MASTER MEIM 2022-2023

Energy planning

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Outline of the course

I. Energy overview

- Energy conversion
- Energy overview

a) Primary energy sources

b) Total final consumption

c) Energy intensity

- Energy problem

a) Consumption disparity

b) Energy poverty

c) Fossil fuels and GHG emissions

II. Renewable Energy Sources as a mitigation action to climate change

- Classification of the energy sources
- Technologies, efficiency and impacts
- Global efforts
- How to integrate RES in energy systems???

III. Energy planning

- Introduction

-Smart city and smart community

- Smart Energy Systems
- Electric surplus
- EnergyPLAN software

IV. EnergyPLAN software training

V. Campania region case study

- H2SCOUT parameters

Energy conversion chain

Primary energy sources, E_P

Conversion and distribution systems, η

Losses= $(1-\eta)\times E_p$

FINAL USES

EE = electric energy

TE= thermal energy

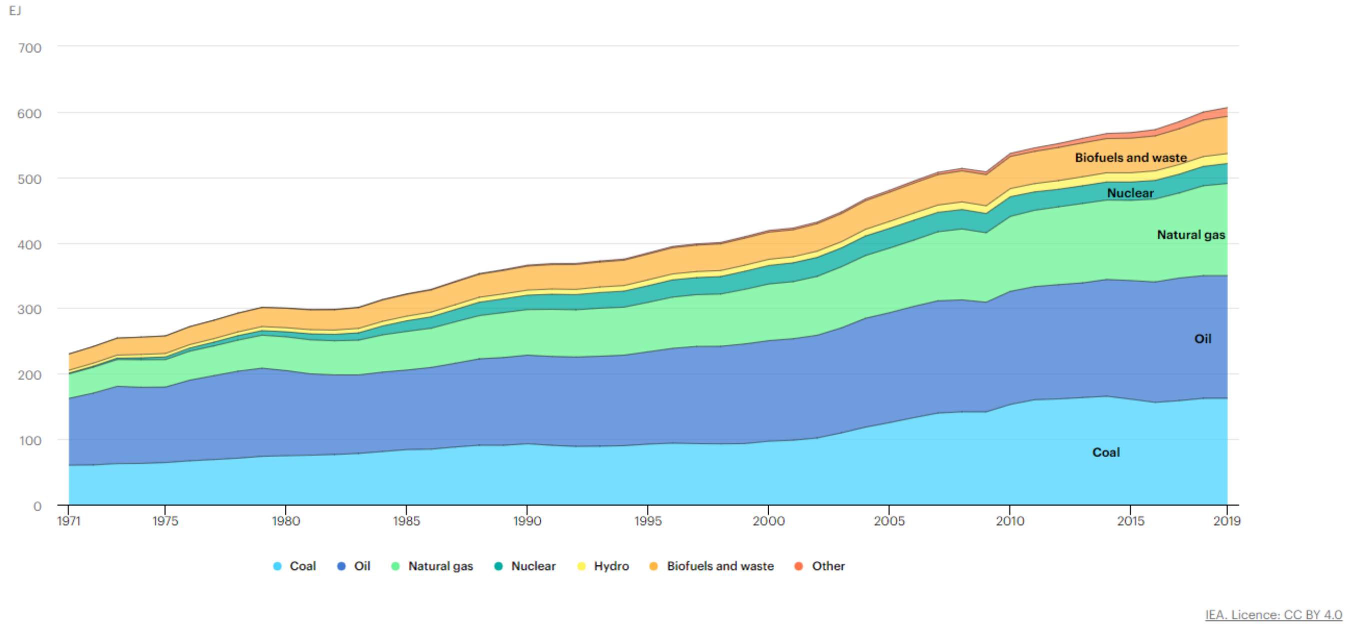
CE= cooling energy (namely, thermal energy removed from user to keep it at low temperature)

ME= mechanical energy

Energy overview: Primary energy world consumption

World total energy supply by source, 1971-2019

Last updated 6 Sep 2021 (source:IEA)

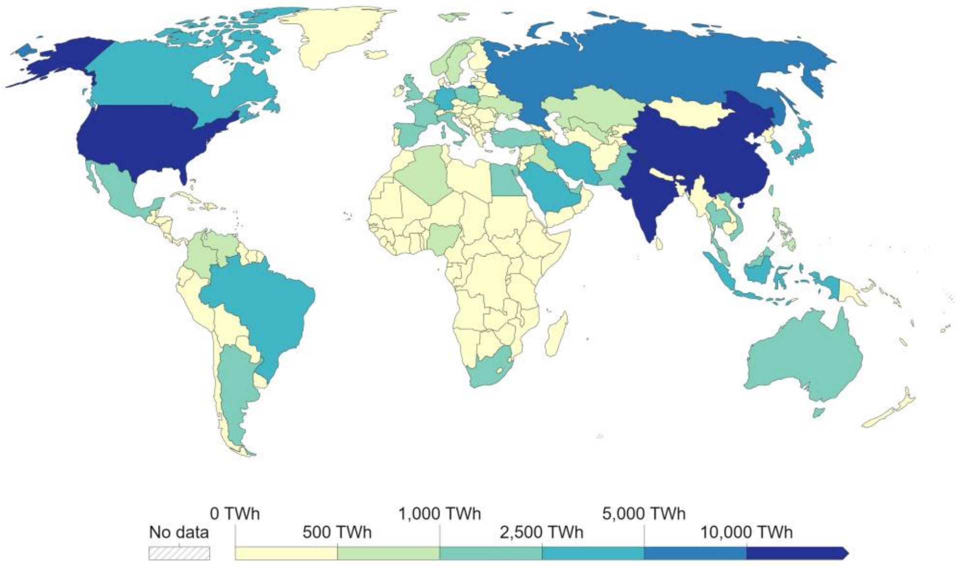


Average per capita consumption ≈ 1,8 tep

Primary energy consumption, 2022

Our World in Data

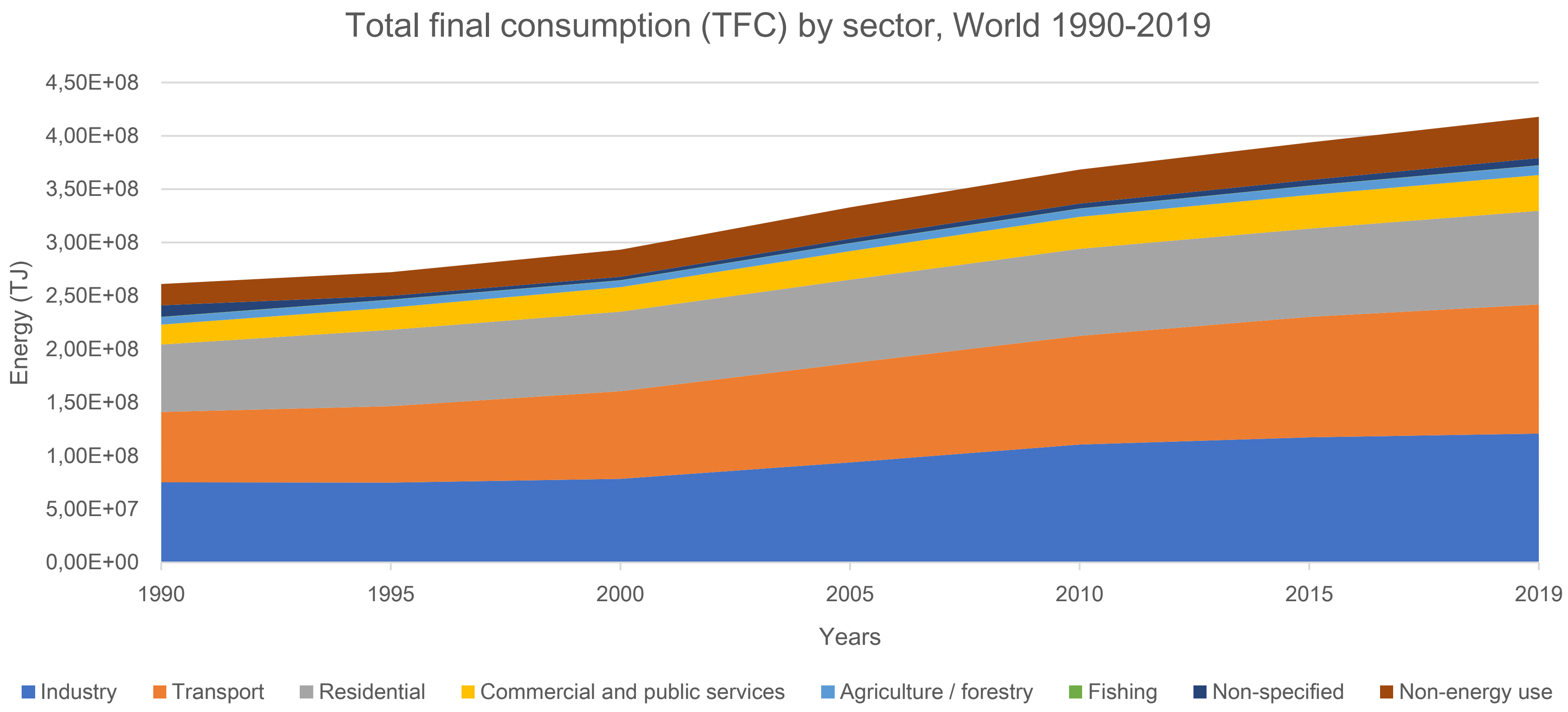
Primary energy[1] consumption is measured in terawatt-hours (TWh).



Source: U.S. Energy Information Administration (EIA); Energy Institute Statistical Review of World Energy (2023)
Note: Data includes only commercially-traded fuels (coal, oil, gas), nuclear and modern renewables. It does not include traditional biomass.
OurWorldInData.org/energy • CC BY

1. **Primary energy**: Primary energy is the energy available as resources – such as the fuels burnt in power plants – before it has been transformed. This relates to the coal before it has been burned, the uranium, or the barrels of oil. Primary energy includes energy that the end user needs, plus inefficiencies and energy that is lost when raw resources are transformed into a usable form. You can read more on the different ways of measuring energy in our article.

Energy overview: Total final world consumption

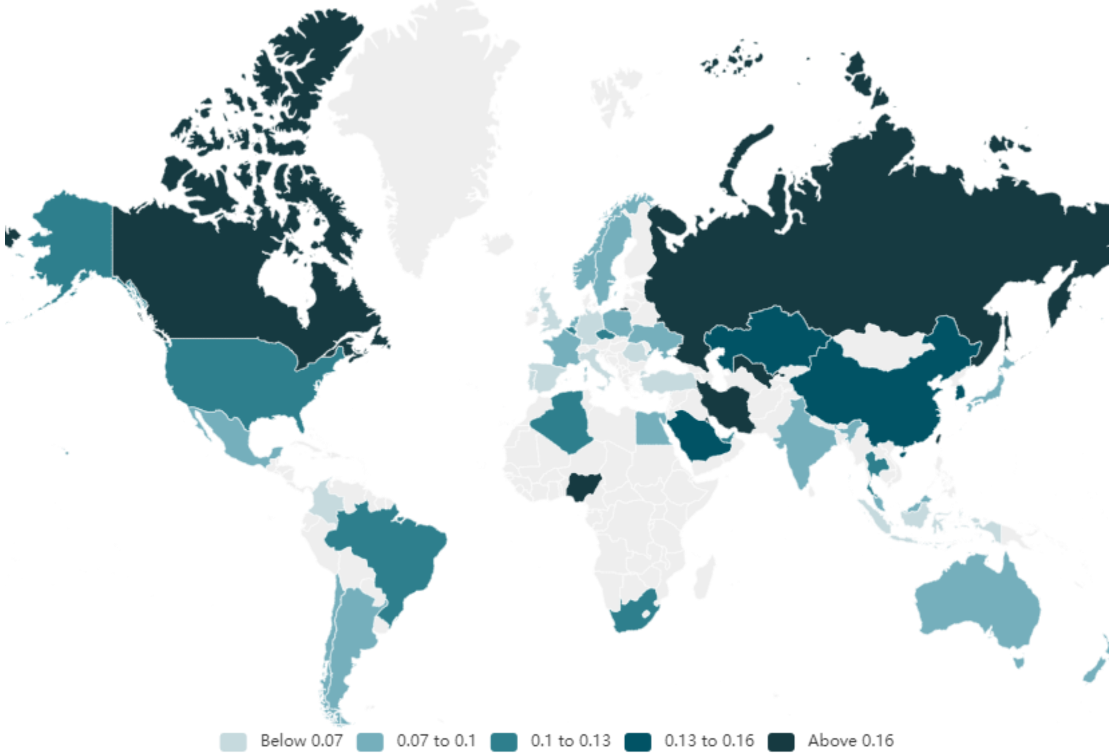


Energy intensity: world situation

What is the outlook for the future?

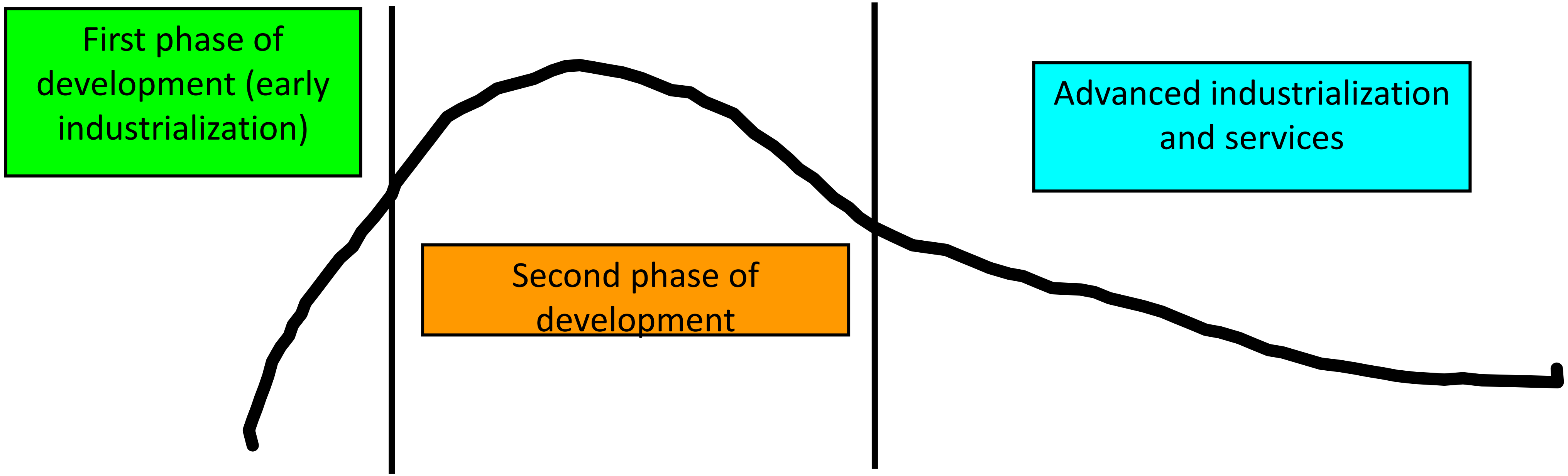
- ✓ The energy needs of a country are linked to several factors:
  - ➢ demographic consistency ➔ inhabitants number, N
  - ➢ level of socio-economic development ➔ GDP per capita
  - ➢ prevalent economic and productive activities
  - ➢ level of technological development and socio-economic progress ➔ ability of a rational and efficient use of resources
  - ➢ climatic factors

Energy intensity: I = E/(N x GDP per capita)



