BUILDING INTEGRATION OF SYSTEMS FOR THE EXPLOITATION OF RENEWABLE ENERGY SOURCES

What, Where, How

From Basics to Advanced Applications

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BASICS & GUIDING PRINCIPLES

- **Reduce loads** (demand)
- **Do not waste** conventional **energy** sources NOR renewables
- **Properly size systems** (smaller systems will be more cost effective)
- **Use throughout the year** (investment will be more cost effective)

BASICS

EU Targets

Renewable Energy

2020	2030
20%	≥32%

RES contribution to EU's gross final energy consumption

Greenhouse Gas Emissions

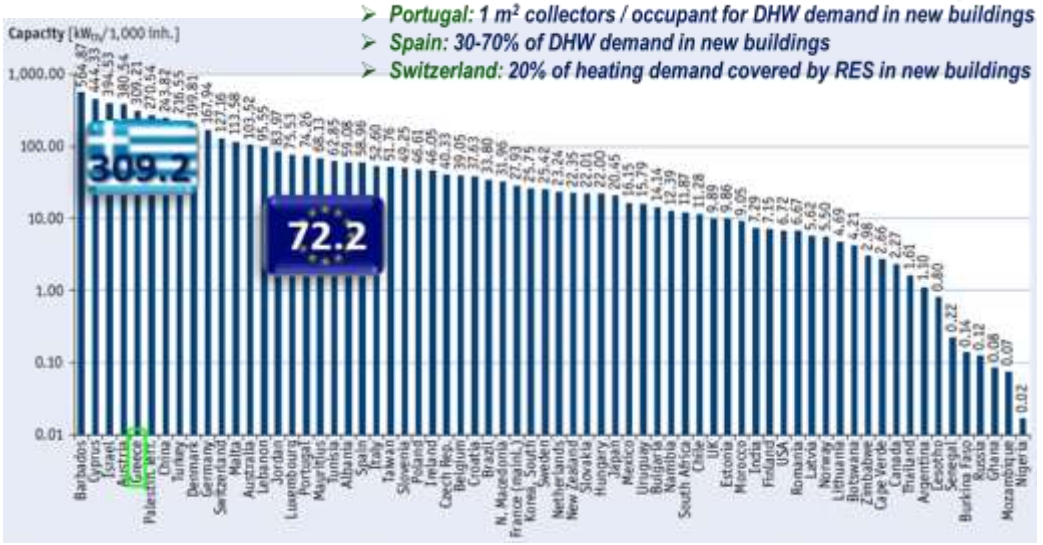
2020	2030
-20%	≥-40%

Energy Efficiency

2020	2030
20%	≥32.5%

All new buildings
nearly Zero Energy Buildings
nZEBs as of 2021

- Germany: 15% of heating demand in new buildings
- Greece: 60% of DHW demand in new buildings
- Ireland: 10 kWh/m² floor space covered by RES in new buildings
- Portugal: 1 m² collectors / occupant for DHW demand in new buildings
- Spain: 30-70% of DHW demand in new buildings
- Switzerland: 20% of heating demand covered by RES in new buildings



Source: Solar Heat Worldwide, 2020

ASHRAE Std 189.1
Mandatory: Renewable Ready

- **On-site renewable energy systems**
  (e.g. PV, solar thermal, geothermal, or wind system, or any combination)
- **Allocated space & pathways for future installation** of on-site renewable energy production
  - **Single story buildings ≥ 20 kWh/m²**
  - **Multistory buildings ≥ 32 kWh/m²**

Helpful Tips

BASICS

Domestic Hot Water (DHW)

