Aalto University
School of Engineering

Distributed Generation Technologies

By: Edris Pouresmaeil

Department of Electrical Engineering and Automation (EEA)
Aalto University, 02150 Espoo, Finland

E-Mail : edris.pouresmaeil@aalto.fi

Fall 2021

Chapter3:
Distributed Generation Technology and it's Application in Power System (i.e., Microgrids and Smart Grids)

The Main Objectives of this Session:

At the end of this session students will be able to answer the following questions:

1. What is the meaning of Distributed Generation (DG) technology?
2. What is the application of DG technology in power network?
3. What kind of technology is used for integration of DG sources into the power grid?

What is Distributed Generation (DG)?

DG is technique of generating electricity on a small scale from renewable and non-renewable energy sources that is on-side or close to the load center.

https://www.youtube.com/watch?v=YAisP5ZBAWA

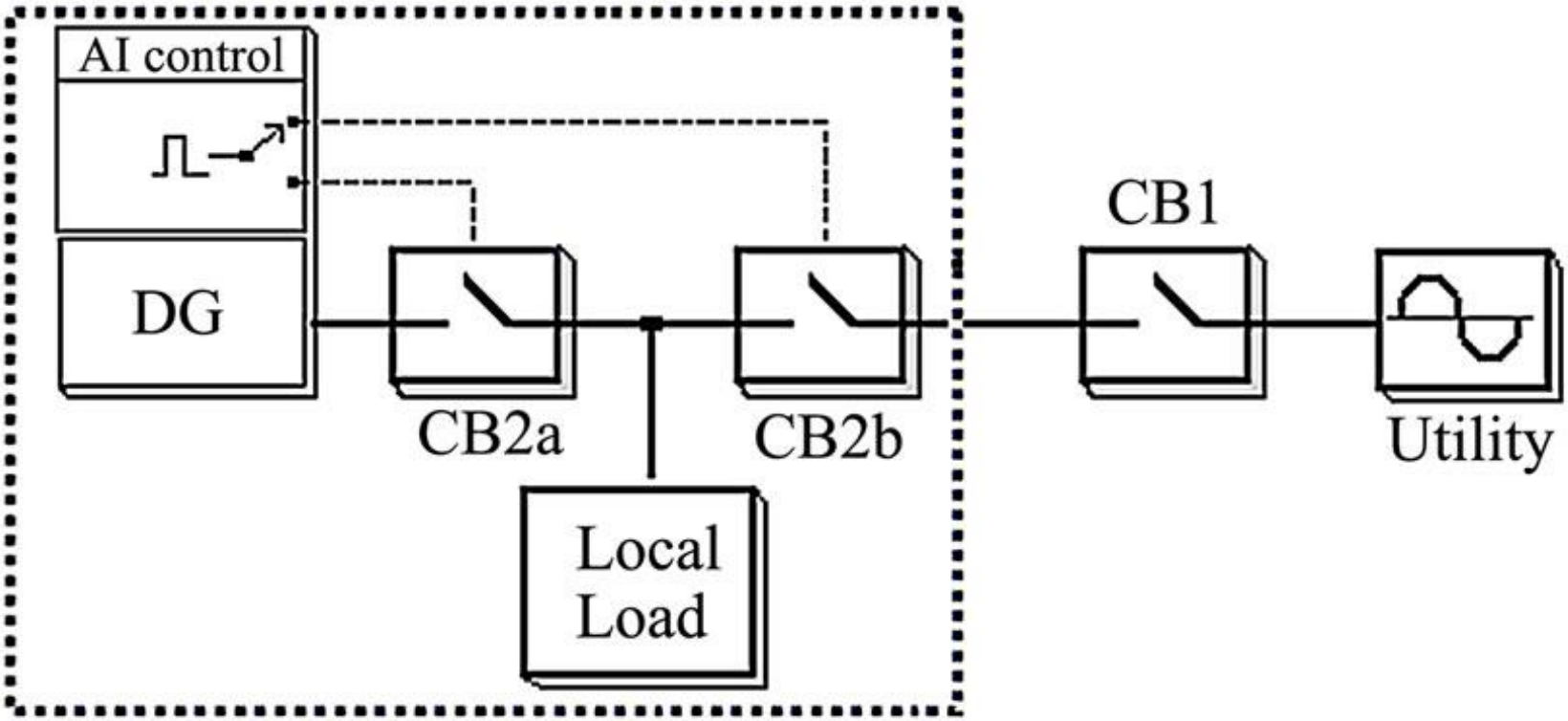
Advantages of DG Technologies

- Increases reliability, and security of the grid.
- Can be configured to match customer demand.
- Diversifies the range of energy sources used.
- Reduces the necessity to build new transmission or distribution lines.
- Reduce carbon emissions and emissions of other air pollutants.
- Increase asset use through integration of distributed systems and customer loads to reduce peak load and thus price volatility.
- Improve system efficiency with on-site DG and improve economic efficiency through demand-side management.

