The economics of distributed generation

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Introduction of Zoltán Lontay

- Mechanical engineer, specializing in energy efficiency and renewable energies.
- Designer, contractor, project developer at a large multinational engineering company.
- Director of a biomass-to-power plant.
- President of the Hungarian Energy Efficiency Association.
- Consultant of ERRA.
- Member of the International Network of Resource Information Centers since 1986.
- Expert of an environmental NGO „Clean Air Action Group”, which is the member organization of Climate Action Network Europe.

My basic understandings for the TENVA-ERRA Consultation Program

- The Turkish electricity market was liberalized not long ago, and the new legal/regulatory framework creates an opportunity for the multifarious not traditional producers (renewables, waste-to-energy, micro-cogeneration, etc.).
- Within this scope distributed generation (DG) represents a huge untapped potential for investors, developers, businesses, equipment suppliers, etc. The following beneficial effects are perceived:
  - lower losses in the network;
  - integration of smaller renewable electricity generators into the system $\rightarrow$ compliance with societal demand for RES;
  - improved supply security;
  - attracting additional capital into the electrical sector;
  - involvement of people into the energy supply $\rightarrow$ **Participatory Development**: give the people a part in initiatives designed for their benefit.

Main categories of DG

A. Licensed generation (LG)-
B. Unlicensed electricity generation (UEG).

- renewable generators with <1 MW capacity;
- micro-cogeneration with <100 kW capacity;
- emergency/autonomous generators not connected to the network;
- renewable self-generators without energy export to the grid.

Regulated feed-in-tariff available for >1 MW renewable generators, too.

Incentives offered by the Turkish regulation:

- easier administrative procedures;
- feed-in-tariff for renewable power producers;
- no need to establish an undertaking;
- no financial guarantees required;
- application time not restricted;
- measurements of performance parameters of generation equipment not obligatory.

