SMART ENERGY SYSTEMS

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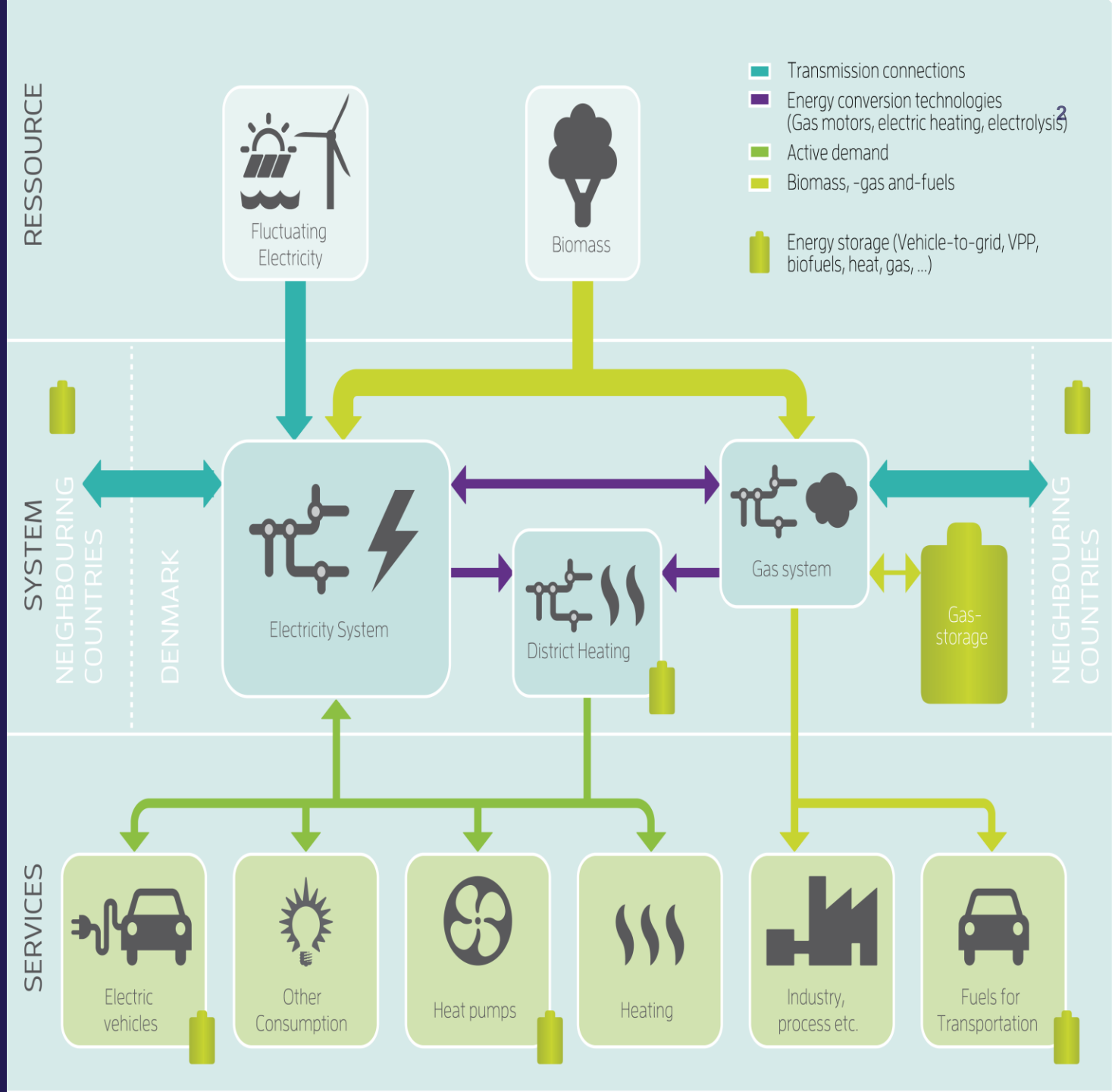
CONTENT

- Definition of the Concept
- Smart Electricity Grid
- Smart Heat Sector
- Smart Cold Sector
- Smart Gas Networks
- Smart Transportation
- Challenges
- A Sample Case Study



DEFINITION OF THE SES

- 100% Share of Renewable and Sustainable Sources
- Strong Synergies Between all the Enregy Sectors
- Utilization of any Waste Energy Flow in the Vicinity
- Involvement of the Most Advanced Technologies
- Demand Side Management

- Highly Environmental Friendly
- Greatly Reliability
- Highest Possible Energy Efficiency
- The Best Achievable Cost-Effectiveness

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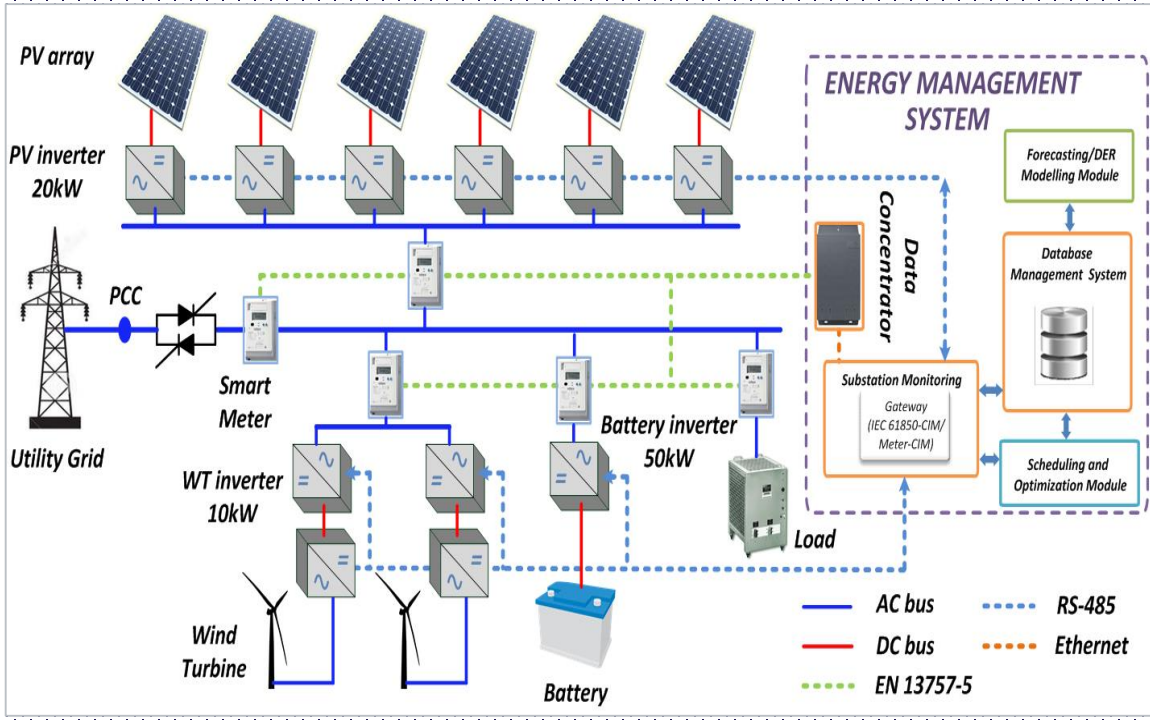
SMART ELECTRICITY GRID

- 100% Renewable Based
- Demand Side Management
- Digital Communications to Detect and React to Changes in the Consumption of the Users
- Advanced Meters, Appliances and Control Methods
- Combination of Grid Connected and Standalone Systems
- Possibility of Two-Way Electricity Tarde with Smart-End-Users



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SMART ELECTRICITY GRID

- Wind Turbines
- PV Farms
- Concentrating Solar Power Plants
- Biogas/Biomass Driven CHP Plants
- Waste Incineration Plant
- Other Renewable Source Power Plants
- New Hybrid Configurations

