Distributed management systems of residential DER

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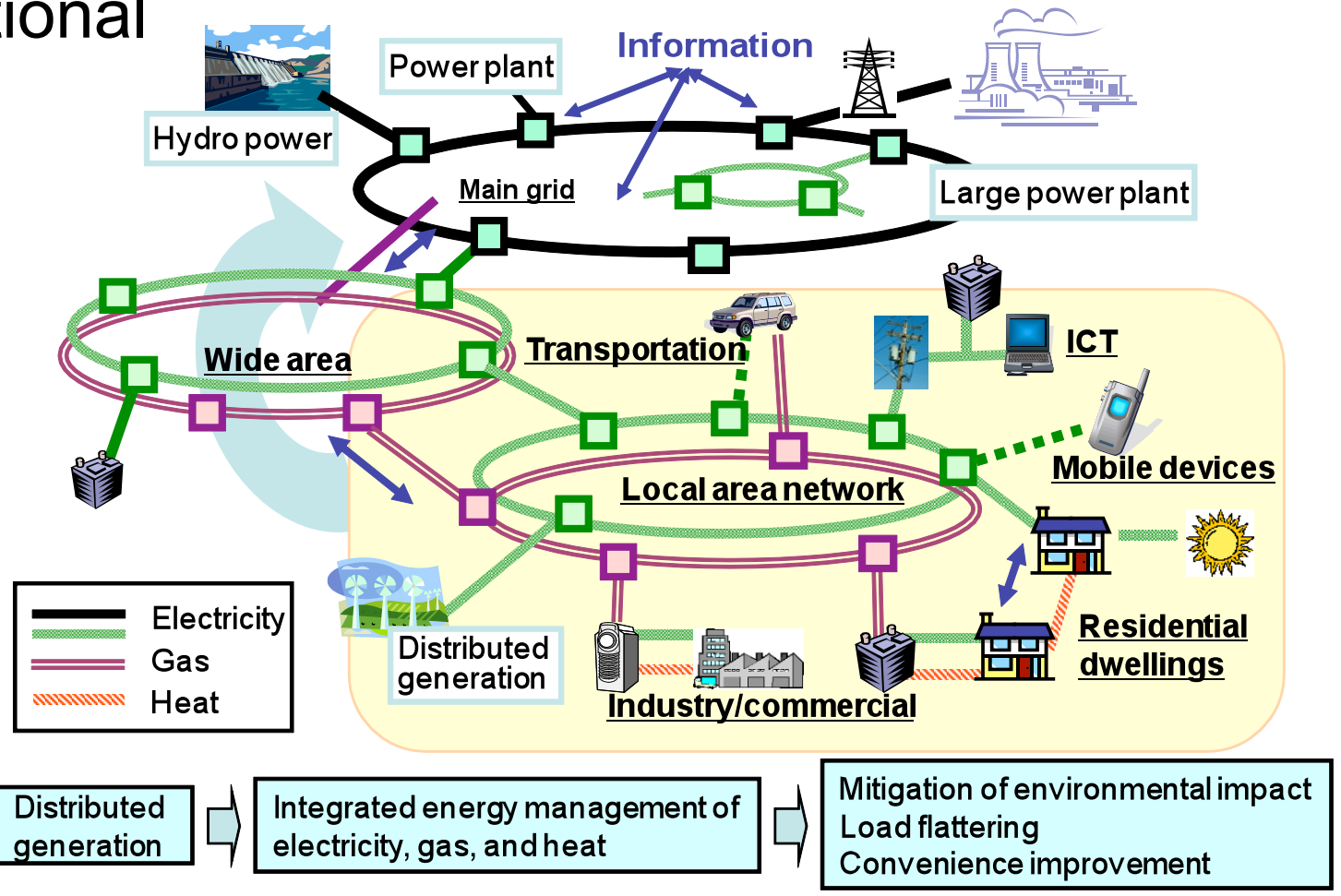
Distributed energy networks (≒ Smartgrid)

- Distributed
- Bi-directional



Distributed

- Distributed Energy Resource (DER)
  = Distributed gen. + demand-side measurements[1]

Generators:	gas-engine, fuel cell, photo-voltaic
Storage:	hot water tank, battery
Load:	air conditioner, refrigerator, lights, water heaters, etc.