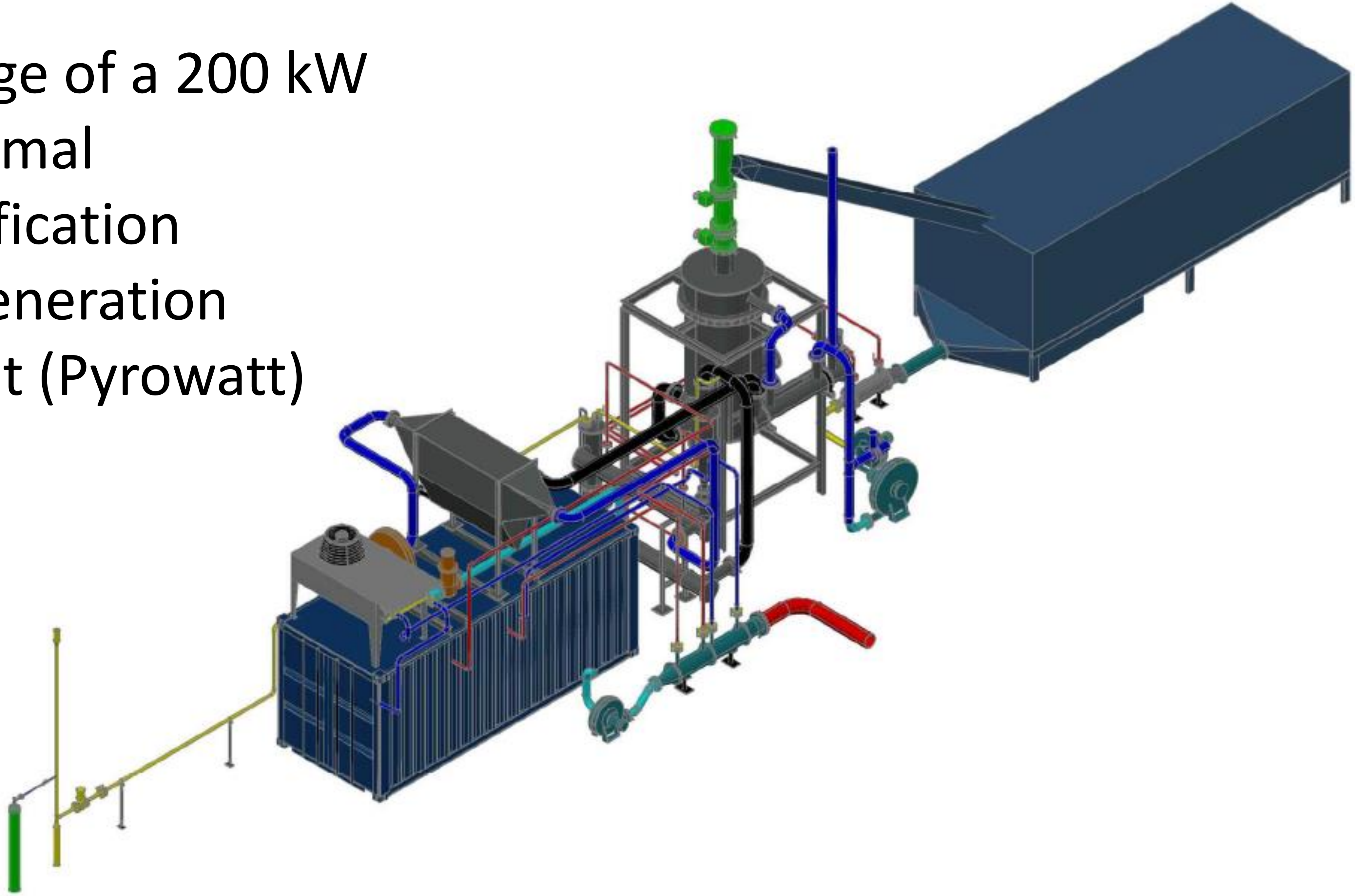
Topics to be discussed

- **The DGs and the network**
  - technical issues;
  - disincentives of DSOs connecting DGs;
  - costs of network connection.
- **Business models of distributed generation in Hungary**

Technologies of practical relevance (UEG or FIT)

Capacity range ca.	Technology
<5 kW	Rooftop solar
<50 kW	Rooftop (industrial buildings) or land-installed solar
50-100 kW	Gas-fueled micro cogeneration
50-500 kW	Thermal biomass gasification with reciprocating engine
0.5-3 MW	Biomass fueled ORC (Organic Rankine Cycle)
>50 kW	Land-installed solar
>2 MW	Biomass steam cycle
50-2000 kW	Biogas (fermentation) with gas engine

Image of a 200 kW thermal gasification cogeneration plant (Pyrowatt)