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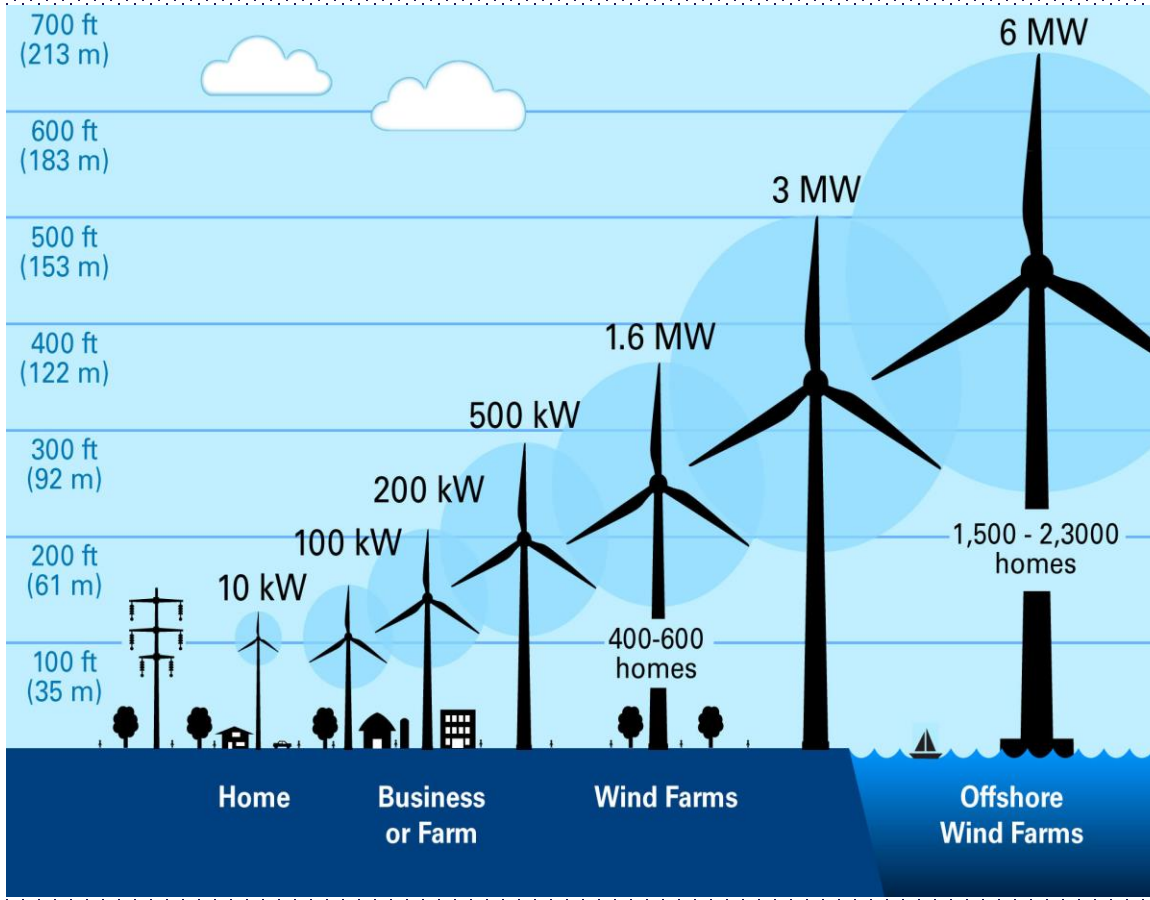
SMART ELECTRICITY GRID

- Wind Turbines
  - Grid-Connected Wind Farms
  - Small-Scale Standalone Wind Turbines

- Wind Power Technologies
  - Off-Shore Wind Power
  - On-Shore Wind Power



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SMART ELECTRICITY GRID

- Largest Wind Turbines Ever
  - In-Operation: MHI Vestas V164-8.0 Product, 8 MW rated power, 80 m blades, Swept area of 21.124 m^2, Approximate hub height of 105 m
  - Tested: General Electric Product, blade length of 107 m, 260 meters tall, capacity of 12 MW (16000 European families electricity demand)

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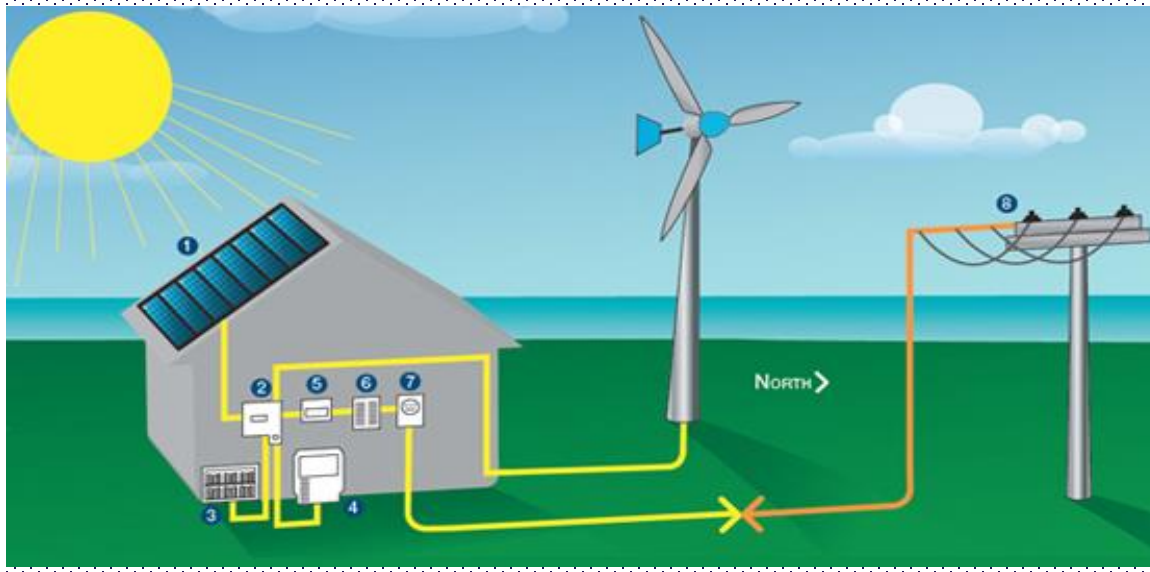
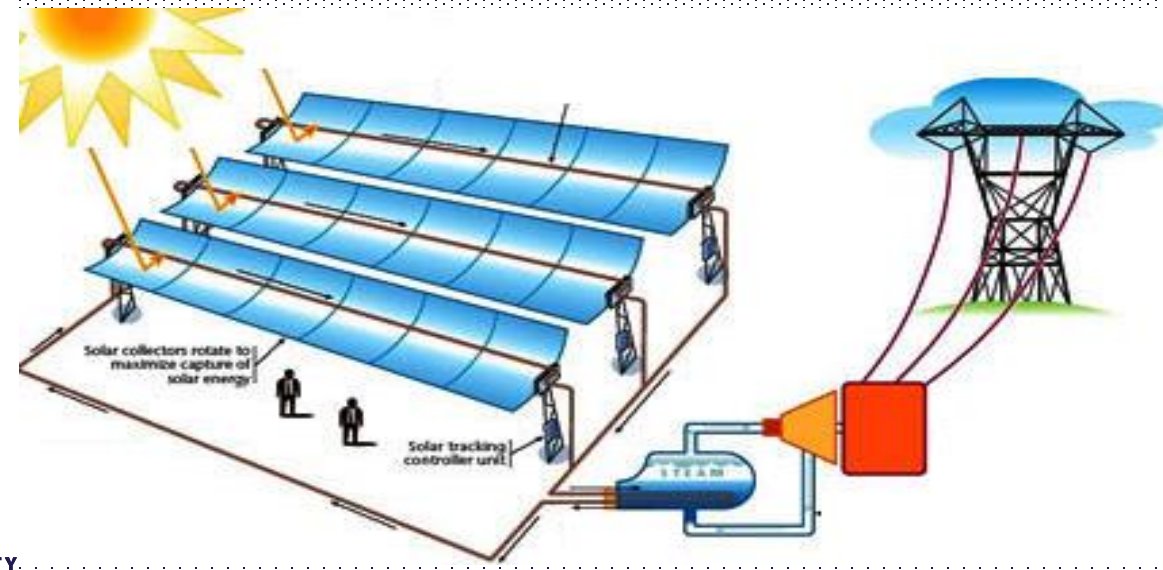
SMART ELECTRICITY GRID

