USAID Distributed PV Building Blocks

Interconnection Processes, Standards, and Codes

Presented by Alexandra Aznar and Sherry Stout
National Renewable Laboratory

May 23, 2018

USAID Distributed PV Pilot Program

- A multi-year program to assist USAID partner countries across the DPV spectrum in developing and implementing pilot projects to accelerate DPV market development.
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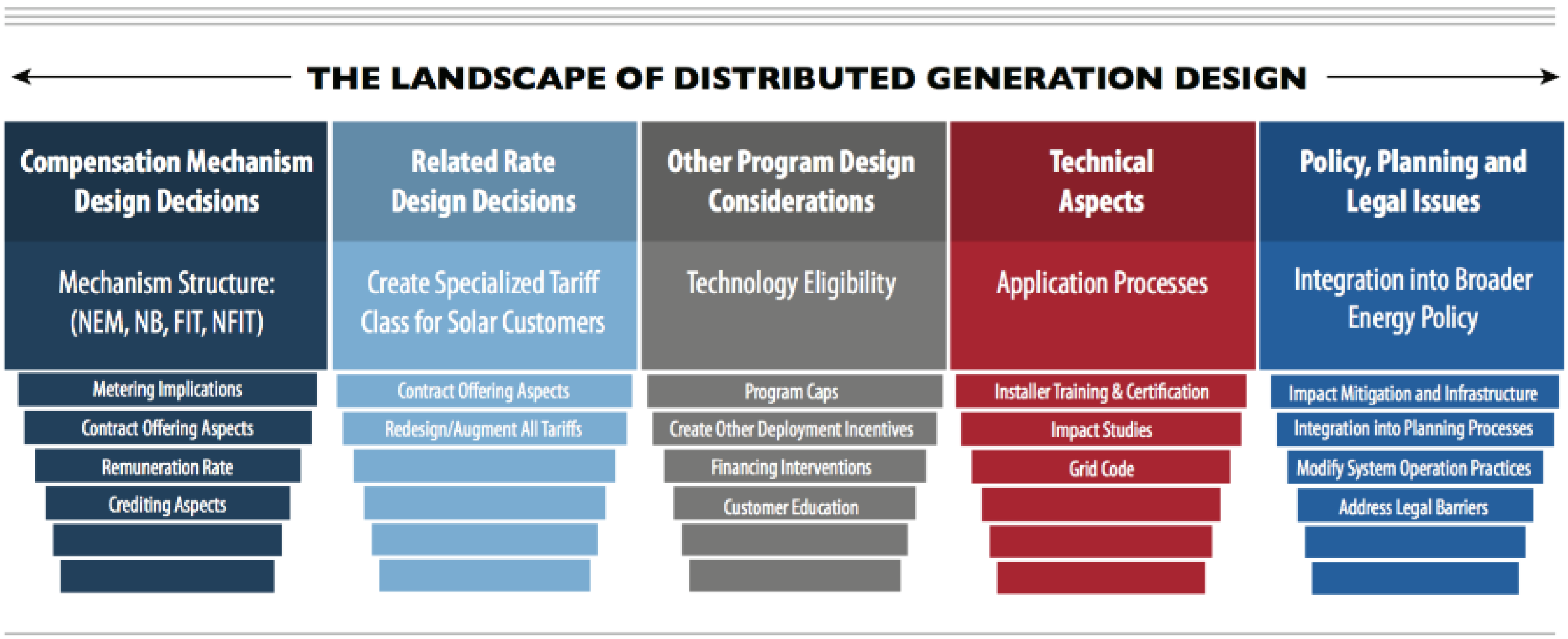
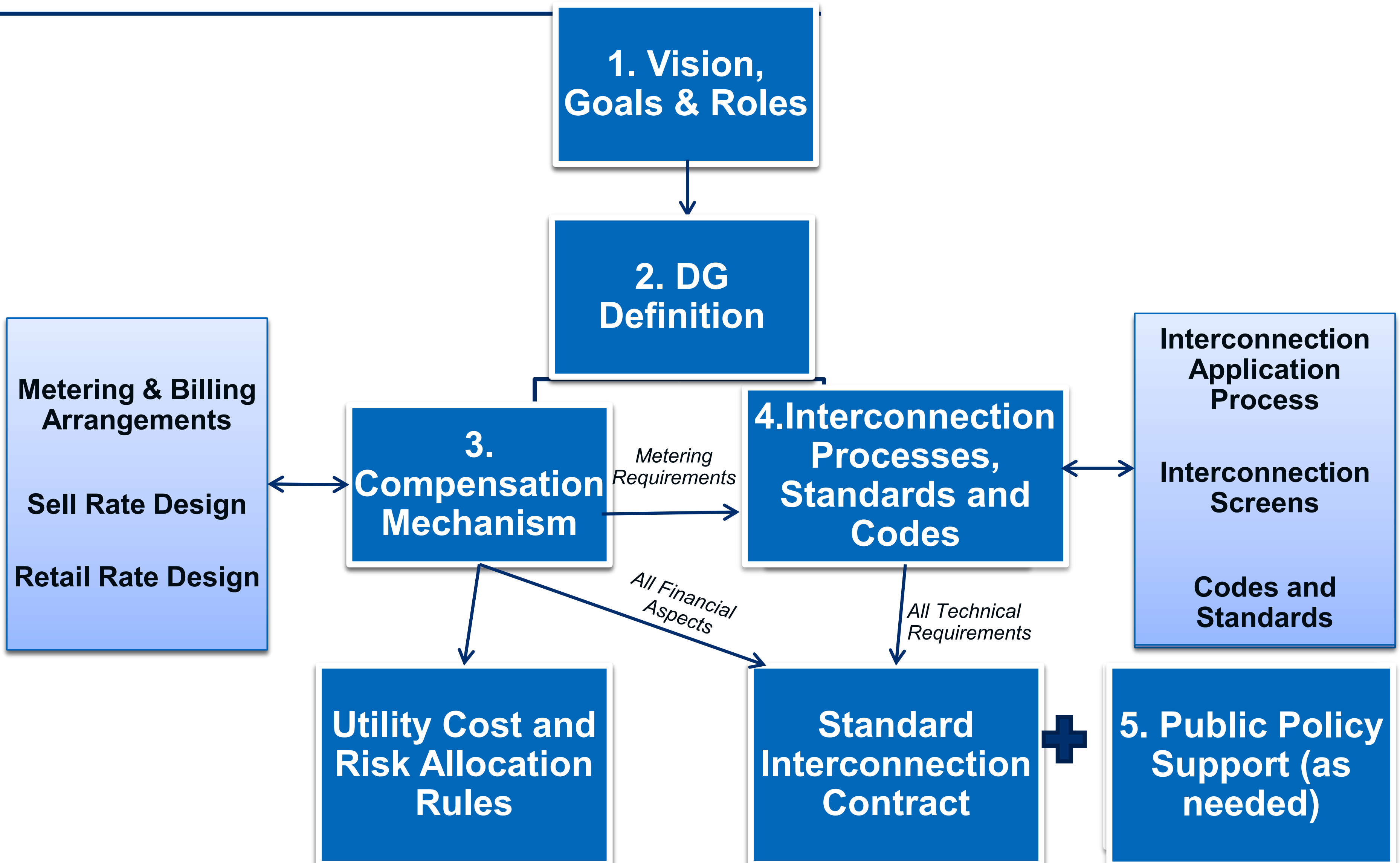