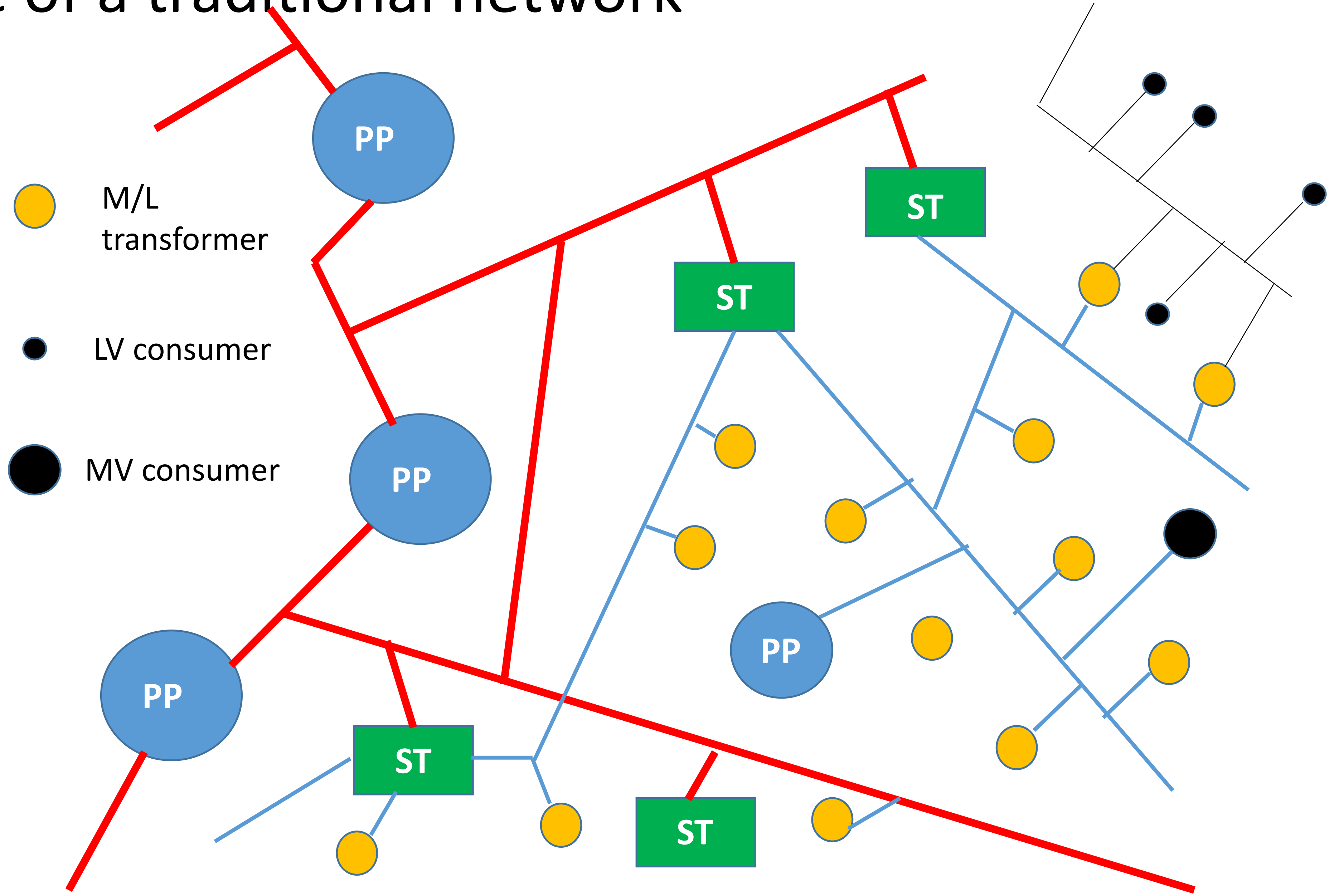


8 MWe biomass power plant

Why to integrate DGs into the grid?

1. **They want to sell their product**: DG-generated power is transferred to the electricity consumers by the help of the grid. Exception: autonomous self producers.
2. Most of the small producers are consumers at the same time, called **prosumers**, who want to enjoy the services of the grid (back-up, voltage and frequency control, etc.).
3. Support schemes for renewable power generation need trustworthy metering and accounting that can only be assured by the involvement of the public grid.
4. The DGs themselves may need energy to start.

Scheme of a traditional network



Characteristics of the networks

- Instead of original radial topologies redundant mesh networks are used to improve reliability.
- Higher voltage parts of the network offer higher transmission/distribution capacities.
- Important parts of the networks are supplied by redundant lines.
- Usual design criterion: supply to critical nodes of the system shall be satisfactory if one system element is out of order.
  → Weakened or (n-1) case.