- **Water storage tank**

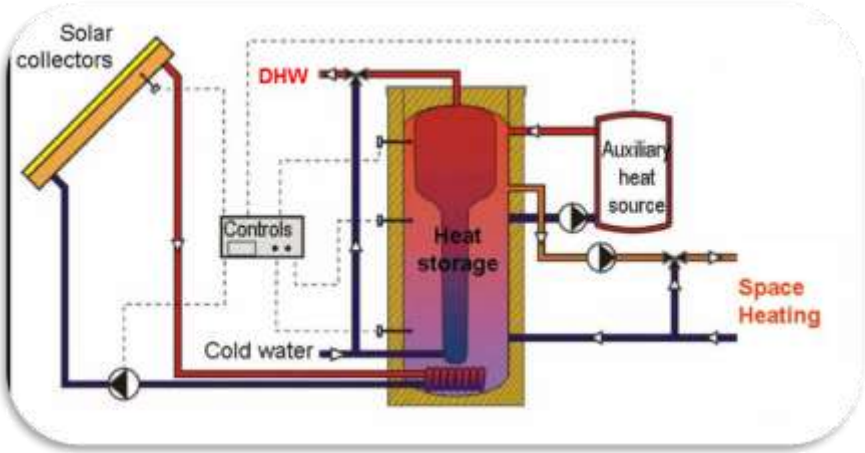
- **Orientation - Shading**

BASICS & MORE

- DHW
- Space Heating

Solar COMBI Systems

- Solar Collectors
- Heat Storage
- Heat Distribution
- Heat Dissipation
- Auxiliary (backup)



Helpful Tips

Common practice

***DHW**: 1m² of flat plate collector per person*

***Space heating**: 1m² flat collector for thermal load 700 W*

***Single Family House**: 15-30m² collectors; 1-3m³ storage*

Design considerations

- **Minimize** heating **loads** & heat **distribution losses**
- **Good operation controls** (higher complexity than solar SHW systems)
- **Preheating with** hydronic systems **(radiators) or coupled with subfloor heating** systems (lower operating temp)

BASICS & MORE

- DHW
- Space Heating

Solar COMBI Systems

17% of the EU market

Distribution of solar thermal systems by application for the total installed water collector capacity by economic region in operation by the end of 2018

Source: Solar Heat Worldwide, 2020

BASICS & MORE

- DHW
- Space Heating

Solar COMBI Systems

Architectural (building) integration
of solar thermal energy systems for LARGE installations


Hamburg Bramfeld, Germany


Ennstal - Neue Heimat – Wohnbauhilfe (ENW)
Graz /Austria


Penthouse Wien, Vienna, Austria

Ref: www.iea-shc.org/task39/projects/projects.aspx

BASICS & MORE

- DHW
- Space Heating

Solar COMBI Systems

SDH solar district heating

SOLAR DISTRICT HEATING

Still in an early market development
~1% of the installed solar thermal capacity

- Technical potential to reach 4-15%
- Costs are lower than 50 €/MWh

✓ **Denmark**: 18 new (2010-2012) plants with a total capacity of 120 MWth coupled with CHP plants, without incentives, reaching a total of 175 MWth

Ref. www.iea-shc.org/task39/projects/projects.aspx

Central SDH plant: The solar collectors deliver heat to a main heating central plant. With large **seasonal heat storage** the solar heating plant can contribute more than 50 % to the total heat demand

Distributed SDH plant: The solar collectors are connected directly to the district heating primary circuit on site. Often these plants use the district heating network as a storage

District Heating & Cooling and CHP Association
EUROHEAT & POWER www.euroheat.org

Same distribution network may be used for district cooling

BASICS & MUCH MORE

- DHW
- Space Heating

Solar COMBI Systems

+

- **Solar Cooling**

COMBI-PLUS

Fundamentals of absorption refrigeration were patented in France by Carré (1859)
First machine was introduced in the market in 1886

- **Peak cooling demand** is associated **with high solar radiation availability**
- **Improve performance of solar-combi systems**
- **Exploit solar & use installation throughout the year**
- **Avoid collector stagnation**

- **First Cost, Limited Practical Experience** with the **Design, Control, Operation, Installation & Maintenance**
- **Complex hydraulics**
- *Limited commercially available low power cooling systems (till recently)*