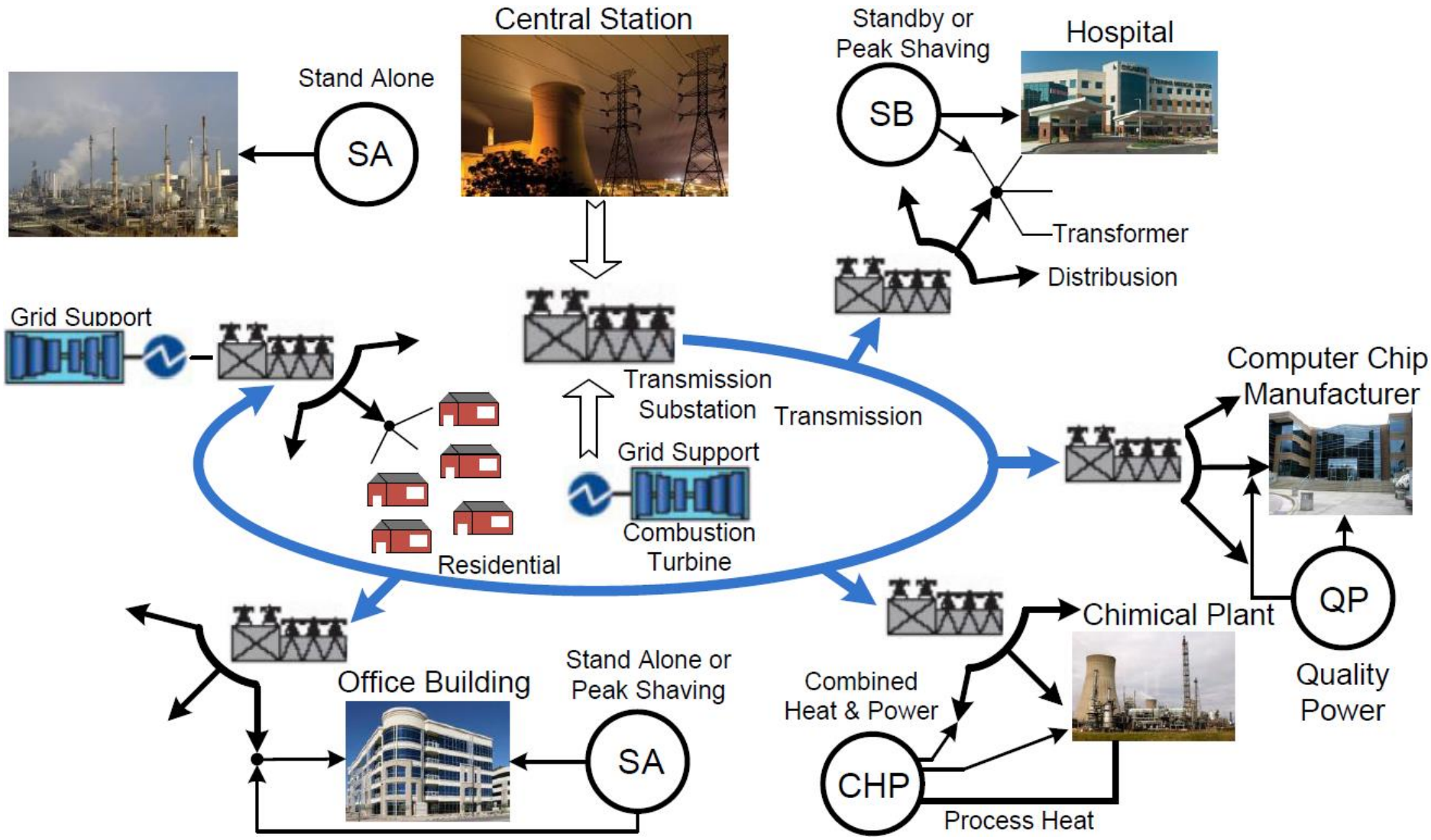
Role of DG Technologies in our Electrical Network

https://www.youtube.com/watch?v=maAmap5kb3k&list=PLqxO2CvERBWUlAUlyzhB0DT5GC7CQ_mEa&index=2

DG Integration



Application of DG Technologies in Power Systems



Application of DG Technologies in Power Systems

https://www.youtube.com/watch?v=mtkyetyCfSg

DG System Configuration

Generation units = microsources (Normally less than 100 kW, but can be up to 10,000 kW)

- PV Modules
- Small wind generators
- Fuel Cells
- Microturbines

Energy Storage (power profile)