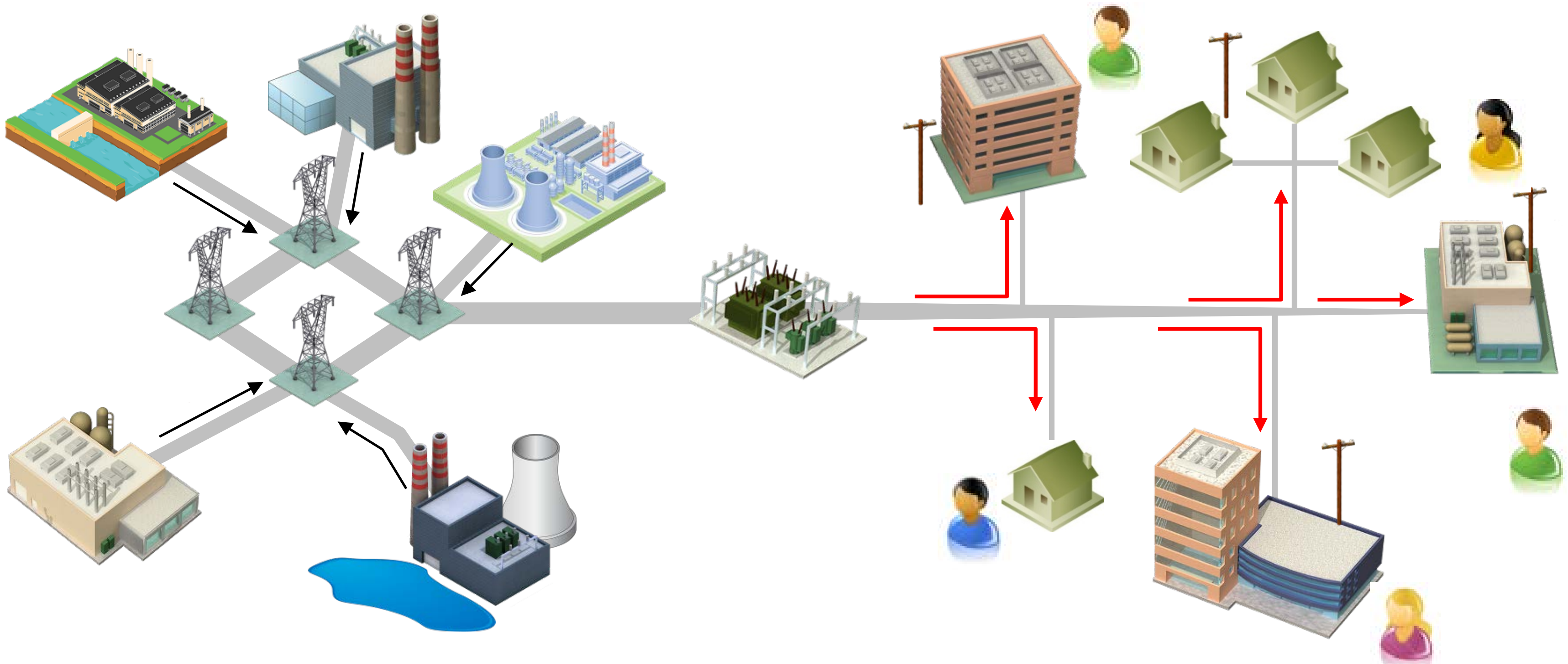
Building Blocks for DPV Deployment



Learning Objectives

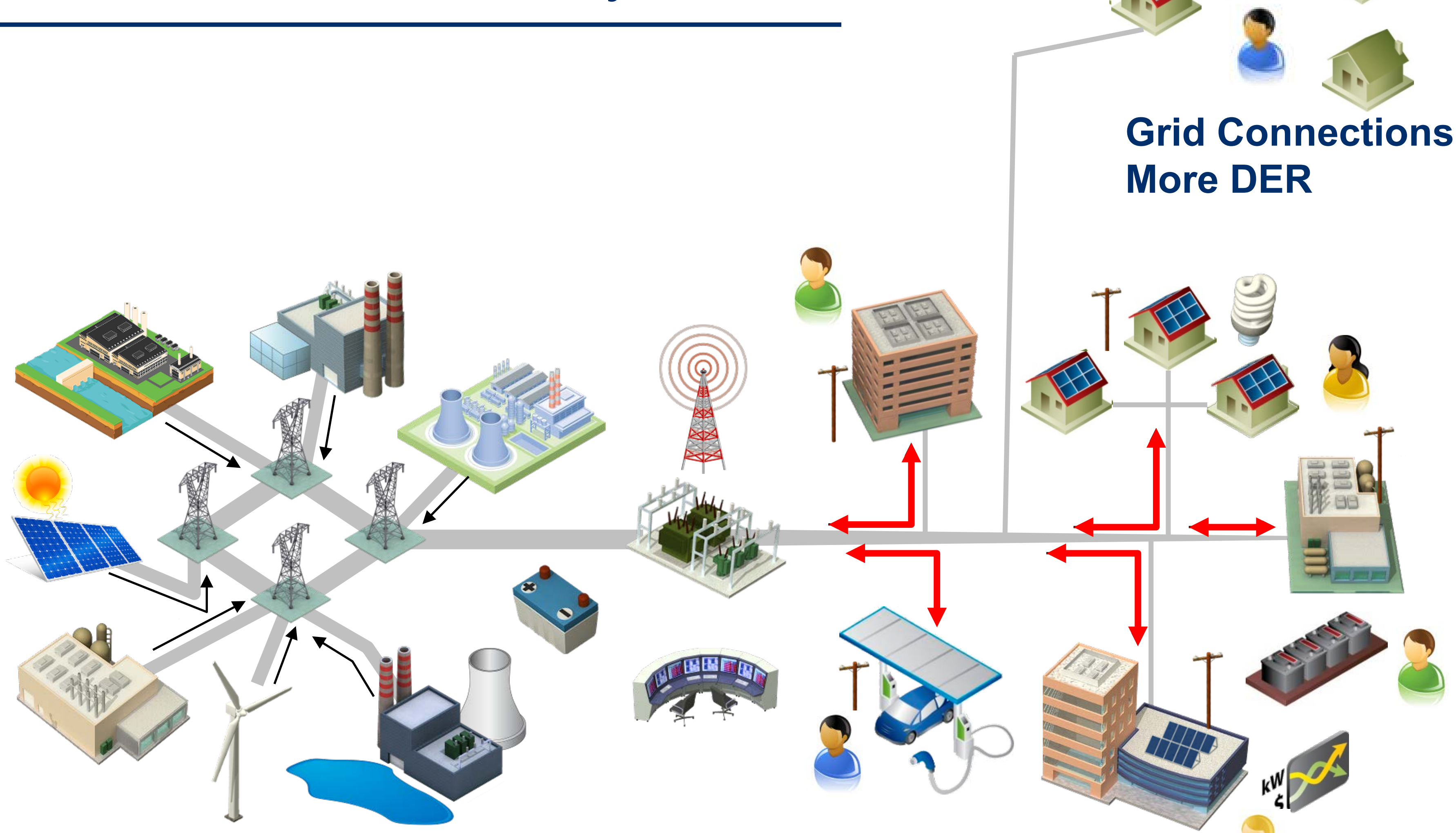
1. Identify basic DPV technical challenges and major concerns of electric utilities
2. Understand the basic interconnection processes and technical screens used for quick review and approval of DPV systems

Today's Power System



Source: Bryan Hannegan. EPRI

Tomorrow's Power System…

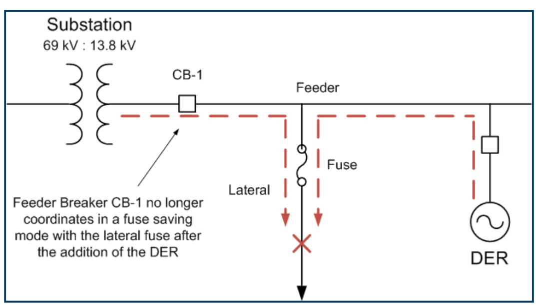


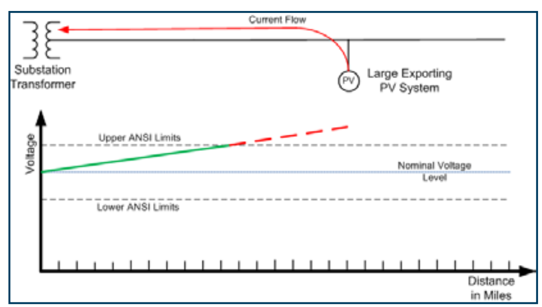
Tomorrow's Power System is Here Today (in Some Countries)