Energy intensity: evaluation

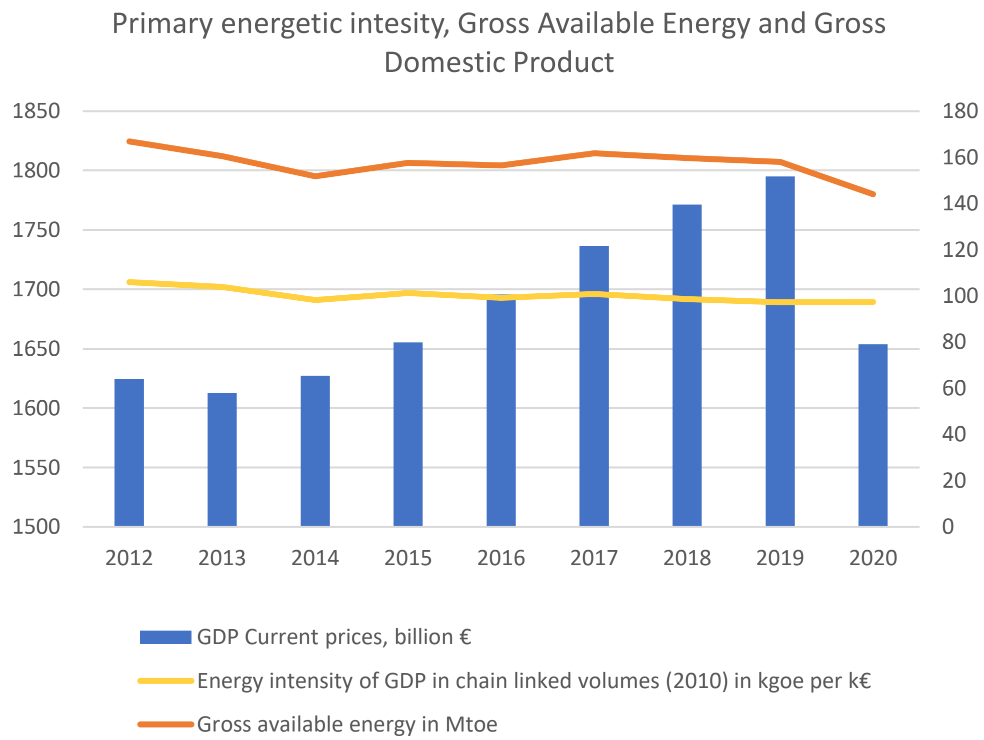
Temporal evolution of energetic intensity



- ✓ Causes of reduction of energetic intensity:
  - *improved techniques for conversion (ex .: Italy);*
  - *transition from industrial to the service sector with higher added value (ex .: Switzerland);*
  - *both cases (ex .: Japan).*

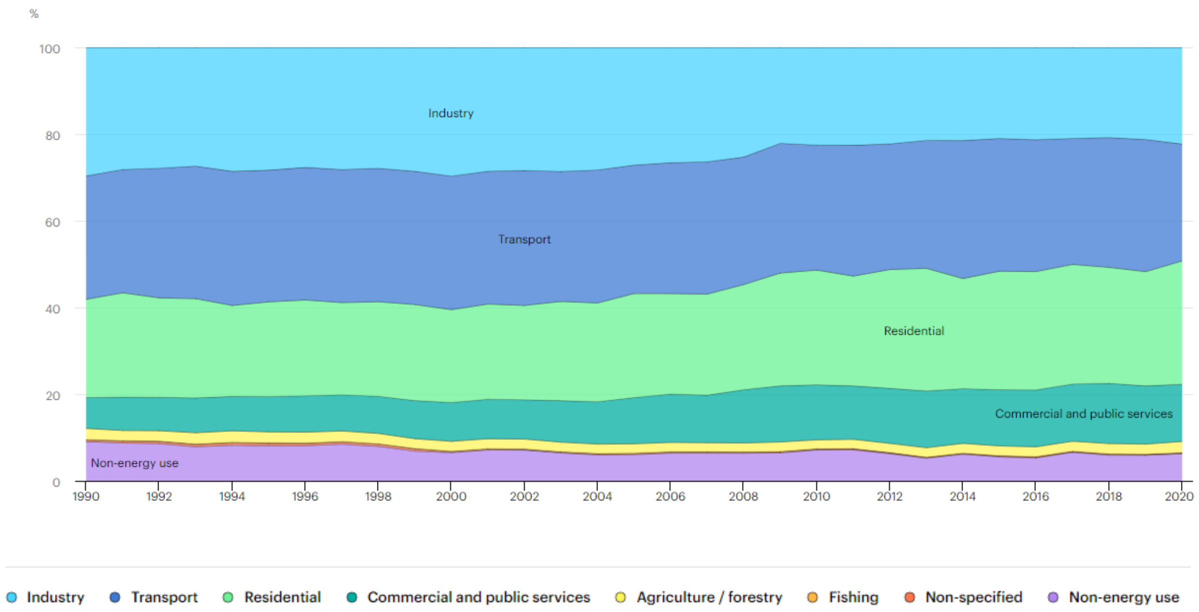
Environmental-energetic framework: national situation

Gross consumption of primary energy in Italy (in Mtoe, source: Eurostat elaboration on the basis od MSE data)



Gross Available Energy: total energy delivered/consumed in a Country

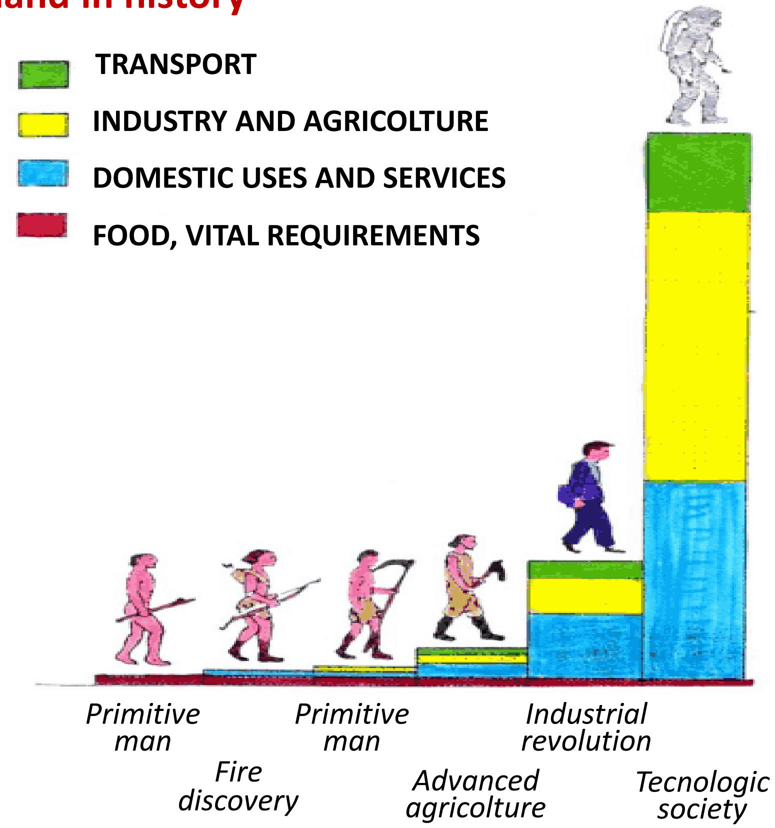
Total final energy consumption in Italy in the main sectors (source: IEA data)



TFC: Total final consumption

Environmental-energetic framework: world situation

Primary energy demand in history



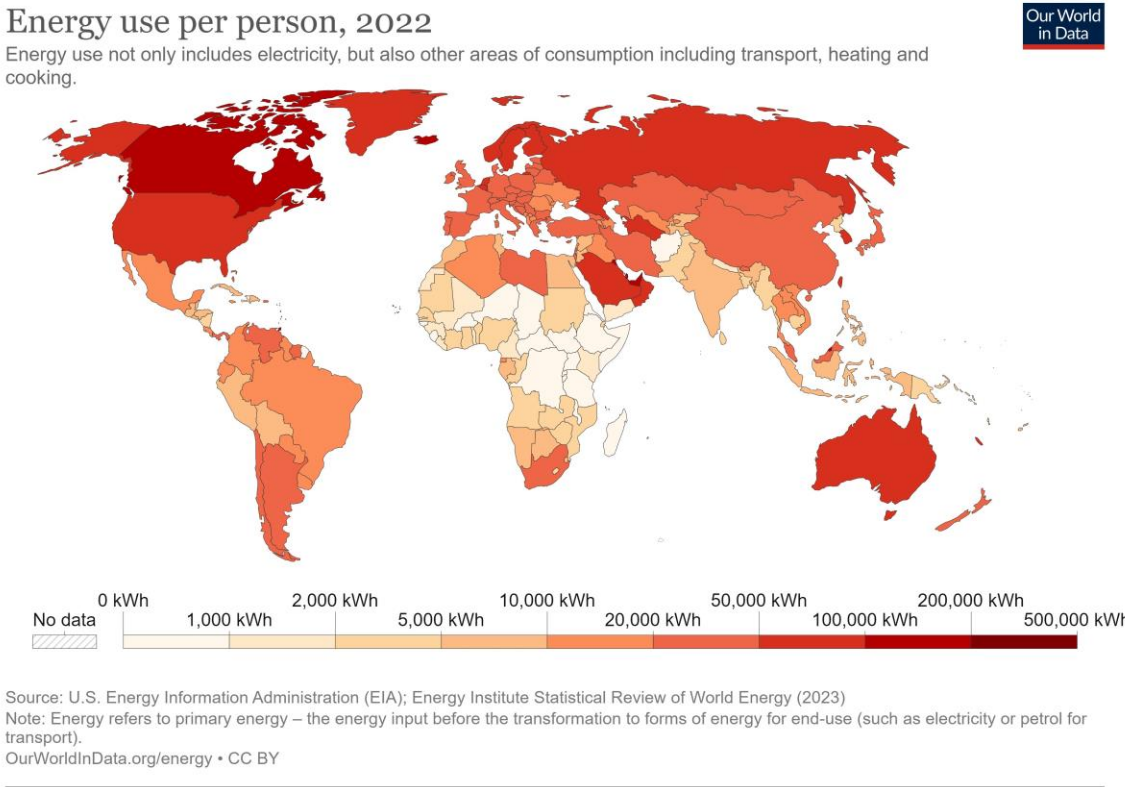
Averange per capita consumption ≈ 50.000 kcal/day

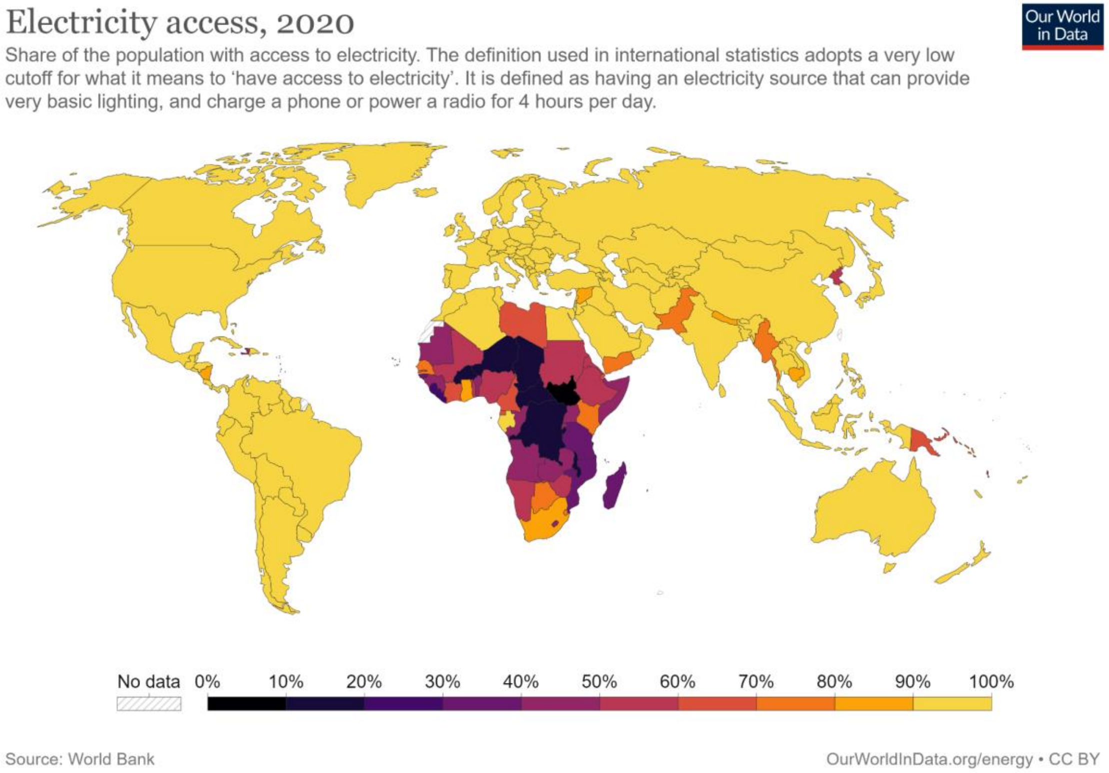
(20 times higher than food requirements)

In USA the consuption is 4 times higher than the mean value, in EU 2 times

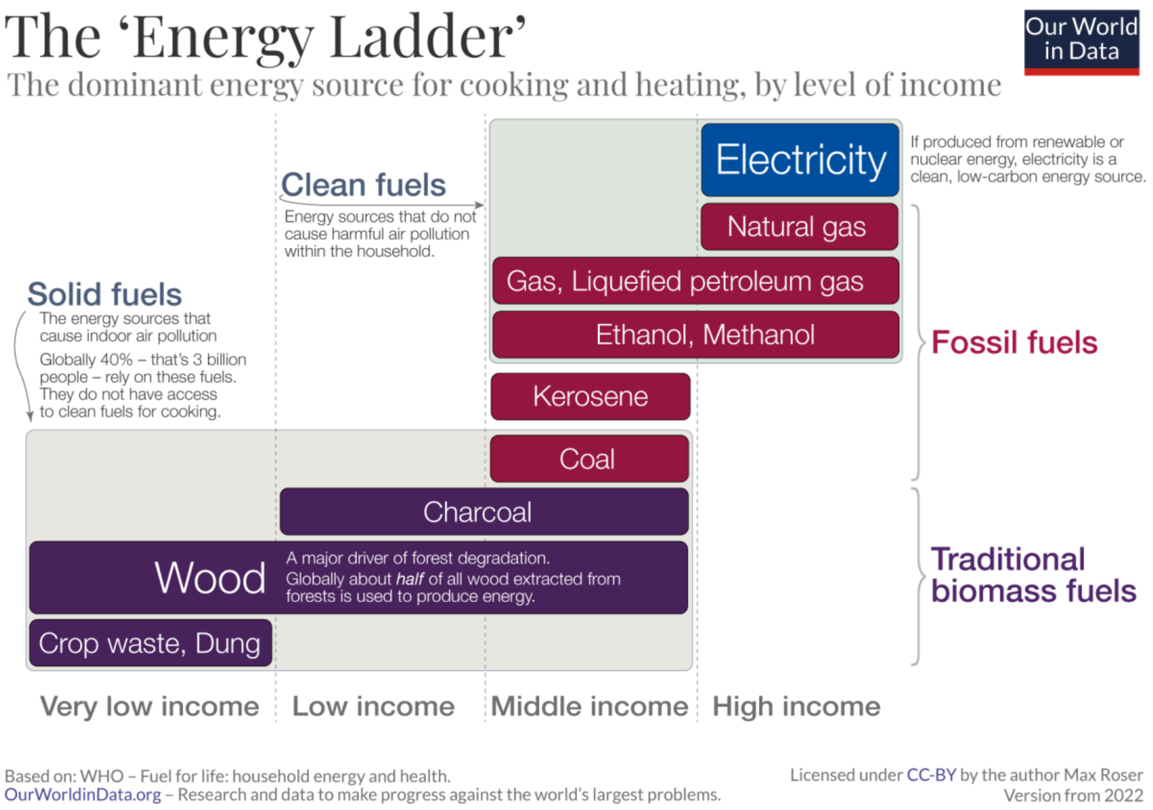
Environmental-energetic framework: world situation

