Beyond Net Metering: Pathways to Value-Based DER Compensation in Brazil

Brazilian Drivers for a New Valuation Approach to MMGD

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Distributed Generation Can Be Beneficial

ECONOMIES OF PROXIMITY

- **Well distributed generation** could provide **savings** by:
  - reducing – or postponing – investments in network expansion
  - reducing losses

- **<u>Dispatchable</u> Distributed Generation** could provide **additional benefits** by:
  - making networks more robust
  - providing localized ancillary services

- **<u>Renewable</u> Distributed Generation** could provide **additional savings and benefits** by:
  - substituting higher cost generation
  - replacing more polluting generation

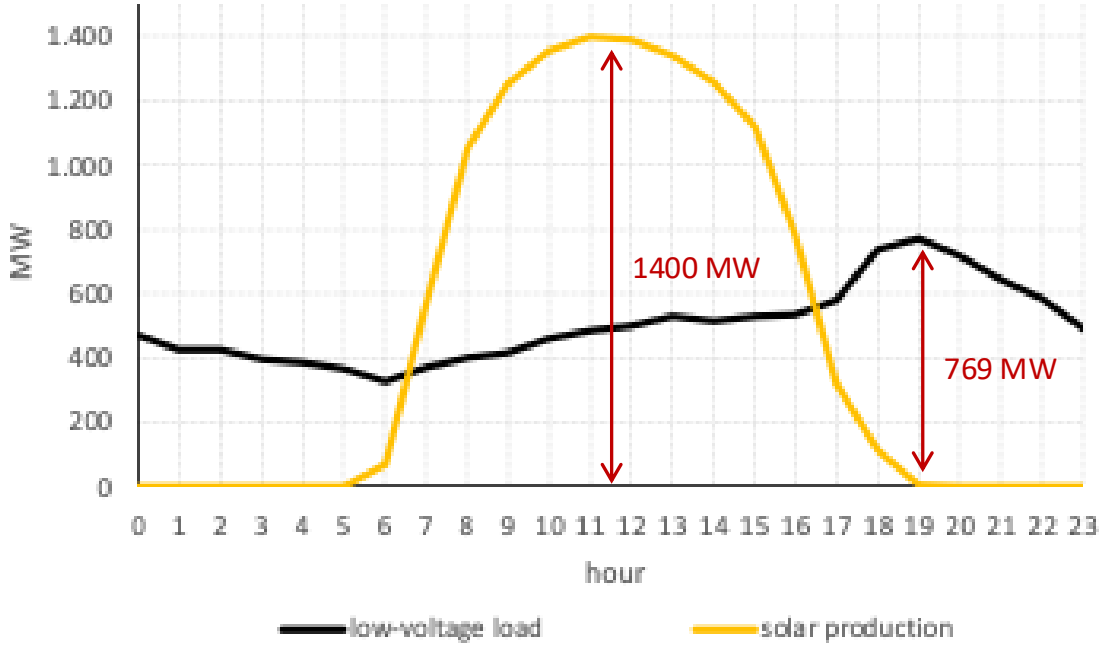
Is this what we generally observe?

Distributed Generation Can Be Costly (1 of 4)

1. UNDISTRIBUTED GENERATION OVER TIME

- The **peak generation of photovoltaic systems** sized to meet the daily load of low-voltage customers is about **twice the coincident-peak load**
- Thus, **distributed generation does not necessarily reduce system load and may actually increase peak load**

LOW-VOLTAGE LOAD AND SOLAR PRODUCTION PROFILE



Data Source: Aneel – Neoenergia Brasilia - 2021.