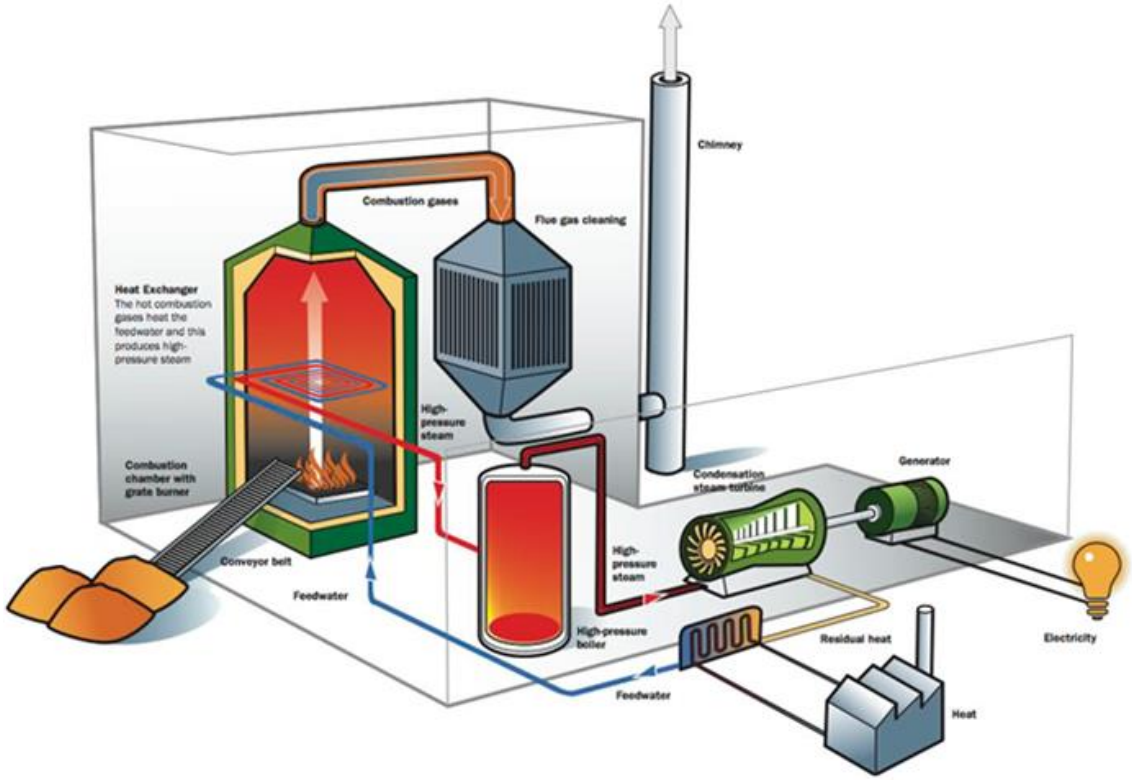
- Solar Power
  - PV and PVT Technologies
    - Grid Connected Farms
    - Standalone PV/PVT Systems
    - Highly Suitable for Smart Energy Buildings
  - Solar Thermal Power
    - For Grid Support Only
    - Necessary for Frequency Balancing





SMART ELECTRICITY GRID

- Biomass / Biogas CHP Plants
  - A More Focus on a Higher Electricity Output
- Waste Incineration Plants
  - Currently In-Operation Systems
    - In Service as a Heat-Only or a CHP Plant
    - Base-Load Supply
  - The Prospective
    - Waste Should be Recycled as much as Possible
    - The Inevitably Available Waste Should be Used for Driving a CHP Plant or as a Backup of Renewable Power Plants



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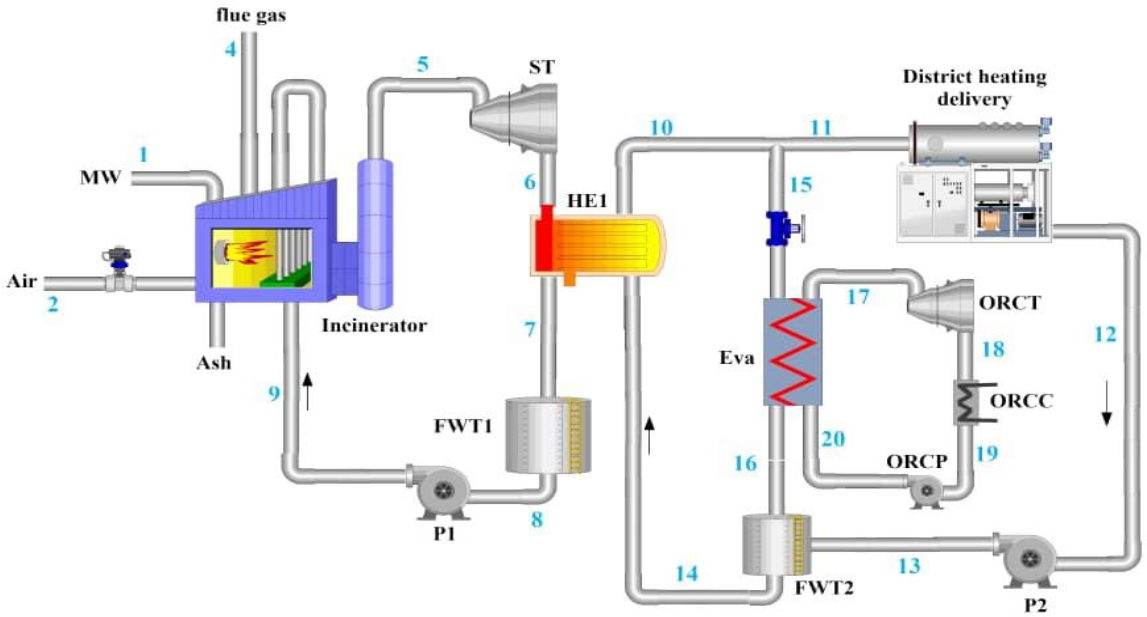
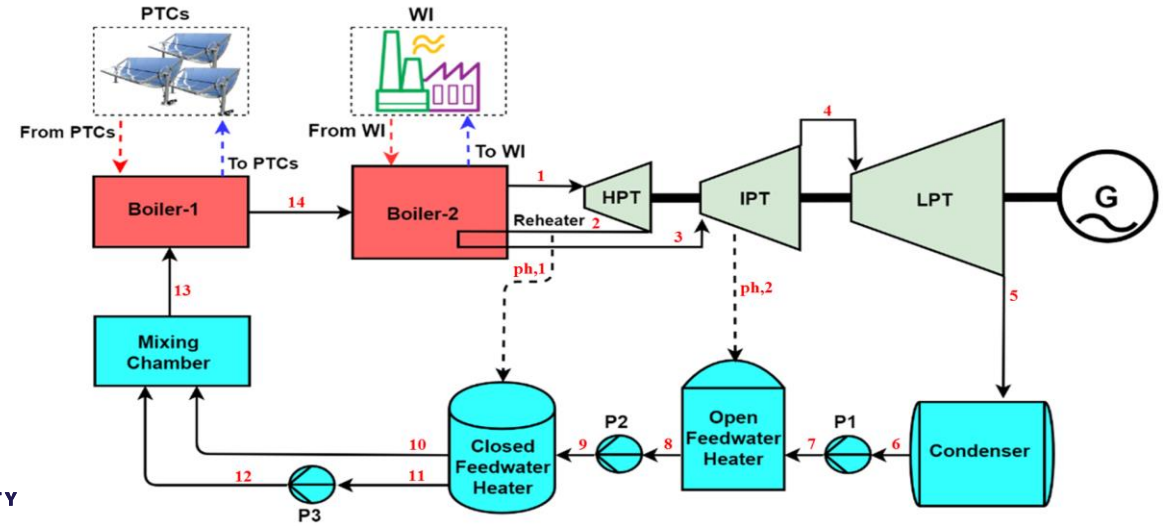
SMART ELECTRICITY GRID

- New Hybrid Configurations
  - A Few Samples
    - Hybrid Solar Concentrating – Waste Incineration Plant
    - Hybrid Biomass/Waste Driven CHP + Small Scale ORC
    - Integrated Large-scale Heat Pumps and CHP Plants
    - An Integrated CHP and Desalination Plant
    - AND MANY OTHERS…