Integration of DGs into the network

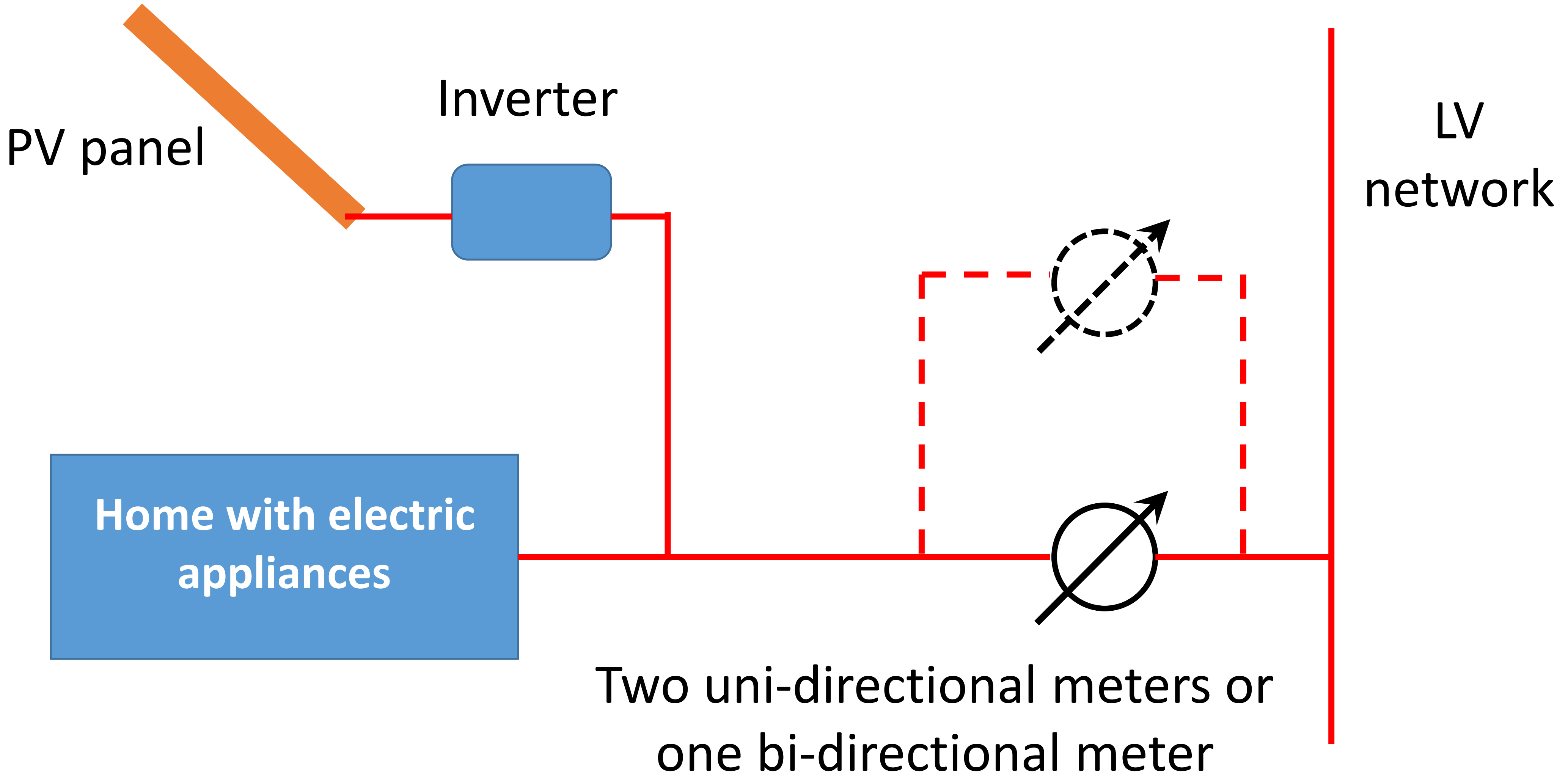
The so called „integration” means:

1. **Connection**: establishing physical contact with the appropriate point of the network.
2. **Hardware developments** in the network to accommodate the DG.
3. **Metering and accounting**.
4. **Load balancing** on the local and the system level.

Technical challenges of integration

- The electrical networks were designed to supply consumers from big central power generation plants. The energy flow was uni-directional.
- With the integration of decentralized generators the conditions change, the networks have to operate in modes they were not designed for.
  - The load on certain network elements (in the surroundings of the DG) increases.
  - The voltage changes in time, depending on weather conditions. Maintaining voltage within the allowed range may be impossible.
  - With bi-directional energy flows arrangements may be needed to maintain system stability.
  - The lifetime of certain elements may be reduced.
  - Additional maintenance costs may occur.
  - System losses change, typically decrease.
- How to tackle the challenges?