Several manufacturers are now offering a range of products

BASICS & MUCH MORE

DHW
Space Heating

Solar COMBI Systems

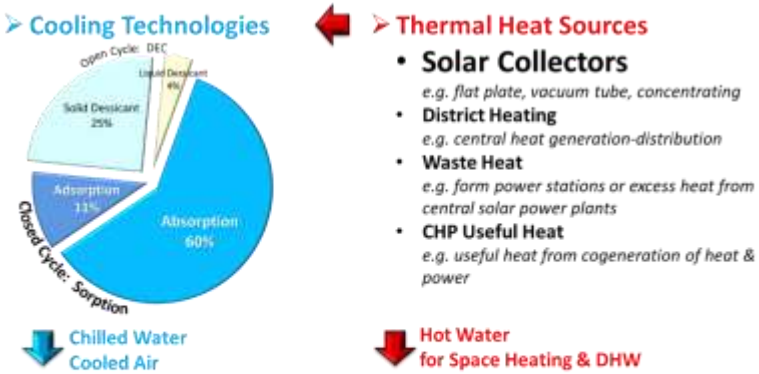
+

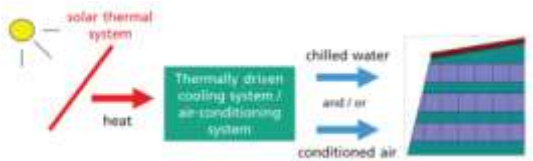
Solar Cooling

COMBI-PLUS

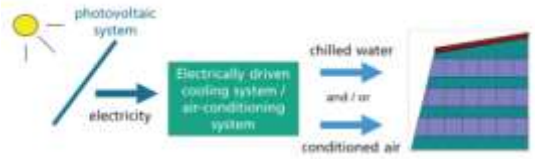
- **CLOSED CYCLE SYSTEMS e.g. Absorption & Adsorption cycles**
  Produce chilled water that can be used in combination with any AC equipment such as an air handling unit, fan-coil systems, chilled ceilings, etc

- **OPEN CYCLE SYSTEMS e.g. Desiccant systems**
  The refrigerant is discarded from the system after providing the cooling effect and new refrigerant is supplied in its place in an open-ended loop





Task 53
SHC
New Generation Solar Cooling & Heating Systems
(PV or solar thermally driven systems)
https://task53.iea-shc.org/



BASICS & MUCH MORE

DHW
Space Heating

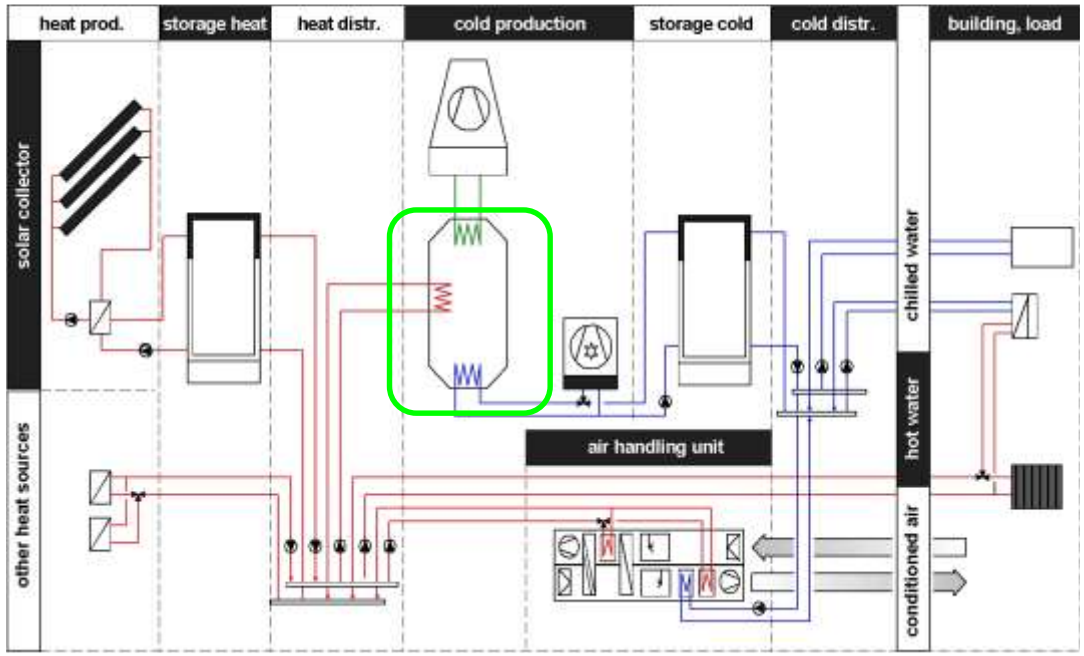
Solar COMBI Systems

+

Solar Cooling

COMBI-PLUS

- Solar Collectors
- Heat Storage
- Heat Distribution
- Heat-driven Cooling Unit
- Cold Storage (optional)
- Air Conditioning System
- Cold Distribution
- Auxiliary (backup)



Helpful Tips

Common practice

***Solar collector area**: 3.6 m^2/kW_c*
***Auxiliary energy use**: 0.255 kWh_e/kWh_c*
***Water consumption:** 4-6 $kg.h^{-1}/kW_c$*
***Exploitation cost:** 0.65 €/kWh*