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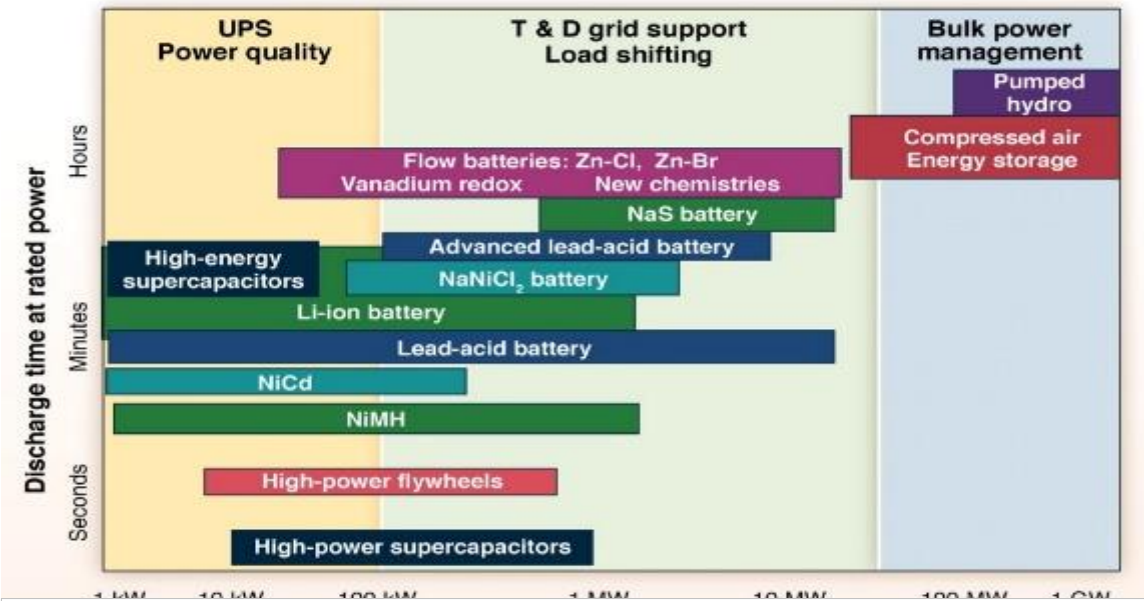
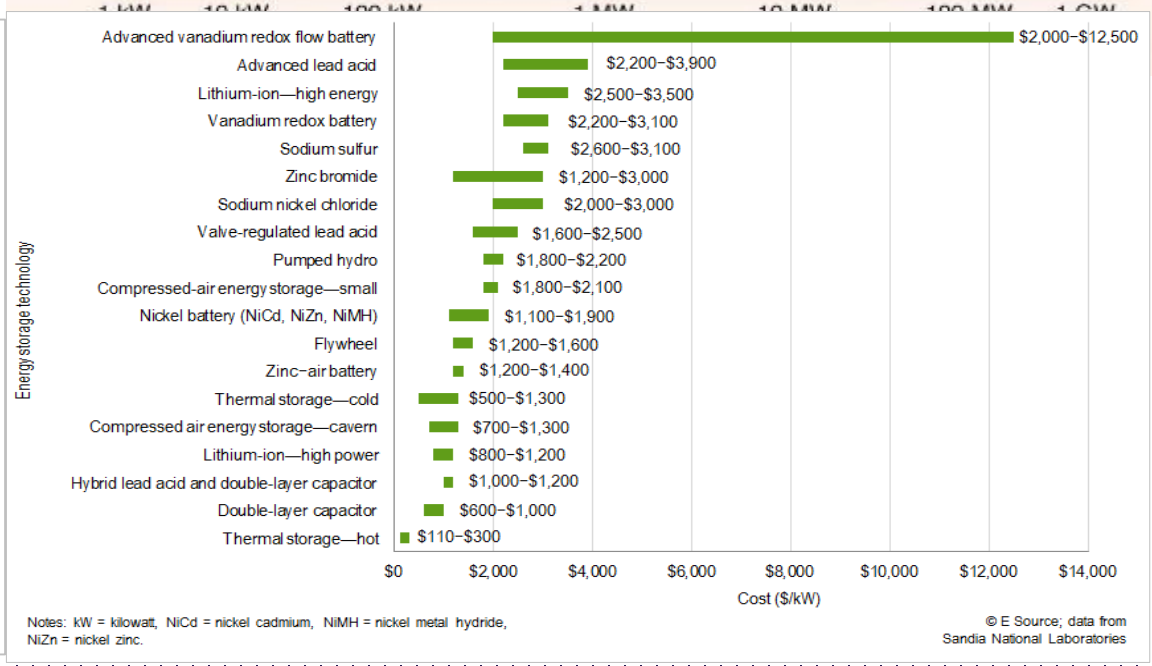
SMART ELECTRICITY GRID

- The Role of Storage Systems
- Why Electricity (Energy in General) Storage Systems are Importnant in an SES?
- Why New Storage Technologies?

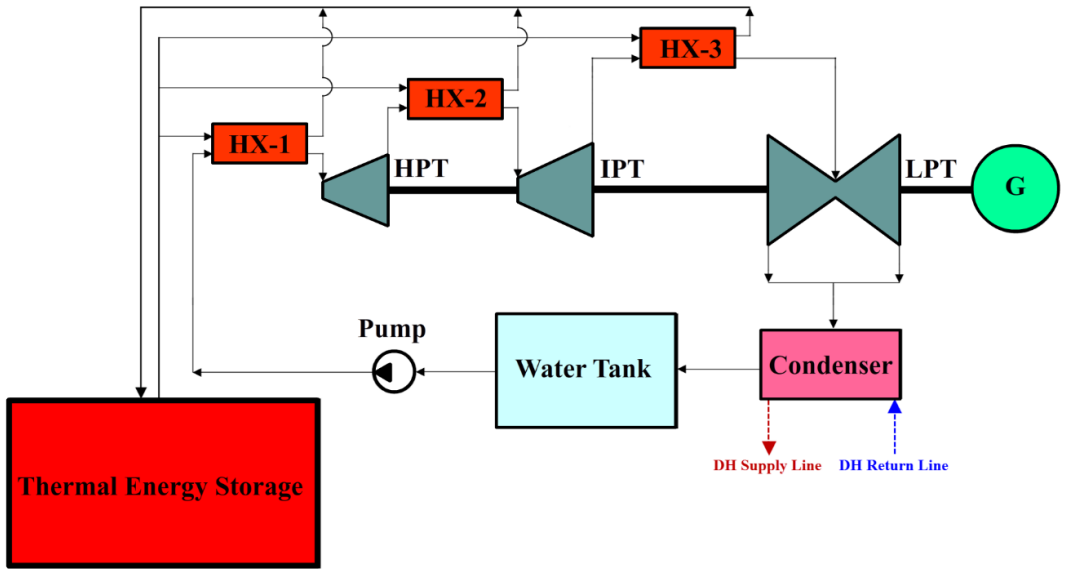


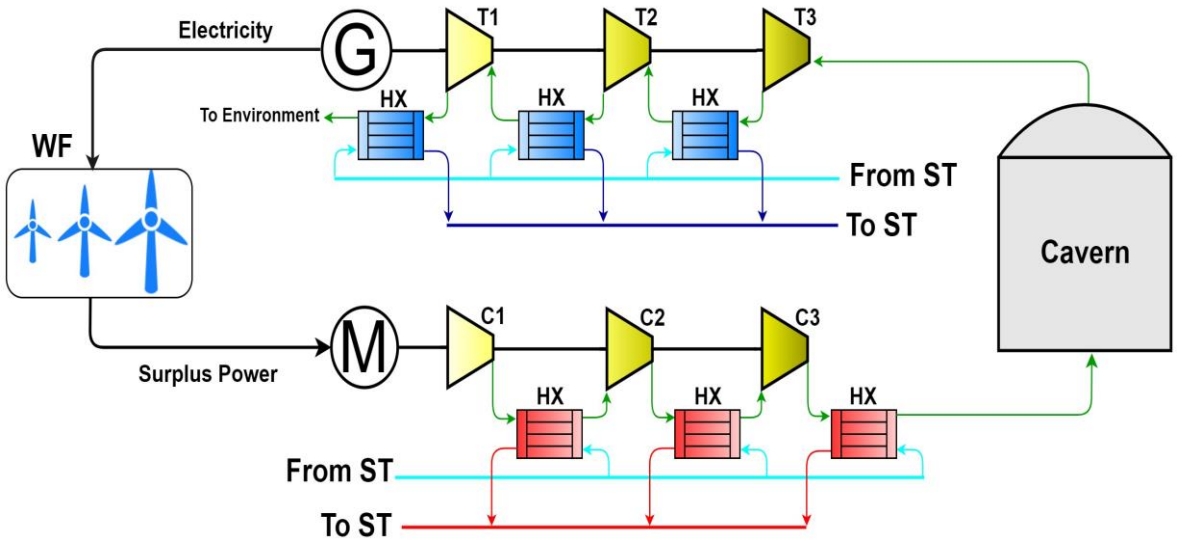
Parameter	Redox-Flow	Lithium-Ion	Lead-Acid	CAES	Rock storage w. Brayton cycle (power only)	Rock storage w. Brayton cycle (power + heat)	Rock storage w. Rankin cycle (power only)	Rock storage w. Rankin cycle (power + heat)
Project specific parameters								
Installed storage power [MW]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Investment Cost	€ 5,000,000	€ 2,400,000	€ 1,200,000	€ 1,112,000	€ 706,000	€ 706,000	€ 1,356,000	€ 1,356,000
C-Rate (nominal) [1/h]	0.25	1.00	1.00	0.13	0.13	0.13	0.13	0.13
Nominal capacity [MWh]	4.00	1.00	1.00	8.00	8.00	8.00	8.00	8.00
Utilization of usable storage capacity	100%	100%	100%	100%	100%	100%	100%	100%
Number of cycles per year	365	365	365	365	365	365	365	365
Project lifetime (T) [year]	25	25	25	25	25	25	25	25
External parameters								
Energy price [Euro/MWh]	30	30	30	30	30	**18**	30	**18**
PIF energy price	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Loan period [years]	10	10	10	10	10	10	10	10
WACC	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Storage specific parameters								
Residual value after end of lifetime (discounted) of investment cost	15%	0%	0%	0%	0%	0%	0%	0%
Effeciency	70%	80%	65%	78%	38%	90%	38%	90%
Maintenance Cost of Investment (per year?)	2%	1%	5%	1.0%	1.5%	1.5%	1.5%	1.5%
Degradation of storage capacity per year	0.1%	2.0%	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%
Calendar lifetime	25	7	3	25	25	25	25	25
Usable storage capacity	100%	80%	50%	100%	100%	100%	100%	100%
LCOE of storage [Euro/MWh]	**€338***	**€1,678***	**€3,072***	**€75**	**€118**	**€43**	**€135**	**€60**