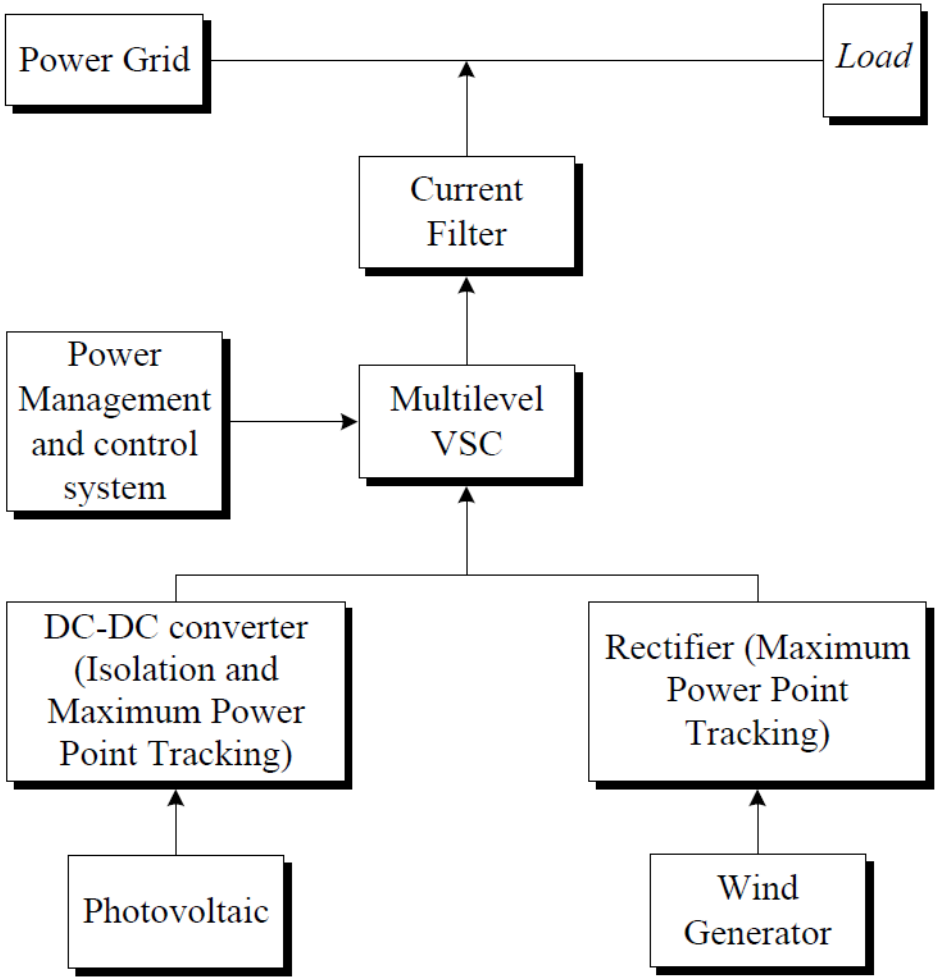
- Batteries
- Ultracapacitors
- Flywheels