Source: Bryan Hannegan. EPRI

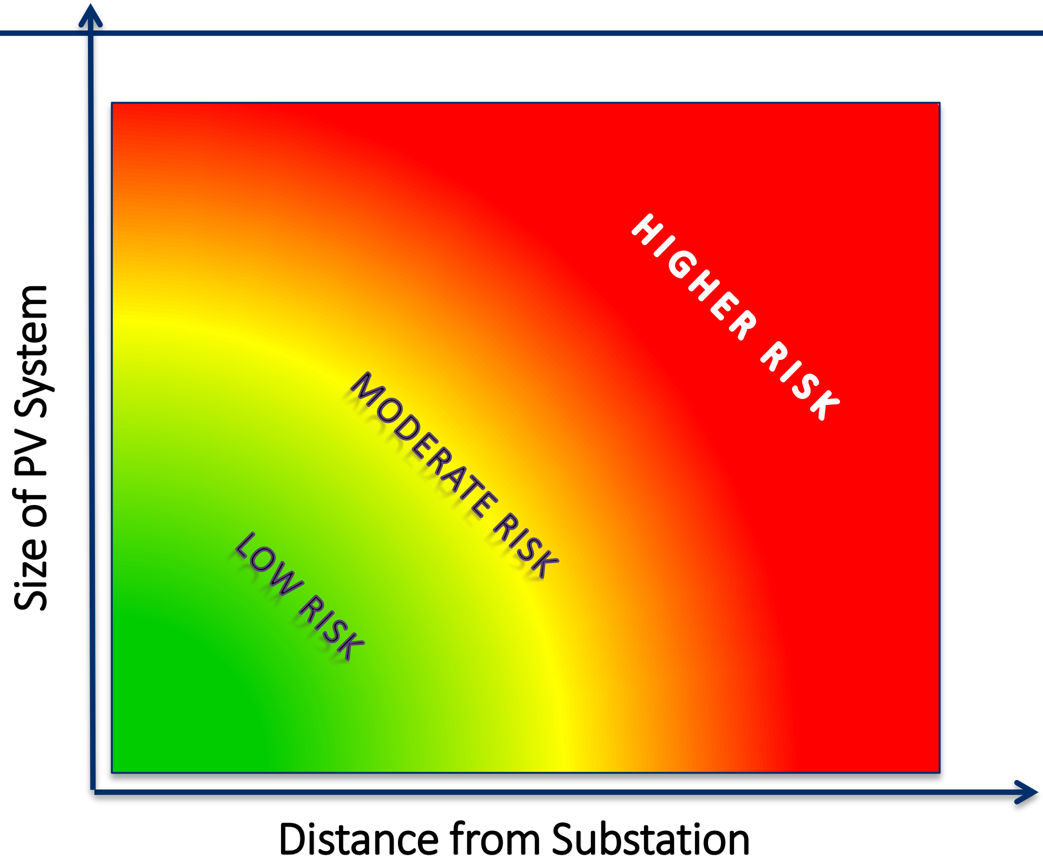
PV Requests for Interconnection Bring Concerns for Utilities

- Voltage regulation
- Reverse power flow
- Protection system coordination
- Unintentional islanding
- Increase in maintenance and decrease in equipment life due to increase switching
- Load masking





How much PV is too much?



Answer: It Depends!

Factors for determining the maximum grid hosting potential for a given feeder are numerous, including:

-Size of each DG system
-Location of each DG system
-Impedance of feeder
-Local cloud variability
-Location of capacitor banks
-Line regulation configuration
-Presence of other DG and loads

<u>Global Experience:</u>
At low* penetrations of DG, technical impacts are typically relatively easy to manage!

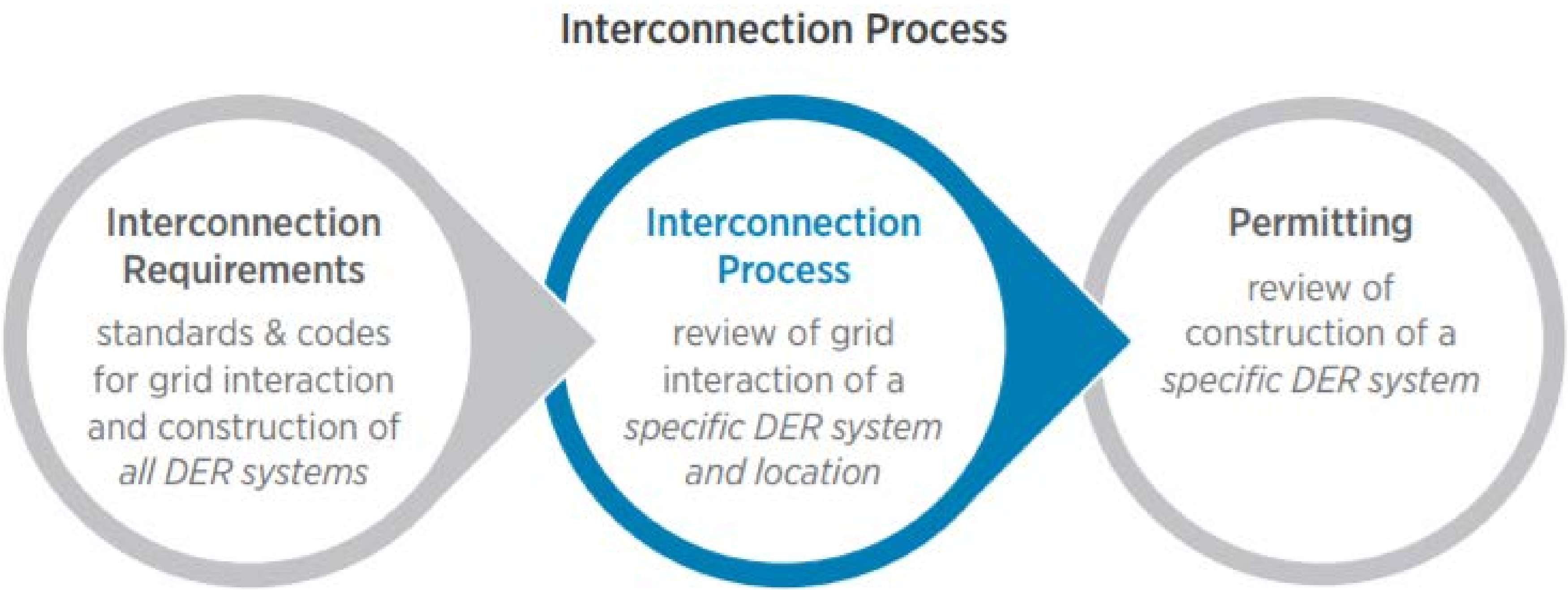
*Less than 15% of Peak Load or 100% of Minimum Daytime Load