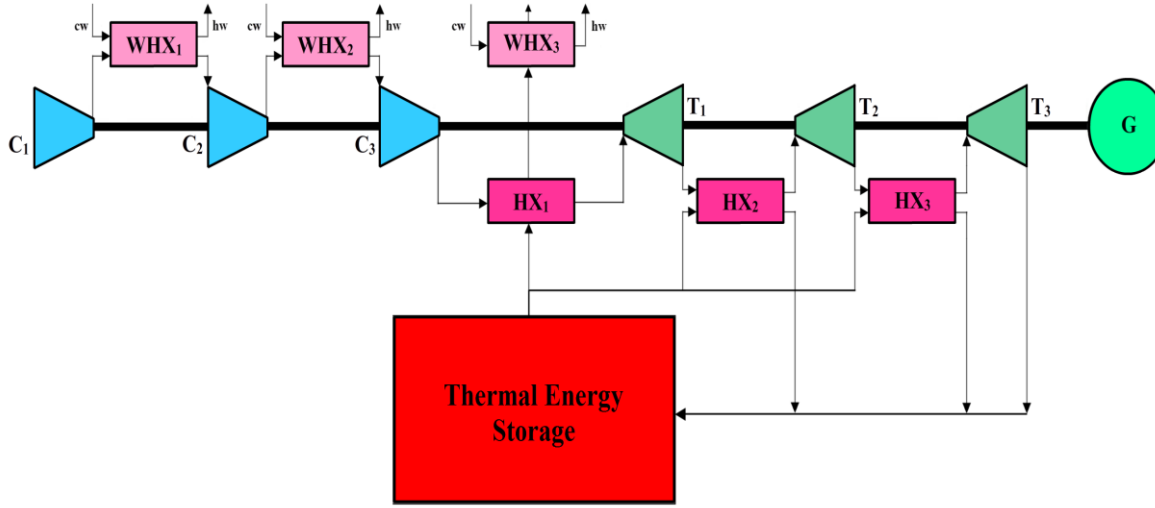


SMART ELECTRICITY GRID

- Multi-Functional Storage Systems
  - A Few Examples
    - Subcooled-CAES
    - High-Temperature Heat and Power Storage