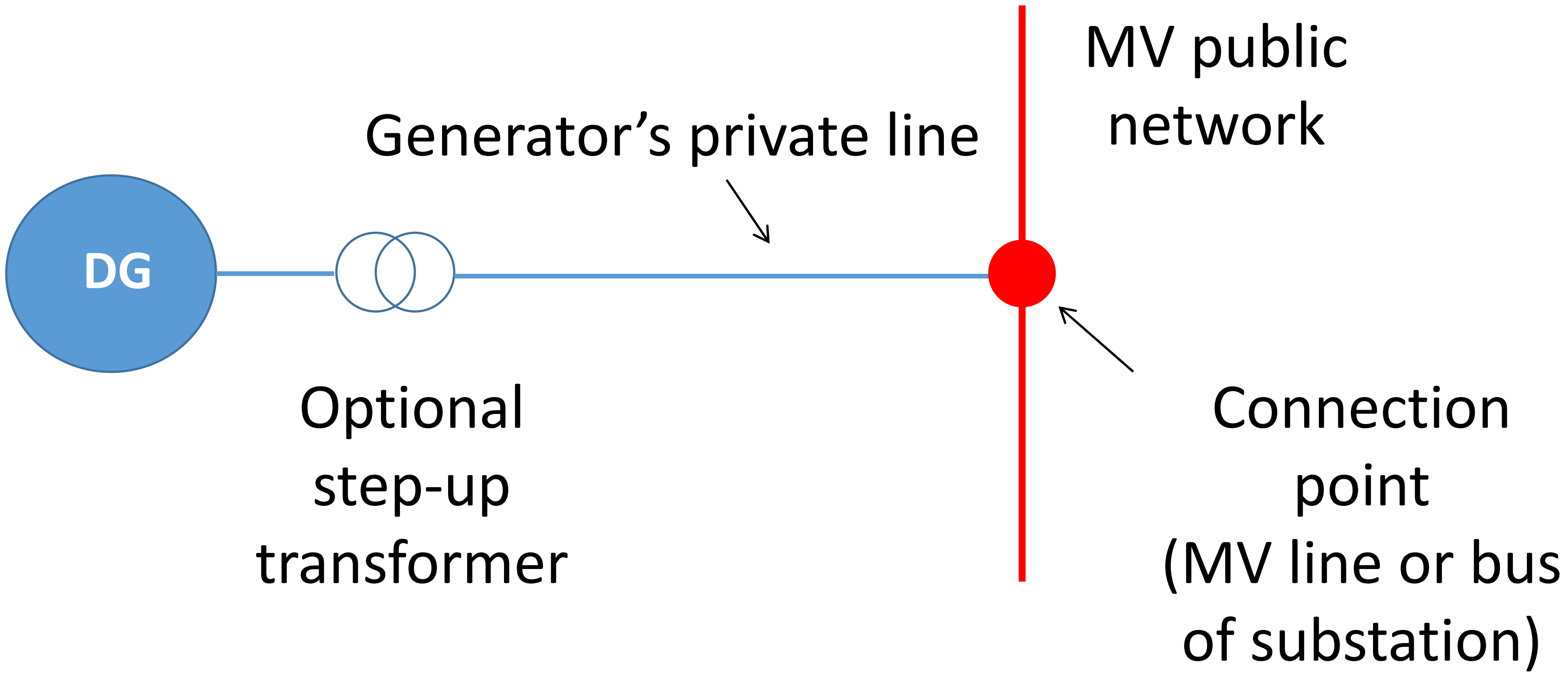
Connection of a grid-tied home solar system



Options for home systems

- Grid-tied
- Grid-tied with battery back-up
- Off-grid (autonomous)
- Grid-assisted autonomous

Connection of a larger DG



Typical connection voltages

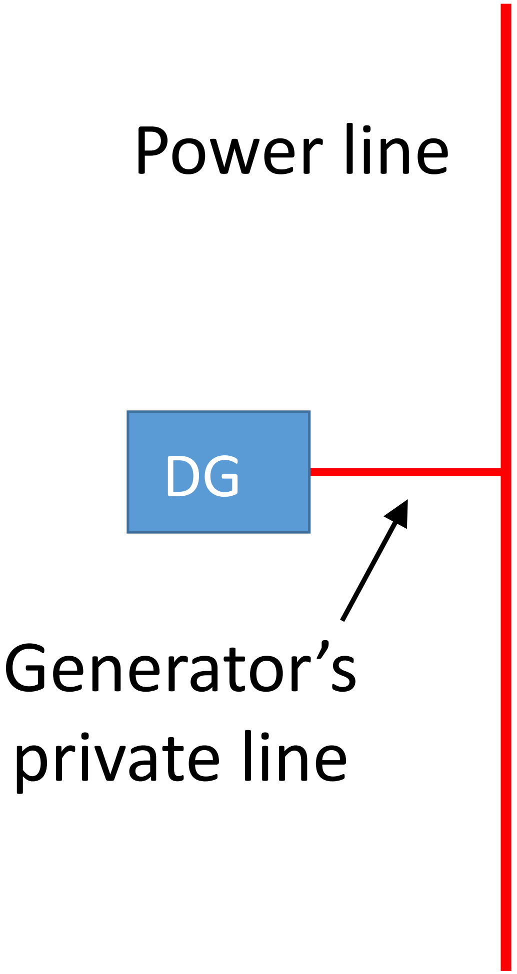
Capacity of DG	Connection voltage
< 30-50 kW (households, offices, schools, small industries, etc.)	Low (0.4 kV)
Up to 1-2 MW	Medium (10-20 kV)
Up to 15-20 MW	Medium or high depending on physical and load conditions of the network
> 15-20 MW	High (132 kV)