Supporting the Electricity Distribution System

Ensure DPV installations are "good grid citizens" that <u>help</u>

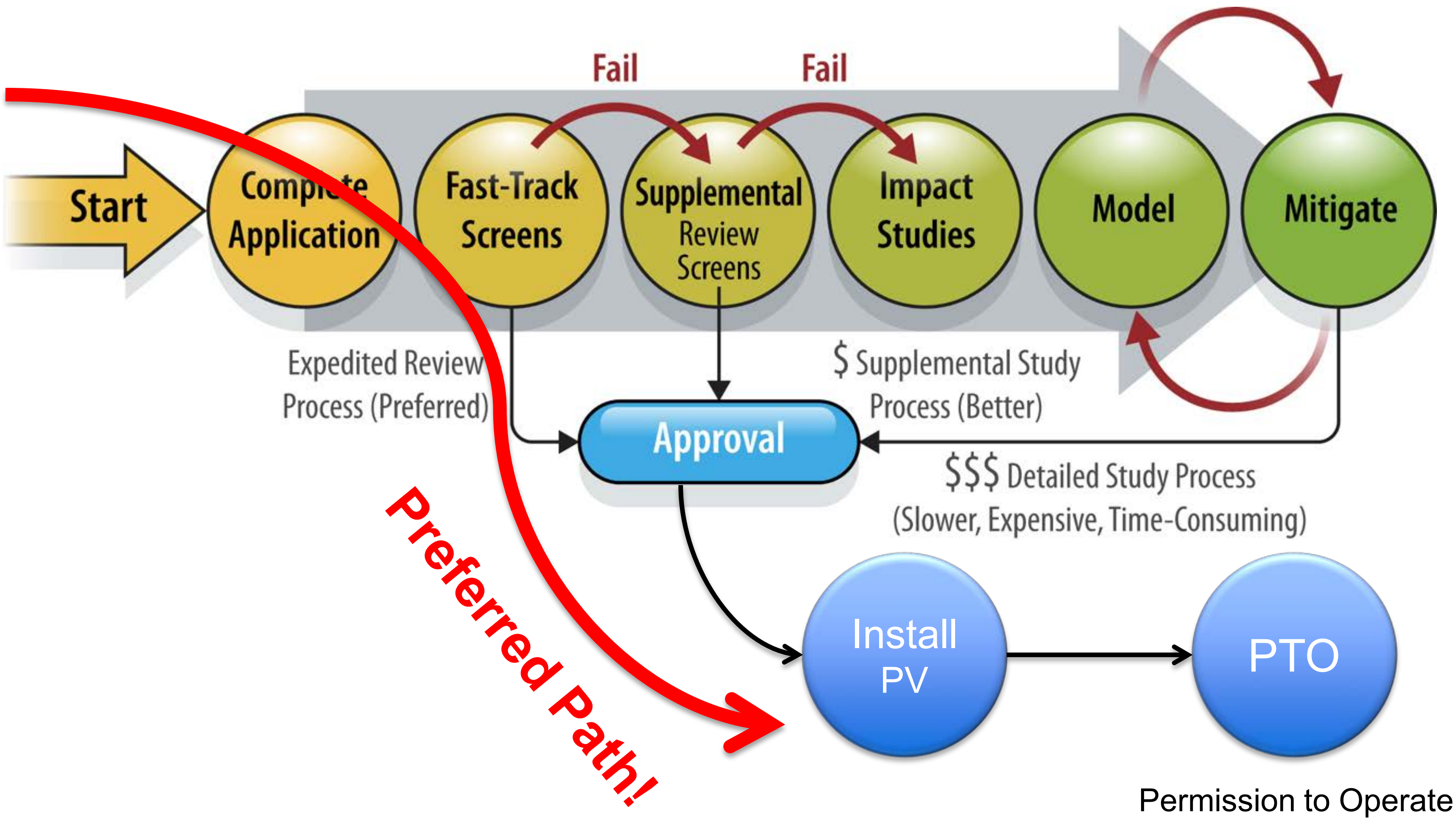
- Voltage and frequency match utility specs
  - Reactive power control helps support voltage
- Voltage ride through and frequency ride through
  - Stay online during grid voltage of frequency dip
  - Improve system stability with high DG saturation
- No unintentional islanding
- Provide excellent power quality
- Maintain system protection and reliability
- Dynamic control
  - Ramp rate and curtailment of real power
  - Communication allows PV to be part of the utility system

Interconnection Process



Source: http://www.nrel.gov/docs/fy17osti/67633.pdf

Classic Interconnection Process

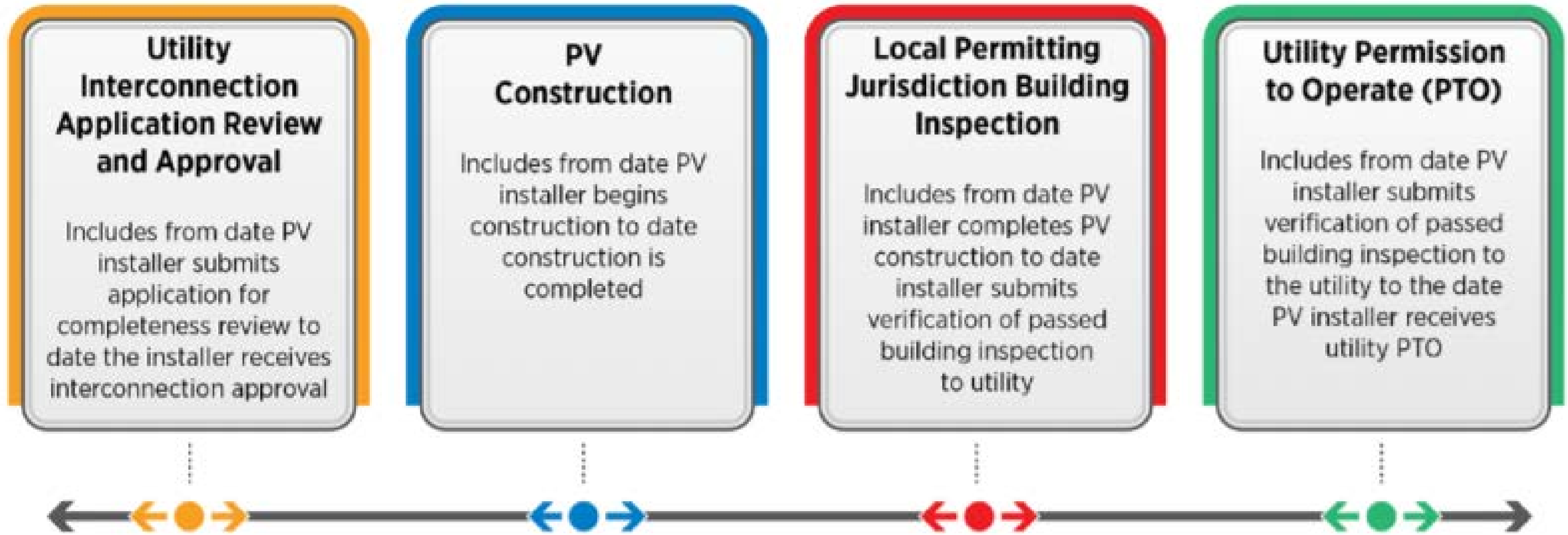


Technical Screening – Example Screens (FERC)

- Screens are simply sets of technical questions.
- Technical screens have been recommended for many utilities (U.S. and other countries).
- German utilities upgrade their grid as-needed and do not screen anything (externally visible).

1. Aggregated distributed generation (DG) <15% of peak load on line section
2. For connection to a spot network: DG is inverter-based; aggregated DG capacity is <5% of peak load and <50 kW
3. Aggregated DG contribution to maximum short circuit current is <10%
4. Aggregated DG does not cause protective device to exceed 87.5% of short circuit interrupting capability
5. DG interface is compatible with type of primary distribution line (wye/delta)
6. For a single-phase shared secondary, aggregated DG capacity <20kW
7. Resulting imbalance <20% of service, transformer rating of 240 V service
8. Aggregated transmission connected DG capacity <10 MW for stability-limited area
9. Construction not required for interconnection

Interconnection Timelines



How long *does* it take?

How long *should* it take?

Source: http://www.nrel.gov/docs/fy15osti/63556.pdf

Interconnection Timelines

Table 1. Total Days for Utility Interconnection for Full U.S. Sample, by Project Size

System Size	Mean	Median	Std. Dev	Sample Size
Residential (up to 10 kW)	60	52	39	7,489
Small Commercial (10–50 kW)	74	62	44	740
Full Sample (up to 50 kW)	63	53	41	8,229

Table 5. PV Projects that Exceeded Application Review and Approval Time Requirement, by State and Size

	Residential (up to 10 kW)			Small Commercial (10–50 kW)		
State	Time Req. (business days)	Applications Exceeding Time Req. (%)	Median for Applications that Exceeded Time Req. (business days)	Time Req. (business days)	Applications Exceeding Time Req. (%)	Median for Applications that Exceeded Time Req. (business days)
CA	25	37%	38	25	47%	39
NY	15	38%	49	15	38%	60
NJ	13	52%	18	18	42%	27
CO	25	58%	50	30	45%	59
AZ	[20]*	53%	43	[20]*	54%	43

* 20-day threshold is assumed for analytic purposes, because Arizona has no interconnection timeframe requirements.

Source: http://www.nrel.gov/docs/fy15osti/63556.pdf

Example: Mandatory Utility Response Times in Mexico

Activity	Responsible Entity	Maximum Working Days for Response
Registry of the request	Retail Provider	1
Verification of information	Distribution Utility	2
Letter of acceptance when no study or infrastructure is required	Distribution Utility	4
Letter with study or infrastructure budget	Distribution Utility	10
Documentation review	Retail Provider	1
Modification of the interconnection infrastructure	Applicant or Distribution Utility	TBD*
Relocation of meter	Distribution Utility	5
Signing of agreement	Retailer	2
Integration to the commercial scheme	Retailer	1
Total time without study or infrastructure modification		13
Total time with study or infrastructure modification*		18

*These times do not include the construction of specific upgrades or the response times of the activities that correspond to the Applicant. In Mexico, either the Applicant or the Distribution Utility can make the required grid upgrades.