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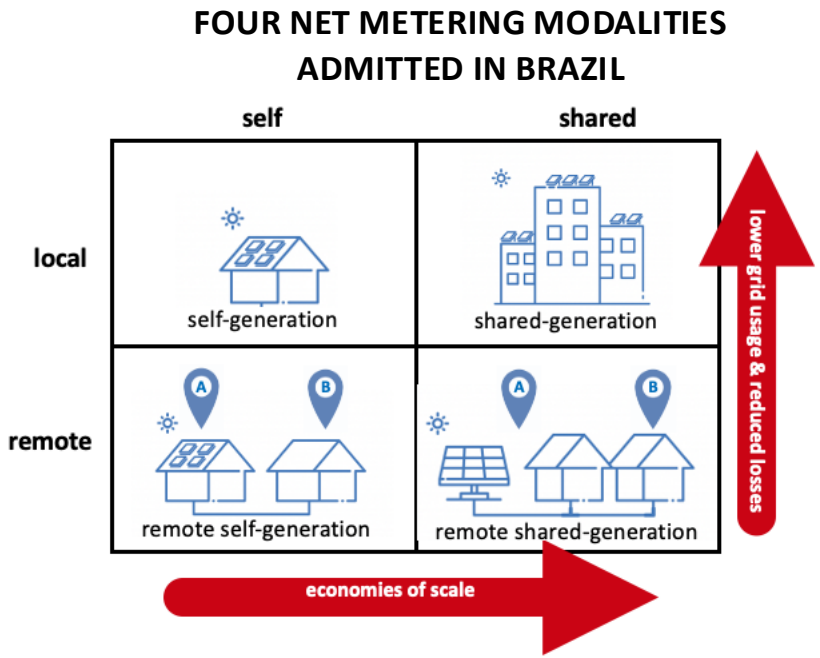
2. UNDISTRIBUTED GENERATION AMONGST LOAD

- Power injections from Distributed Generation located in **remote segments of the network**



Source: Hochstetler and Born (2022) in *Energy Communities* - ch. 19

SHARED AND REMOTE GENERATION

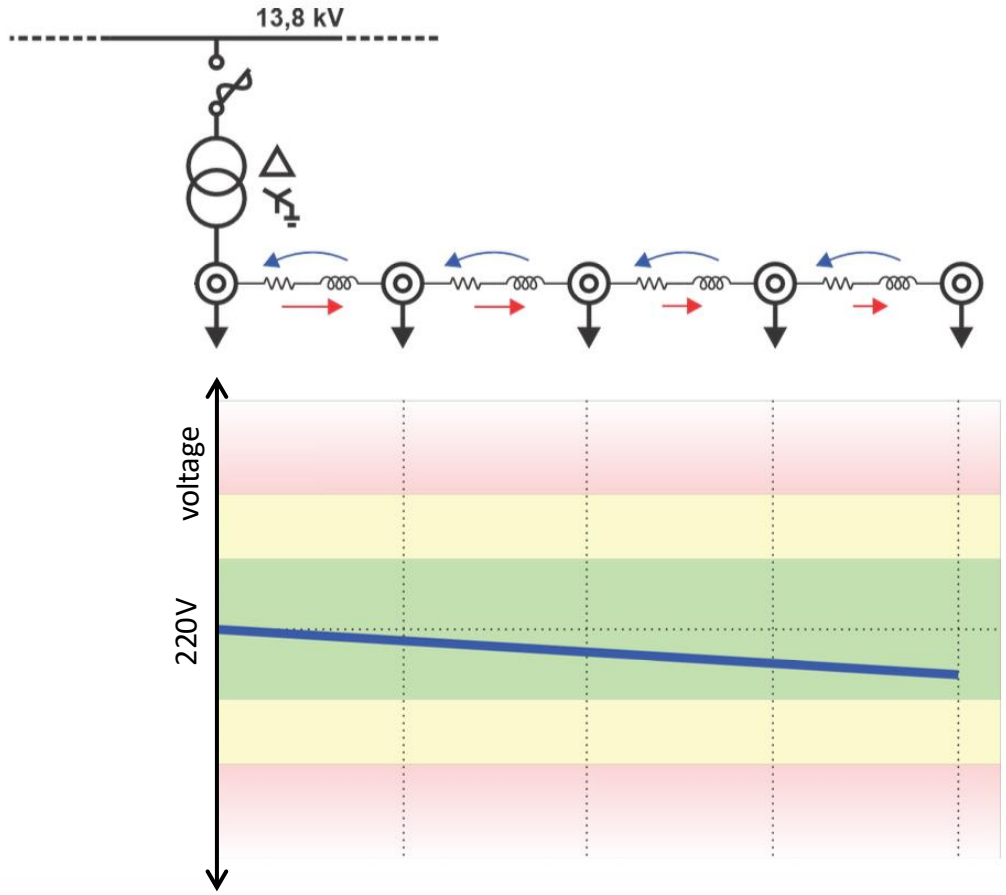
- involves more intensive use of network
- changes the pattern of power flows on the network