- Distributed generations (CHP, PV) contribute to CO_2 mitigation & energy conservation

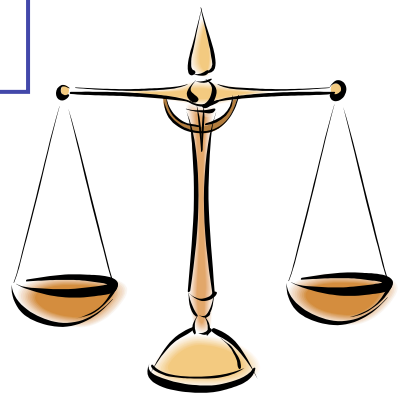
- DER can generate, store, and consume energy
  → Can contribute to power system operation

[1] IEA, “Distributed Generation in Liberalised Electricity Markets”

Bi-directional

- Energy and communication: one-way → two-way
- Interaction between supplier and consumer

Suppliers and consumers are responsible to power system operation



- Demand and supply balance must be maintained every second

  (Balance fault → large blackout)

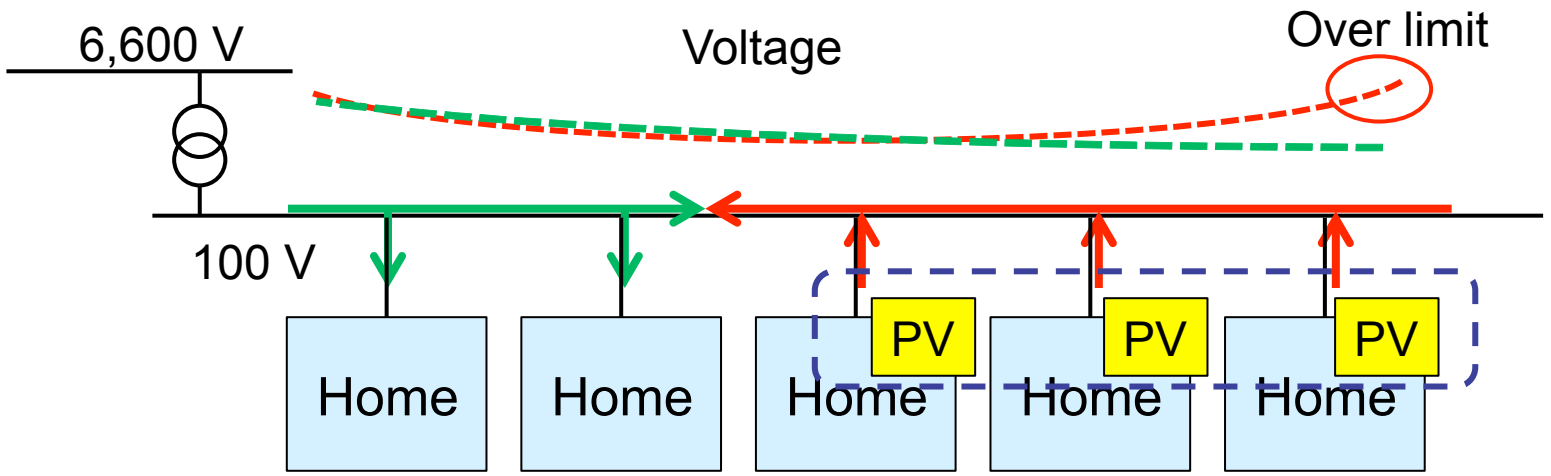
	Now	Future
Measure	Control generation (supply) to match demand	Control both supply and demand
Controller	Supplier	Supplier + consumer

Energy management capability of DER (1)

- Voltage rise of distribution feeder by photo-voltaic generation

  Critical issue on PV penetration

  - Collaborative operation of PVs is the smart solution

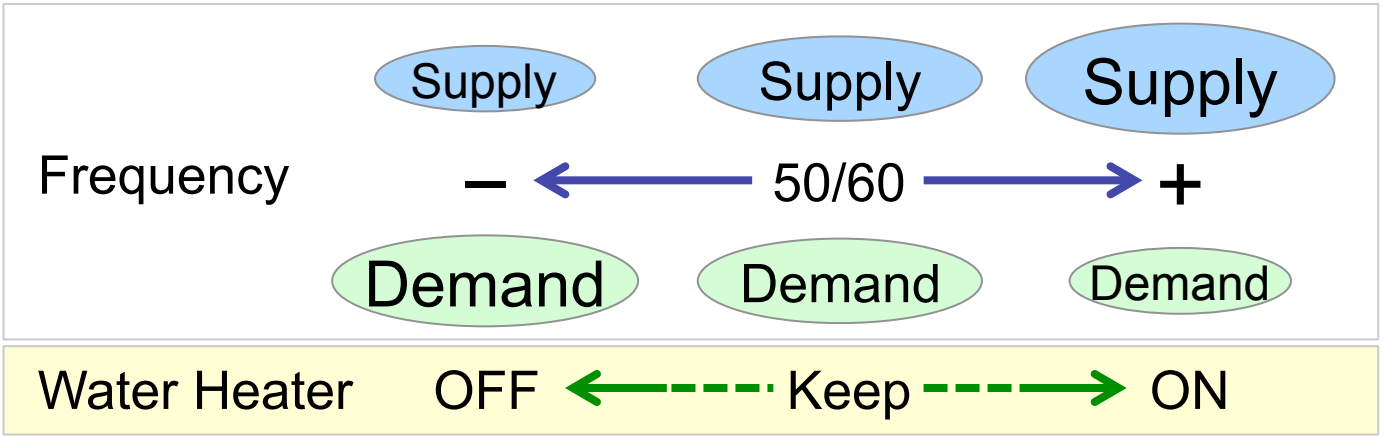


Energy management capability of DER (2)