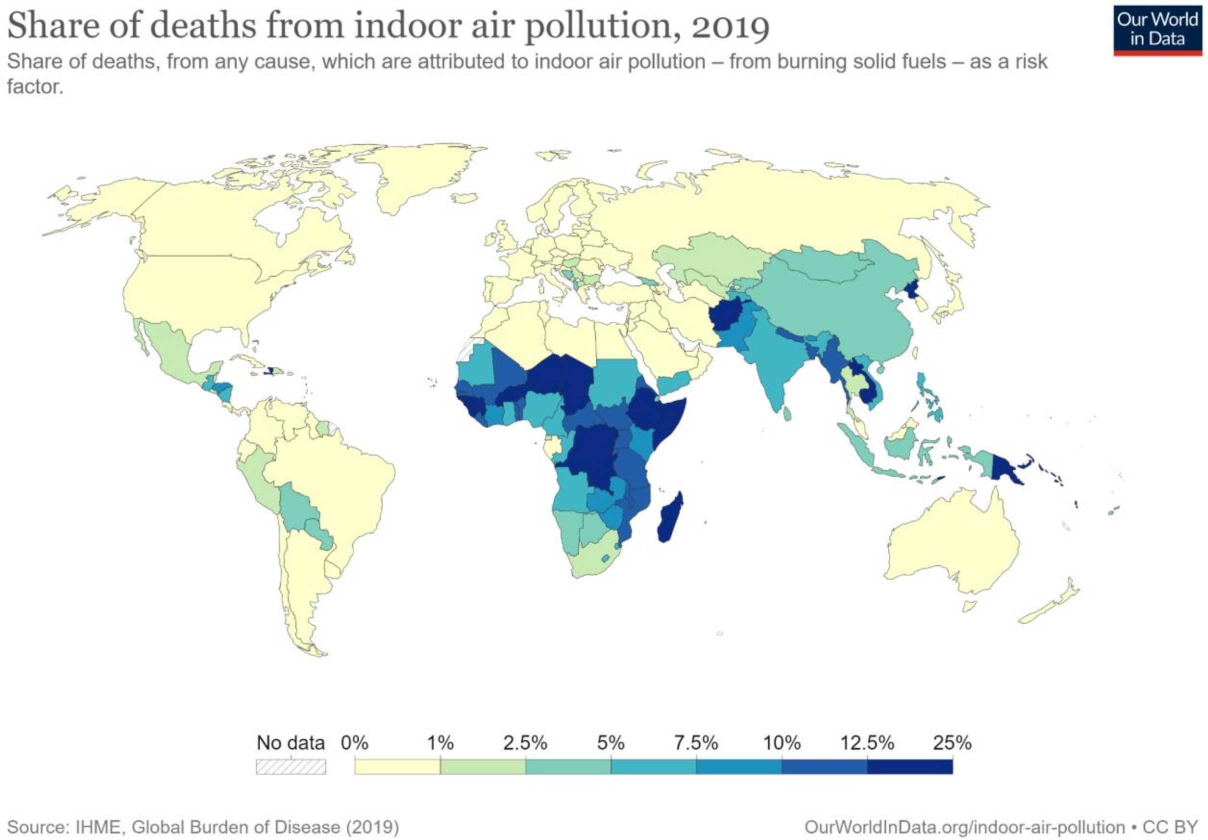
Lack of access to energy





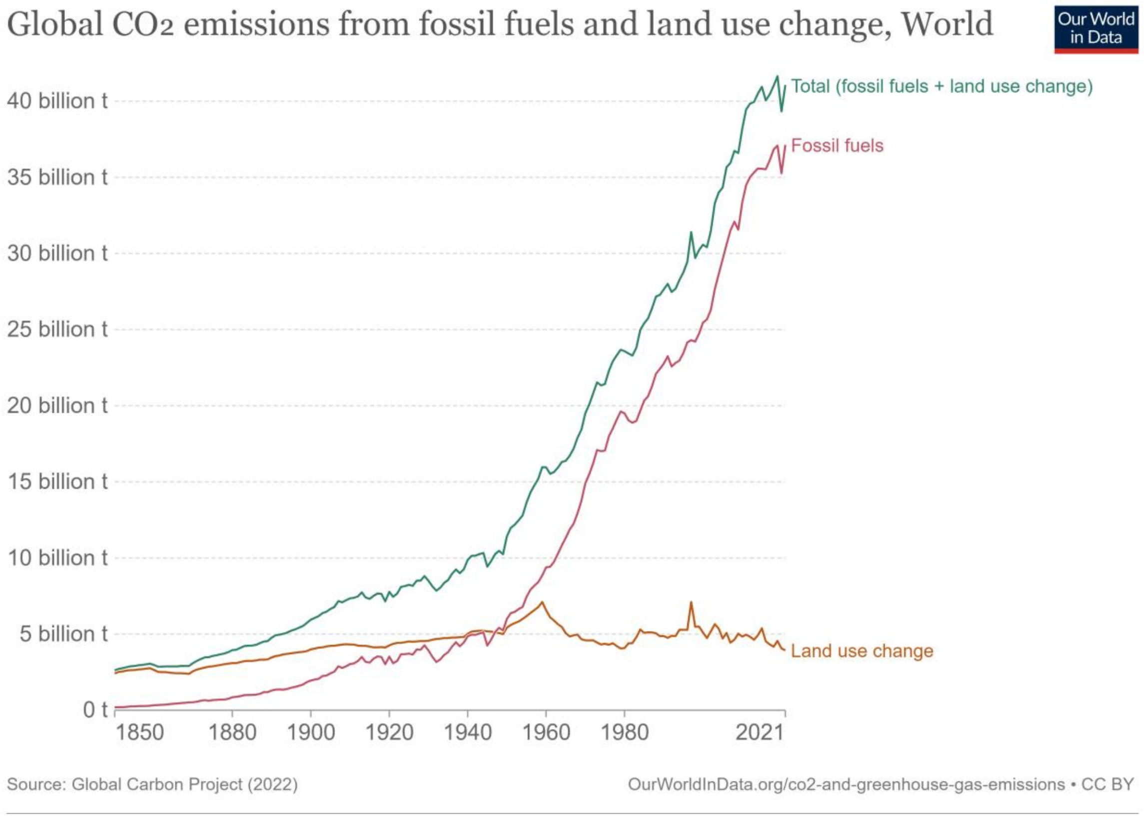
Environmental-energetic framework: world situation

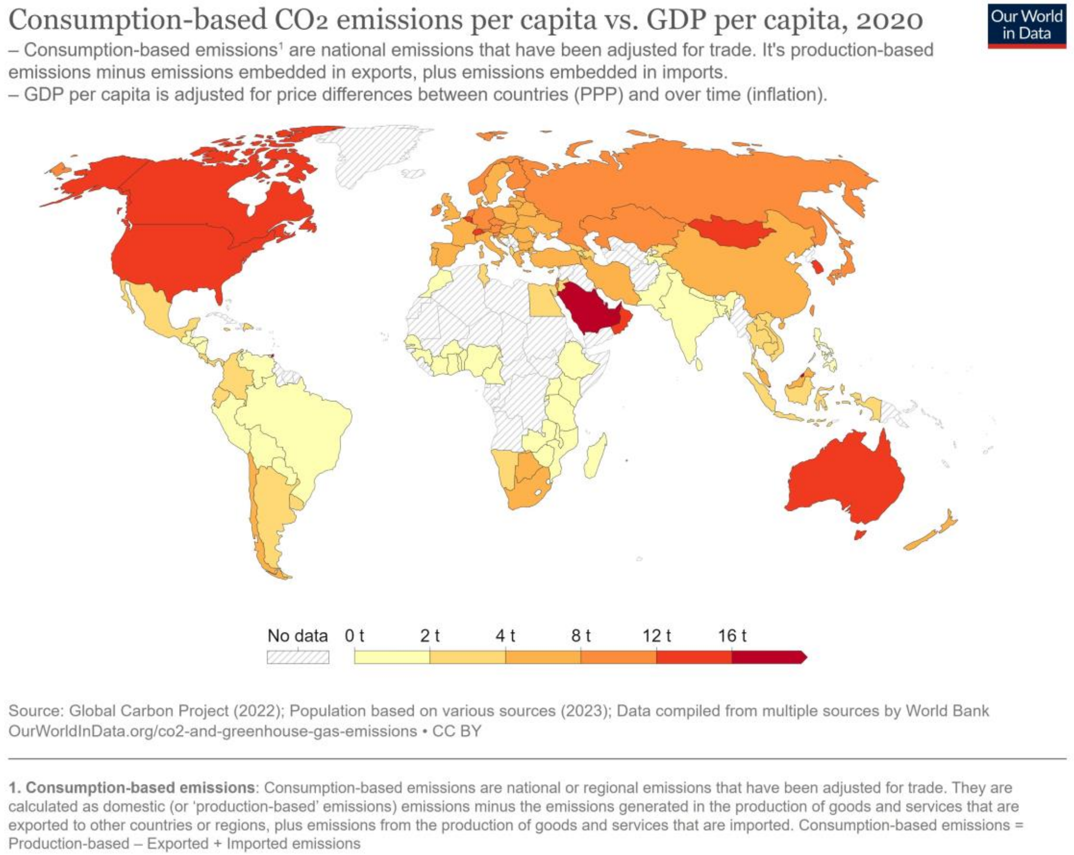




Environmental-energetic framework: world situation

Greenhouse gas emissions by sector (Source: ourworldindata)



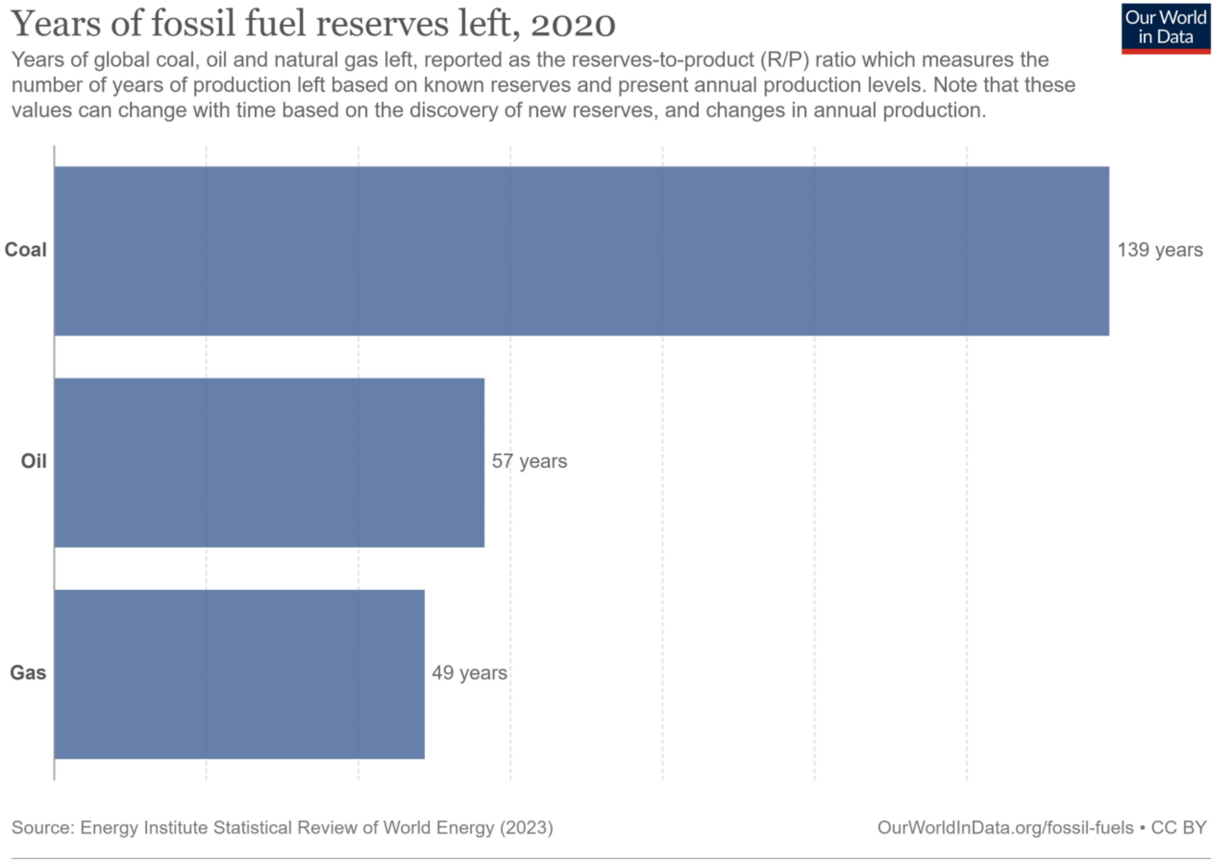


Environmental-energetic framework: problems and future prespective

Fossil resources: problems to be faced

- ✓ Current problems:

  geo-political and economic aspects, related to:
  - ➢ non-uniform distribution of resources
  - ➢ health impact due to the use of very polluting fuels in cases of lower access to cleaner energy
  - ➢ environmental impact (in particular: the greenhouse effect and global warming)
  - ➢ financial speculation
- ✓ In the medium and long term:
  - ➢ exhaustion of resources



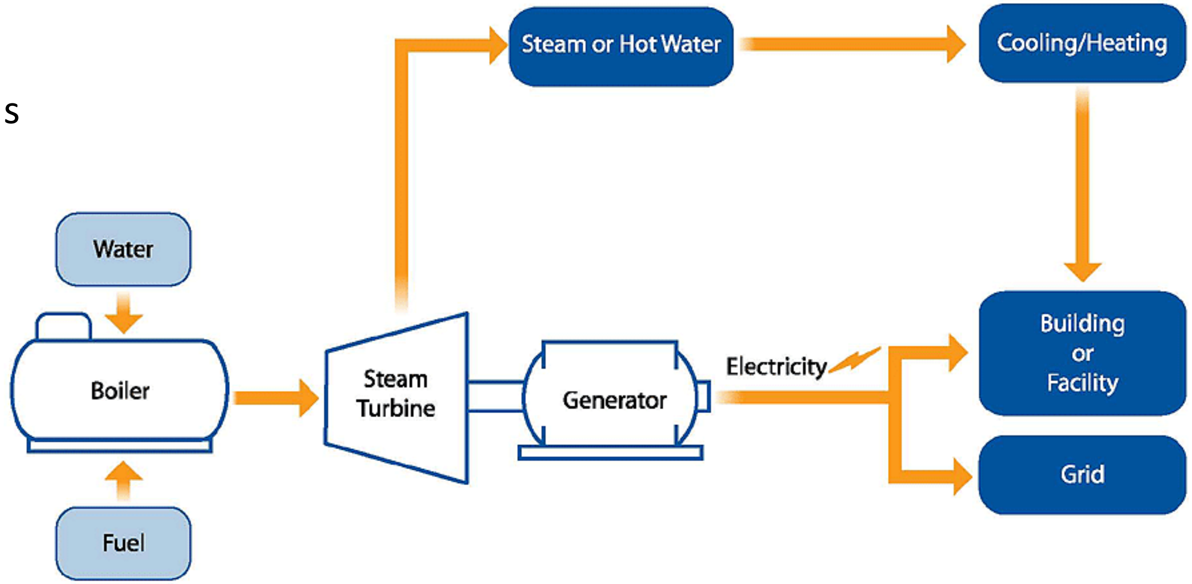
Classification of energy source: RES

Source:https://www.energy.gov/fecm/science-innovation/

	Solar	Wind	Tidal	Geothermal	Hydroelectricity	Biomass
						
$\frac{Output\ (heat, electricity)}{Input\ (kinetic, radiation, chemical)}$	 Exploitation of the solar radiation to produce electricity through photoelectric effect or heat	 Kinetic wind energy into electricity. A rotor that spins a generator and creates electricity	 Kinetic energy of the water waves pushes the turbine to generate electricity	 Natural heat below the earth's surface used for heating, cooling, and generating electricity	 Water flow of water drives a turbine to generate electricity	 Converts raw organic material into solid, liquid, and gas fuels
Conversion efficiency	Heat=90% Electricity= 15-20%	20-40%	80%	Heat>100% Electricity= 6-25%	90%	CHP plant = 23-80% Heat plant = 74-90% Electric plant = 24-31%

Classification of energy source: non RES

- Fossil fuel-based power plants
- Carbon emissions is the main concern in these systems
- Conversion efficiency
    - Coal based = 33 %
    - Oil based = 28-46 %
    - Natural gas based = 42-60%