Distributed Generation Can Be Costly (3 of 4)

3. POWER INJECTED IN LOW-VOLTAGE CIRCUITS

- Low-voltage circuits have **higher impedance**
- **Voltage drops** as distance from feeder increases
- Distribution systems were **configured for unidirectional flows**

VOLTAGE LEVEL ALONG A LOW-VOLTAGE CIRCUIT



Source: UFU- Prof. José Rubens Macedo Jr – 1º Simpósio de Valoração da MMGD.

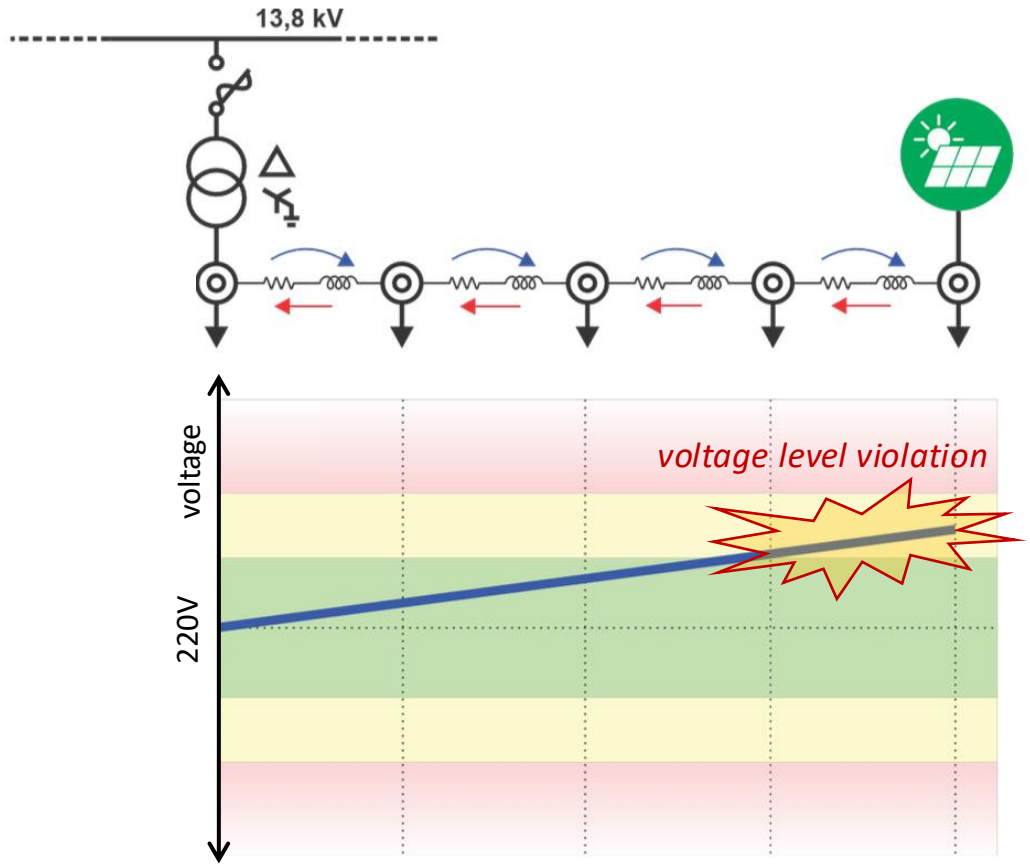
Distributed Generation Can Be Costly (3 of 4)