- Frequency control of power system
  - Frequency control = balance supply and demand
  - Critical issue on wind penetration at mid-night

    Demand is low → fluctuation by wind turbine is critical
  - Solution: control electric water heater at mid-night

    Check frequency and control autonomously
    Enough water is heated up by morning



Energy management capability of DER

- DER contribute to:

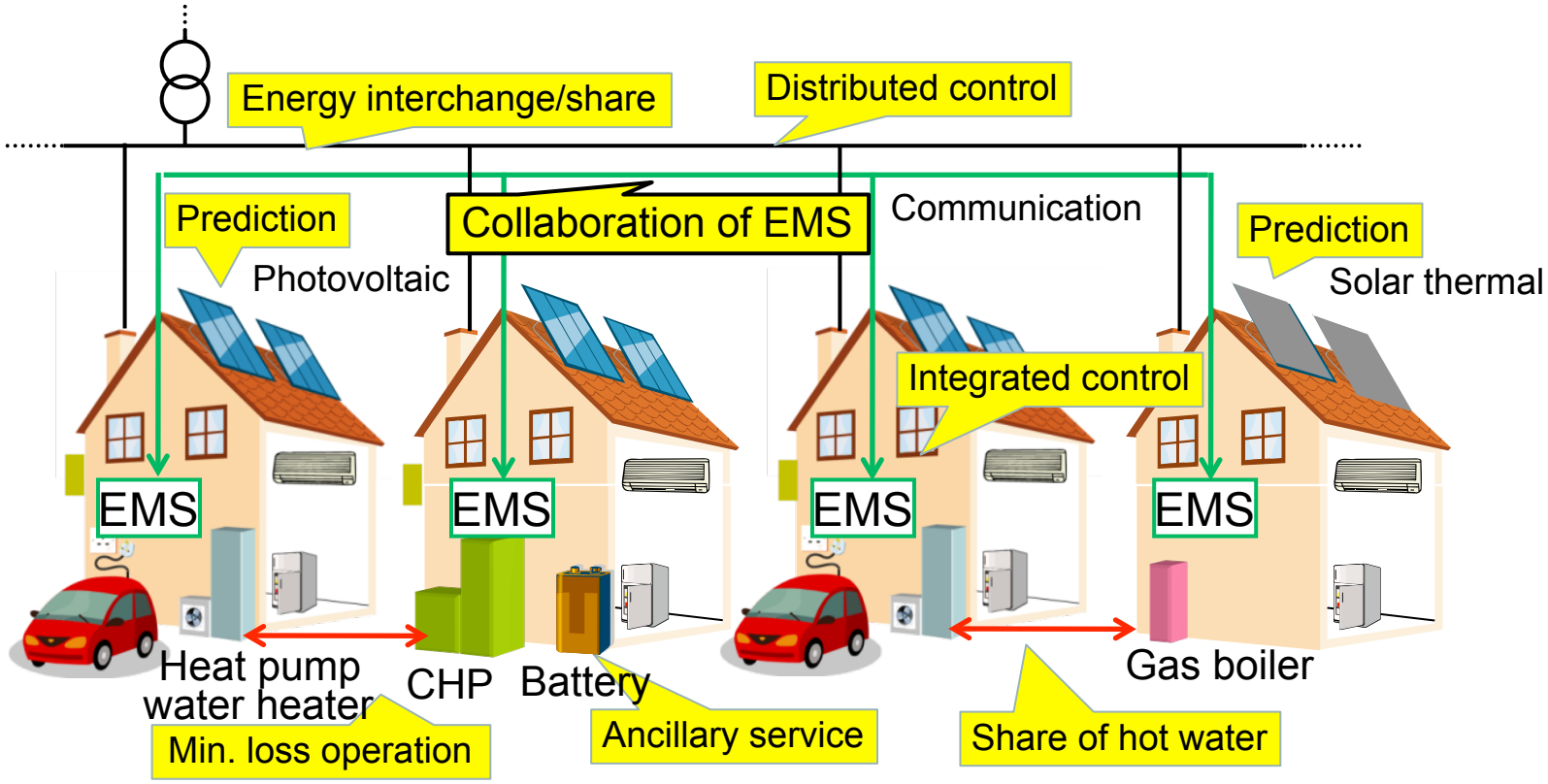
  - Voltage rise of distribution feeder by photo-voltaic generation

  - Energy efficiency improvement by energy management in community
    Sharing of equipment and energy
    (scale: 2 – 100 houses / an apartment bldg.)