COP ~ 0.7 *(Double effect 1.3)*

Ratio of cooling capacity to heating power delivered to the system by solar (directly or indirectly by storage)

BASICS & MUCH MORE

- DHW
- Space Heating

Solar COMBI Systems

+

- Solar Cooling

COMBI-PLUS

Depends on:

- Cooling capacity, Size
- Solar collector type
- Stage of development
- Working principle

Avg total initial cost

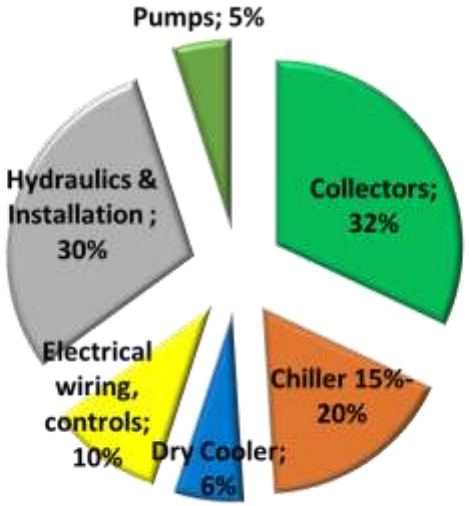
Dropping trend

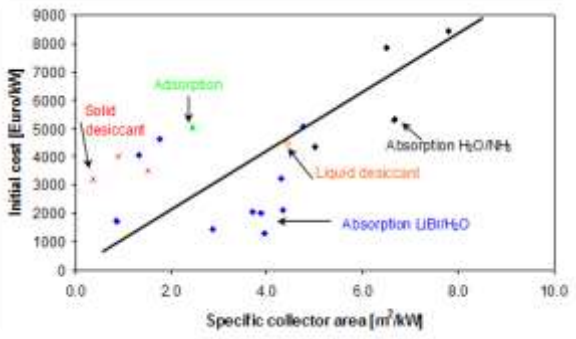
Chiller: 400 - 700 €/kWc

Complete Installation:

Large (>150kW$_c$) ~1,300 €/kWc

Small ~2,000 €/kWc





BASICS & MUCH MORE

- DHW
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Solar COMBI Systems

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- Solar Cooling

COMBI-PLUS

Cosmetics factory: 22,000m² cover 40% of cooling load
Flat plate solar collectors: 2,700 m²
Adsorption chillers: 2 x 350kW

Hotel 35 rooms: 2,400m²
Flat plate solar collectors: 450m²
Absorption chillers: 105kW

Hotel 60 rooms: 3,000m²
Flat plate solar collectors: 500m²
Absorption chillers: 105kW

BASICS & MUCH MORE

- DHW
- Space Heating

Solar COMBI Systems

+

- Solar Cooling

COMBI-PLUS

Austria-1, Gleisdorf
Town Hall & Service Centre (2,533m²)

Absorption 35 kW
304 m² collectors
4,600 lt stratified storage tank
Fan-coils & floor heating in TH
Chilled/heated ceilings & AHU in SC

Austria-2, Gleisdorf
Office building (1,000m²)

Absorption 24 kW
130 m² collectors
10,000 lt heat storage tank
Chilled/heated ceilings & radiators

Greece, Athens
Office building (427m²)

Absorption 35 kW
95 m² collectors
58,000 lt stratified STES
Fan-coils

Spain, Barcelona
Social housing & health care

Absorption 70 kW
200 m² collectors
8,000 lt stratified heat storage tank
Fan-coils & AHU

Italy, Milan
Sports centre (660m²)

Absorption 35 kW
120 m² collectors
30,000 lt weekly heat storage tank
Fan-coils & AHU