Typical connection points

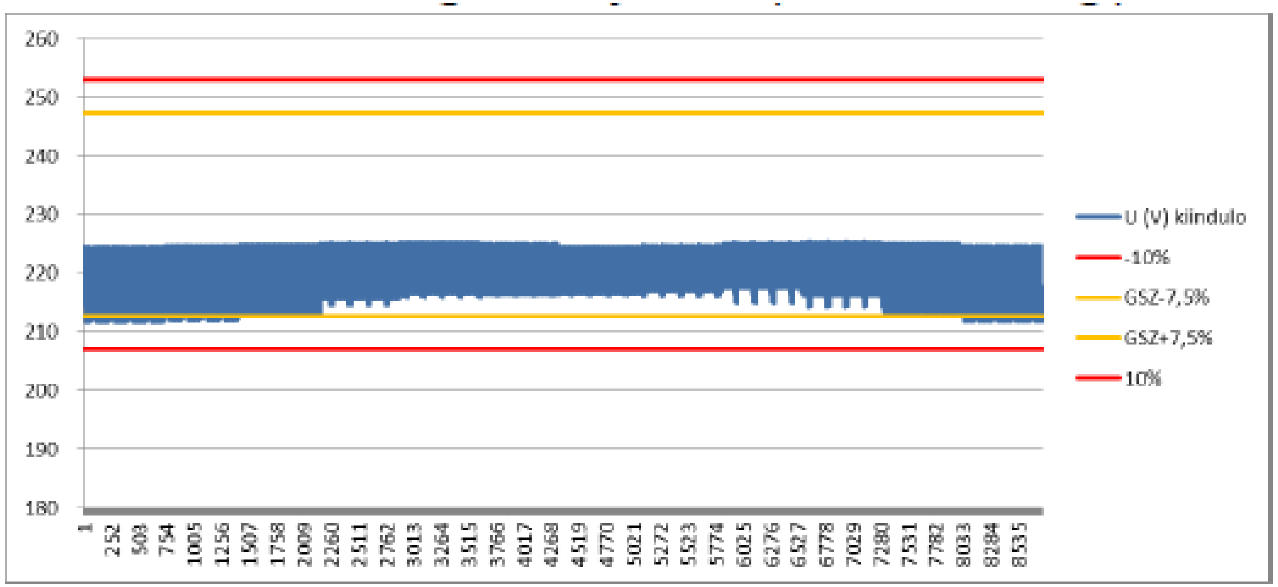
Capacity of DG	Connection point
< 30-50 kW	Low voltage line or end-user terminal
Up to 1-2 MW	Medium voltage line with „T” connection
Up to 15-20 MW	Medium voltage bus of **substation**
> 15-20 MW	High voltage bus of **substation**