  - Power system stabilization
    Frequency control, spinning reserve (ancillary service)

Integrated-Distributed Energy Management System: IDEMS

- Collaboration of consumers
  - Distributed control: a group of homes
  - Integrated control: each home



Energy generation and consumption prediction → Planning & Operation

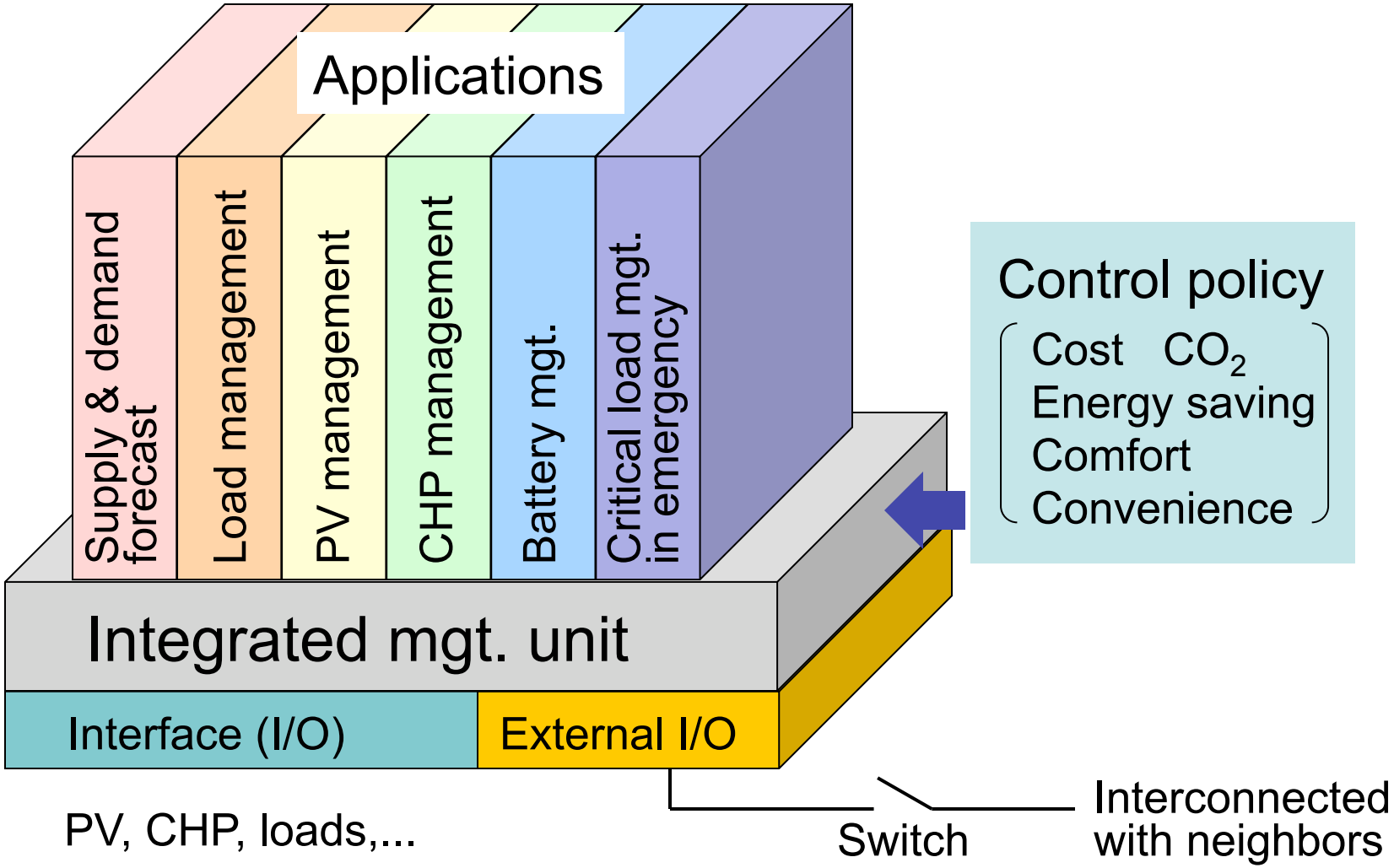
What is needed?

