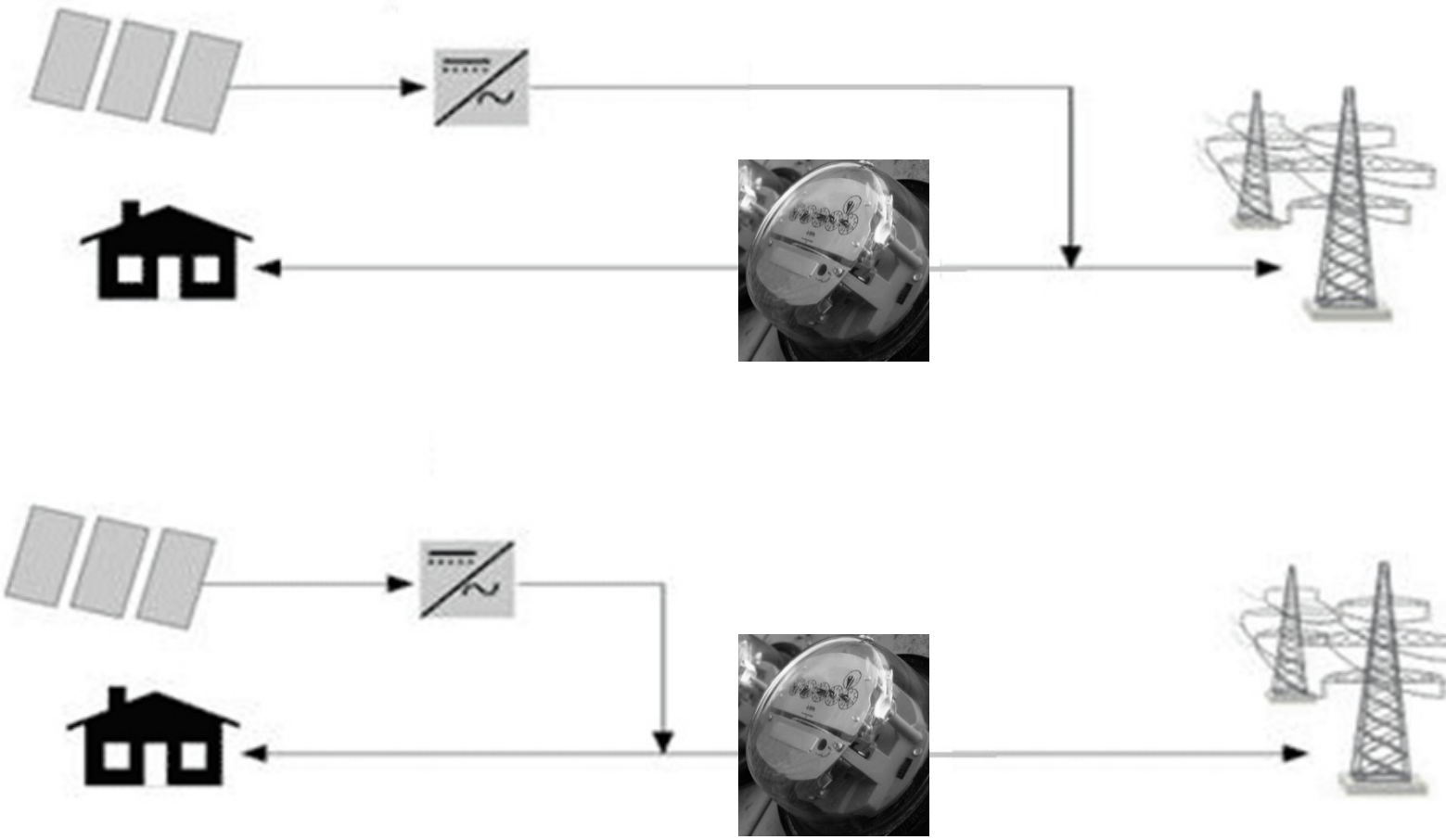
1. Where do you put in meters?
   a. Cannot be answered independently of payment schemes?
      i. What happens when you want to change your mind?
2. How is a meter capable of Net-metering technologically different?
   a. Import and Export registers
   b. Tampers encoding
3. What is the legal status of 3rd party ownership
4. How are readings taken?
   a. Digital downloads vs. AMR vs. AMI

Where do you meter?