Fuel =

Coal

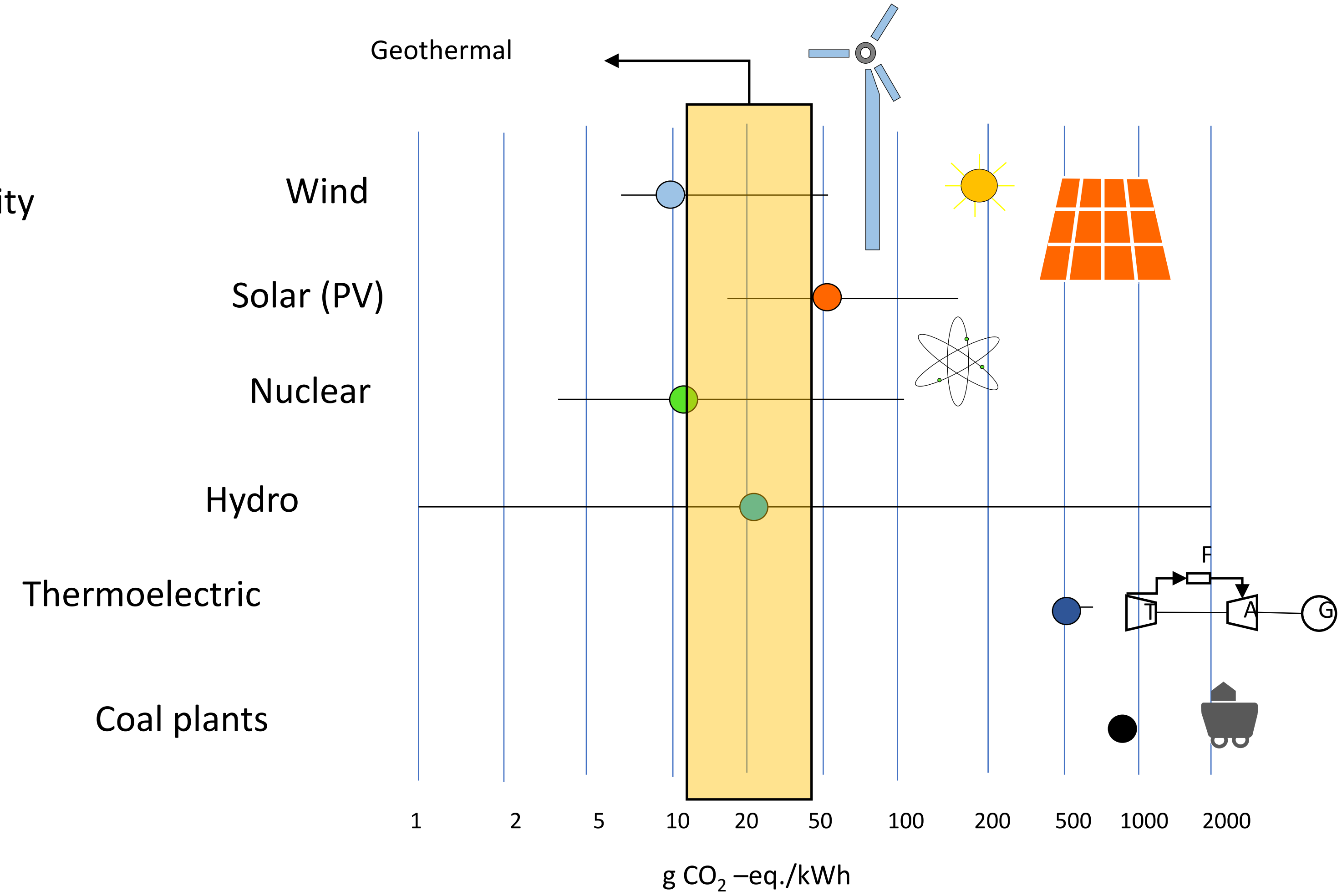
Oil

Natural gas

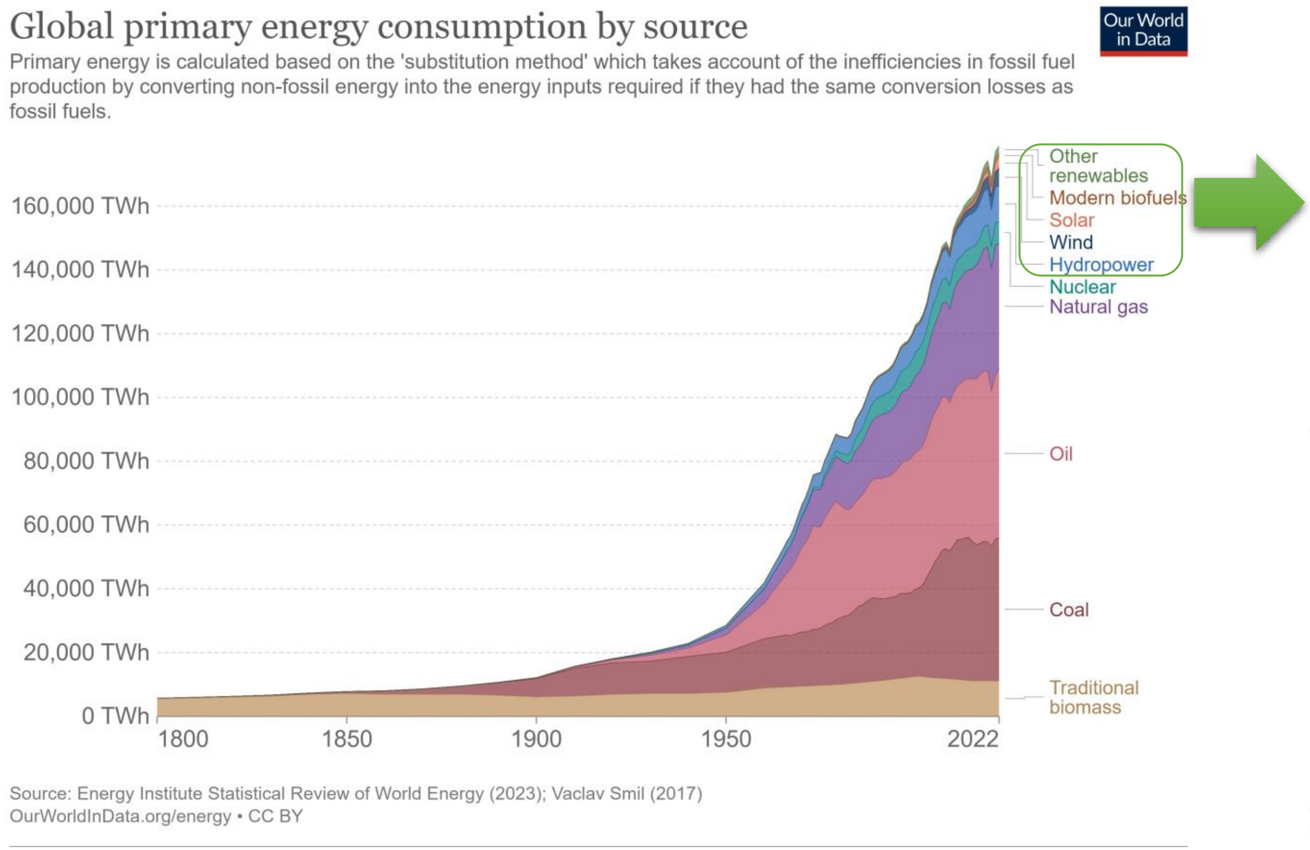
Source:https://archive.ipcc.ch/publications_and_data/ar4/wg3/en/ch4s4-4-3-1.html