Loads

- Electronic loads
- Plug-in hybrids
- The main grid

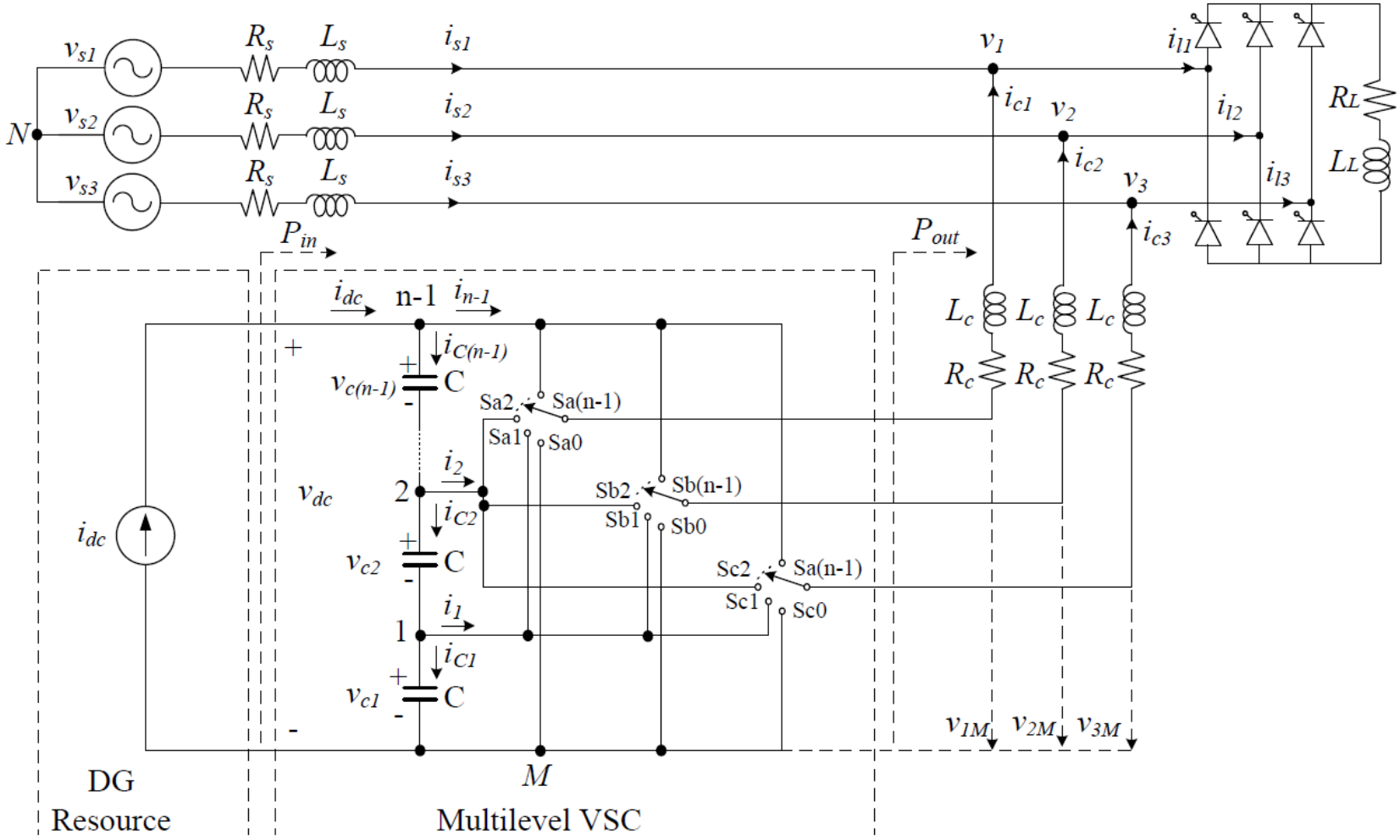
Power electronics interfaces

- dc-dc converters
- dc-ac converters
- Rectifiers



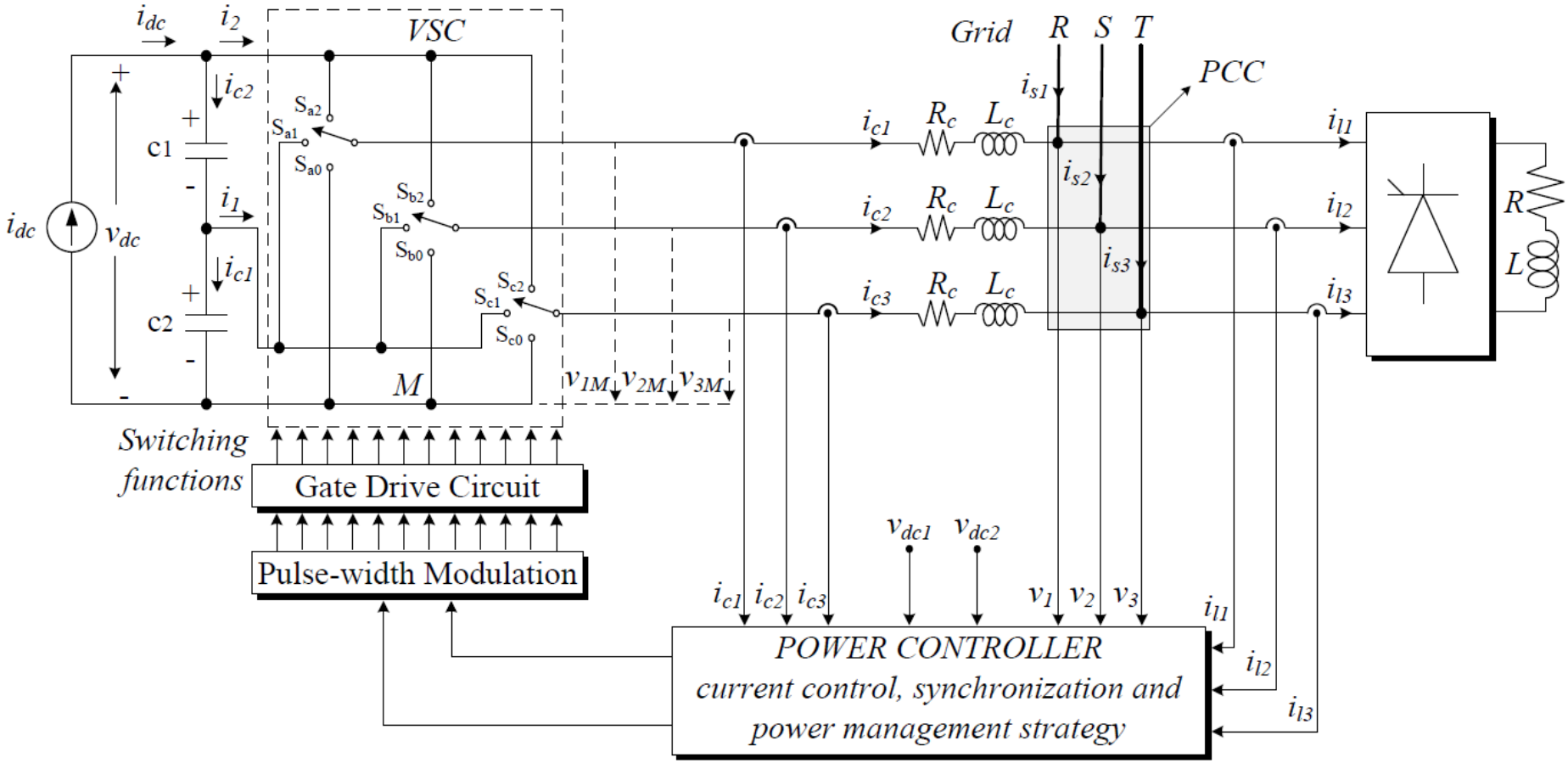
General Configuration of DG System

Configuration of a Grid-Connected DG System



General Structure of a Grid-Connected DG System

Detailed Configuration of a Grid-Connected DG System



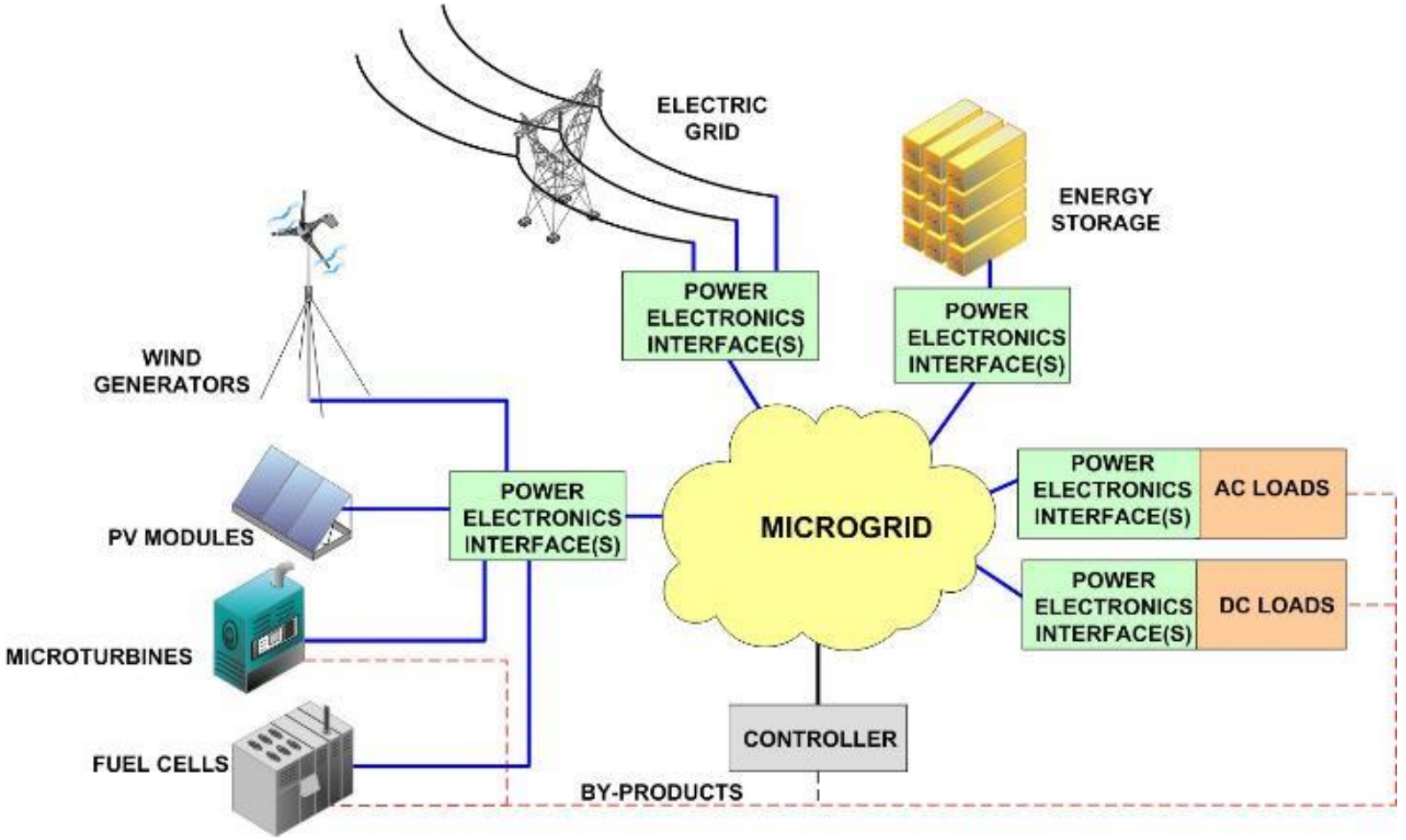
General Structure of a Grid-Connected DG System Including the Control Loop