- This fundamentally links to the payment schemes (gross vs. net)
- Gross generation
  - Right after the inverter
  - BUT, what about a battery?

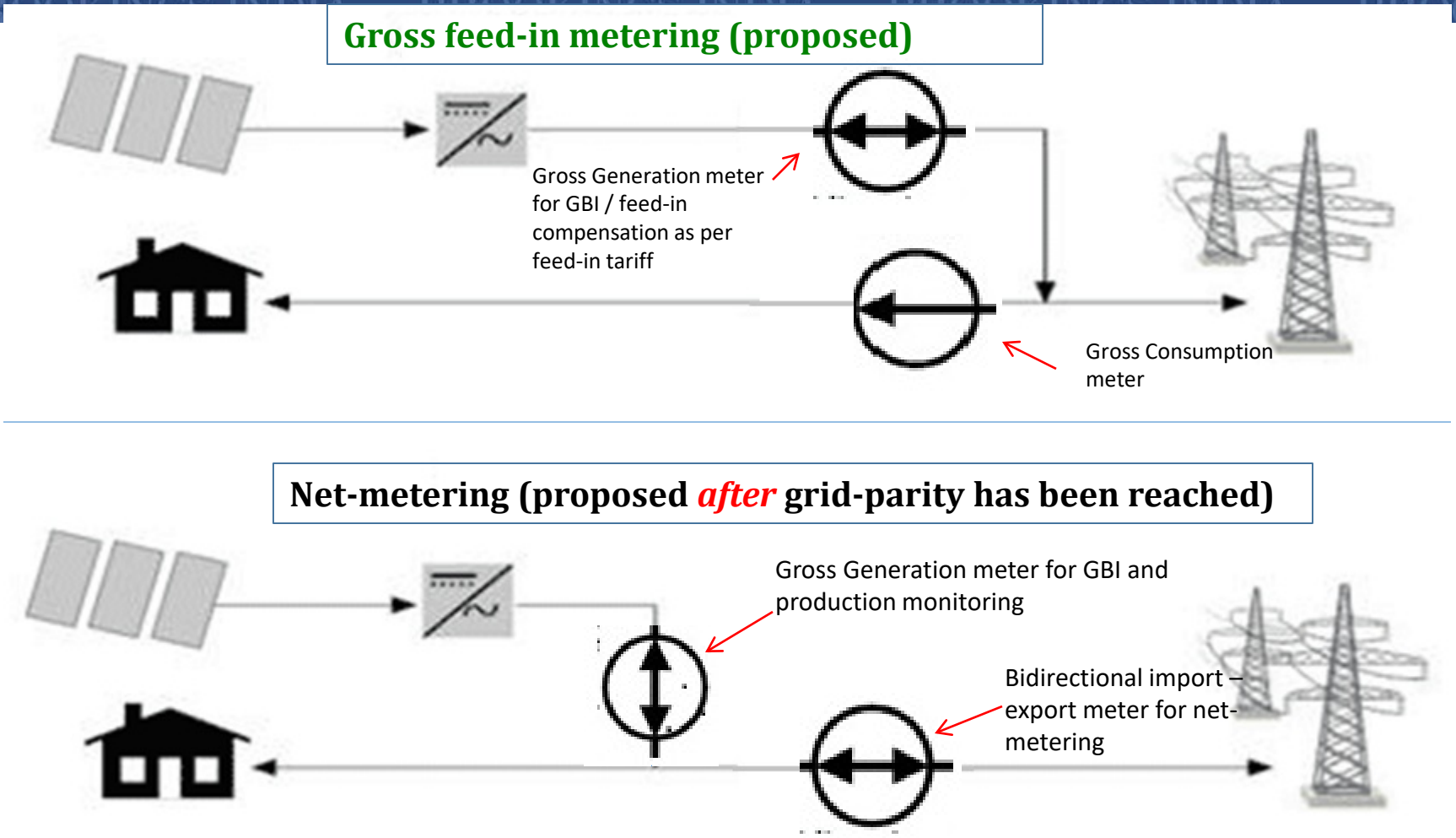
Where do these go?

??