USA, Schottsdale, AZ
High school

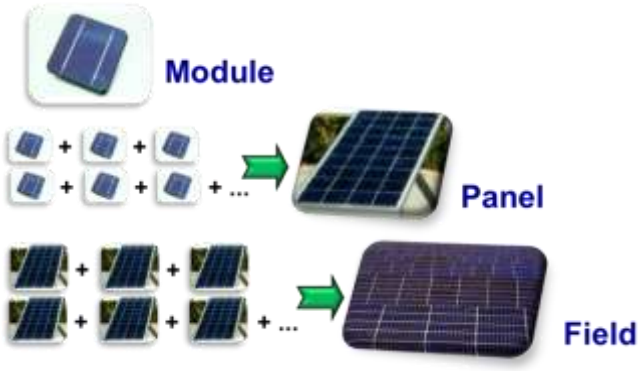
Source: IEA Task 48 Best Practices

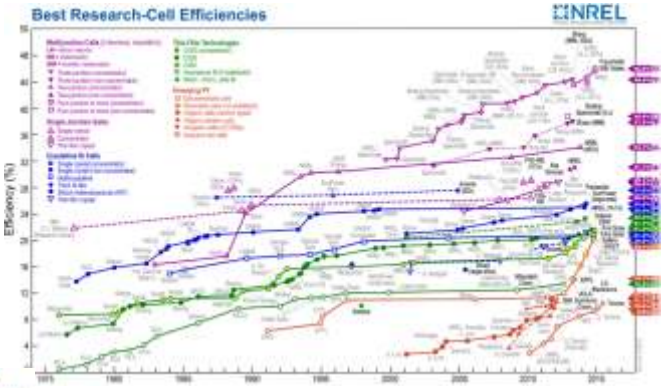
BASICS

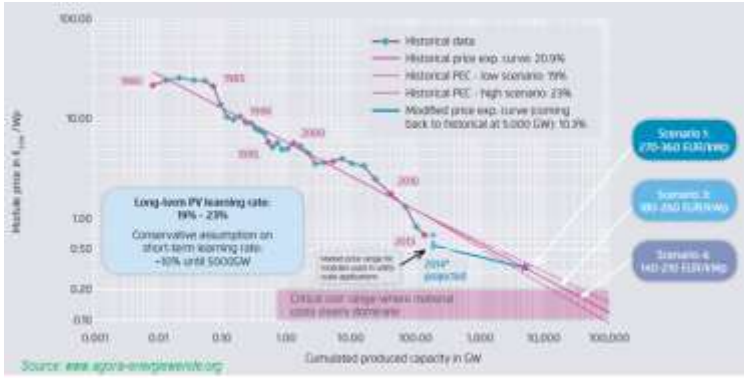
Photovoltaics

PVs convert **solar energy** (*beam* & *diffuse solar radiation*) to produce **DC**

- **Direct use** to cover electric loads or **feed in** the main **grid** (*use an **inverter** to AC*), or use **batteries** for **storage**