Classification of Power Electronics Interfaces

Application of Different Converter Interfaces for Integration of DG Sources into the Loads and/or Grid

Power Electronic Interfaces

- Power electronic converters provide the necessary adaptation functions to integrate all different DG units into a common system.



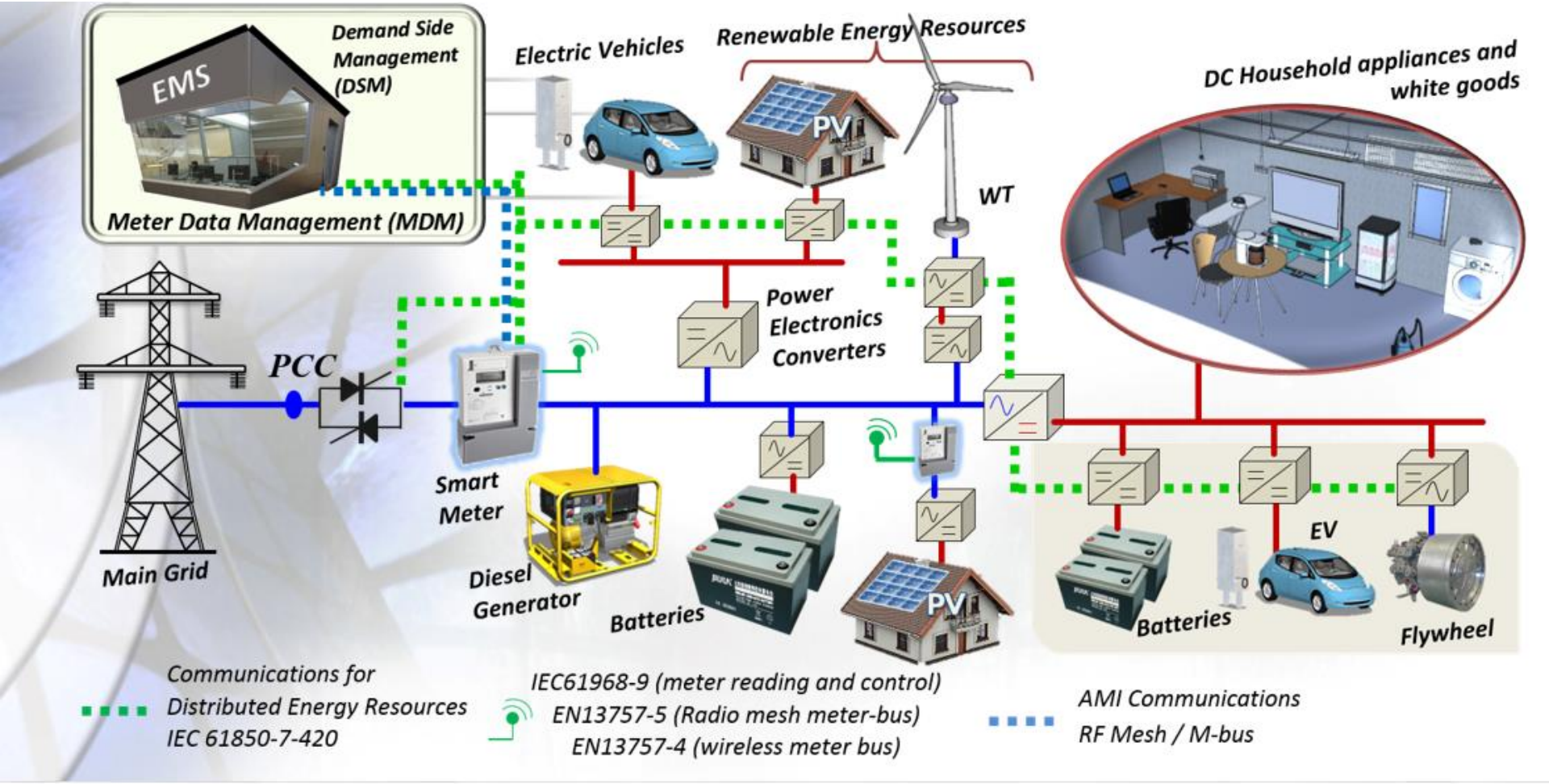
Application of Different Converter Interfaces for Integration of DG Sources into the Loads and/or Grid