3. POWER INJECTED IN LOW-VOLTAGE CIRCUITS

- Low-voltage circuits have **higher impedance**
- **Voltage drops** as distance from feeder increases
- Distribution system **configured for unidirectional flows**

- **Change direction** of power flows
- **May increase losses**
- **Voltage imbalances**
- **Network reinforcement or reconfiguration** is needed

VOLTAGE LEVEL ALONG A LOW-VOLTAGE CIRCUIT



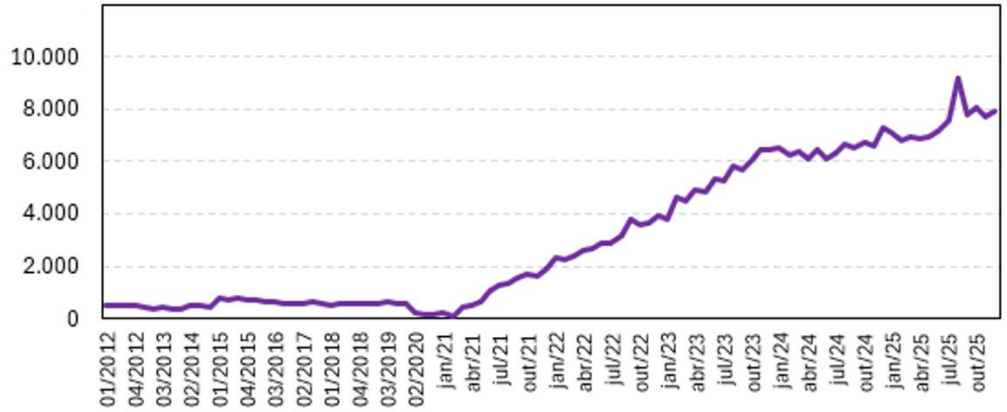
Source: UFU- Prof. José Rubens Macedo Jr – 1º Simpósio de Valoração da MMGD.

Distributed Generation Can Be Costly (3 of 4)

3. POWER INJECTED IN LOW-VOLTAGE CIRCUITS

- Increased network investments are required for voltage regulation as DG increases

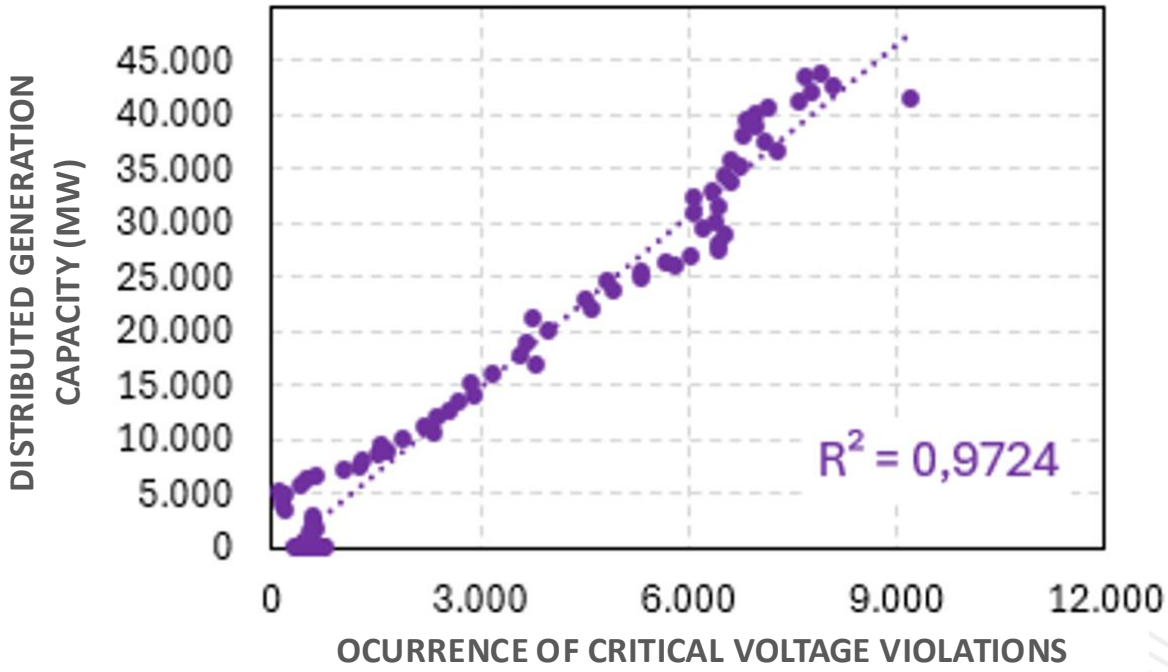
OCCURANCE OF CRITICAL VOLTAGE VIOLATIONS