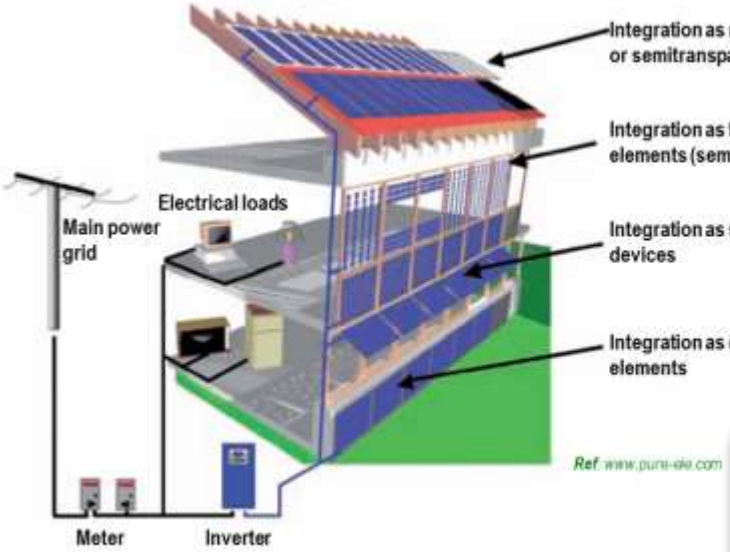




BASICS & MORE

Photovoltaics

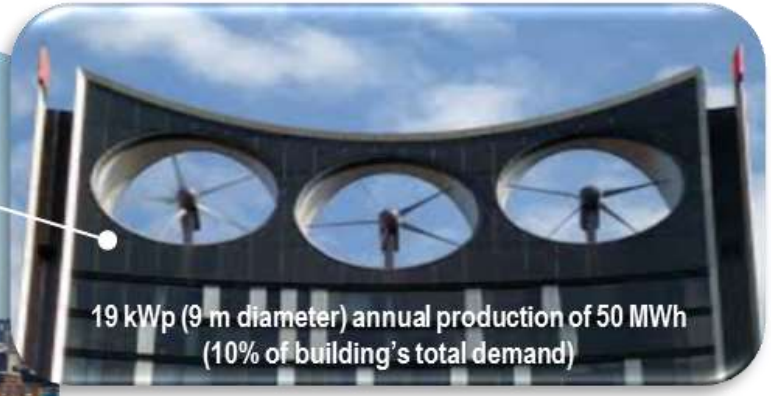
BUILDING INTEGRATION



BASICS & MUCH MORE

- Photovoltaics
- Solar Thermal
- Wind

BUILDING INTEGRATION



www.anemogennitria.gr

TOWARDS THE FUTURE

➢ DISTRIBUTED PV

- PVs installed on homes, commercial buildings & industrial facilities
- Transform the ways in which electricity is generated & used

Distributed solar PV remuneration schemes: ***1) buy-all, sell-all; 2) Net metering; 3) Real-time self-consumption at the wholesale price; 4) real-time self-consumption at a value-based price*** *(usually between the wholesale and retail price), whereby utilities or regulators estimate the value of PV generation based on avoided generation capacity expansions, fuel expenditures and any additional costs, and on benefits to the system or society (grid integration costs, CO2 reduction value, capacity credits, etc.); and* ***5) Real-time self-consumption at zero remuneration***

IEA REPORT - Renewables 2019, Market analysis and forecast from 2019 to 2024
https://www.iea.org/renewables2019/solar