Distributed Generation and Microgrid

What is Microgrid?

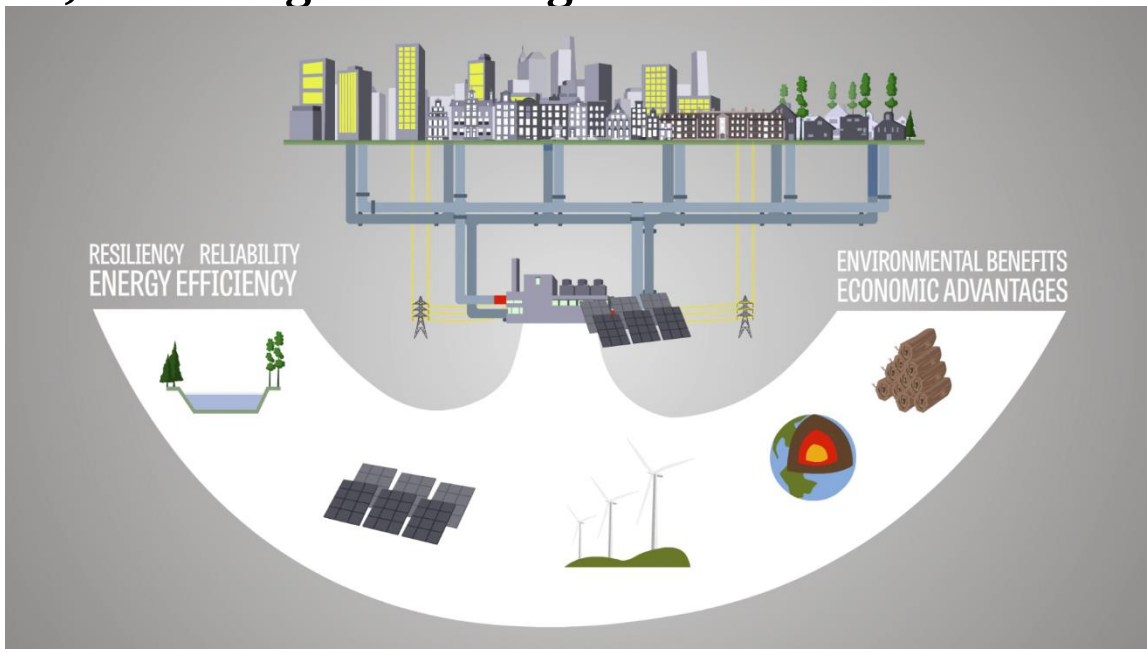
- A microgrid is a small-scale power supply network that is designed to provide power for a small community.

Schematic diagram of Microgrid



Distributed Generation: Advantages with Microgrid

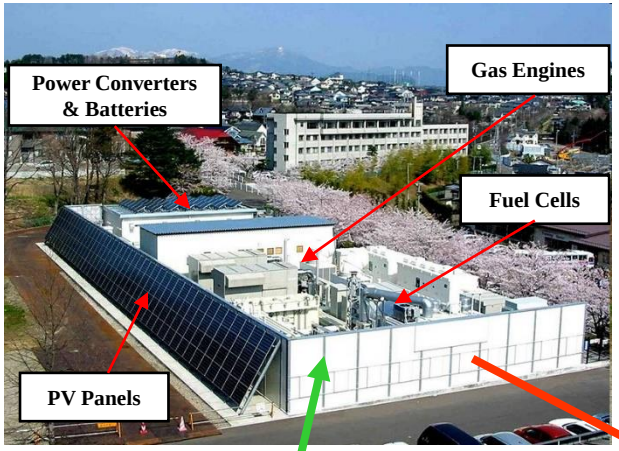
With respect to the traditional grid, well designed Microgrids are:



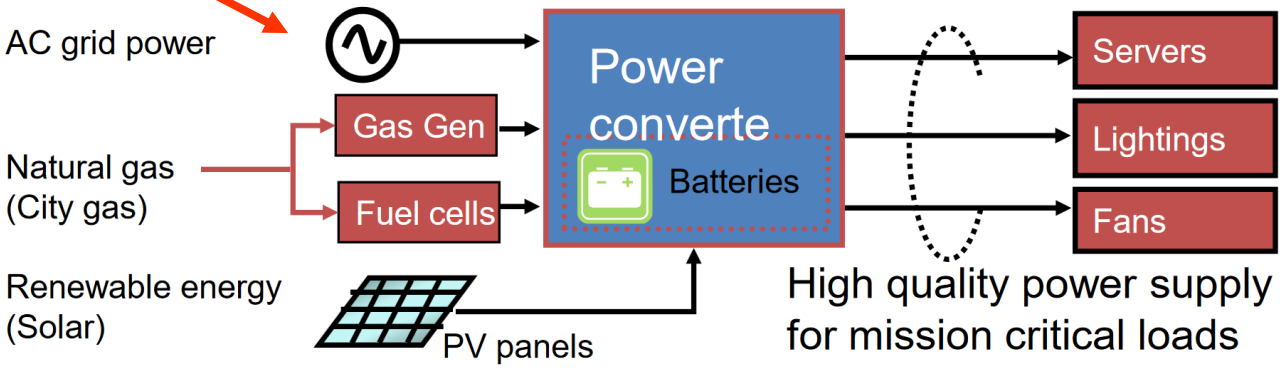
- More reliable
- More resilience
- More efficient
- More environmentally friendly
- More flexible
- More Secure
- More modular
- Easier to control
- Secure to issues occurring elsewhere
- Capital investment can be scaled over time
- Microgrids can be integrated into existing systems without having to interrupt the load
- Microgrids allow for combined heat and power (CHP) generation

Microgrid Example: 1

- **Resilient power supply during disasters**
  - **Microgrid** constructed in Sendai city to supply high quality power for mission critical loads.
  - Power electronic enabled micro-grids can be the solution that achieves reliable power during disasters (e.g. NTT's micro-grid in Sendai, Japan).



Sendai Microgrid



Microgrid Example: 2

- **Isolated microgrids for remote areas: Villages in Alaska**
- Wind is used to supplement diesel generators (diesel is difficult and expensive to transport in Alaska)

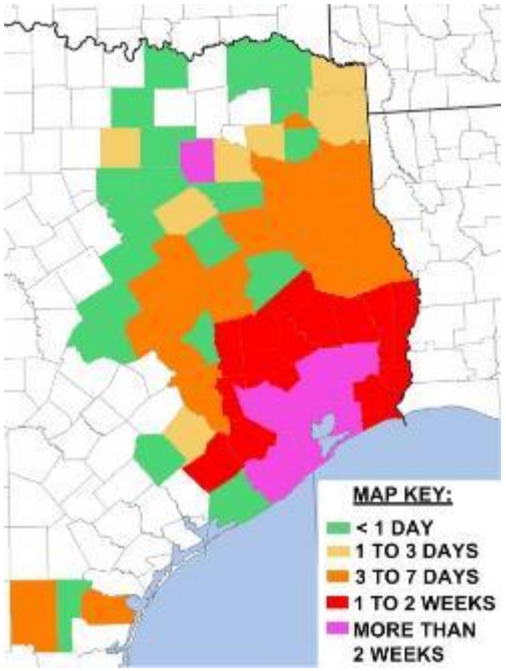
- **Toksook Bay**
- Current Population: 638
- Incorporation Type: 2nd Class City
- Total Generating Capacity (kw): 2,018
  - 1,618 kW diesel
  - 400 kW wind
  - (tieline to Tununak and Nightmute)

Information from "Alaska Village Electric Cooperative"

http://avec.org/wp-content/uploads/2014/11/Toksook-Wind-Tower-Bulk-Fuel-and-Power-Plant.jpg

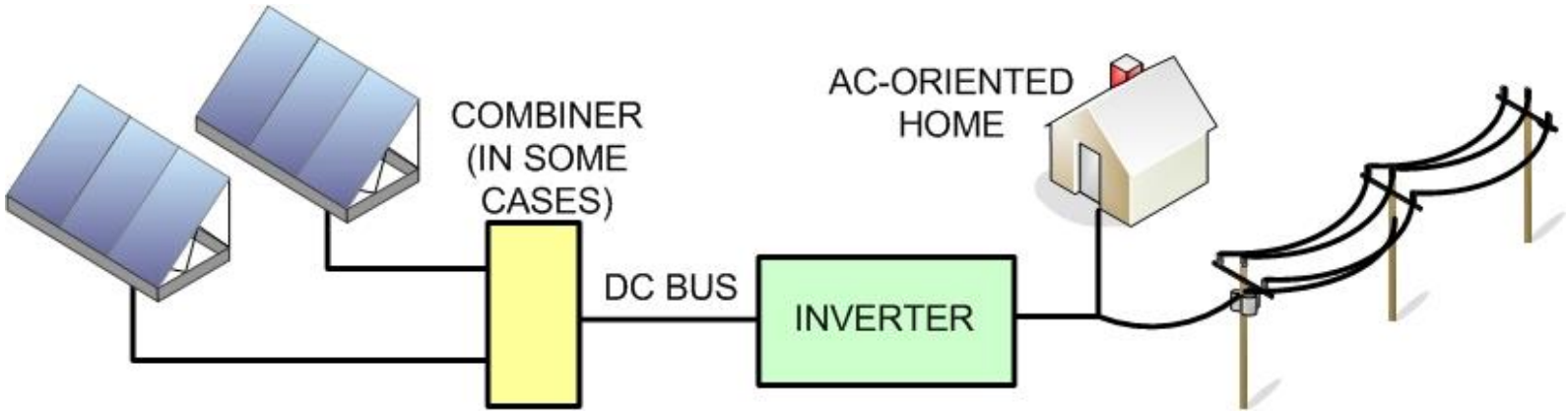
Microgrids and Grid Resiliency

- Power grids are extremely fragile systems.
- Power supply issues during disasters is a grid's problem transferred to the load.



