Distribution Network Tariffs and Distributed Generation: Need for an Innovative Methodology to Face New Challenges. Application to a Case Study

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Tariff: general issues and challenges
- General tariff structure:
  - Fixed charge (€/period)
  - Volumetric charge (€/kWh/period)
  - A capacity charge (€/kW/period)
- New costs arising from DG integration
  - Initial network investments
  - Changes in operation and maintenance costs
  - Changes in the long-term network planning
- Main DG-related challenges
  - DG exemption from distribution tariffs
  - Load-tailored schemes applied to DG (e.g. combination of net metering and volumetric tariffs)

Methodology
- Network costs calculation
  Reference Network Models (Greenfield+brownfield model)
  \[ \text{Pure load cost share}_i = \frac{\text{Total annual network cost}_i \cdot \text{Aggr. pure load energy}_i}{\text{Total annual network cost}_i - \text{Pure load cost share}_i} \]
  \[ \text{Prosumer load cost share}_i = \frac{\text{Total annual network cost}_i - \text{Pure load cost share}_i}{\text{Pure load cost share}_i} \]
  \[ \text{Prosumer total cost share}_i = \text{Prosumer load cost share}_i + \text{DG driven network cost}_i \]
- Tariffs determination
  Net metering case:
  \[ \text{Unit volumetric tariff}_i = \frac{\text{Total annual network cost}_i}{\text{Aggr. annual net energy}} \]
  \[ \text{Two meters case:} \]
  \[ \text{Load volumetric tariff}_i = \frac{\text{Aggregated annual load energy}_i}{\text{DG driven network cost}_i} \]
  \[ \text{DG volumetric tariff}_i = \frac{\text{Aggr. annual DG energy}_i}{\text{DG driven network cost}_i} \]
- Tariff performance assessment
  Net metering case:
  \[ \text{Pure load payment}_\text{NET}_i = \text{Unit volumetric tariff}_i \cdot \text{Aggr. pure load energy}_i \]
  \[ \text{Prosumer payment}_\text{NET}_i = \text{Unit volumetric tariff}_i \cdot \text{Aggr. prosumer load energy}_i \]
  \[ \text{Prosumer payment}_\text{NET norm}_i = \frac{\text{Pure load payment}_\text{NET}_i}{\text{Pure load cost share}_i} \]
  \[ \text{Prosumer payment}_\text{NET norm}_i = \frac{\text{Prosumer payment}_\text{NET}_i}{\text{Prosumer total cost share}_i} \]
  \[ \text{Unitary cross subsidization}_\text{NET}_i = \frac{\text{Pure load payment}_\text{NET}_i \cdot \text{Prosumer payment}_\text{NET norm}_i}{\text{Prosumer payment}_\text{NET norm}_i} - \text{Prosumer payment}_\text{NET norm}_i \]
  \[ \text{Two meters case:} \]
  \[ \text{Pure load payment}_\text{TWO}_i = \text{Load volumetric tariff}_i \cdot \text{Aggr. pure load energy}_i \]
  \[ \text{Prosumer payment}_\text{TWO}_i = \text{Load volumetric tariff}_i \cdot \text{Aggr. prosumer load energy}_i + \text{DG volumetric tariff}_i \cdot \text{Aggr. DG energy}_i \]
  \[ \text{Prosumer payment}_\text{TWO norm}_i = \frac{\text{Pure load payment}_\text{TWO}_i}{\text{Pure load cost share}_i} \]
  \[ \text{Prosumer payment}_\text{TWO norm}_i = \frac{\text{Prosumer payment}_\text{TWO}_i}{\text{Prosumer total cost share}_i} \]
  \[ \text{Unitary cross subsidization}_\text{TWO}_i = \frac{\text{Pure load payment}_\text{TWO}_i \cdot \text{Prosumer payment}_\text{TWO norm}_i}{\text{Prosumer payment}_\text{TWO norm}_i} - \text{Prosumer payment}_\text{TWO norm}_i \]

Case study and results
- Urban fictitious network, Denver (Colorado)
- PV penetration scenarios:

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Fig. 1. Annual network costs for scenarios of increasing PV penetration.

Fig. 2 and 3. Unit volumetric tariff and pure loads’ and prosumers’ normalized payments (net metering case).

Fig. 4. Unit cross subsidization rate (net metering case).

Fig. 5 and 6. Unit volumetric tariffs for loads and PV and pure loads’ and prosumers’ normalized payments (two meters case).