- Controller (energy management system)
  = Hardware & applications
  - Installed to consumers
  - manage/control equipment
  - realize **autonomous control/collaboration with others**
- Hardware
  - Physical controller: CPU, data storage, I/O, firmware
- Applications
  - management/control algorithms
    e.g. load, mgt., distributed generation mgt.

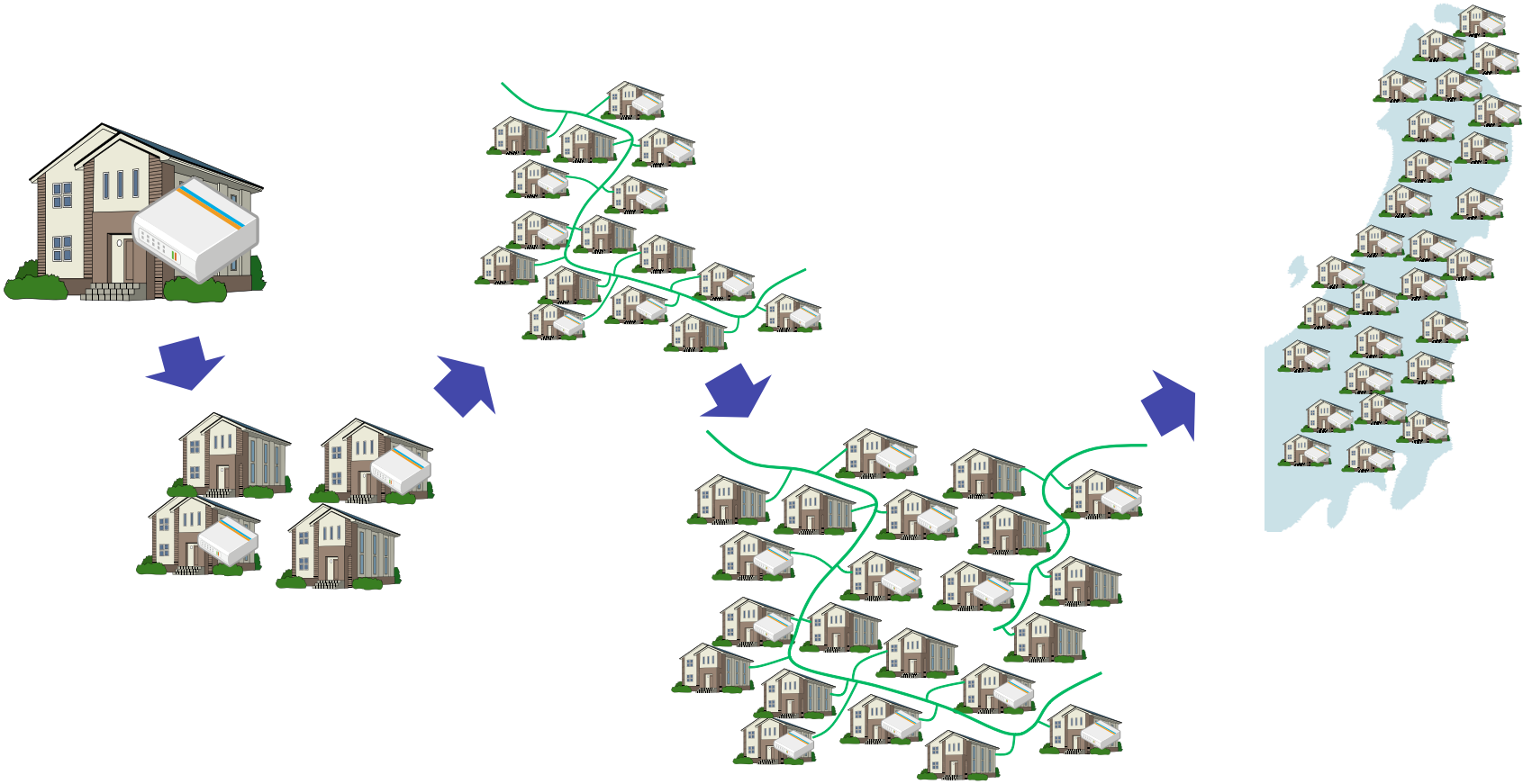
Required functions

- **No physical central server**
- **Control policy is decided by consumer**
- **Connected/disconnected switch**
- Plug & Play
- Equitable sharing of profit & cost
- Privacy

Controller (IDEMS)