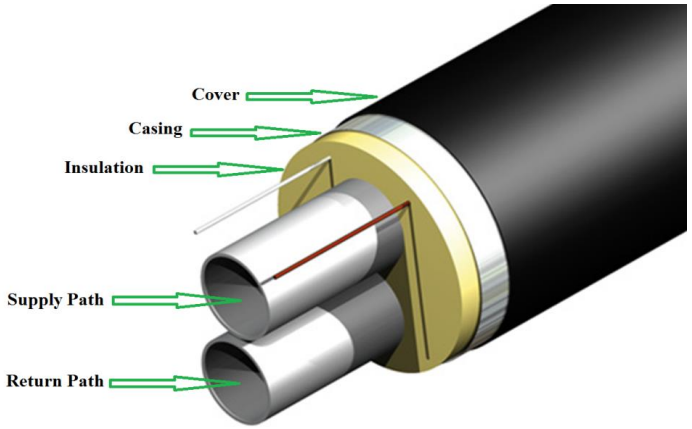


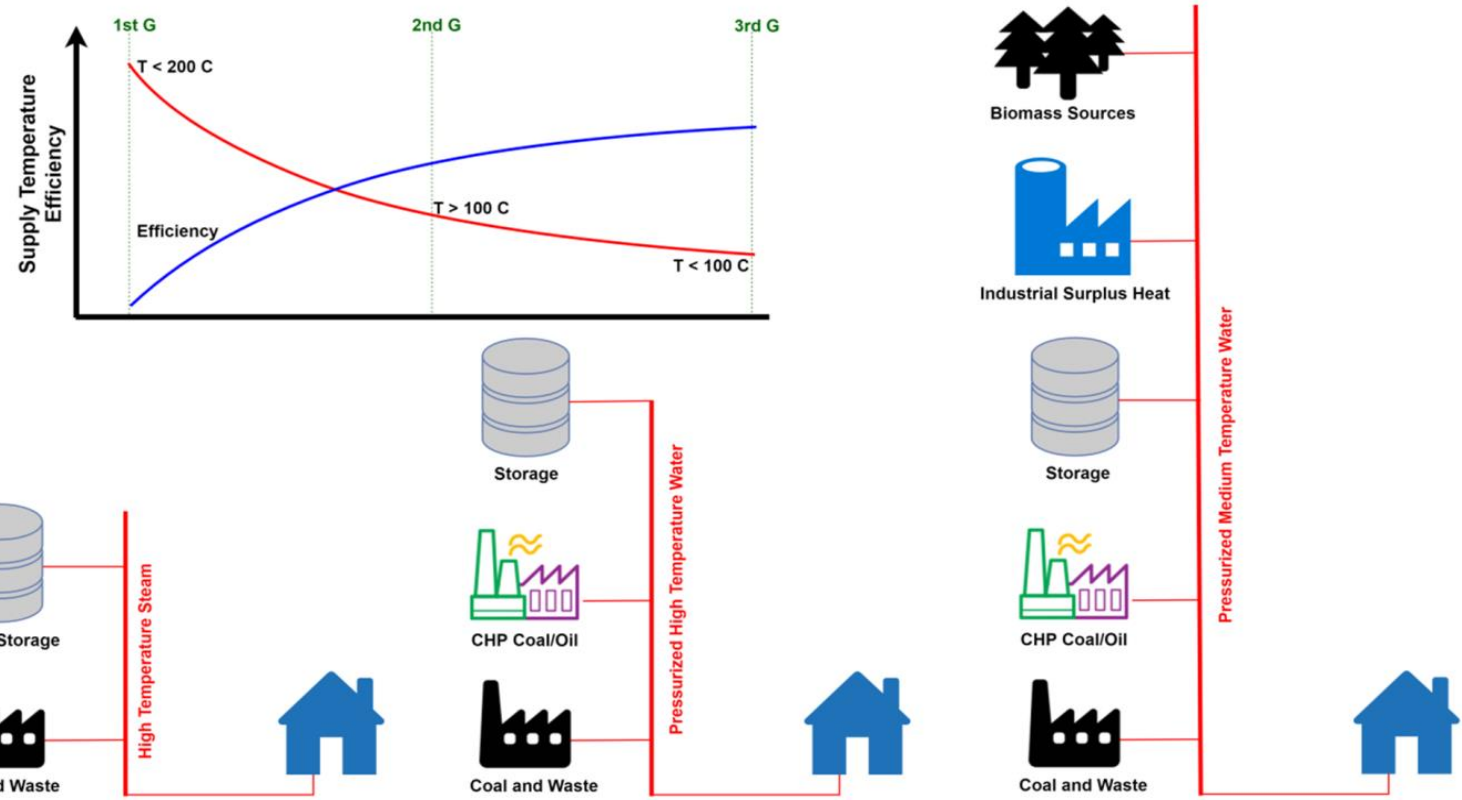




SMART HEAT SECTOR

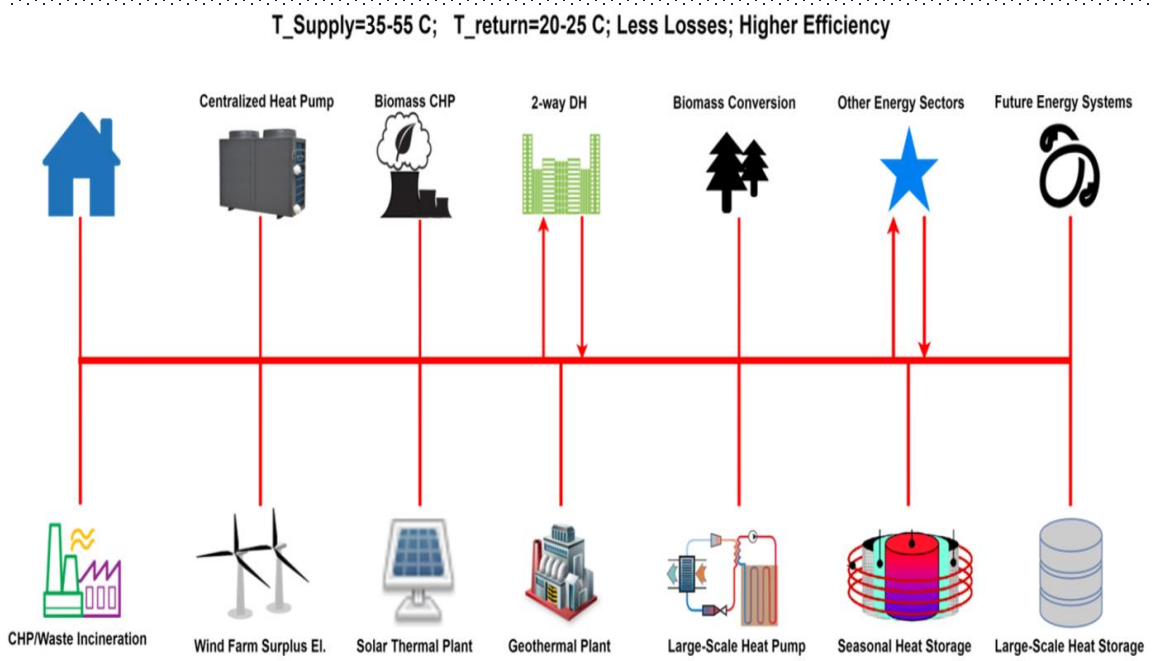
- District Heating
- The Previous Generations of District Heating Technologies
  - The First Generation
  - The Second Generation
- The Current Generation (3rd)





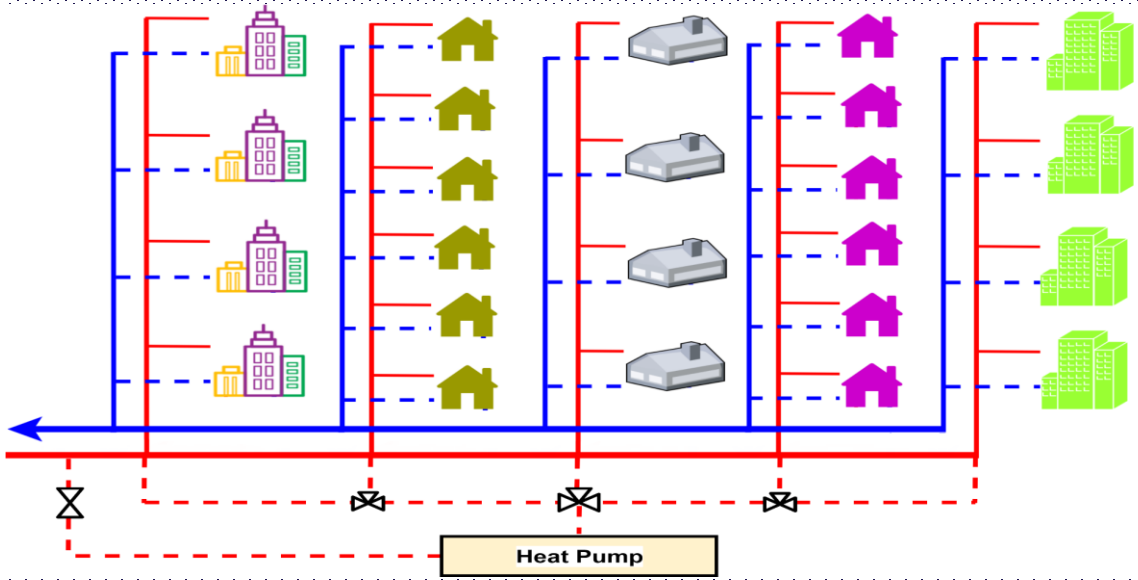
SMART HEAT SECTOR

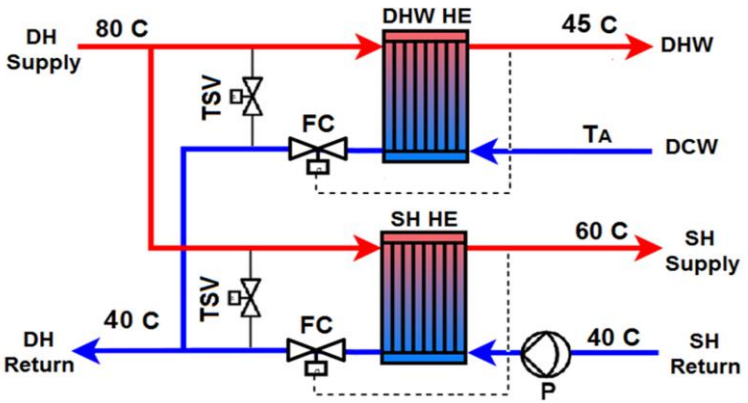
- The Fourth Generation District Heating (4GDH) Systems
  - Lower Supply and Return Temperatures
  - A Revision of the Components in Heat Production Chain, with a Certain Emphasis on Renewable Energy Systems
  - Revision of the Network Components Including Substations, e.g. Pipes, Heat Exchangers, etc.
  - Involvement of Energy Efficienct Buildings
  - Two-Way Heat Trade
  - High Integrity with Other Sectors via e.g. Heat Pump

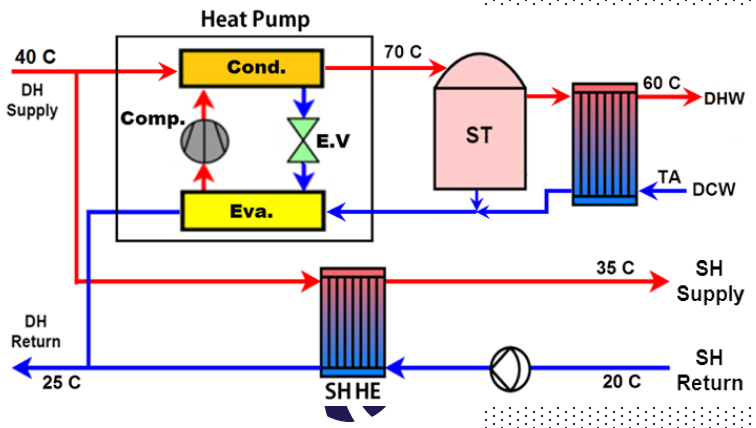


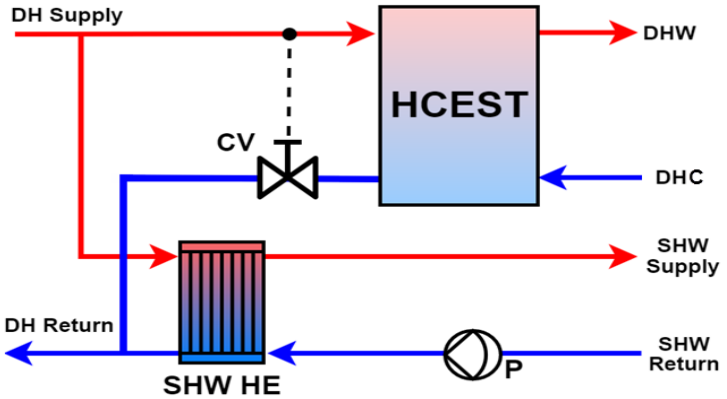
SMART HEAT SECTOR

- The Possible Solutions
  - Low-Temperature DH Systems
  - Ultralow-Temperature DH System
  - Variable-Temperature DH System
  - Any Other Scheme??!!