Applying Interconnection Codes & Standards

Electric Utility
T&D Systems

National Electrical Safety Code

Utility Manual of Safe
Practices

Point of
Common
Coupling

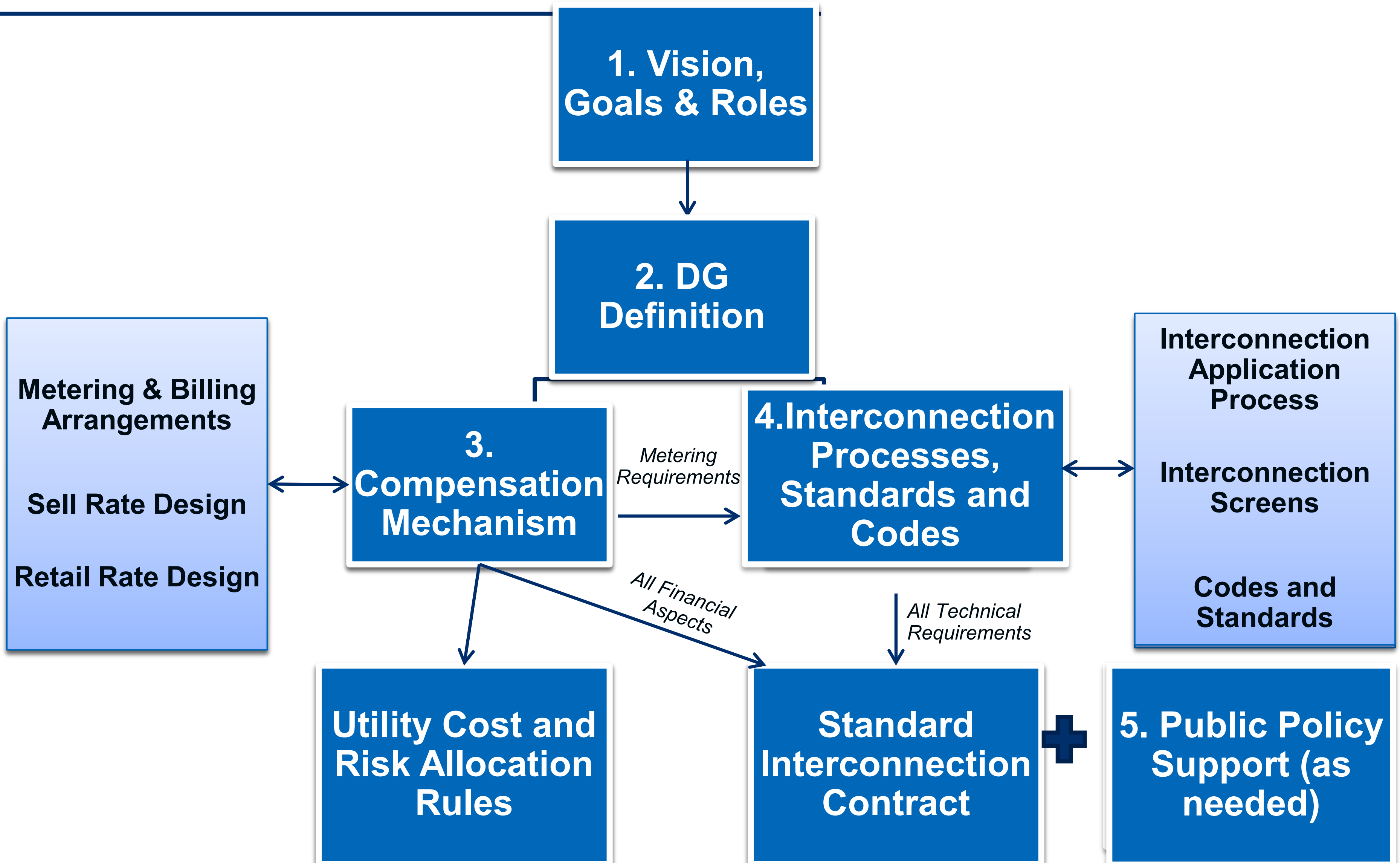
IEEE 1547

Industrial,
Commercial,
and Residential
Buildings

National Electrical Code

UL 1741

Building Blocks for DPV Deployment



Best practices and emerging trends in distributed photovoltaic (DPV) financing and business models

Presented by Jason Coughlin
National Renewable Laboratory

May 23, 2018

Learning Objectives

- **Understand both established and emerging DG solar financing options**

- **Understand the kinds of business models that can enable DG solar deployment and market growth**

Financial Incentives

- **What are you trying to do?**
  - Lower the cost of buying and installing distributed PV systems
  - Improve the return on investment
  - Attract investors to the solar industry

- **Who can provide them?**
  - National or subnational governments, utilities, philanthropies, etc.

Financial Incentives: Tax Credits, Deductions and Exemptions

Production-based tax credits

- Tax credit for every kWh of renewable energy produced
- Earned over time with energy production (e.g., 10 years)

Investment-based tax credits

- Allows PV system owner to claim a tax credit equal to a fixed percentage of eligible project costs, for example, 10% or 30%.
- Percentage can adjust downward over time
- Accelerated Depreciation can lower your tax bill as well.

Tax Exemptions

Eliminate or reduce the following taxes

- Sales Taxes
- Taxes on imported equipment
- Property taxes on value of solar system

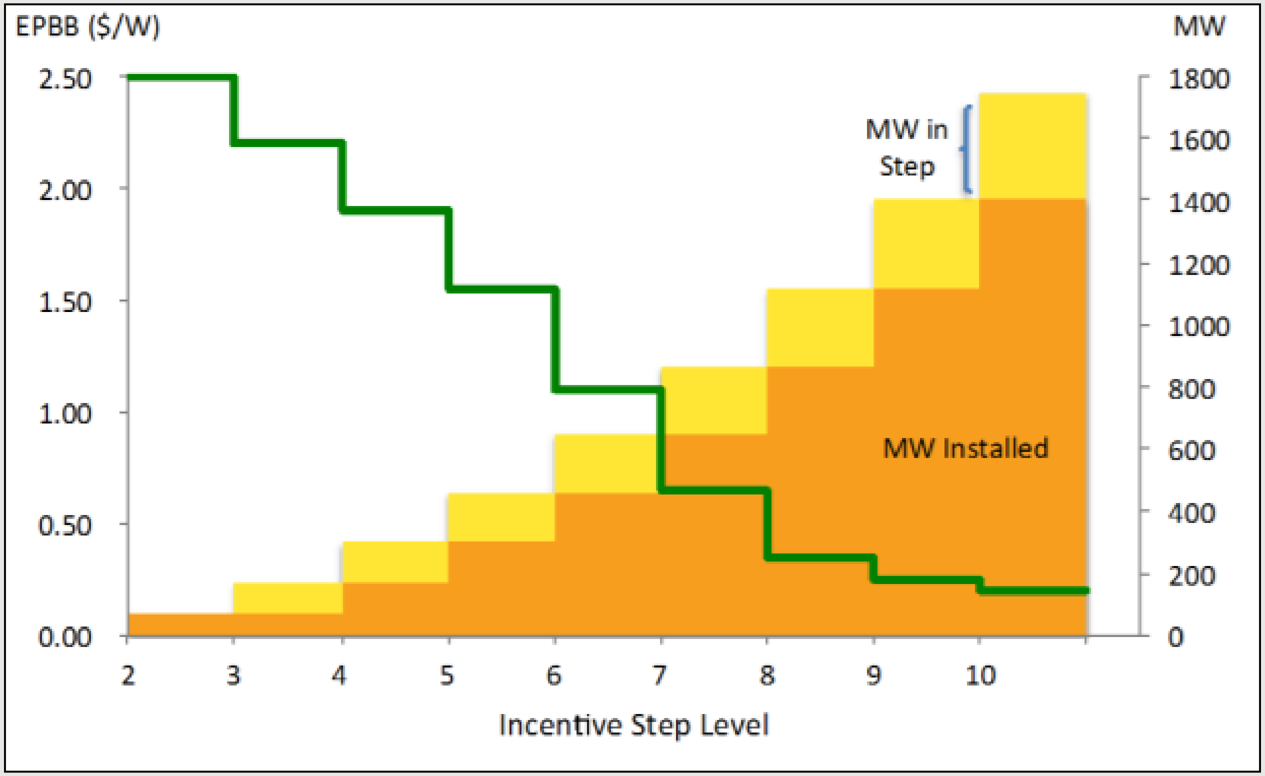
Financial Incentives: Cash payments and rebates

- At state, local, or utility level
- Value of incentives typically decline over time as certain installed capacity targets are reached or with declines in distributed PV system costs.
- Incentives can be tailored to support specific market segments like low income households or former industrial sites that may be contaminated with no other potential use.