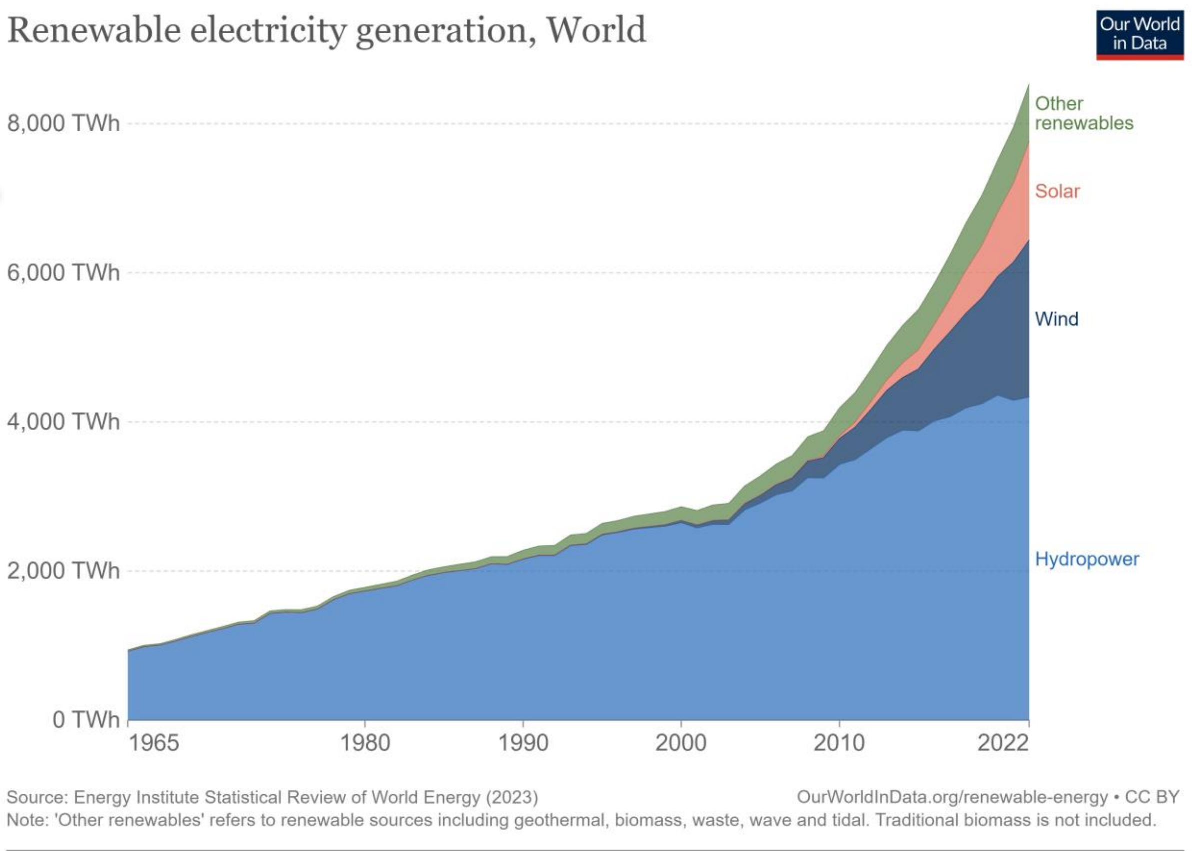
GHG from RES

Minimum and maximum carbon intensity by technology

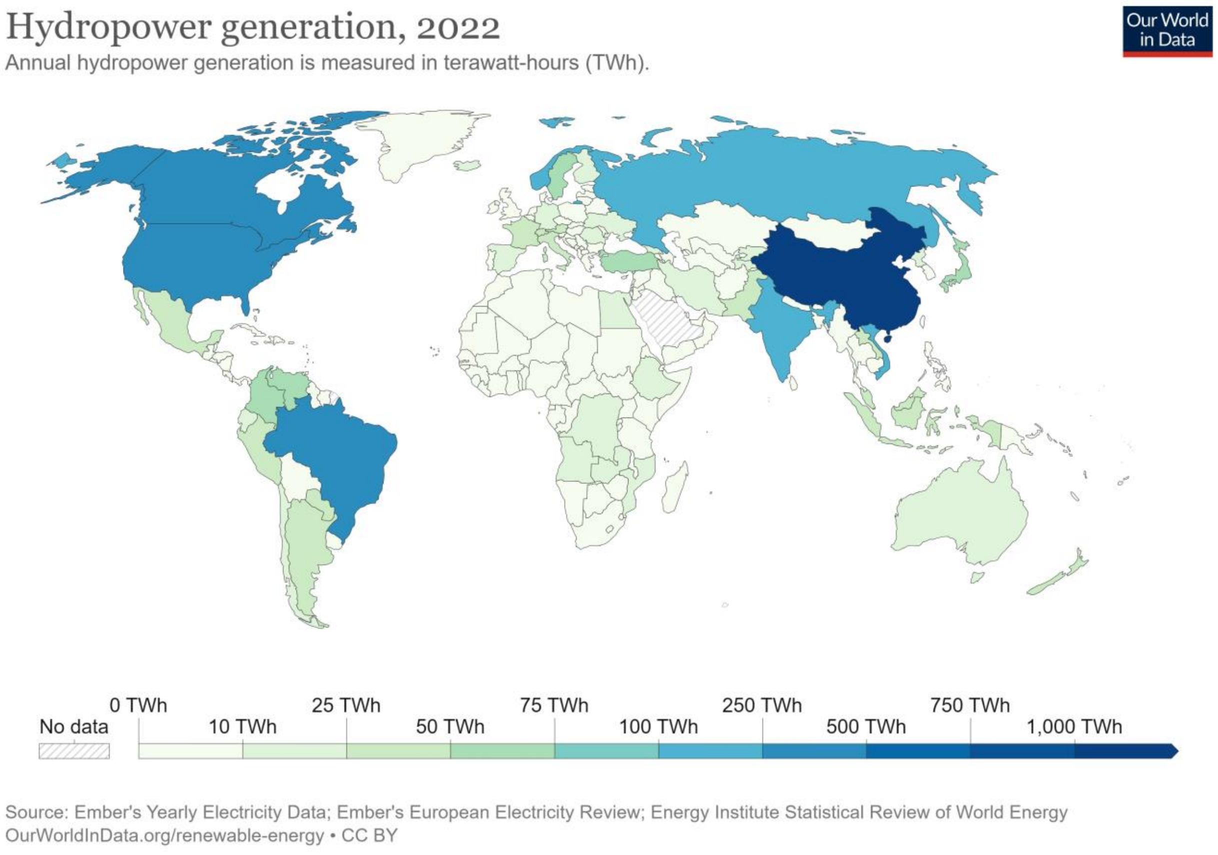


Renewable energy sources use





Renewable energy sources

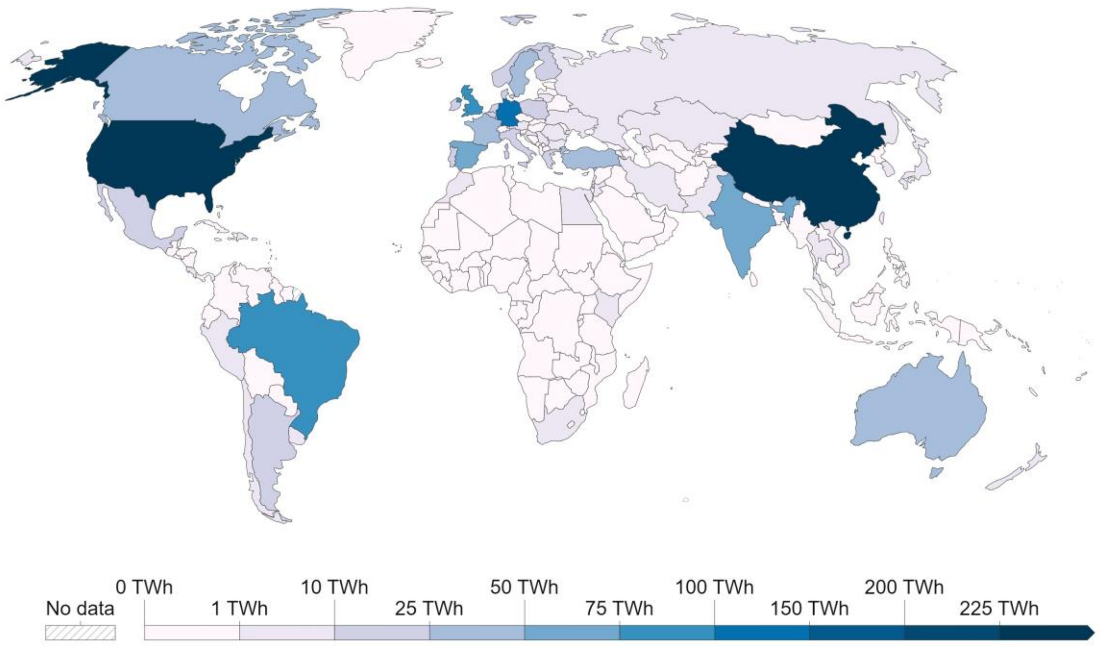


Renewable energy sources

Wind power generation, 2022

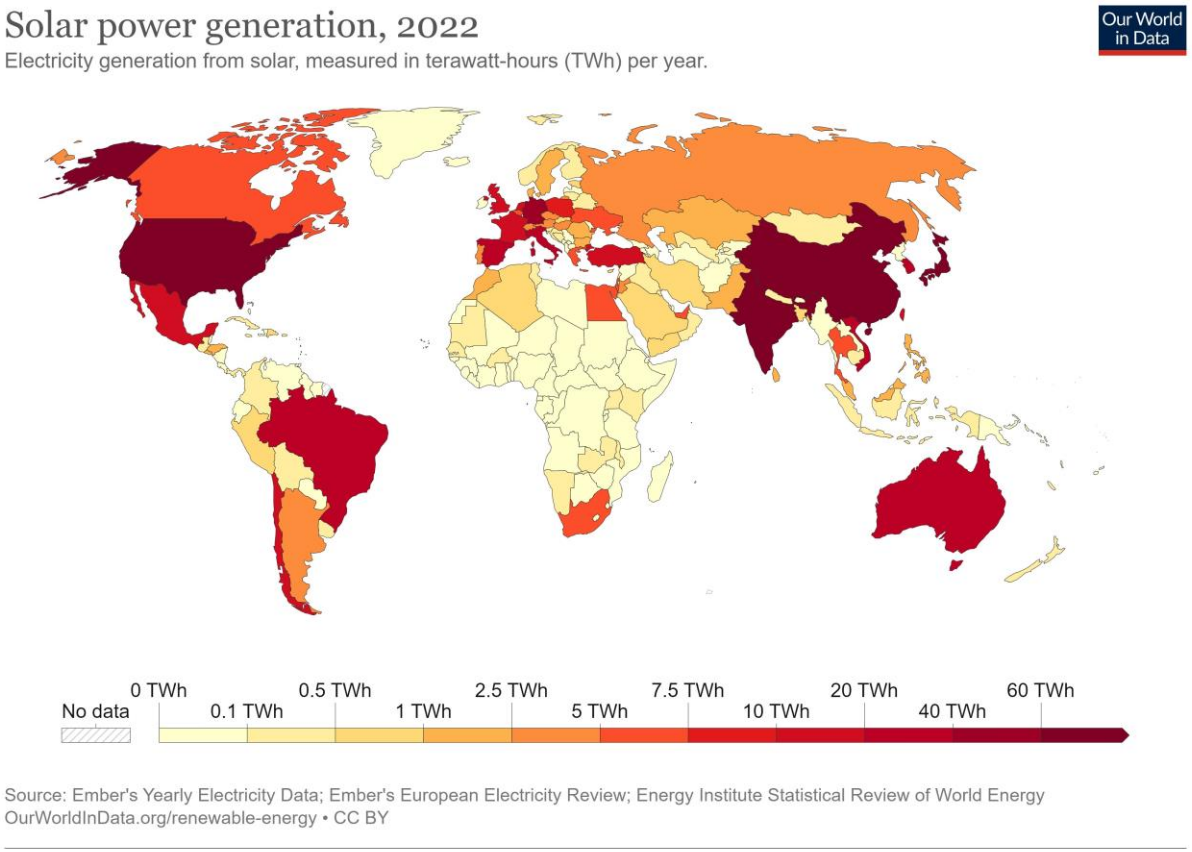
Our World in Data

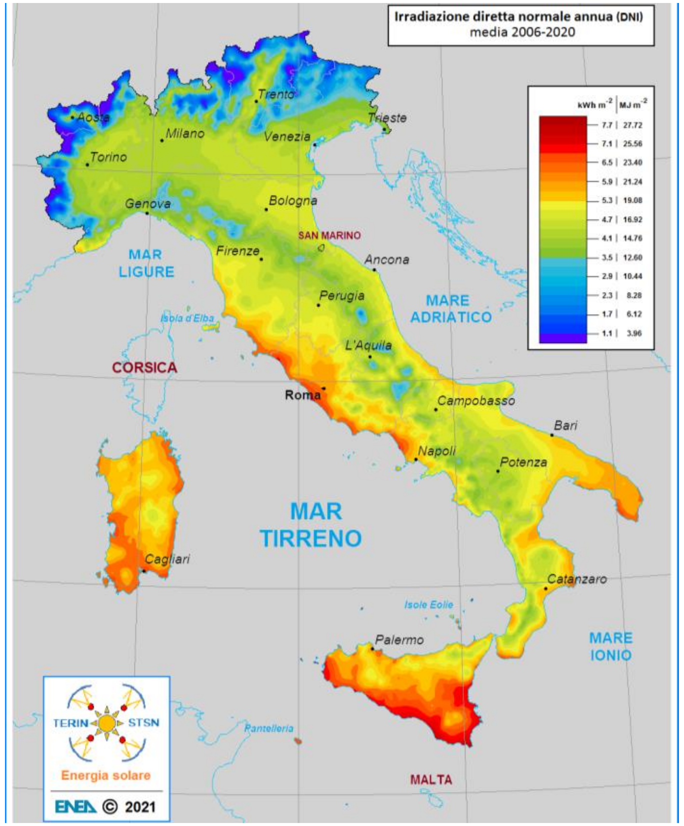
Annual electricity generation from wind is measured in terawatt-hours (TWh) per year. This includes both onshore and offshore wind sources.

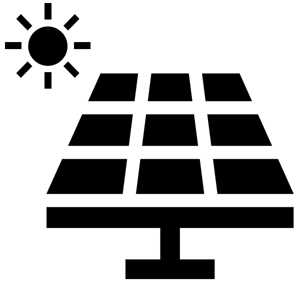


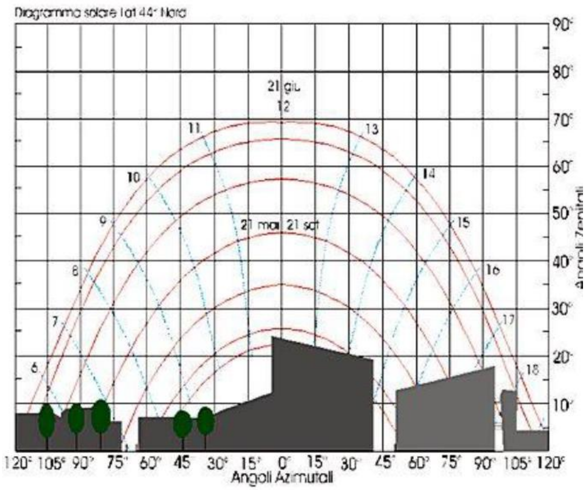
Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
OurWorldInData.org/renewable-energy • CC BY