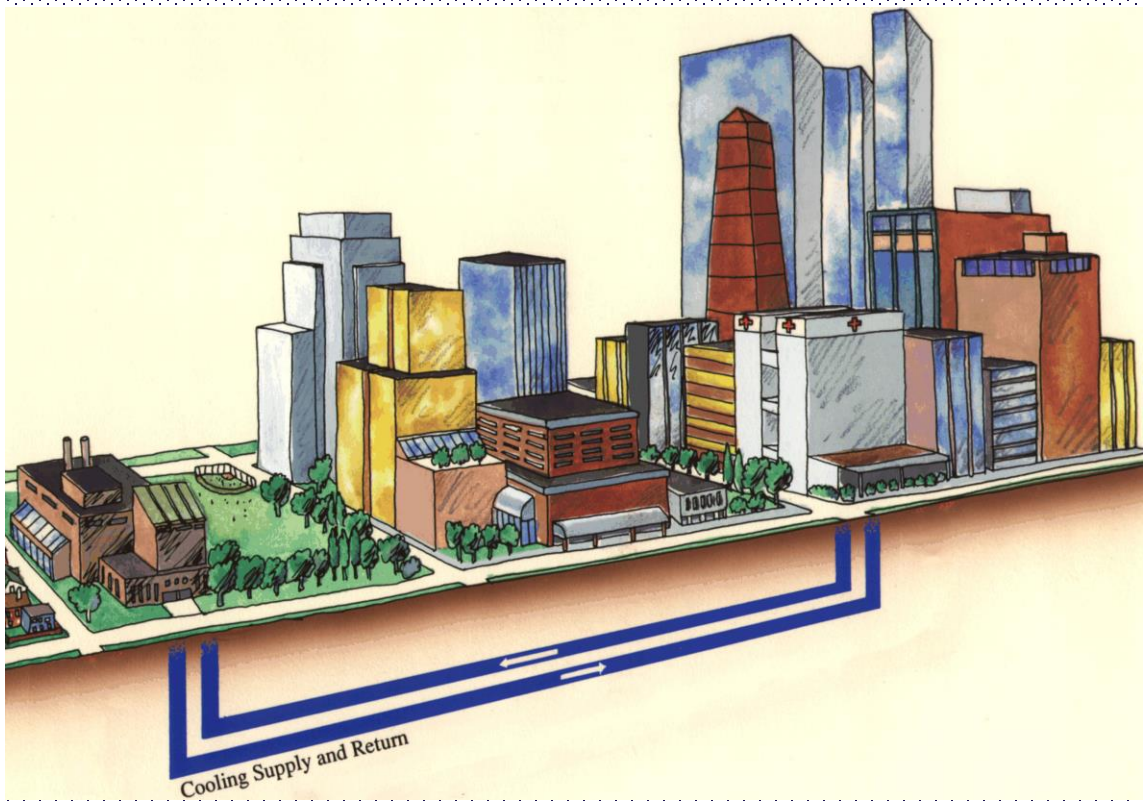






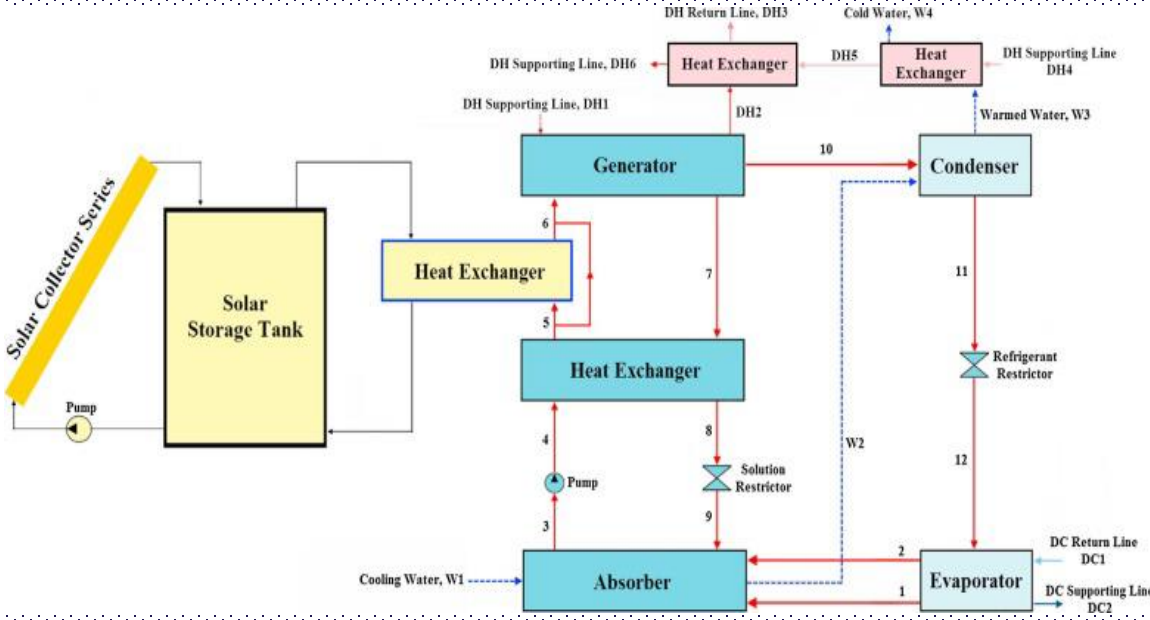
SMART COLD SECTOR

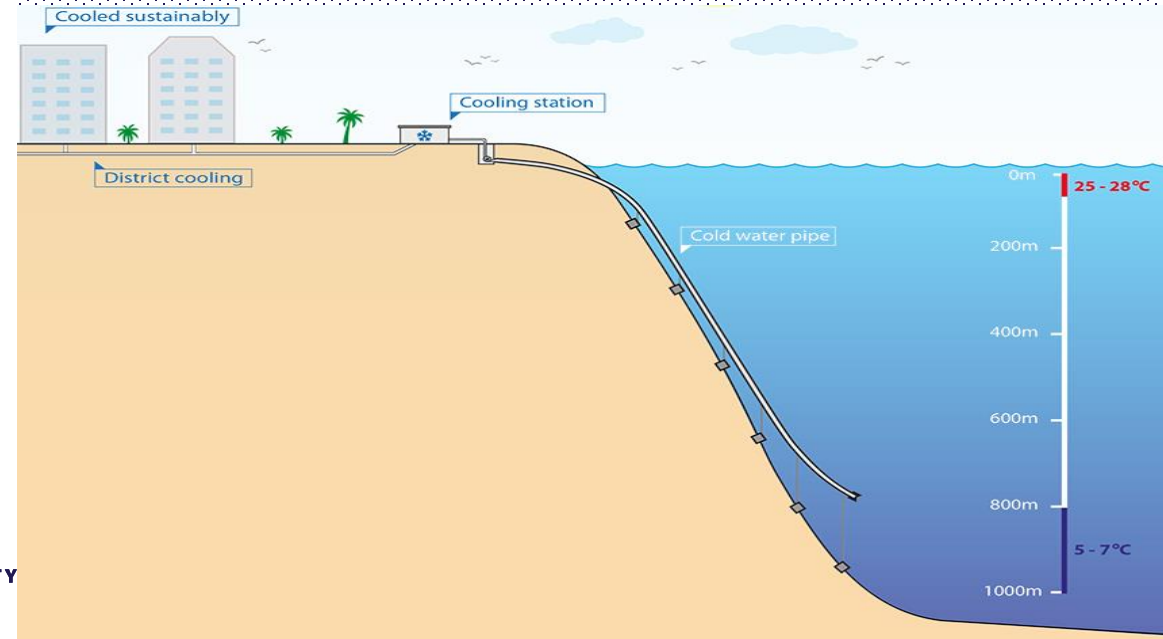
- Maturity vs. Popularity
  - Globally, as Important as District Heating, but not so Distributed Because . . .
  - Sweden is a Pioneer for This, 40% Coverage
- District Cooling Networks
  - Residential Applications
  - Industrial Applications
  - Specific Applications, e.g. a Hospital



SMART COLD SECTOR

- Of Interest Technologies
  - Large-Scale Comprression Chillers
  - Large-Scale Absorption Machines
  - Renewable-Driven Absorption Chillers
  - Sea-Water District Cooling