Source: Norven/UFU- PDI Custos e Benefícios da MMGD.

- Observation from the **occurrence of critical voltage violations** and **distributed generation installed capacity** from 2012 to 2025 demonstrates a clear relationship between the two variables

CORRELATION OF DISTRIBUTED GENERATION CAPACITY AND CRITICAL VOLTAGE VIOLATIONS

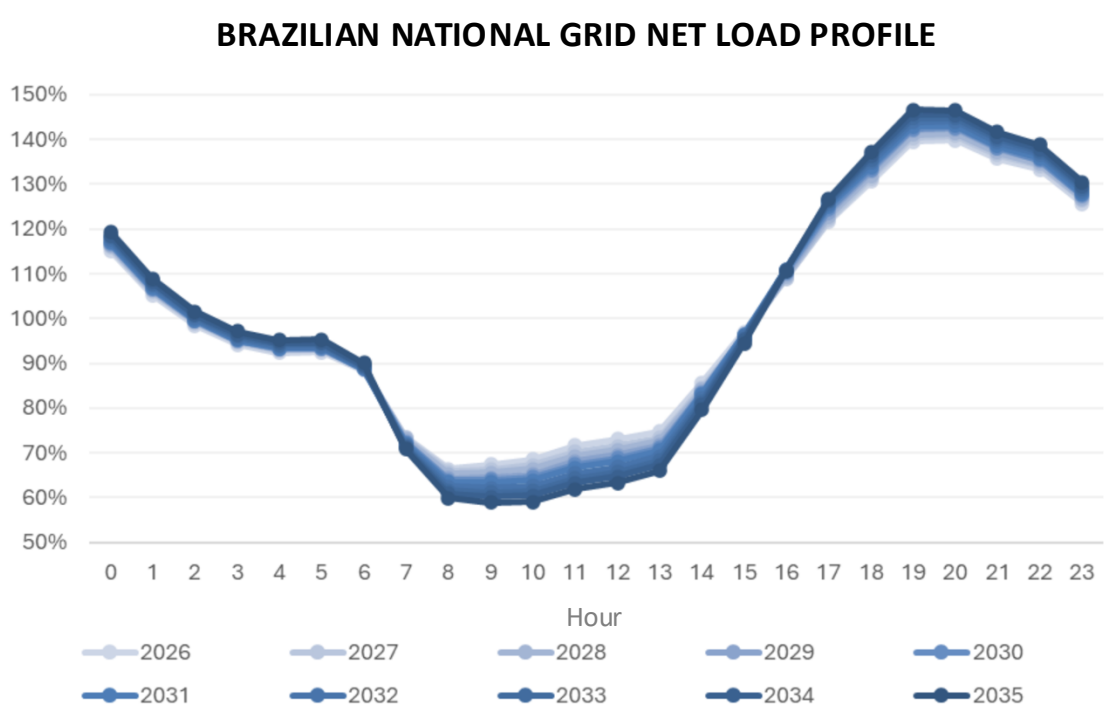


Source: Norven/UFU- PDI Custos e Benefícios da MMGD.

Distributed Generation Can Be Costly (4 of 4)

4. DISTRIBUTED GENERATION IS VARIABLE

- **Change in load profile**: "Duck Curve"
  - increased variability of load
  - steeper shoulders
- More **operational flexibility** required to **meet net load**
  - increased cycling of power generation units
  - increased ramping capability
  - more ancillary services required
  - curtailment of centralized generation sources
- **Uncertainty** regarding the **power injections from Distributed Generation**
  - higher operational reserve margins required
  - hinders expansion planning



Source: EPE – PDE 2035.