Source: ISGF

One proposed metering schema (ISGF, courtesy S. Govindarajan)

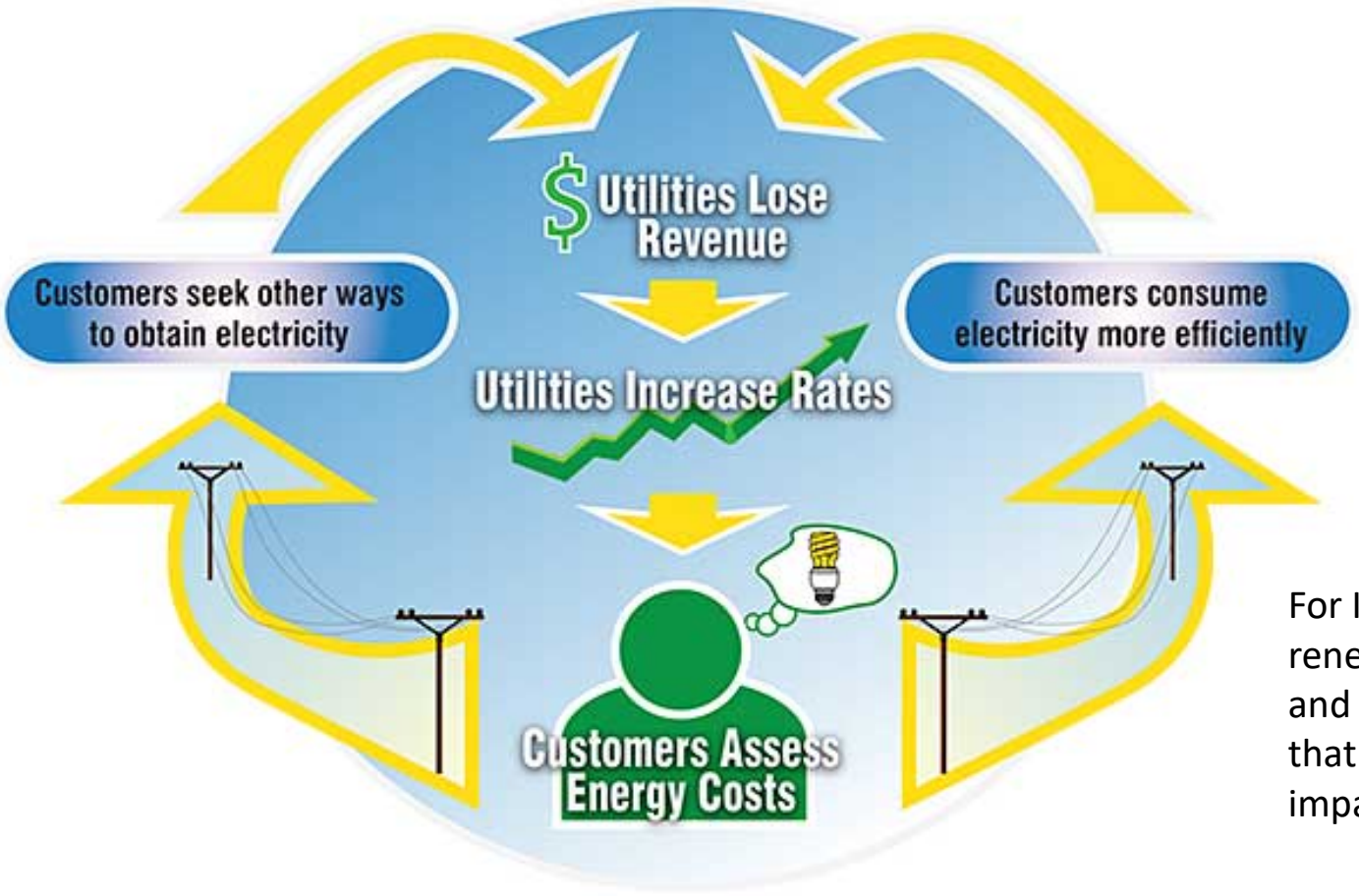


Source: ISGF

Policies in India

- There is no single policy
- States and even utilities have offered different mechanisms
  - Capital subsidies
  - Operating support
    - GBI (Generation Based Incentive)
    - Feed-in-Tariff
  - Etc.
- Other mechanisms
  - SPOs (overall or by consumer type)
    - 6% SPO by generation means FAR more by capacity
  - Mandatory rooftop solar PV (Haryana), and now Chandigargh
  - Mandatory solar *thermal* in Bangalore
    - Avoids est. 400+ MW of morning load
- CEA has notified some technical specifications for <33 kV interconnections to the grid
- There are often other restrictions, e.g., Mumbai and construction