Upfront Rebate	Reduces initial cost of installing DGPV system
Performance-based Rebate	Provides ongoing payments to system owner based on the system's actual kilowatt-hour production

California Solar Initiative (CSI)

CSI EPBB Capacity Steps and Rebate Levels



Structured incentive decline over time provided clear market signal to reduce costs

Source: https://emp.lbl.gov/sites/all/files/lbnl-6927e.pdf

Distributed PV Generation Business Models

Customer or Third-Party Owned PV Systems

- Customer-owned model
- Third-party-owned model
- Group buy programs
- Community solar model

Utility Investments in Solar

- Utility build-own-operate
  - Rent a roof
- Utility-led community solar projects
- Utility investments in solar companies and projects

Direct Customer Ownership of PV Systems

- **Cash purchase**

- **Loan financed**
  - Secured or unsecured loans
  - Solar loans
  - Home-equity based financing
  - Subsidized loans

- **Property tax-based financing**
  - Private investors or local governments fund the up-front cost of energy improvements, including PV, on commercial, non-profit and residential properties;
  - Property owners then pay back financing over time through additional property tax payments.

Business Models: Third-party Ownership

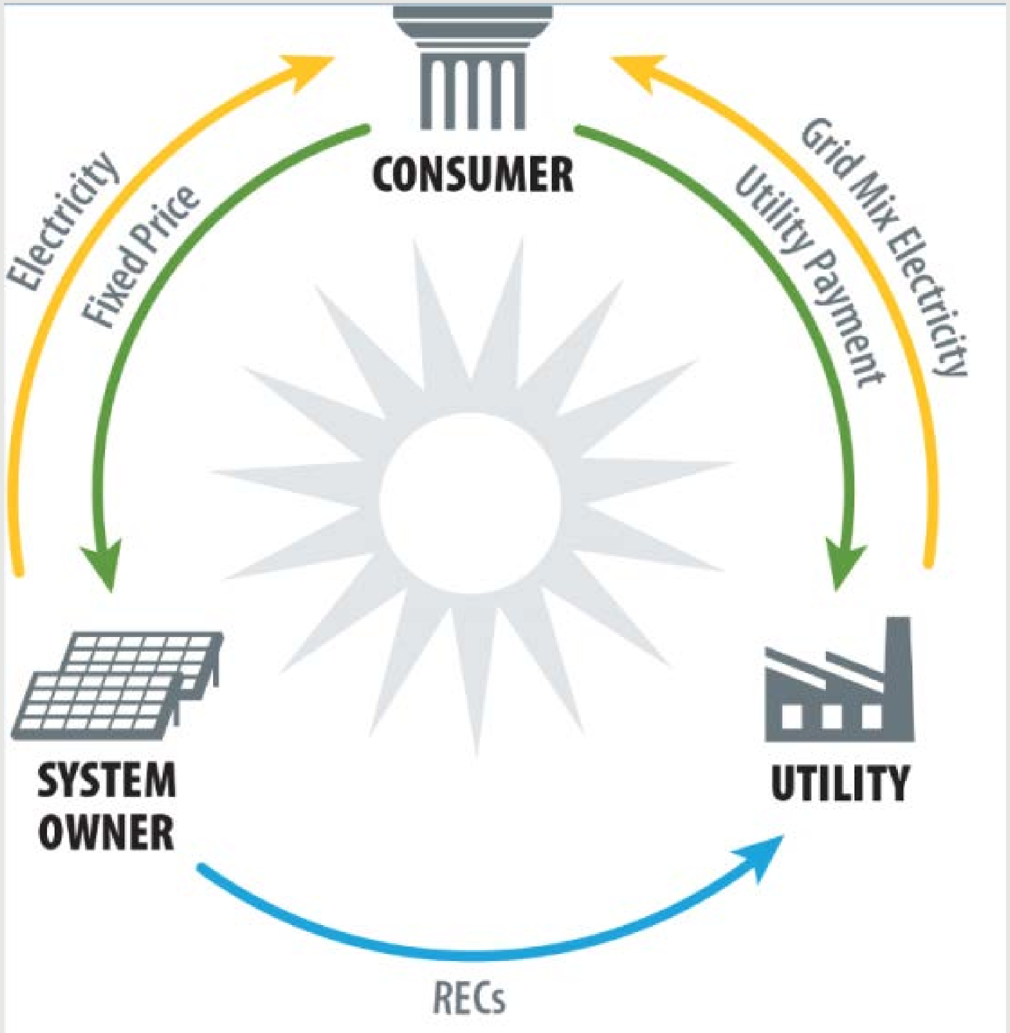
The role of the third-party developer

- Procures, finances, and owns a PV system *instead* of building owner
- Can monetize tax credits and incentives
- Behind the meter systems

The role of the building owner

- Hosts the PV system on the roof or property
- Purchases electricity generated from PV system through a contract know as a power purchase agreement (PPA).

Power Purchase Agreement (PPA)



Note: RECs can also flow to the consumer instead of the utility, depending on the structure of the contracts.

Source: NREL 2016

Business Models: Customer-Owned-Group Purchase Programs

What?

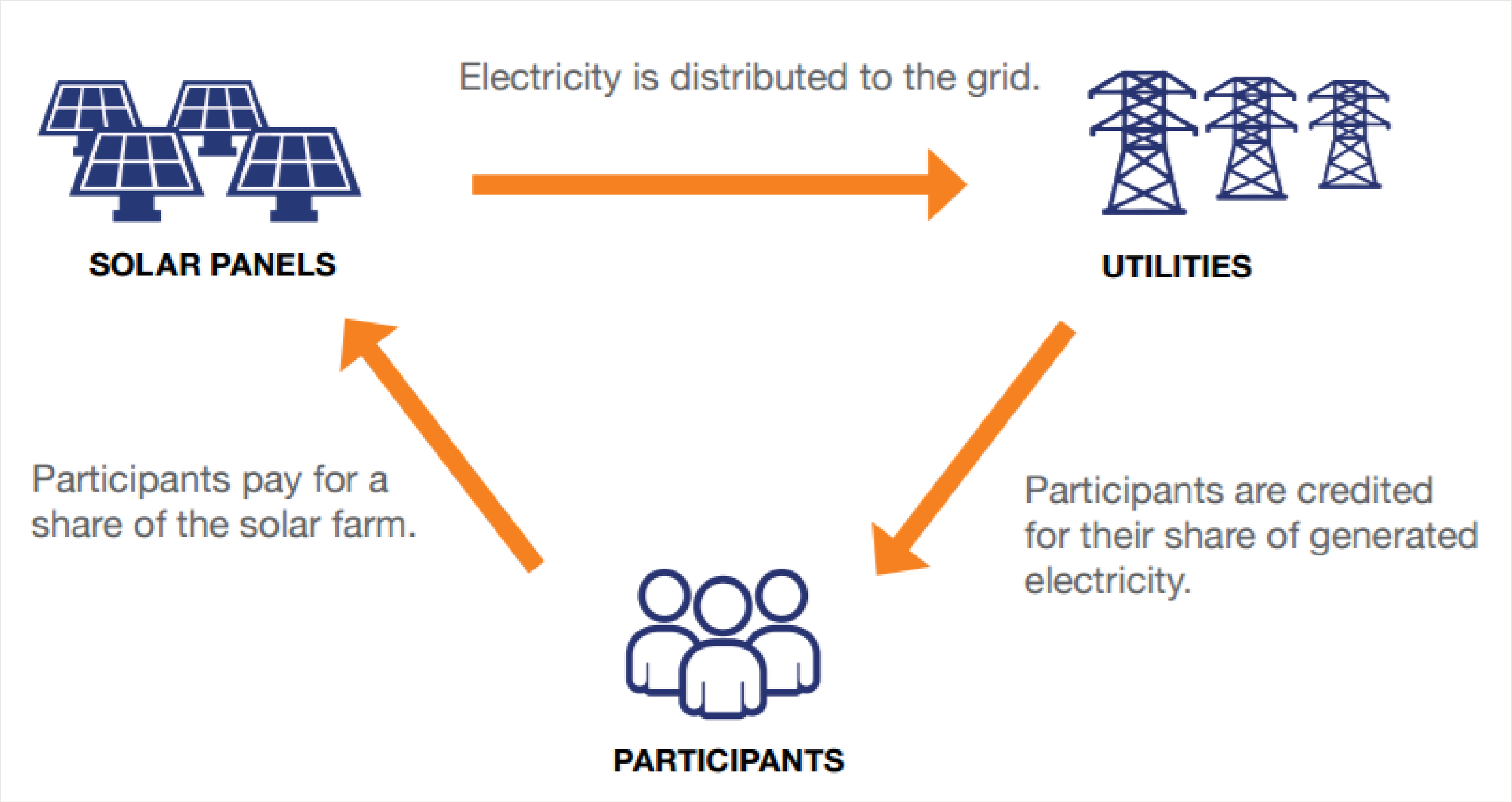
- Homeowners and business owners select solar installer and negotiate a discount by buying in larger quantities.