Pathway to a Value-Based Compensation Framework

TWO-STEP APPROACH

1. *COST ANALYSIS*

- Study to **understand how Distributed Generation impacts costs**

2. *TARIFF STRUCTURE RECOMMENDATION*

- Analyze **how to structure tariffs** to better reflect costs and to provide appropriate price signals to system users

Methodological Architecture

Impacts on distribution

Impacts on transmission and operation

Impacts of externalities

Survey with prosumers and DG suppliers

Regulatory solution: Tariff structure

1. COST ANALYSIS

2. TARIFF STRUCTURE RECOMMENDATION

UNDERSTANDING OF MAIN TARIFF CONCERNS

MAPPING OF RELEVANT EFFECTS

TYPIFICATION OF EFFECTS & BEST PRACTICES

METHODOLOGY FOR QUANTIFICATION OF EFFECTS AND COSTS

TARIFF STRUCTURE THAT CAPTURES MAIN COST DRIVERS

COMMUNICATE PROPOSED TARIFF STRUCTURE TO STAKEHOLDERS

Pathway to a Value-Based Compensation Framework

RATE MAKING METHODOLOGIES*

- Ideally it would be desirable to set tariff rates based on **long-run incremental costs**
- Given marginal cost uncertainty, **fully distributed costs** may be the most appropriate approach

LONG-RUN INCREMENTAL COSTS

- *main feature:* forward-looking marginal/incremental costs
- *strength:* provides price signals to guide investment and consumption decisions
- *weakness:* may increase tariff instability between revisions, and may need complementation to ensure total revenue requirement
- *recommendation:* preferred method for cost components for which there is high confidence regarding long-run incremental cost estimate

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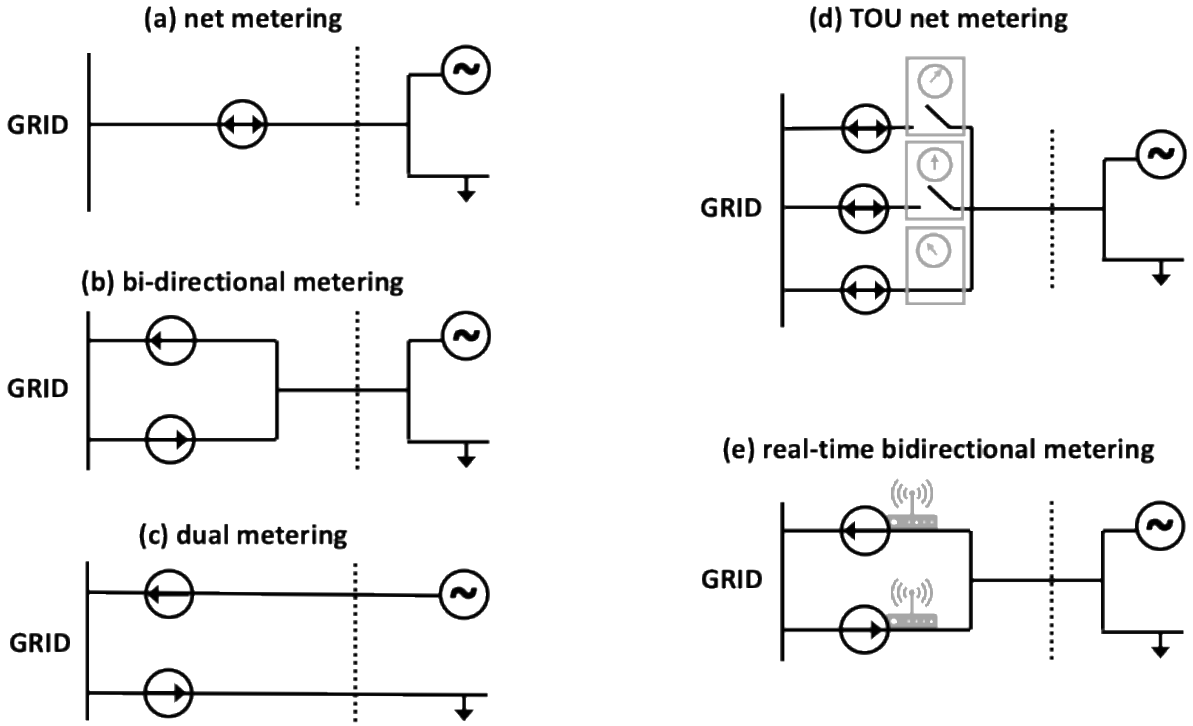
FULLY DISTRIBUTED COSTS