Utility Death Spiral…driven by Solar



Source: The Appalachian Voice

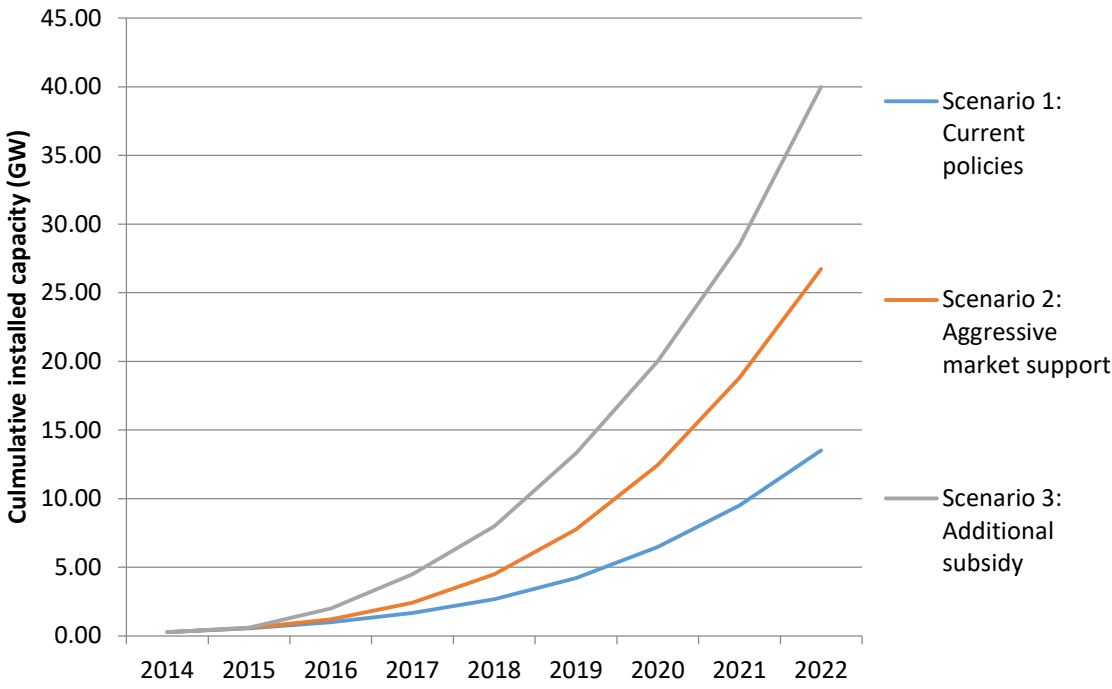
For India, it's not renewables but theft and tiered slabs (tariffs) that can have similar impacts

Where is the conversation in India?

- Limited or no talk about Smart Inverters (IEEE 1547)
- The economics are a main issue AT A SYSTEMS LEVEL
  - Most consumers use the grid as a battery
  - *Should we allow ~free banking?*
- What about actual PLFs?
  - Cleaning matters
- Where are RESCos/YieldCos?
  - At most they talk to C&I

Also see Rooftop Solar Policy Coalition's Report (2015-16)

- We have lots to grow, but are NOT on track for the 40 GW target
- Complexity, human capacity, and incentive (conflicts) are the main challenge
  - Even if someone WANTS it, what are the practical, on-ground challenges



What does this all mean?

- Think from a consumer perspective
  - Is this worth it?
  - What's my net cost vs. benefits?
    - Depends on the scheme
    - Depends where I am (my SLAB in tariffs) [if net]
  - "Why not wait?" – prices are falling
  - What else can I do with my capital/roof/land/etc.?
- Think from a utility perspective
  - Is this worth it?