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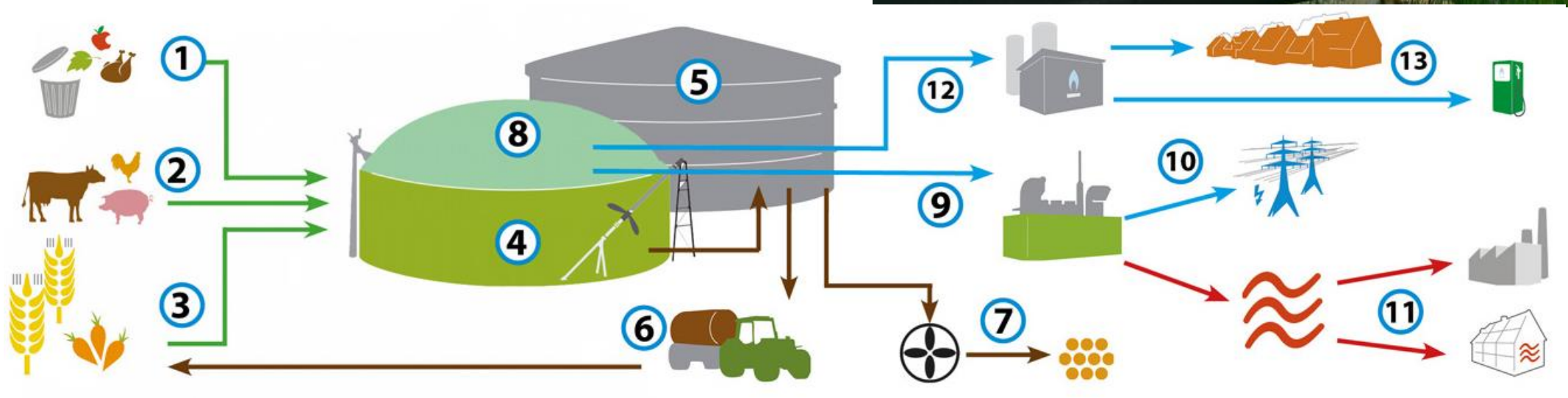
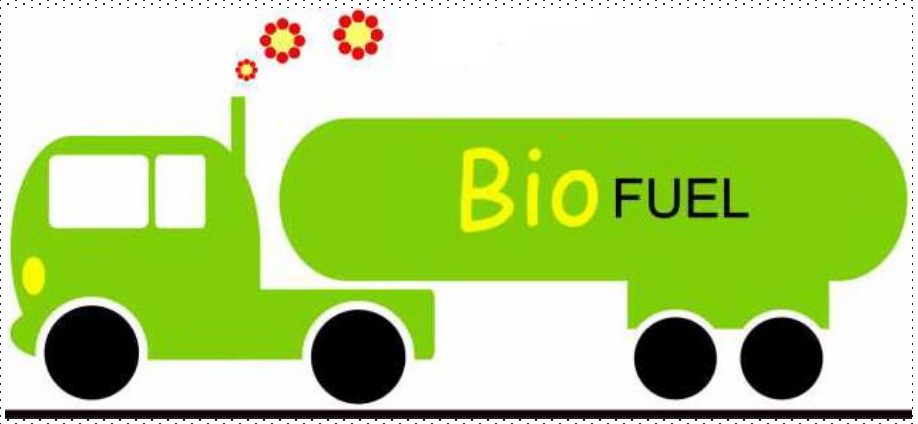
SMART GAS NETWORKS

- The Future of Exisiting Gas Networks
- The Necessity for This Change
- Future Gas Network Will Play a Key Role in Transportation Sector



SMART TRANSPORTATION

- Electrical Vehicles Will be the Main Focus
  - This Includes Either Chargeable Vehicles or Those Equipped with Solar Cells (or Other Renewable Actuators!!)
- A Pure-Electrical-Based Transportation System Will not be a Realistically Achievable Solution
- The Best Solution Would be a Combination of Biofuel- and Electricity-Based Transportation Sector
- Renewables Play a Key Role in Green Fuel Production



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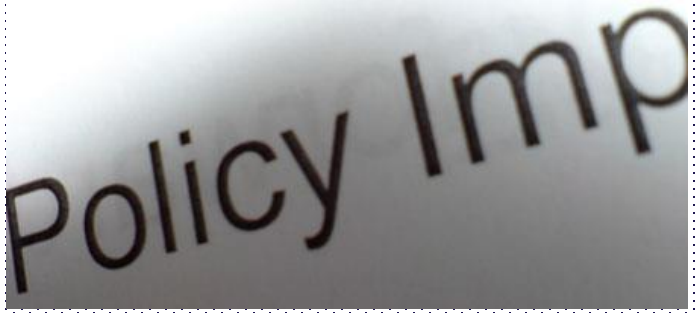
CHALLENGES OF SES

- Technical Challenges
  - Immature Energy Conversion and Energy Storage Technologies.
- Institutional Challenges
  - Existing Regulatory Frameworks and Tariff Systems Does not Offer Enough Support to This Transition
- Socio-Economic Challenges
  - Lack of Incentives among System Owners, Building Owners, Authorities and End-Users for Flexible Consumption



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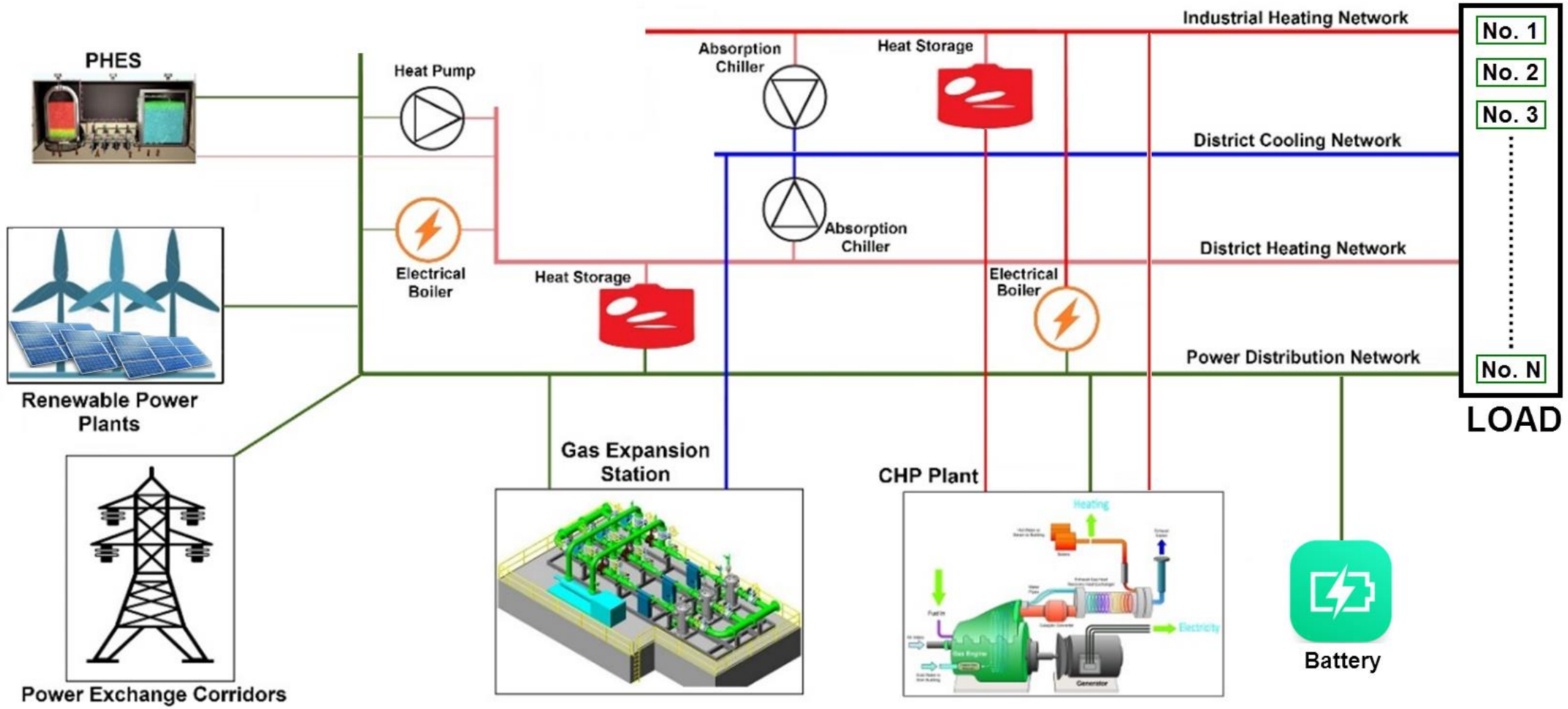
A SAMPLE CASE STUDY

- A Chinese Industrial Park Being Supplied by an SES



THANK YOU FOR YOUR ATTENTION

ANY QUESTIONS?

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