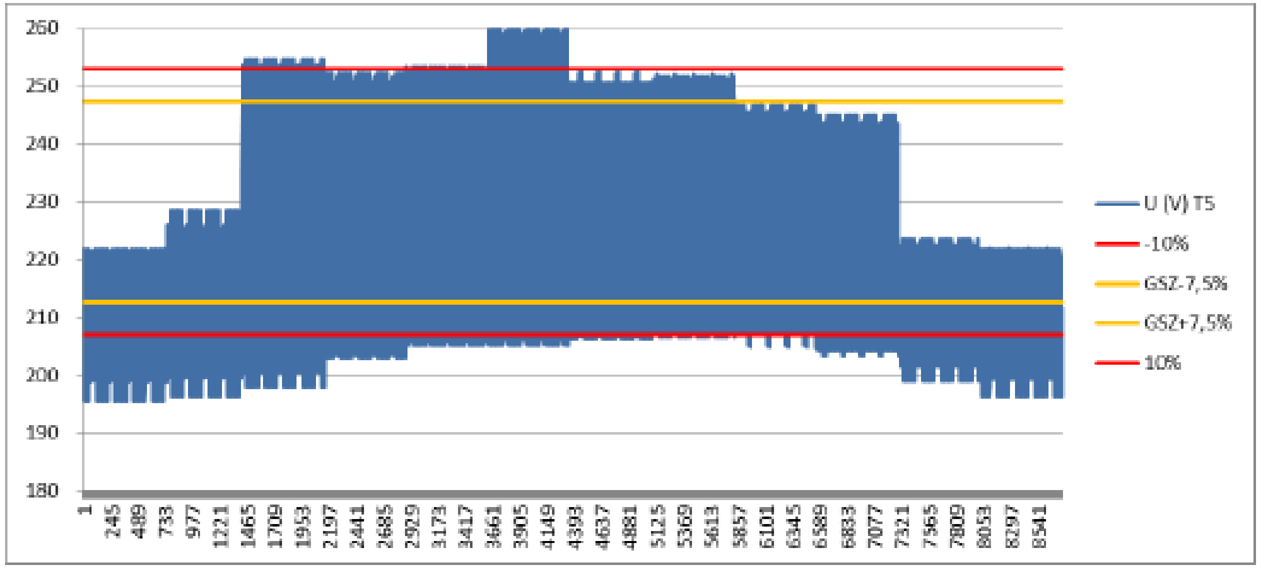
„T” connection

- Simple and cheap.
- Limited reliability.
- Safety issues have to be addressed.
  - When maintenance is executed on the network, the generators have to be disconnected. Options: switch on public territory or self-disconnecting function at the inverters, which break the circuit when the network is earthed.
- Applied only for low capacity DGs.



Stabilization of voltage within the tolerable range may be impossible if the network is not dimensioned for high loads.





Tackling the technical challenges

- Load on system elements is higher then they were dimensioned for: **capacity upgrading**.
- Voltage fluctuations:
  - **capacity upgrades** (voltage drop decreases in both directions);
  - **more sophisticated voltage regulation**;
  - **load management**, including demand side interventions;
  - **electricity storage** in appropriate points of the network.
- Reduced lifetime of elements: **more maintenance**, more frequent replacement.

Active Network Management (ANM)

- With the help of state-of-the-art IT solutions (smart network) the energy flows, demands, and available capacities in the network are monitored.
- Both the DGs and the consumers are involved in optimization of system operation by the help of real time management techniques.
- Demand response (DR): influencing the electricity consumers so that their load matches better the supply.
  - Utilities signal their customers about availability/price of power.
  - Customers manage their load according to the price.
  - Off-peak/smart metering.
- Issues:
  - Spending for demand side flexibility is not in-line with the interests of the DSOs.
  - Security of data obtained from smart meters.

Costs of integrating DGs

- **Administrative and project management costs**. With a large number of applications it can be significant.
- **Network development CAPEX costs**
  - eliminating bottlenecks,
  - new meters at the producers,
  - creating connection points for larger DGs,
  - more advanced controls,
  - storage.
- **Additional costs of system management**.
- **Costs on the DG side**: private line to connection point (larger DGs).

Who should bear the costs?

- With larger DGs the (most of the) network connection costs are typically **born by the producers**.
- The network connection costs of UEGs are borne in most European countries by the DSOs, who can involve them in their justifiable cost base. This is an important incentive for UEGs. Other incentives may be:
  - Net metering.
  - Feed-in-tariffs.
  - Investment subsidies.
  - Tax credits.
  - Favorable financing.