Renewable energy sources

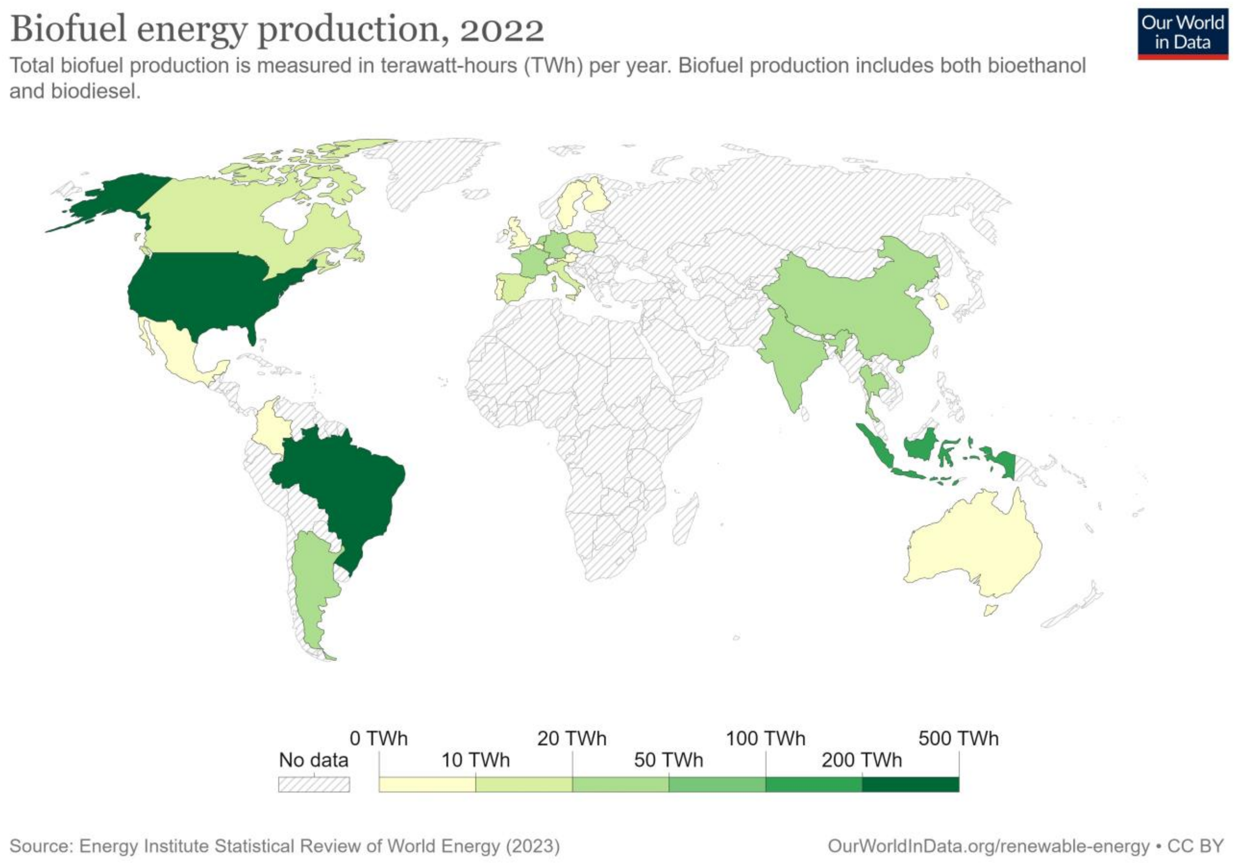


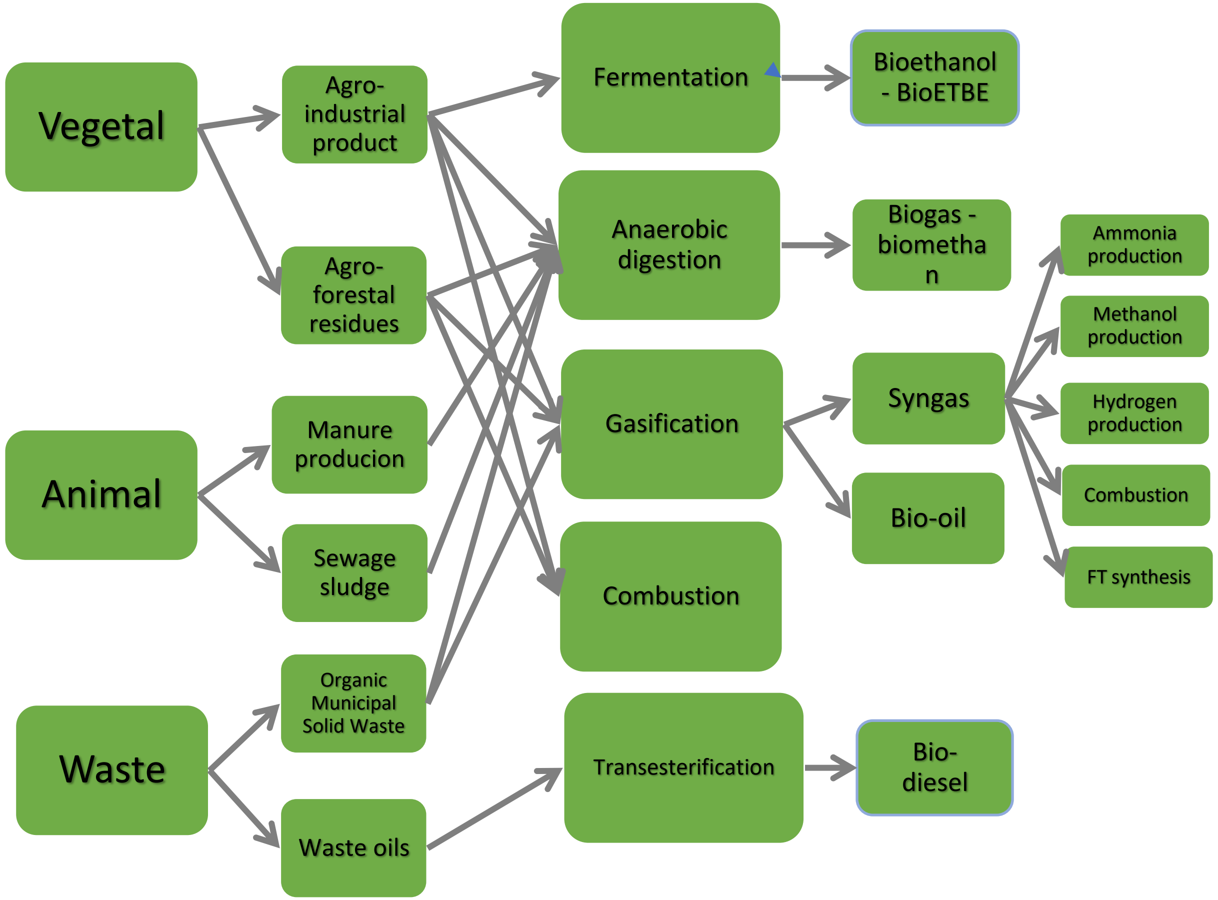




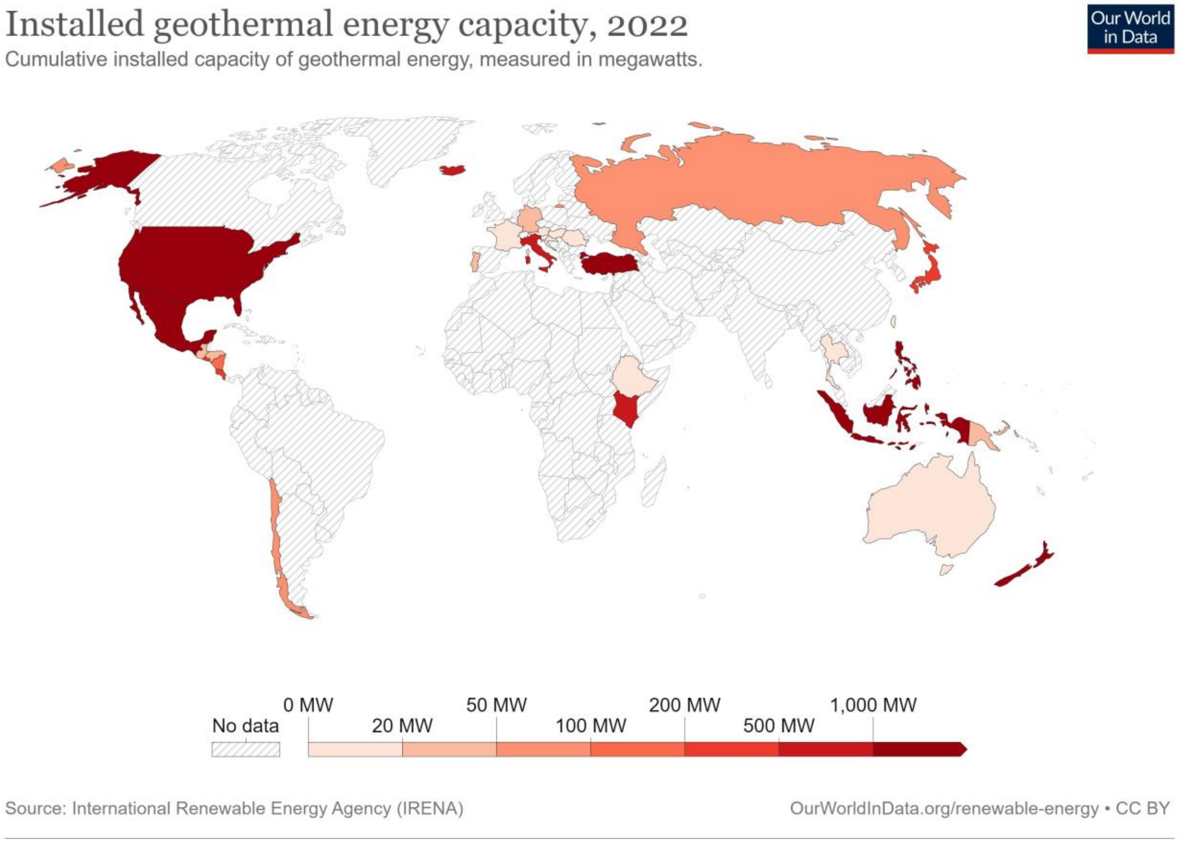


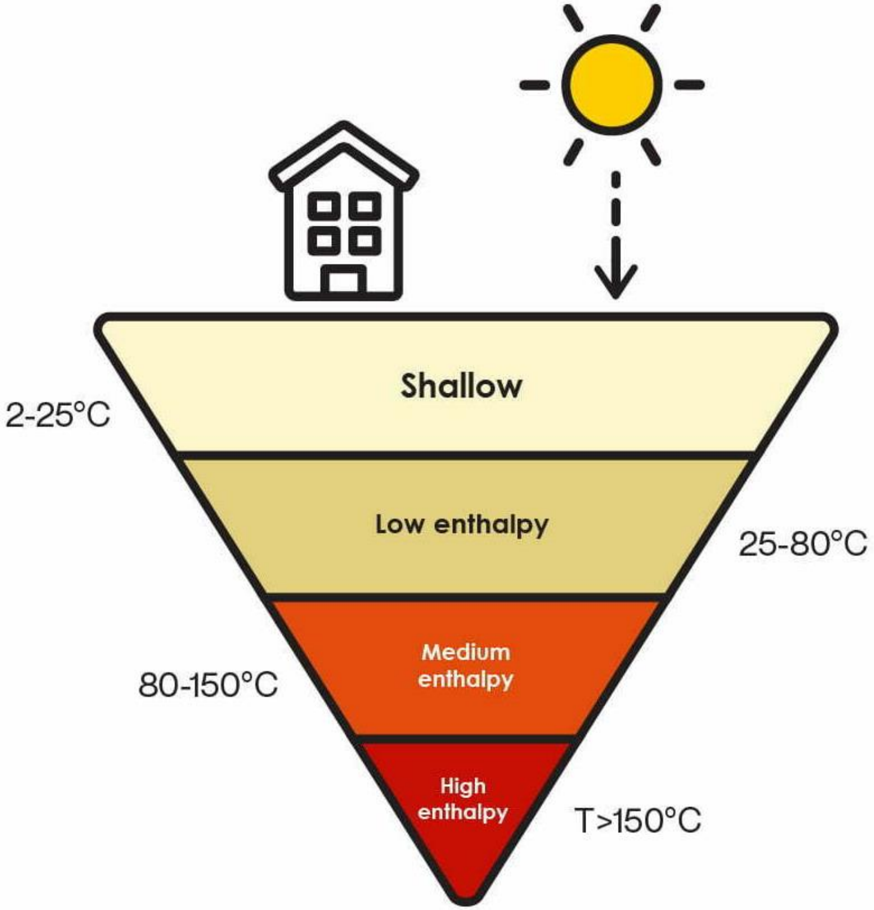
Renewable energy sources





Renewable energy sources

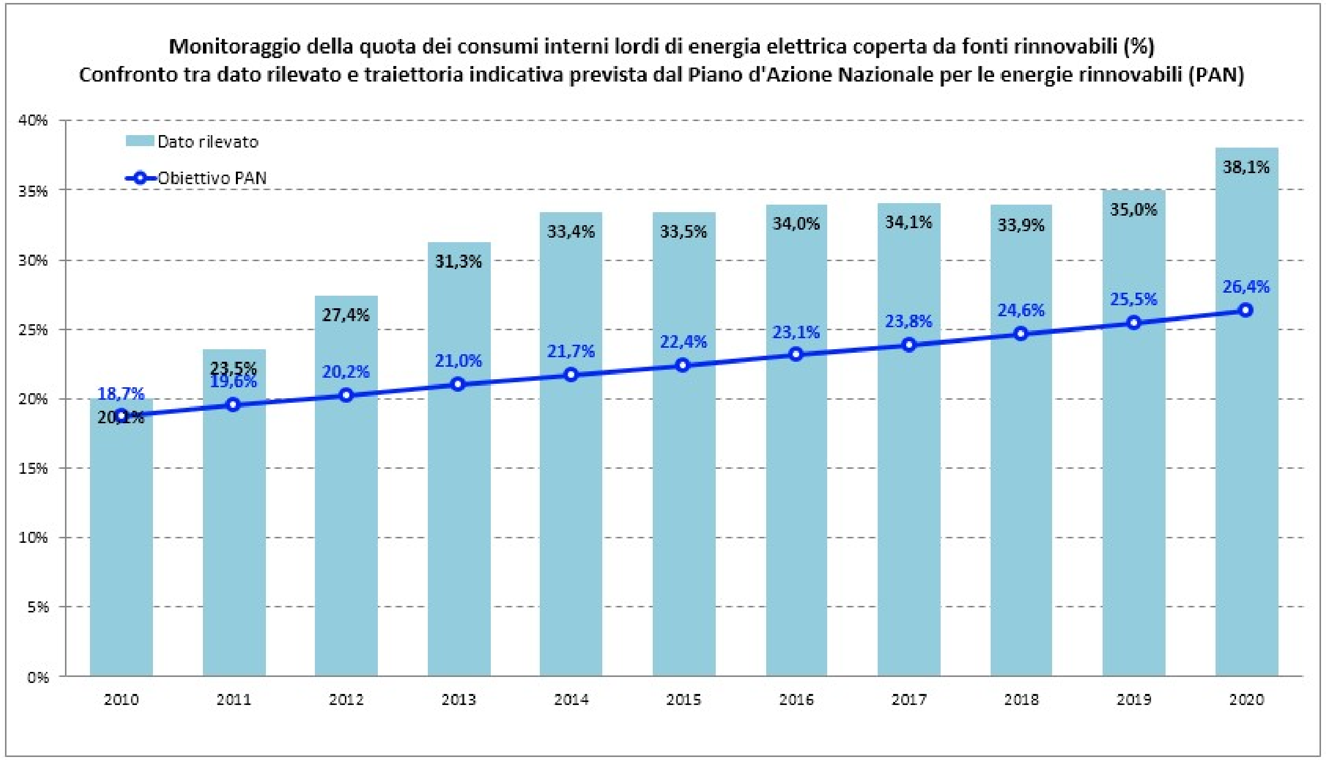




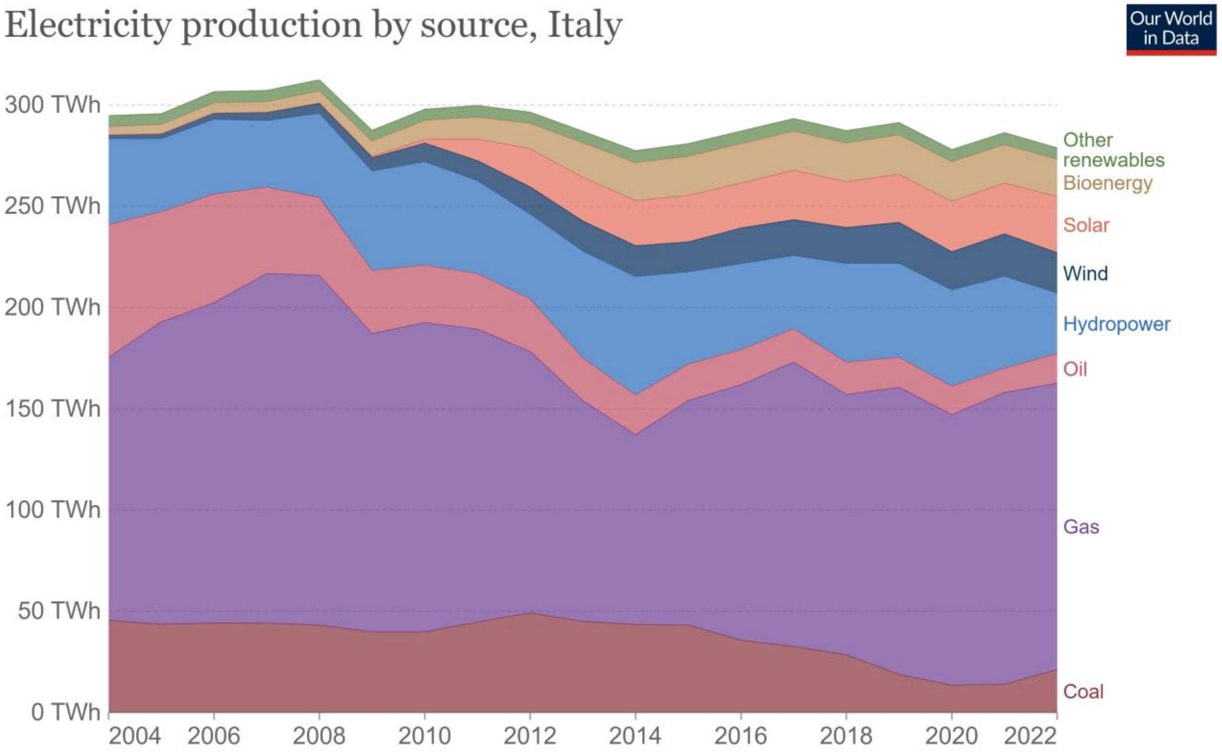
International and national energy policies: National level

The National Action Plan for Renewable Energy (June 2015)

Total contribution from RES in the electricity sector in Italy (% of gross final consumption, 2005-2020 – GSE data)



International and national energy policies: National level



Source: Ember's Yearly Electricity Data; Ember's European Electricity Review; Energy Institute Statistical Review of World Energy
Note: 'Other renewables' includes waste, geothermal, wave and tidal.

How can society maximize the use of RES???

Energy planning: definition

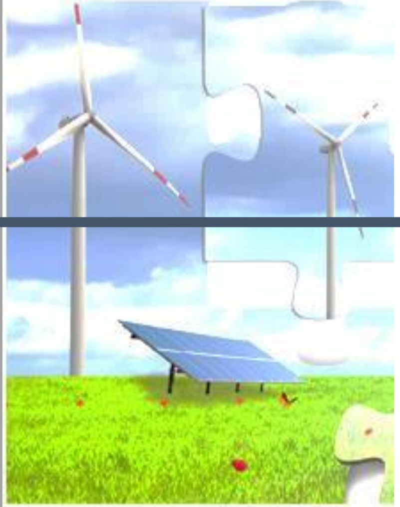
Territorial energy planning is a process for coordinating different energy flows and is an instrument based on the rational utilization of conventional and / or renewable energy (locally bound) that must be harmonized with territorial development.

Through the concept of energy planning, the territory no longer varies marginally but becomes the dominant one.

Energy planning: definition

Planning

Energy



Territorial

Strategic planning is an organization's process in order to analyze, manage and change the…

… present energy balance taking in account the demand and the production, the resources and the existing power plants..

…by reference to a specific territory and ..

…developing alternatives for future actions and policies.

Energy planning for mitigating the environmental impacts of the energy sector

Process → Design of alternatives → Feasibility study → Public Regulation → *Analyze, manage and change…*

Energy system →

→ *… Today's energy system and local features…*

Awareness of Alternatives → Plan A → Plan B → *…Future actions*

Why energy planning?

Environment

- ✓ Fight Climate Change;
- ✓ Improve Air Quality;
- ✓ Protect the Environment and the Soil.

Policy

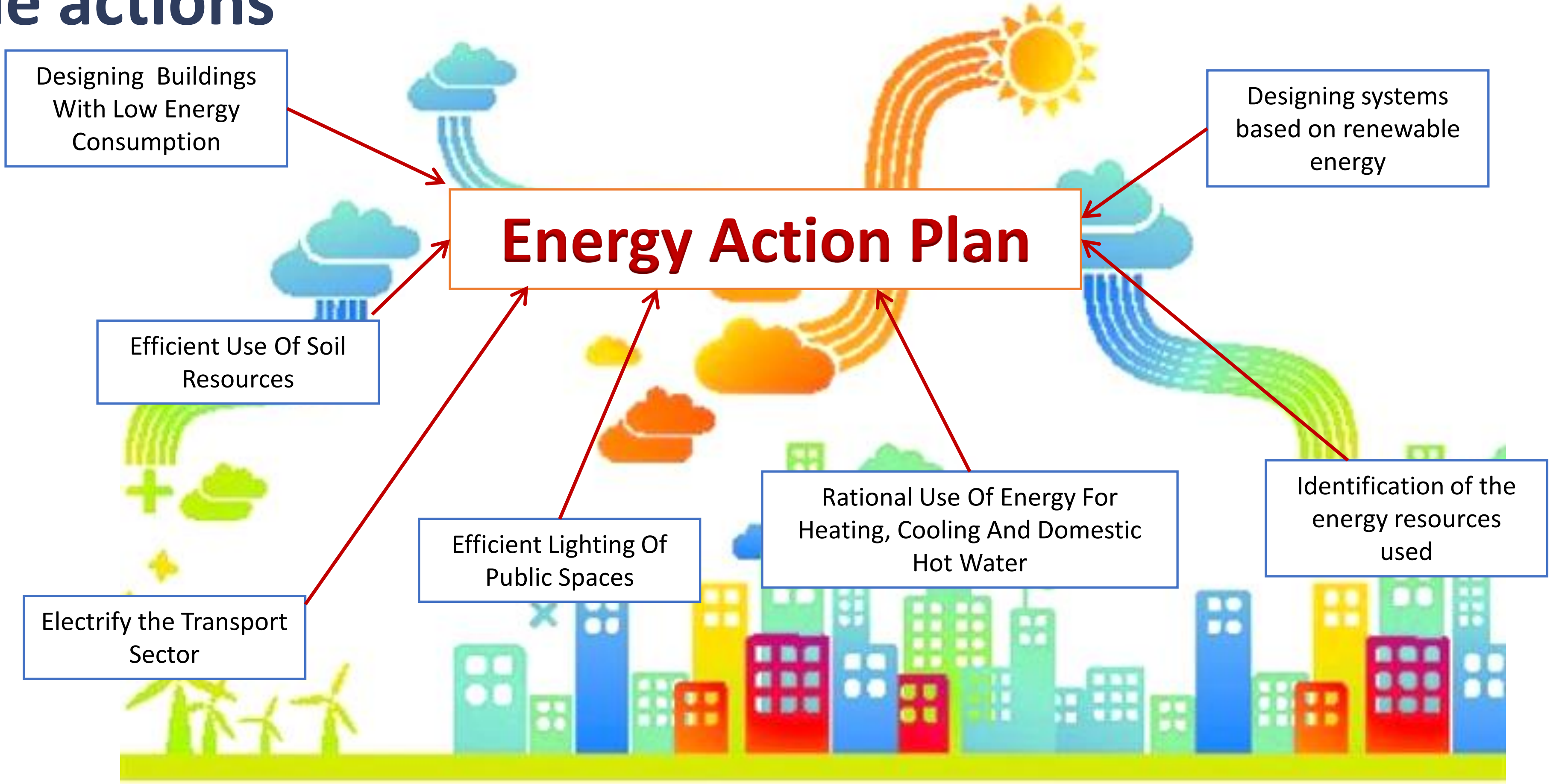
- ✓ Europe asks to fulfill its obligations under the Climate-Energy Package;
- ✓ Create new partnerships (Universities, Energy Agencies, Other Agencies ...) for the Local Authority;
- ✓ Choice the Possible Future Energy Supply Scenario.

Economy

- ✓ Cost Savings due to the energy efficiency measures and to the use of renewable energy sources;
- ✓ Local/National Energy security;
- ✓ Green Economy and Sustainable Development;
- ✓ Sustainable Tourism Development.