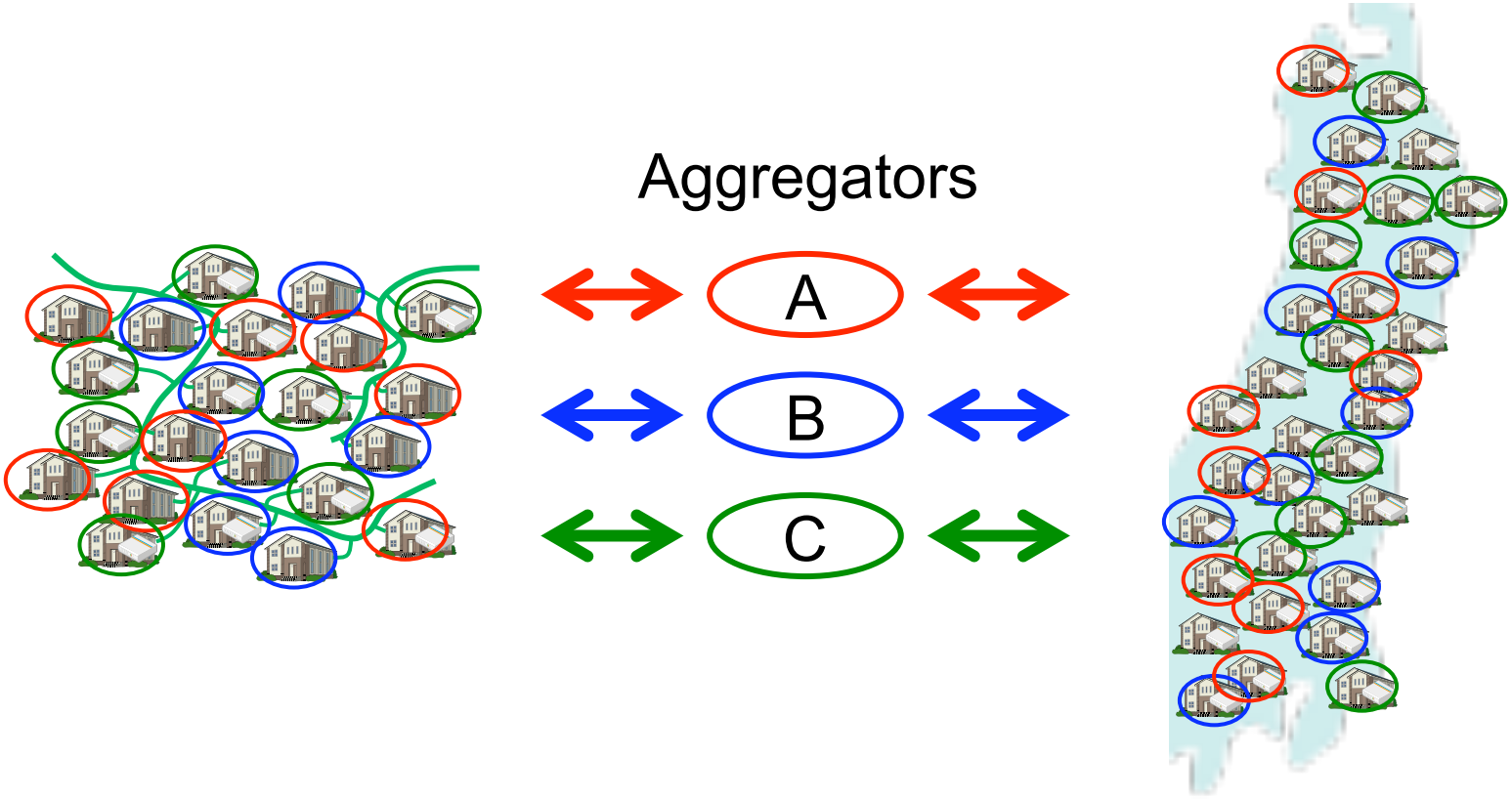


Flexibility on scale



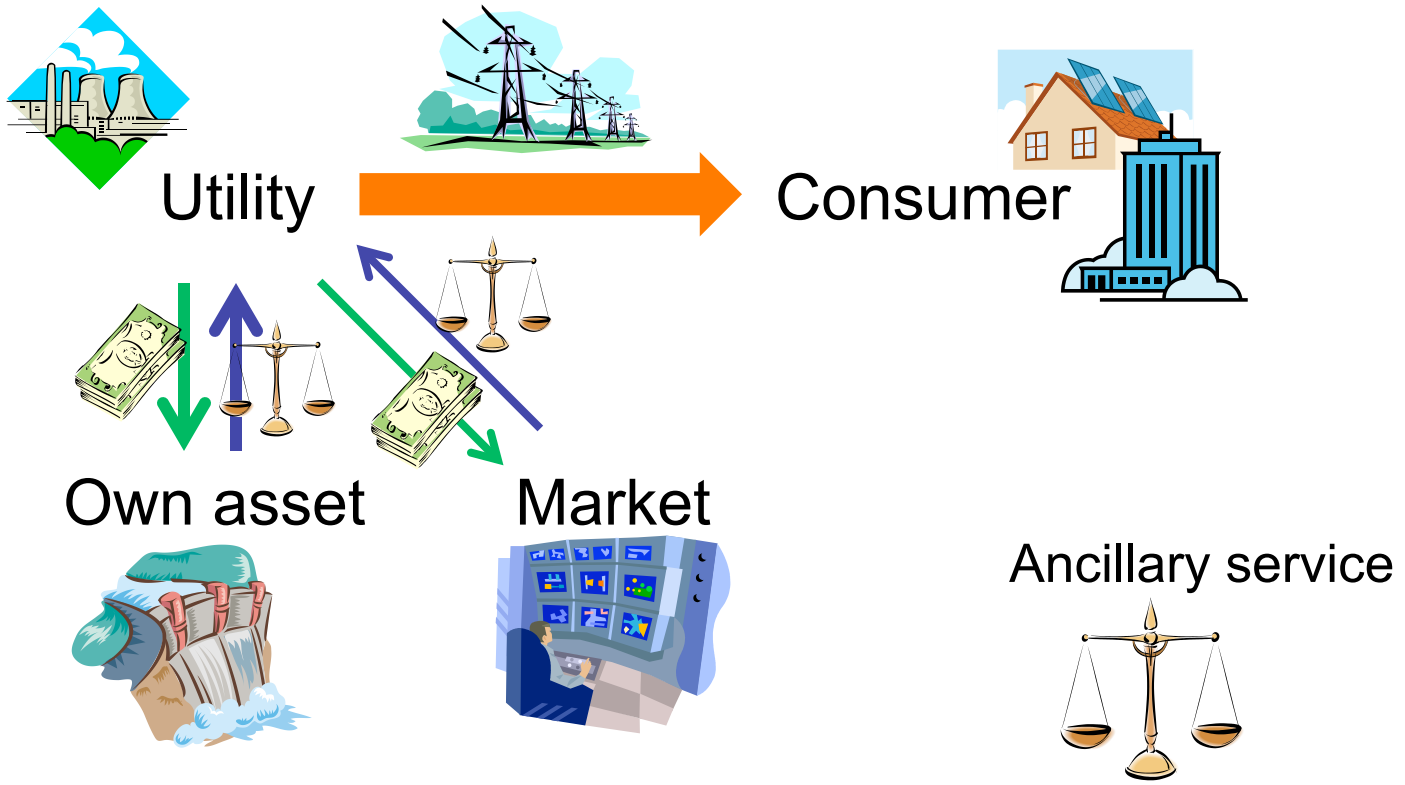
Consumers can choose