Basic calculations (estimates)

- Just talked to a large household user who paid (2017) for:
  - 6 kW system (no battery – that would raise costs)
  - 2.83 lakh cost AFTER 30% subsidy (else 4.10 lakh)
  - Net cost?
    - Depends on discount rate
    - Assuming a low discount rate (low risk) then power is about Rs. 4.5/kWh only
      - Marginal tariff is over 7….
  - 2018 numbers are about 25% lower maximum
  - It is viable?
    - For some consumers
    - Assuming it works on time and continuously
    - Benefit from free banking within the month
  - WHY do we have subsidies for the rich?

Challenges

- Bi-directional meters are needed
- Techno-economic challenges
  - Investments are relatively high, viewed as risky
  - Grid scale (large) is itself expensive
    - What is parity?
  - Tariff slabs impact different folks differently
  - Marginal costs and value
    - Time of Day and other pricing??
  - Germany as an example and warning – is very expensive
- Unstable grid
  - Most grid-tie systems disconnect on grid failure
- Inverter technology improvements – IT'S NOT JUST THE METER THAT MATTERS!
  - Hawaii demo'ed Smart Inverters
    - Can provide reactive power
    - Can manage variations in the local grid
  - Proposed updates to IEEE 1547

Implications for Business Models

- The economics are not YET ripe – esp. as a win-win-win (utilities, consumers, and society)
  - Else we wouldn't need support mechanisms
- What else can we appeal to or rely on?
  - Social responsibility
  - CSR
  - Vanity
- Business models
  - Lessons from wind
    - SIMPLIFICATION
      - Investor just gives money
  - Here, they would also offer rooftop space

New Finance Options…

- Mortgage loan funding – slightly cheaper than market
- Per unit payout models
  - Consumer bears little risk
- YieldCos (?) – Subset of patient capital (like a rental instead of flipping)
  - Most worried about risk – what if they invest but don't get paid?
    - Disputes over baseline can be avoided via gross metering
    - What happens if they cannot clean?
      - Leaving to the consumers to clean has dual problems
        - No incentive to clean
        - Poor quality (damaging) cleaning
  - Consumer risk profiles (credit ratings) are sketchy at best
- New idea being discussed: Can the utility become involved?

Some Recommendations

- Psychology – people must want it
- New builds – enable the infrastructure
- If "net", offer the highest possible slab else will lose consumer interest
- Change the metering as/when grid parity is reached??
  - *Start with a feed-in tariff mechanism and transition to net-metering when solar energy costs reach grid parity (?) [ISGF recommendation]*
  - *OR, just leave it as gross metering??*
- Non-financial instruments for support
  - Enhanced FSA/FAR build-ups

Future of Rooftop solar and net metering

- Future policy discussions cannot ignore storage technologies, Electric Vehicles, etc.
- Time of Day tariffs will also become critical
- Will this be a niche technology or widespread?
  - If we truly want it to scale, it should NOT depend on support (else, will be a burden on the utilities, or perhaps exchequer)
- Good news is technology is improving, esp. for batteries but also panels and inverters
  - This then becomes a useful tool in the portfolio of solutions for energy security and sustainability

Grid Scale PV Finance

- "Green Finance" means what?
  - Designated?
  - Lower costs of capital
- What are the risks for solar?
  - NOT fuel risks (ala coal)
  - Biggest is counter-party risk (utilities)
    - Poor cash flows
    - Delayed payments (contracts don't help as no one calls in failure i.e., dispute/arbitration)
    - Attempts to re-negotiate PPAs
      - New solar is usually cheaper than old solar
    - Cancelling bids
      - Some price rise wasn't markets only – change in govt. policy (such as GST, import tariffs of 25%, etc.)

Ultimate Aim – Cheap Global Capital

- The pension and sovereign funds are willing to take a VERY low rate of return
  - BUT that is in USD or Euros – today's forex hedge is about 6% cost
- What such investors want is not returns but risk-adjusted returns
  - Their priorities are:
    - Governance
    - Predictability
    - Returns (in that order)

Government policies to ease large scale financing

- Understand different capital is best suited to different stages of a project
  - Only AFTER operations and secure cash flows can we move to low-cost global debt
- Up front capital is high risk – needs higher RoR
- AND, we have to enable frictionless (or low-friction) transfers
  - More than an “exit” per se

The future is already here – it's just not evenly distributed

- William Gibson