Why?

- Reduces complexities associated with installing solar
- Competitive price for consumer; economies of scale for installer
- Overcomes customer inertia
- Reduces customer acquisition costs for installer

Source: http://solaroutreach.org/solarize/#.WCzzMrIrKpo

Business Models: Community Solar



Source: http://www.sepapower.org/media/422095/community-solar-design-plan_web.pdf

Business Models: Utility Ownership of Distributed PV

- Utility build-own-operate (i.e., “rent a roof”)
- Utility-led community solar projects
- Utility investments in distributed solar

Business Models: “Rent-a-roof” (Gujarat, India)

- “Rent-a-roof” concept
- 5 MW public-private partnership
- Two private solar companies selected through competitive bidding process
- Solar companies lease rooftops (government buildings and residents); install and connect panels
- Rooftop hosts receive Rs 3 ($0.05/kWh) per unit produced
- Solar operator receives a 25-year Feed in Tariff payment of Rs 11.21 ($0.18/kWh)

Source: https://handshake.pppknowledgelab.org/features/rent-a-roof-in-india-2/

Map Source: https://upload.wikimedia.org/wikipedia/commons/thumb/7/78/Gujarat_in_India_(disputed_hatched).svg/951px-Gujarat_in_India_(disputed_hatched).svg.png

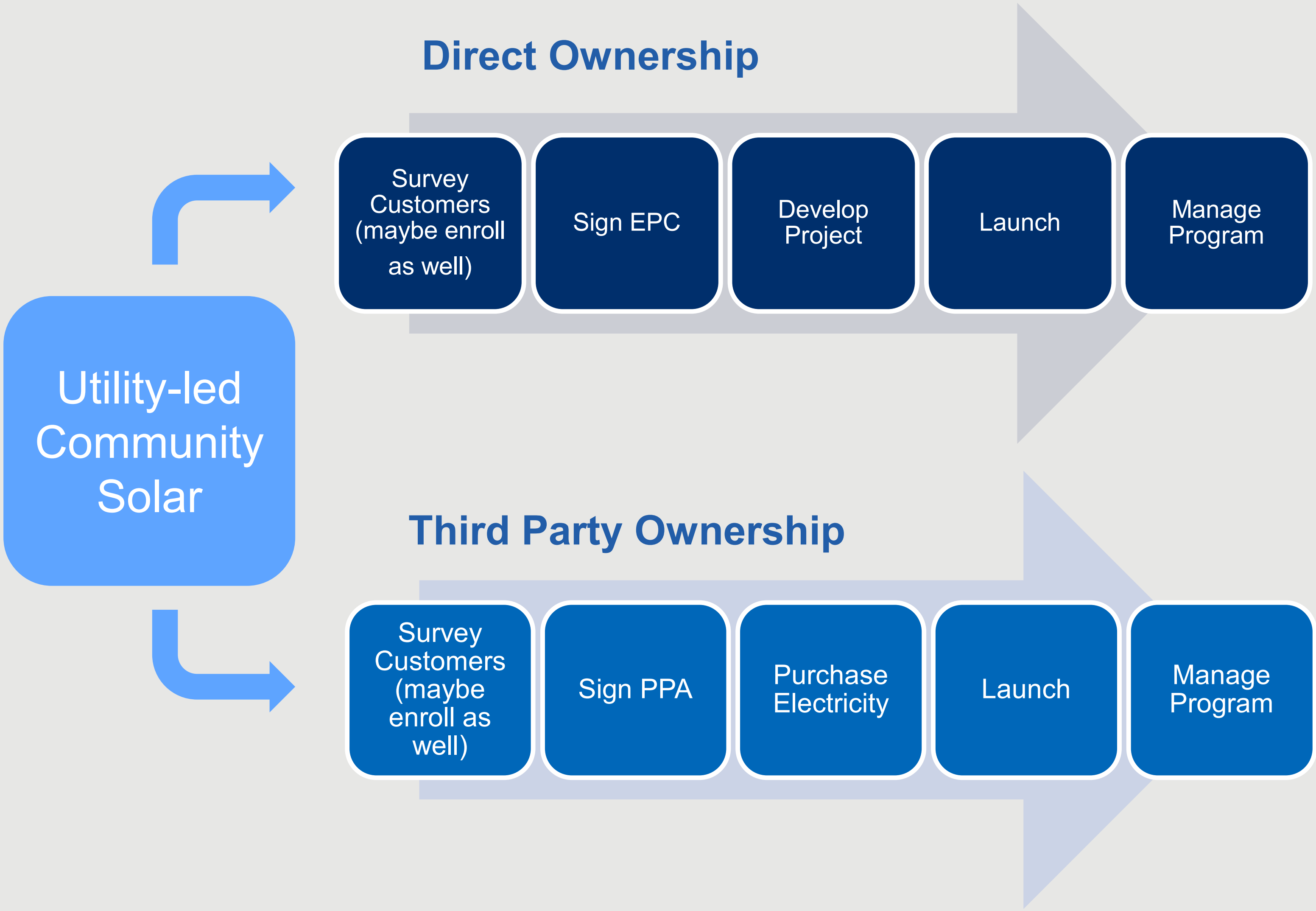
Utility rooftop pilot PV programs in the U.S.

Rather than simply facilitate interconnections of DPV systems on their grids, some utilities have developed business models where they own and operate DPV systems on customer rooftops.

- Arizona Public Service (APS)
  - $10 million pilot resulting in 1,670 systems installed
  - APS leases customers' roofs for $30/month for 20 years
- Tucson Electric Power (TEP)
  - $10 million pilot for 600 homes
  - Customer pays fixed monthly price for solar which covers all of their electricity needs
- Los Angeles Department of Water and Power (LADWP)
  - $30/month roof lease payment to customers for 20 years
  - Focus is on neighborhoods with minimal installed capacity

Sources:
https://www.aps.com/en/ourcompany/aboutus/investmentinrenewableenergy/Pages/solar-partner.aspx?src=solarpartner;
https://www.tep.com/residential-solar/;
https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-commsolarprogram?_adf.ctrl-state=9bowsdso1_4&_afrLoop=558473828575995

Utility-led Community Solar



Utility investments in distributed solar

Utilities have made significant investments both in distributed solar companies as well as in tax equity funds that invest in solar projects.