Energy planning process

Possible actions



Energy planning goals

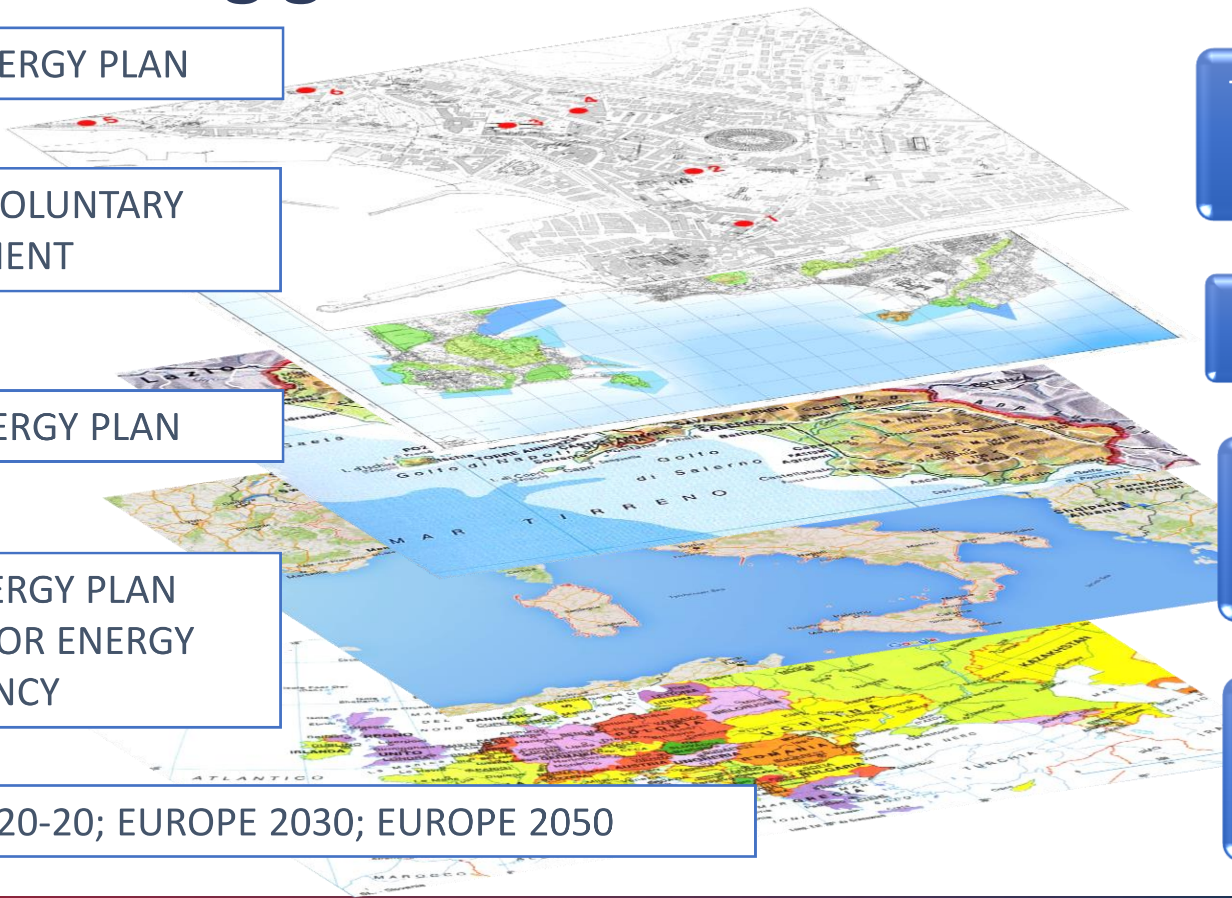
MUNICIPAL ENERGY PLAN

TERRITORIAL VOLUNTARY AGREEMENT

REGIONAL ENERGY PLAN

NATIONAL ENERGY PLAN
ACTION PLAN FOR ENERGY EFFICIENCY

EUROPE 20-20-20; EUROPE 2030; EUROPE 2050



Specific aim related to energy needs and energy sources in the area

↓

Territorial agreements in order to establish energy exchanges between the municipality, on the basis of resources and demand

↓

Regional Energy Strategy Development

↓

National Energy Guidelines for the development on the basis of the European Community Directives

↓

European Vision: achieve a low-carbon economy in Europe, in line with the energy security, environmental and economic goals.

Scenarios planning

Territorial Analysis

Consumption/Production of:

- Electrical Energy;
- Thermal Energy;
- Cooling Energy;
- Fuel for Transport

Analysis Of Energy Production Plants;
Possible Energy Efficiency Measures;
Recognition Of The Renewable Energy Sources In The Area And Projects For plants To Exploit Them.

Data processing

Energy Demand Of The Territory

+

The Potential Savings And Energy Production In The Territory

New Territorial Energy Scenarios

Energy Planning

Some examples of mitigation targets against climate change…

International and national energy policies: global agreements

COP21 -2015
Governments agreed:

- a long-term goal of keeping the increase in global average temperature to well below 2°C above pre-industrial levels;
- to aim to limit the increase to 1.5°C, since this would significantly reduce risks and the impacts of climate change;
- on the need for global emissions to peak as soon as possible, recognising that this will take longer for developing countries;
- to undertake rapid reductions thereafter in accordance with the best available science.

International and national energy policies: EU agreements

Europe Energy Target 2030

The 2030 climate and energy framework sets three key targets for the year 2030:

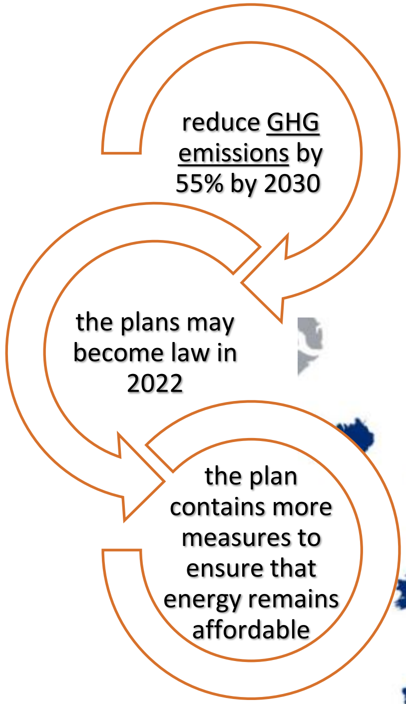
- At least 40% cuts in greenhouse gas emissions (from 1990 levels)
- At least 27% share for renewable energy
- At least 27% improvement in energy efficiency

Europe Energy Target 2050

The European Commission low-carbon economy roadmap suggests that:

- By 2050, the EU should cut greenhouse gas emissions to 80% below 1990 levels
- Milestones to achieve this are 40% emissions cuts by 2030 and 60% by 2040
- All sectors need to contribute
- The low-carbon transition is feasible & affordable.

Fit for 55



Some examples of energy plans…

National energy plans

Energy plans

National goals for 2030

SEN

- Share of RES of TFC 30%
- Share of RES of transport TFC 22%
- Reduction of the primary energy with respect to the PRIMES 2007 scenario -43%

Decarbonization
Self-consumption
Security
Energy efficiency
Integration with the EU

Regional

Regional Environmental Energy Plan

Study Plan

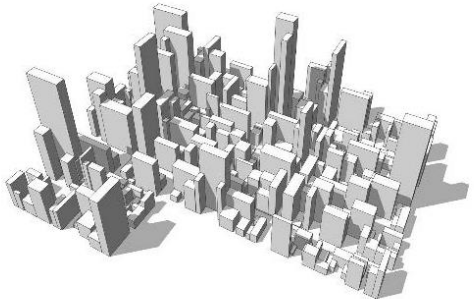
- Cognitive framework of the territory
- Scoreboard of possible interventions
- Framework of scenarios

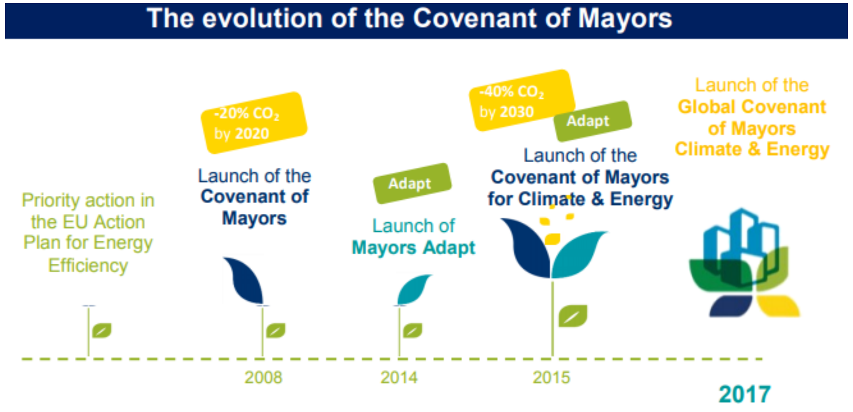
Operational Plan

- Definition of objectives
- Interconnection with other sectors and plans
- Financial resources
- Realization times
- Stakeholders and participants

Municipal

Covenant of Mayors for Climate & Energy



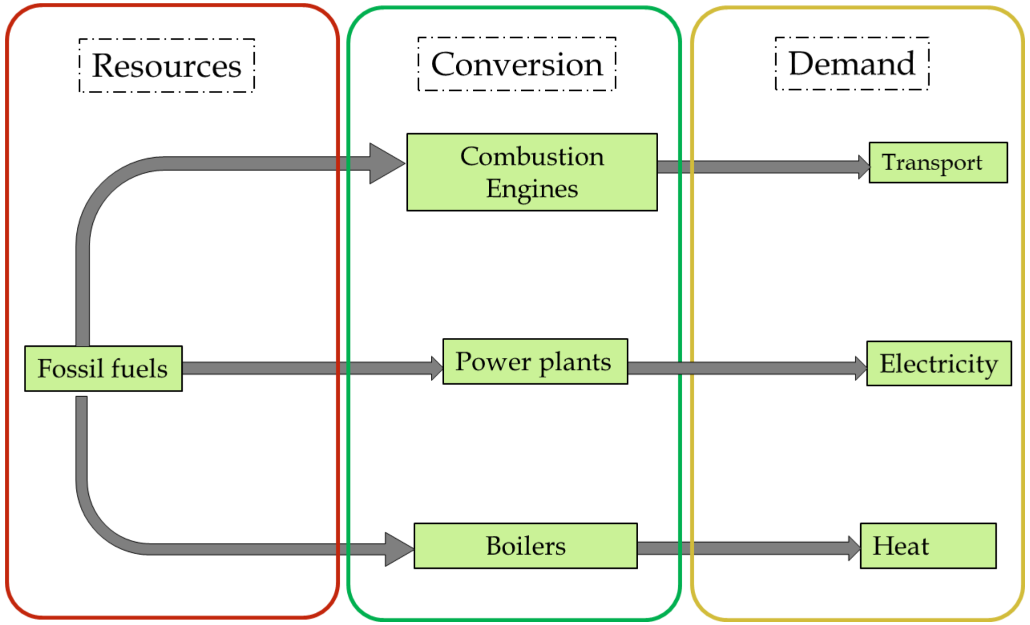


International and national energy policies: EU and National level

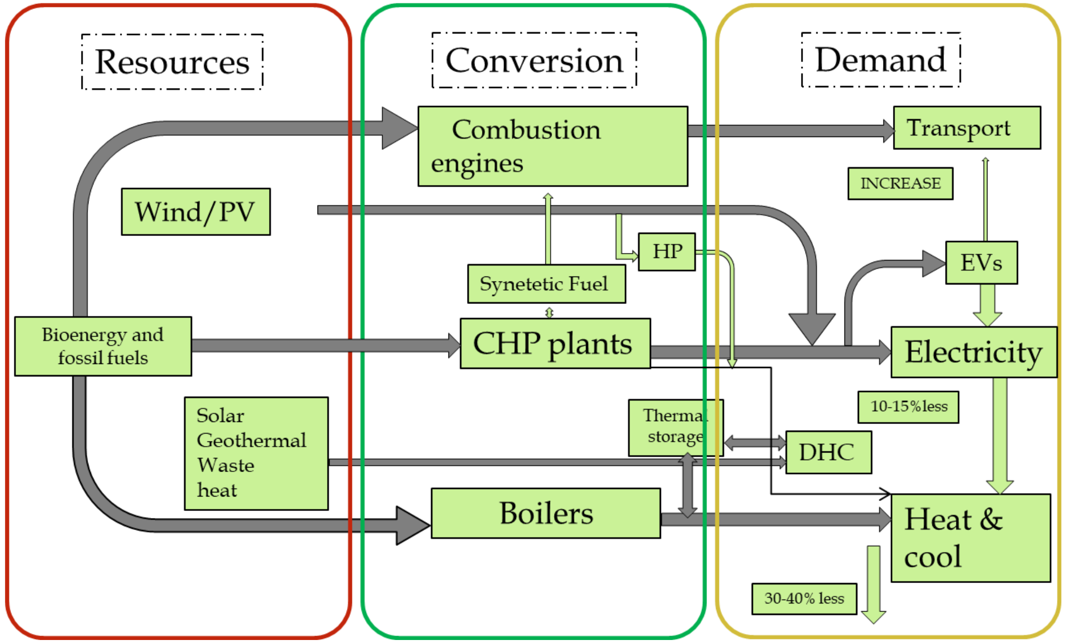
Objectives 2030		
	UE	ITALY INECP
	Renewables	
Share of RES of TFC	32%	30%
Share of RES of transport TFC	14%	22%
Share of RES of heating and cooling TFC	+1.3% each year	+1.3% each year
	Energy efficiency	
Reduction of the primary energy with respect to the PRIMES 2007 scenario	-32.5%	-43%
Reduction of the primary energy with respect to the PRIMES 2007 scenario	-0.8%	-0.8%
	GHG emissions	
GHG reduction vs 2005 for all the ETS plants	-43%	
GHG reduction vs 2005 for non ETS plants	-30%	-33%
GHG reduction vs 1990 levels	-40%	