- *main feature:* backward-looking based on embedded costs
- *strength:* enables pricing based on verified costs
- *weakness:* in changing cost conditions, it will always lag real-costs; it relies on allocation rules
- *recommendation:* pragmatic alternative for cost components for which there is ambiguity regarding long-run incremental costs

* In Aneel's *Tomada de Subsídios* 23/2025, the two rate-making alternatives considered – Option A (Tariff Differentiation / Tariff Integrated) and Option B (Aggregate Form / External Valuation) – were defined differently but share some of the same considerations: Option A is more closely related to the Fully Distributed Cost methodology, while Option B is more closely related to the Long-Run Incremental Cost methodology.

Analytical Representation of Metering Alternatives



Source: Hochstetler and Cho (2023) in *The Future of Decentralized Electricity Distribution Networks* - ch. 13.

a. **net metering** – *the problem:* measures only net consumption over billing period
   - does not measure network usage
   - does not distinguish cost of energy and service in different moments

b. **bi-directional metering**: enables billing based on net and gross consumption

c. **dual metering**: enables billing based on total generation and total consumption

d. **TOU net metering**: enables time-varying pricing on pre-specified time intervals

e. **real-time bi-directional metering:** enables billing of power flows in and out of the grid at each moment

peak capacity metering: enables billing of capacity requirement for maximum consumption and injection of energy from/to the grid

Desirable Data and Metering Requirements

DESIRABLE FEATURES

- *bi-directional flows:* measurement of flows into and out of the grid is desireable to evaluate **effective network use**
- *flows at different times:* measurement of power flows during different time periods is desireable given **time-varying costs of energy and network congestion** *(addresses desalignment between production and load profile)*
- *capacity requirement:* measurement of customer's share of **coincident-peak demand for network capacity** *(addresses network investment requirements – both for consumption and injection peaks)*
- *location:* **differentiated connection pricing** is needed to provide price signals to coordinate placement of new Distributed Generation and to better reflect actual costs

POLICY CONSIDERATIONS

- It is important to consider the various costs involved:
  - cost of the **new meters**
  - **cost of early retirement** of existing meters
  - **labor costs of rapid replacement** of large inventory
- A more elaborate tariff structure can be adopted based on **load profiles of each customer class** while **maintaining existing meters**
- Such a pragmatic approach enables reasonable cost allocation among customer classes, but it **does not provide any dynamic feedback to individual customers**, which is necessary to provide incentives for demand response on an individual level
- It is also important to consider the relatively **short life span** of advanced metering

RECOMMENDATION

Enable accelerated adoption of advanced metering with **intracycle investment integration in rate base**

Temporal and Locational Signaling

TEMPORAL PRICING

- **Time-differentiated pricing is a must** – this is a common feature of net metering reforms around the world – it is relatively simple to implement and eliminates many externalities (cross-subsidies)

Time-of-Use Pricing
Simpler, easier to understand and effective for dealing with standard "Duck Curve" (daily net load profile)

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Real-Time Pricing
Better suited to reflect current net load profile (which may vary considerably on a day-to-day basis)

LOCATIONAL PRICING

- **Locational pricing is desirable, but challenging** – international experience shows this is rarely implemented due to difficulties in its implementation
- Locational signaling is diserable to **coordinate Distributed Generation expansion** – the desirable signaling is best provided by a connection fee

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