- According to market research from GTM* since 2010, nearly $3 billion dollars has been invested by utilities in both North America and Europe into distributed energy companies, including distributed solar.

- Utility-affiliated companies have also made investments in investment funds that invest in residential solar projects. Benefits from such investments include tax benefits as well as a better understanding of distributed solar markets and customers.

https://www.greentechmedia.com/articles/read/utilities-have-invested-over-2-9-billion-in-distributed-energy-companies#gs.I5oJHr0

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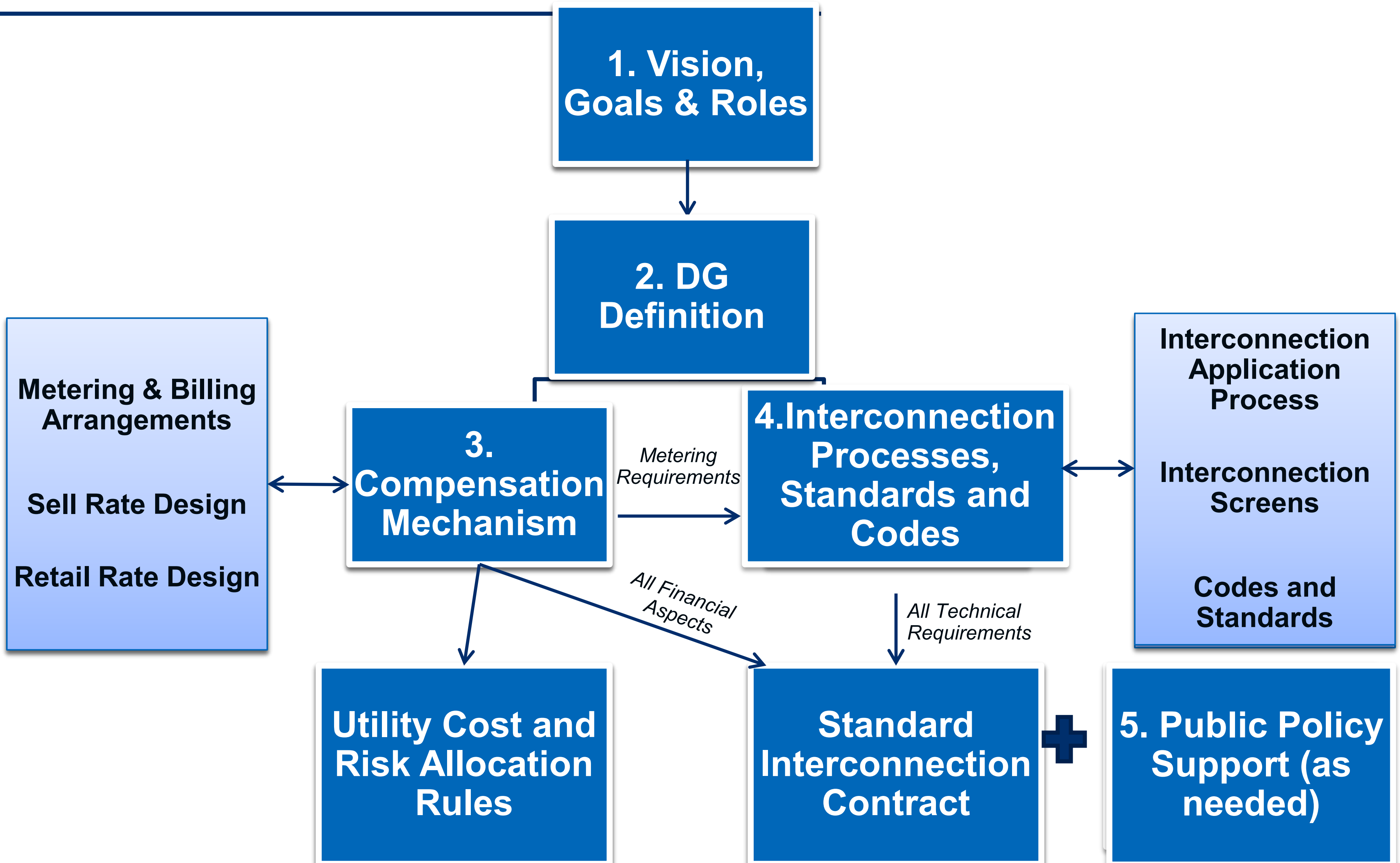

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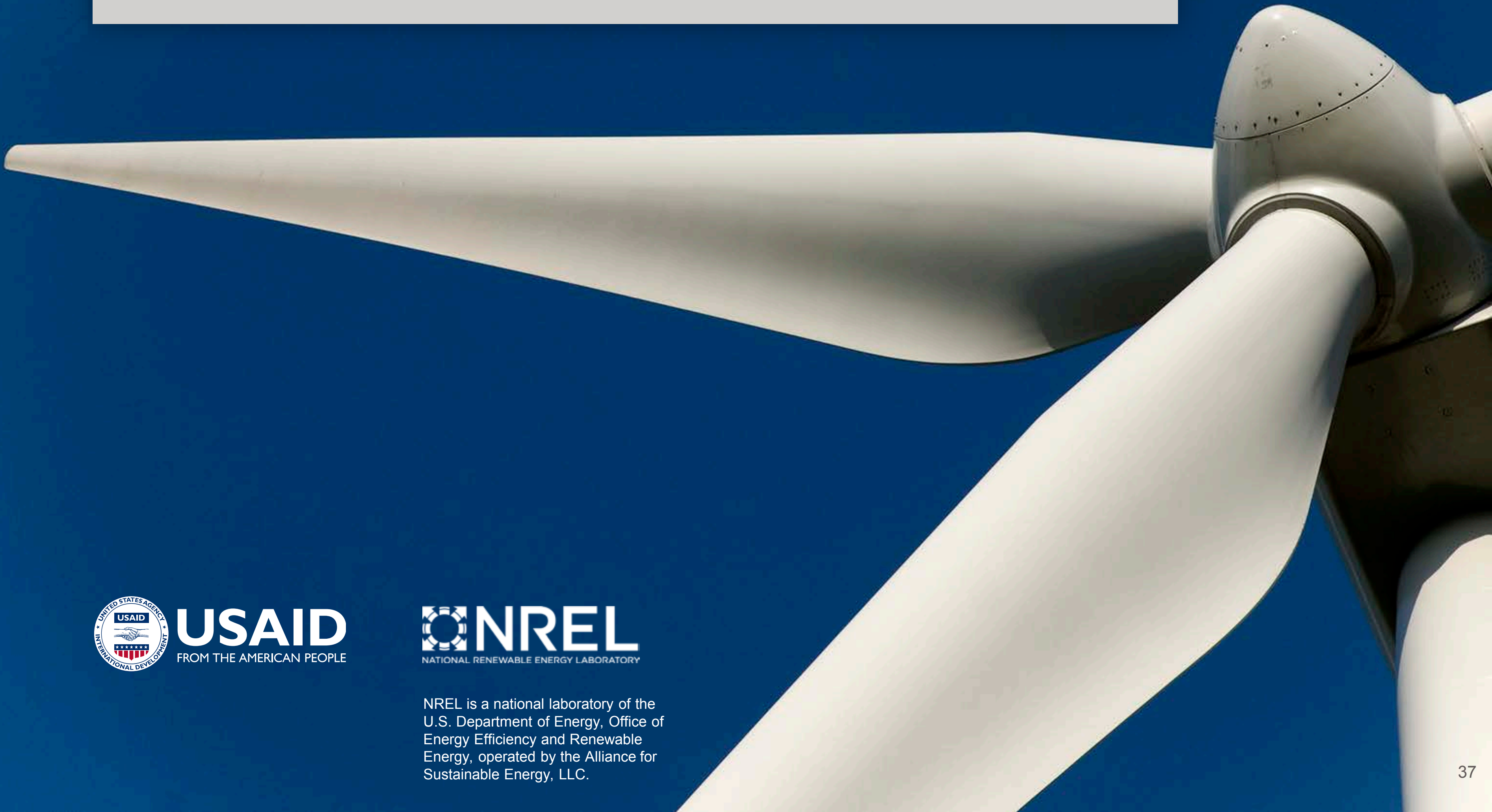

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