- Aggregators / autonomous (independent)
- No monopoly



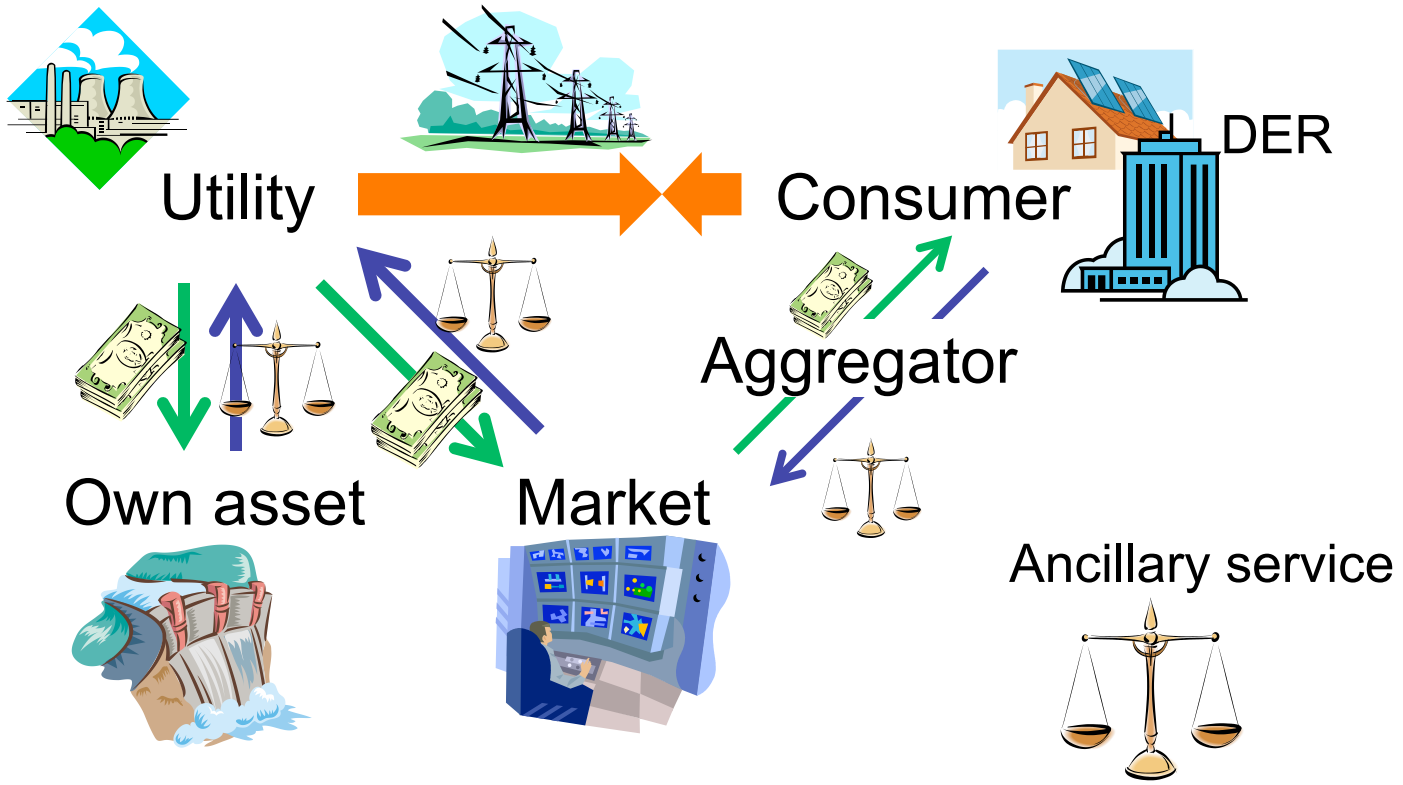
Contribution of DER on power system operation