Disincentives of the DSOs connecting DG

- They face additional investment and operational costs, which may be difficult to reimburse through the network tariffs.
- With many small producers connected to the grid, maintenance can be much more difficult.
- Maintaining quality of service may be difficult or impossible.
- The affluent customers, who invest into DG, enjoy technical and economical benefits compared to the less effluent ones.
- The network tariff is usually made of capacity and volumetric components. With net metering the consumption, upon which the volumetric component may be applied, decreases, what decreases the income of the DSOs.
- The DSOs would prefer higher capacity-based tariffs, and dynamic network pricing with time-of-use tariffs. It would incentivize the more efficient use of the network.

Business models of low capacity distributed generation in Hungary (1)

1. Individual private projects in the residential sector
    - Investor: the owner of the house.
    - Technology: rooftop solar (rarely wind).
    - Capacity: according to the annual power consumption, typically 2-3 kW.
    - Network connection: **grid-tied**.
    - Battery back-up: no.
    - Accounting: **net metering**.
    - Incentives: saving in purchased energy; regulated purchase price available for the surplus energy delivered to the system; reduced network charge paid for the surplus energy delivered to the system.
    - Financing: private investment, usually no bank financing. **Only affluent people** can afford investing into DG. (Interest on bank deposits is very low.)
    - Investment subsidy: occasionally.
    - Payback time: ca. 10 years.

Business models … (2)

2. Public institutions's projects (schools, hospitals, mayor's offices, etc.)
   - Investor: the **public owner** (state organization or municipality).
   - Technology: rooftop solar (rarely wind).
   - Capacity: according to the annual power consumption, typically 5-10 kW.
   - Network connection: grid-tied.
   - Battery back-up: no.
   - Accounting: **net metering**.
   - Incentives: saving in purchased energy; regulated purchase price available for the surplus energy delivered to the system; reduced network charge paid for the surplus energy delivered to the system.
   - Financing: **investment grant**, with bank financing for the own contribution.
   - Investment subsidy: yes, depending on government policy.
   - Payback time: ca. 3-6 years, depending on the share of investment subsidy.

Business models … (3)

3. <u>Small and medium size enterprises</u>
   - Investor: the enterprise.
   - Technology: solar (rarely wind).
   - Capacity: according to the annual power consumption, < 50 kW.
   - Network connection: grid-tied.
   - Battery back-up: no.
   - Accounting: **net metering**.
   - Incentives: saving in purchased energy; regulated purchase price available for the surplus energy delivered to the system; reduced network charge paid for the surplus energy delivered to the system.
   - Financing: private investment, **balance sheet bank financing**.
   - Investment subsidy: occasionally.
   - Payback time: ca. 10 years.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Business models … (4)

1. <500 kW investment type projects
    - Investor: **private for-profit capital investor**.
    - Technology: solar (rarely wind).
    - Capacity: max. 500 kW (license required but fairly simple procedure).
    - Network connection: grid-tied.
    - Battery back-up: no.
    - Accounting: **feed-in-tariff. No balancing obligation**.
    - Financing: private investment, possibly with **project financing**.
    - Investment subsidy: occasionally. If subsidy is received, the FIT is reduced by the regulator.
    - Payback time: ca. 6-8 years.

Business models … (5)

5. Investment type projects up to 1000 kW installed capacity
   - Investor: private for-profit capital investor.
   - Technology: solar (rarely wind).
   - Capacity: max. 1000 kW (license required but fairly simple procedure).
   - Network connection: grid-tied.
   - Battery back-up: no.
   - Accounting: **feed-in-tariff**. **Balancing obligation: yes**.
   - Financing: private investment, usually with bank financing (**project finance**).
   - Investment subsidy: occasionally. If subsidy is received, the FIT is reduced by the regulator.
   - Payback time: ca. 6-8 years.

Business models … (6)

5. Self generation
   - Investor: private capital investor, owner of a facility or possibly an ESCO (Energy Service Company = a venture offering comprehensive services for energy end-users).
   - Technology: solar (rarely wind).
   - Capacity: less than the minimum demand excluding power export to the grid.
   - Network connection: grid-tied.
   - Battery back-up: typically no. Using the network as the back-up through a capacity reserve contract is cheaper.
   - Accounting: **the cost of purchasing electricity (energy + network use) is reduced**.
   - Financing: private investment, usually with bank financing.
   - Investment subsidy: occasionally.
   - Payback time: ca. 6-8 years.

See you on Friday

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