What is not a microgrid?

- Residential conventional PV systems (grid-tied) are not microgrids but they are distributed generation systems.
- Why are they not microgrids? Because they cannot operate isolated from the grid. If the grid experience a power outage the load cannot be powered even when the sun is shinning bright on the sky.



Distributed Generation and Smart Grids

Smart grid is an electrical grid that intelligently predicts and responds to the behaviors of electric power users;

So, it efficiently delivers reliable, economic, and maintainable electricity services.

Smart grid focus:

• Reliability.

• Integration of environmentally friendly generation and loads.

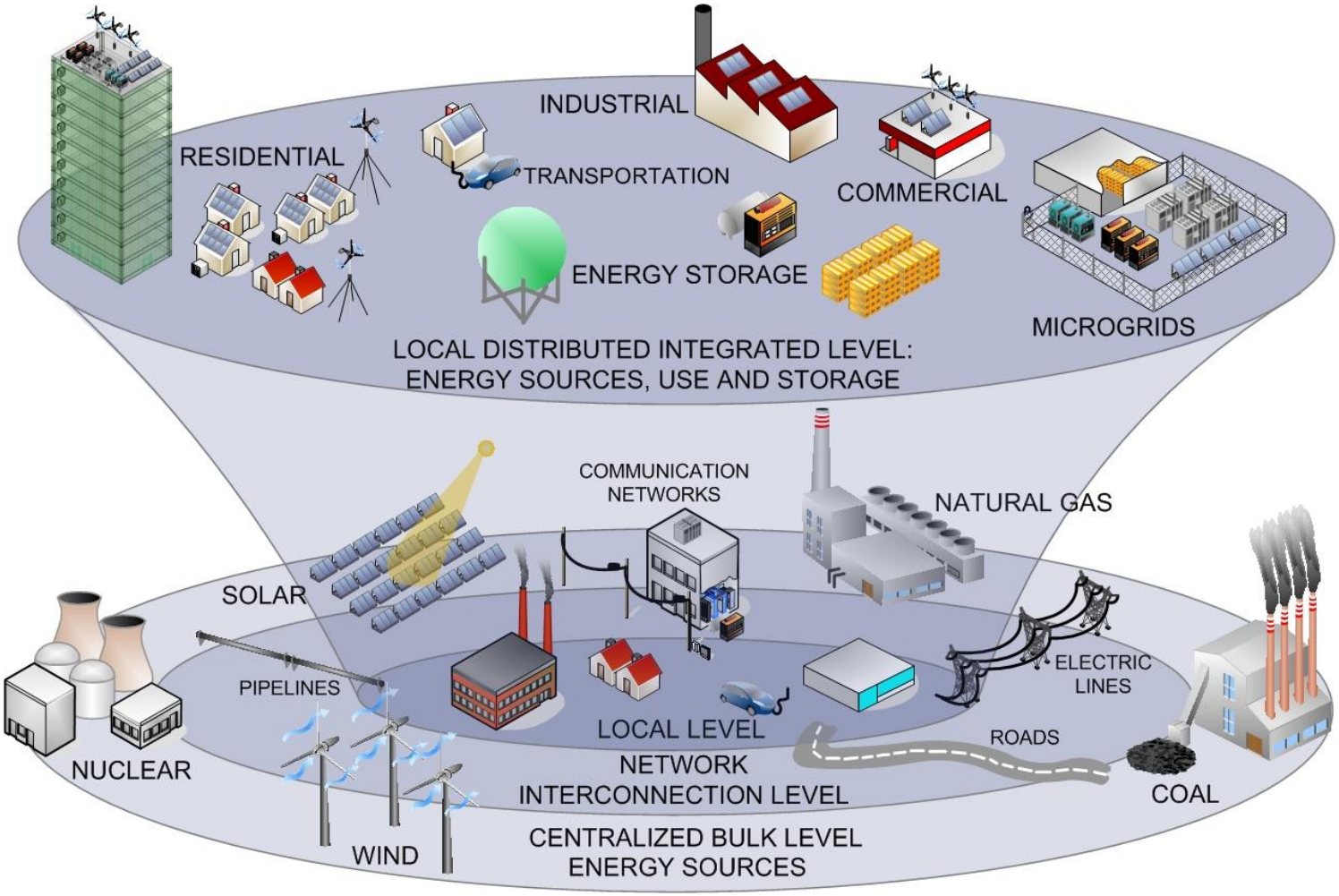
Concept evolution:

• "Smart grid 1.0": Smart meters, limited advanced communications, limited intelligent loads and operation (e.g. demand response).

• "Smart grid 2.0" or "Energy Internet": Distributed generation and storage, intelligent loads, advanced controls and monitoring.

Smart Grids

- A customer-centric view of a power grid includes microgrids as one of smart grids technologies.



Smart Grids

https://www.youtube.com/watch?v=JwRTpWZReJk

Questions and comments are most welcome!