FUTURE ENERGY HUB

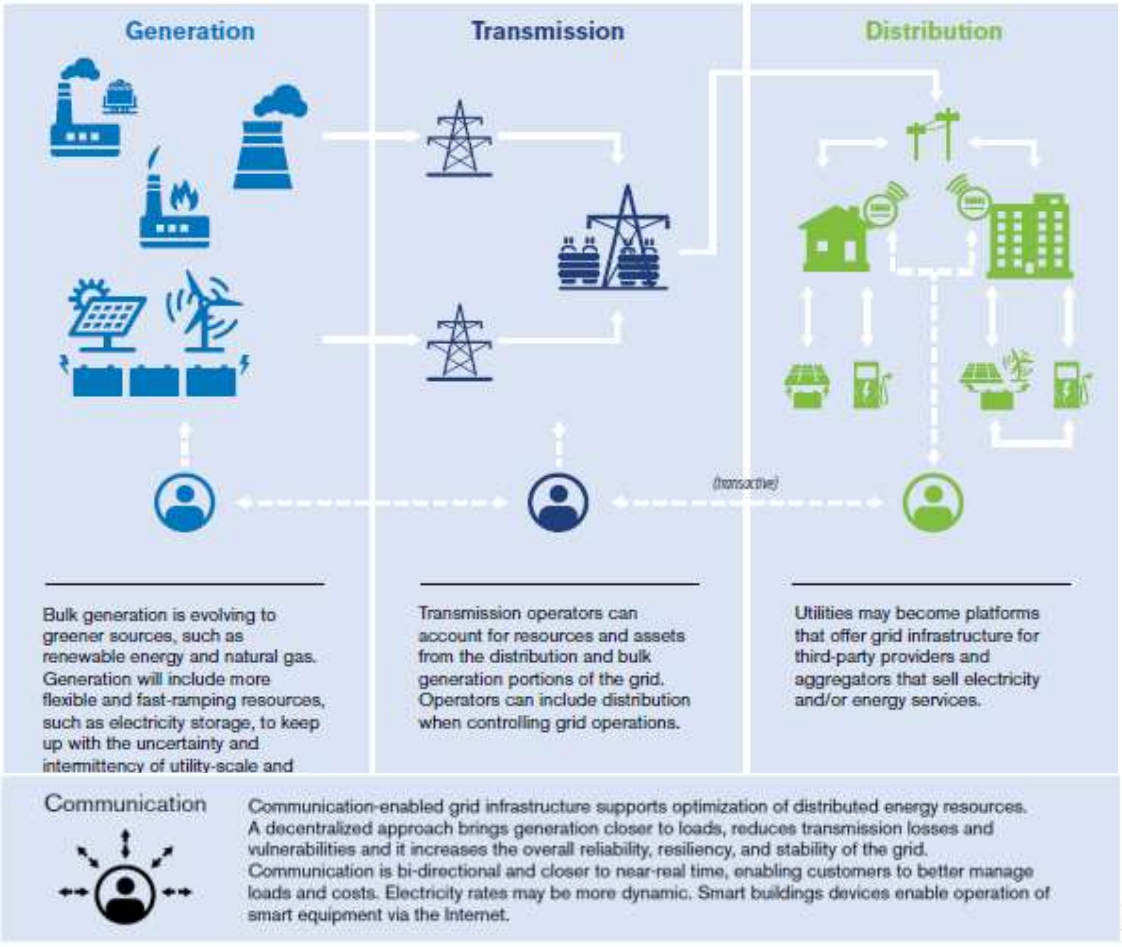
AT BUILDING CLUSTER LEVEL

Ref: X. Zhang et al., Applied Energy 230 (2018) 1034–1056 https://doi.org/10.1016/j.apenergy.2018.09.041

TOWARDS THE FUTURE

SMART GRID

Allow bi-directional flow of electricity & communication between electricity providers & consumers



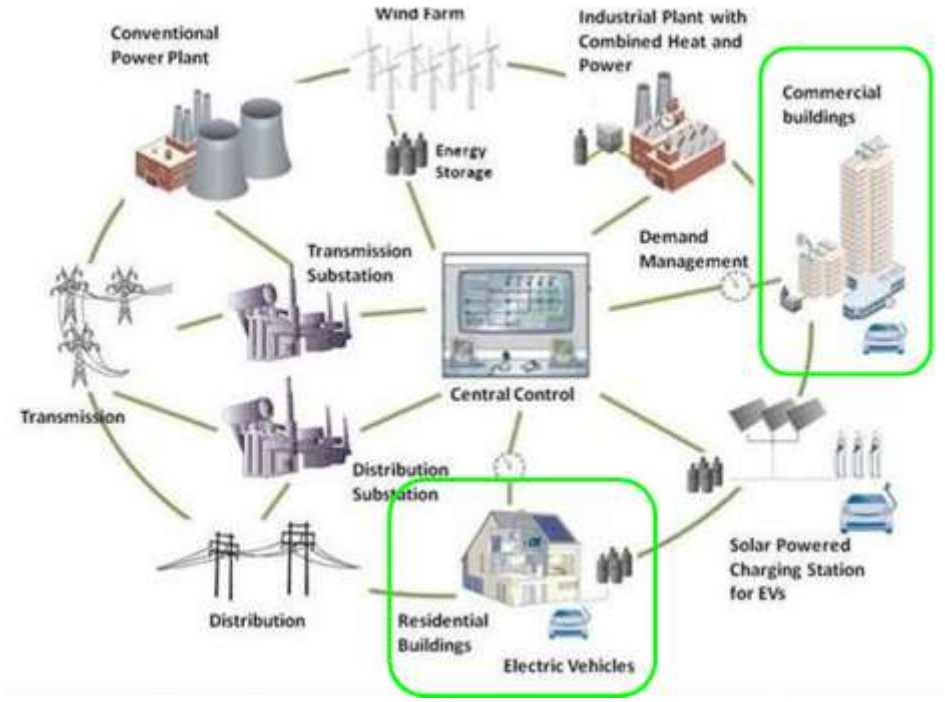
BUILDINGS ARE TRANSFORMED FROM RELATIVELY PASSIVE LOADS ON THE GRID TO DYNAMIC PARTNERS IN THE ELECTRICITY SECTOR, providing (potentially selling) electricity & exchanging information that allows for load balancing to support a stable-reliable grid

Ref: ASHRAE - Building Our New Energy Future, Sheila Hayter 2018-19
https://www.ashrae.org/File%20Library/About/Leadership/new_energy_future_web_061518.pdf

TOWARDS THE FUTURE

SMART GRID … SMART CITIES

IoT - Internet of Things



Ref: Climate and Energy Policy Laboratory, https://cepl.gatech.edu/projects/sgp/policies

- Meet the **growing electricity demand** & improve **stability**, **reliability** & **resilience** of electric grids, with two-way **digital communication** & **computer processing technologies** in electricity networks
- Enable **energy efficiency improvements** & the **integration of renewables** in electricity generation, transmission & distribution systems
- Use **efficient networks** & **services** with digital & telecommunication technologies for the benefit of citizens & businesses in **Smart Cities** (better resource use & less emissions)

BUILDING INTEGRATION OF SYSTEMS FOR THE EXPLOITATION OF RENEWABLE ENERGY SOURCES

Thank you for your attention …

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