- Now: power system operation is done by utility only



Contribution of DER on power system operation

- Now: power system operation is done by utility only
- Future: consumers join through markets

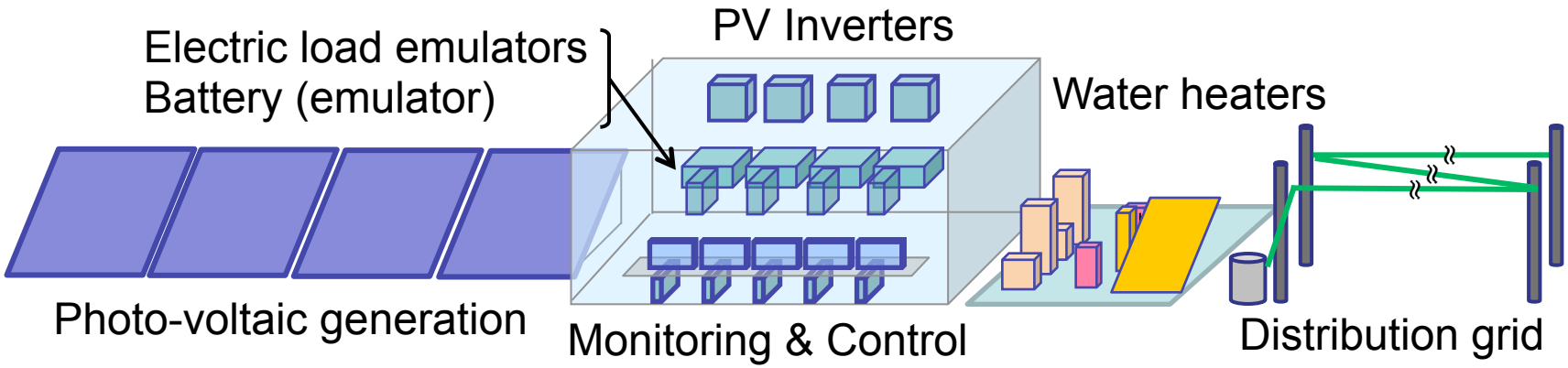


Advantages of distribute management

	Centralized mgt.		Distributed management	
Control		Centralized		Distributed, autonomous (Centralized ctrl is available)
Function, algorithms	B	Single function, no add-on	A	Various control algorithms installed, add-on available
Energy management	B	Recording energy consumption only	A	Control of equipment and energy interchange/share
Scale	C	Fixed (up to100–500)	A	Flexible (a home – nation wide)
Controller	C	Specific controllers must be installed to all sites	A	Open standard base, controllers supplied by various venders
Aggregator	B	Monopoly	A	No monopoly

Energy Network Experiment Facility in AIST

- Emulate energy systems of 4 homes
- Used for development of IDEMS (controller and applications)



Concluding remarks

- Utility + consumer will be responsible on power system operation, in the future
- Distributed Energy Resources (DER) can contribute to power system operation
- Distributed management of DER is smart solution
- IDEMS (energy management system, controller) plays important role to manage DER