Energy systems' configuration

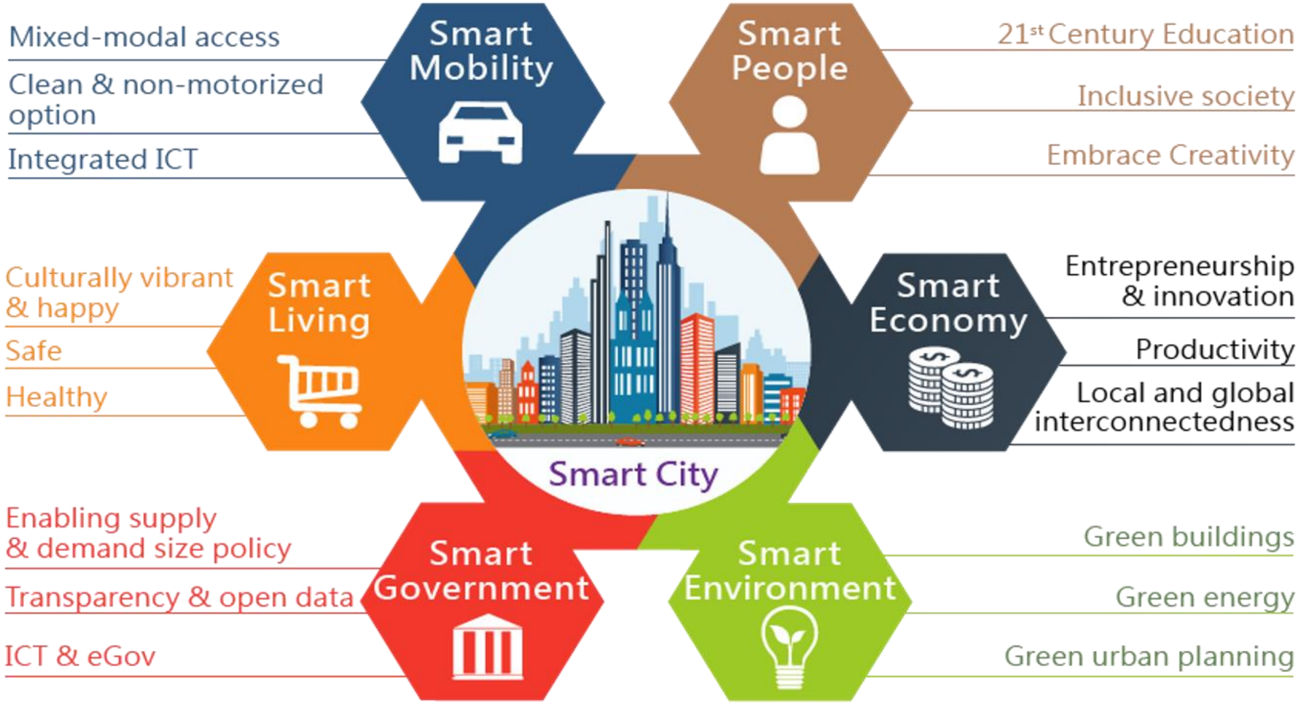
Energy system today

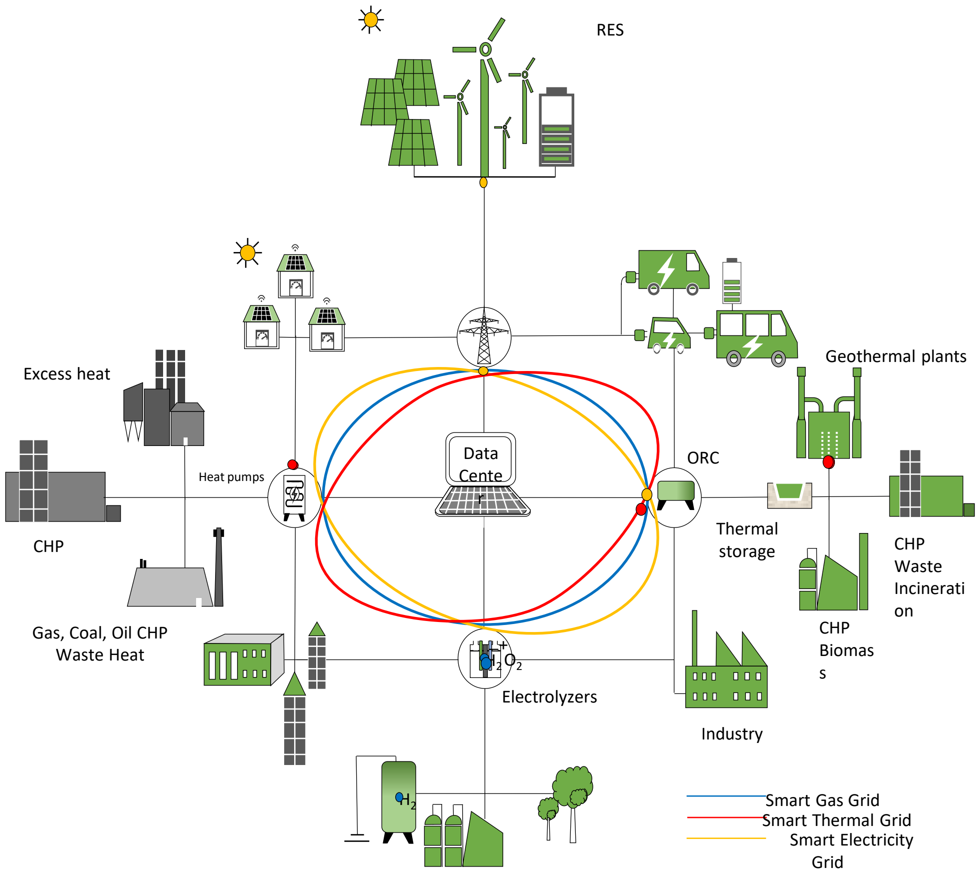


Future smart energy system



Smart CITIES and COMMUNITIES





Source: M. Oberascher, W. Rauch, and R. Sitzenfrei, "Towards a smart water city: A comprehensive review of applications, data requirements, and communication technologies for integrated management," *Sustain. Cities Soc.*, vol. 76, no. October 2021, p. 103442, 2022.

Source: R. Obringer and R. Nateghi, "What makes a city 'smart' in the Anthropocene? A critical review of smart cities under climate change," Sustain. Cities Soc., vol. 75, no. July, p. 103278, 2021.

Smart energy systems: definition

- It include the entire energy system in its approach to identifying suitable energy infrastructure designs and operation strategies
- It consists of “new technologies and infrastructures which create new forms of flexibility, primarily in the ‘conversion’ stage of the energy system
- It combines the electricity, thermal, and transport sectors so that the flexibility across these different areas can compensate for the lack of flexibility from renewable resources such as wind and solar

Lund H, et al., Smart energy and smart energy systems, Energy (2017), http://dx.doi.org/10.1016/ j.energy.2017.05.123

Smart energy systems: definition

www.energyplan.eu/smartenergy

Smart energy systems

- A sole focus on renewable electricity (smart grid) production leads to electricity storage and flexible demand solutions!

- Looking at renewable electricity as a part of the smart energy systems including heating, industry, gas and transportation opens for cheaper and better solutions…

→

Power-to-Gas
Power-to-Transport
Power-to-Heat

Smart grids

Smart Energy System is built around three grid infrastructures:

- Smart Electricity Grids to connect flexible electricity demands such as heat pumps and electric vehicles to the intermittent renewable resources such as wind and solar power.
- Smart Thermal Grids (District Heating and Cooling) to connect the electricity and heating sectors. This enables the use of thermal storage for creating additional flexibility and the recycling of heat losses in the energy system.
- Smart Gas Grids to connect the electricity, heating, and transport sectors. This enables the use of gas storage for creating additional flexibility. If the gas is refined to a liquid fuel, then liquid fuel storages can also be used.

In Smart Energy System smart electricity, thermal and gas grids are combined with storage technologies and coordinated to identify synergies between them in order to achieve an optimal solution for each individual sector as well as for the overall energy system

Synergies

- Energy savings in buildings make low-temperature district heating possible to use which utilize low-temperature sources from industrial surplus heat and CHP
- Excess heat from industry and electricity production can be used for heating
- Electricity for heating purposes allow to use heat storage and provides a more flexible CHP production
- Heat pumps for heating can provide cooling for DHC networks
- Electricity for heating may be used for balancing power and electric grid
- Electricity for vehicles can be used to replace fuel and provide for electricity balancing

Surplus Electricity Production

Surplus Electricity Production (SEP) *is defined as situations in which the electricity production exceeds the demand in a given area.*

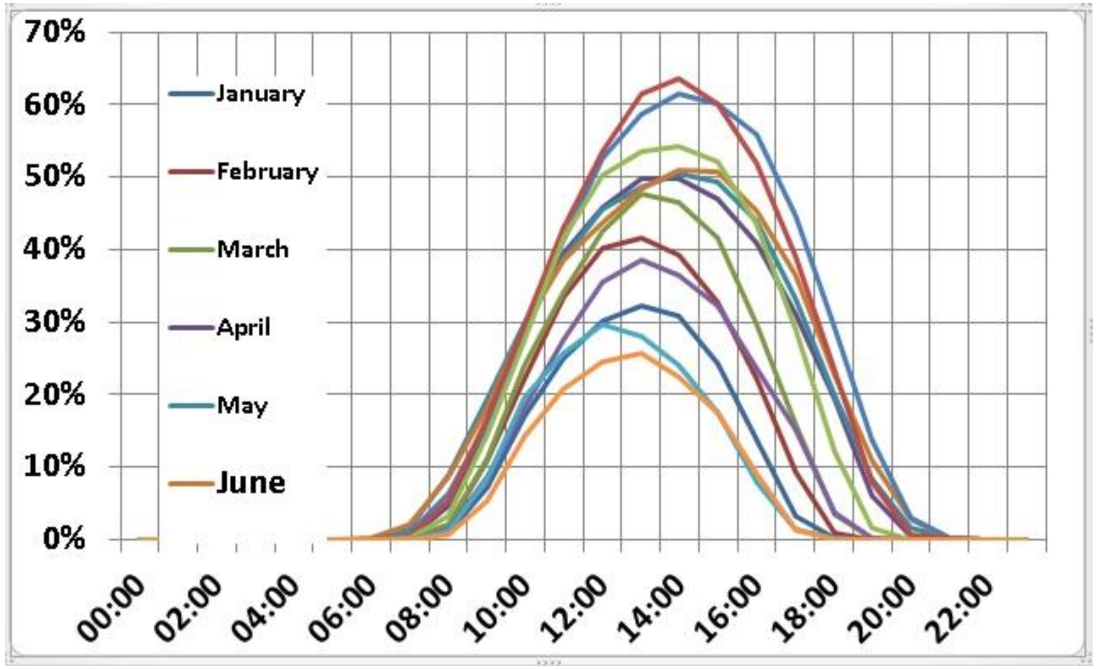
The SEP can be defined as:

- Exportable Surplus Electricity Production (ESEP): *when it can be exported;*
- Critical surplus Electricity Production (CSEP): *when cannot be exportable.*

In some cases, the surplus production exceed the technical possibilities of being exported, for instance if the surplus production becomes higher than the capacity of existing transmission lines.

Why does it happen???

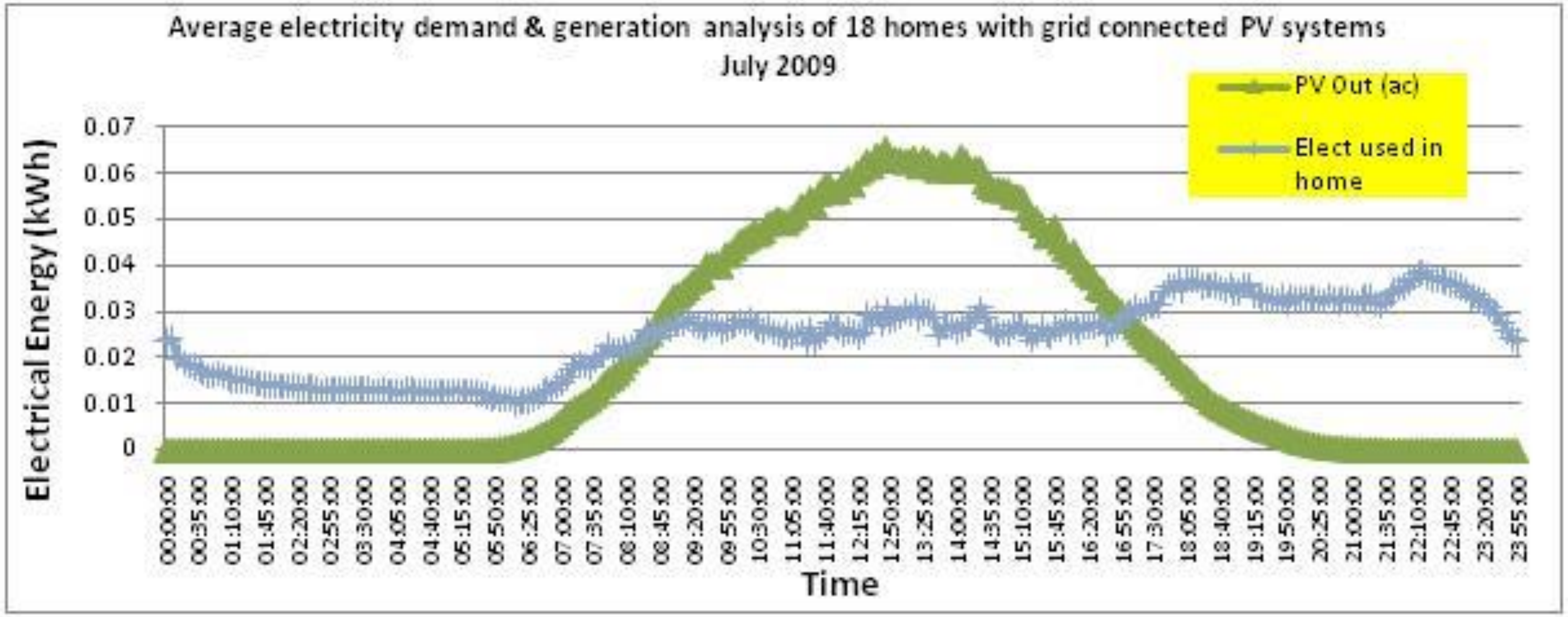
- In stock-based electricity production systems, conversion technologies (e.g., nuclear, coal, oil and gas generators) produce steady output flows. In these situations, inflexibility of supply can be managed. However, flow-based energy sources such as run-of-river hydropower, solar power, and wind energy, do not allow for supply-side control without additional investments and storage losses.
- Solar and wind plants deliver energy stochastically as a function of weather conditions.
- Once the infrastructure for these technologies has been installed (e.g., a photovoltaic panel, a wind turbine or a solar thermal concentrator) it can produce anything from 0% to 100% of nameplate capacity, relatively independent of demand..



Why does it happen???

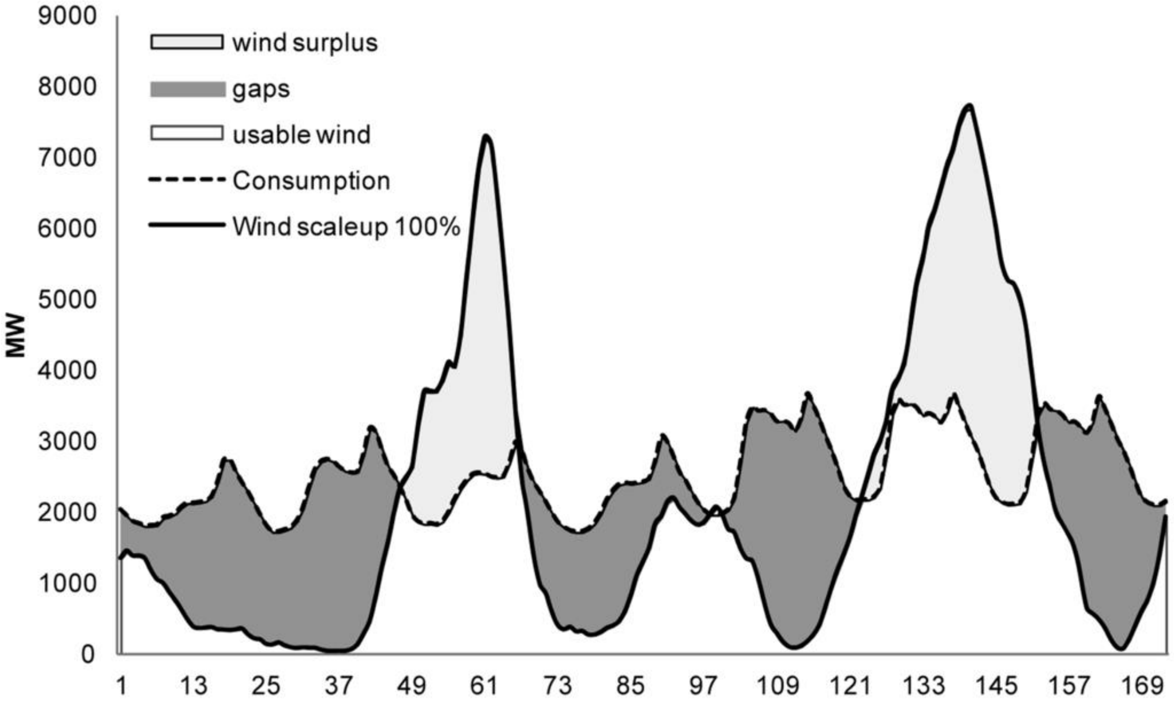
Exportable o Critical?

It depends on capacity of existing transmission lines



Source: Technical and policy challenges of wide-scale integration of PV systems into UK homes *Joynal Abedin, Loughborough University*

Why does it happen???



A similar problem arises with the wind plants.

Wind power production (scaled to 100% annual electricity consumption) plotted against actual gross consumption for electricity in Denmark West

Exportable o Critical?

It depends on capacity of existing transmission lines

How to avoid the issue of SEP?

1) New Electric Energy System: RES electricity plants combined with Stable Output Technologies and Flexible Technologies;

2) Increasing the electricity grid capacity;

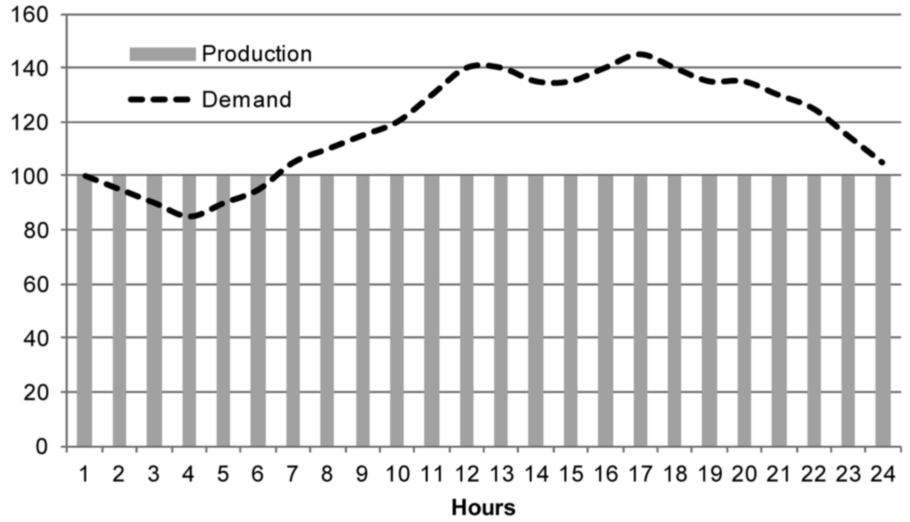
3) New Energy System: Power-to-X;

4) Management of supply.

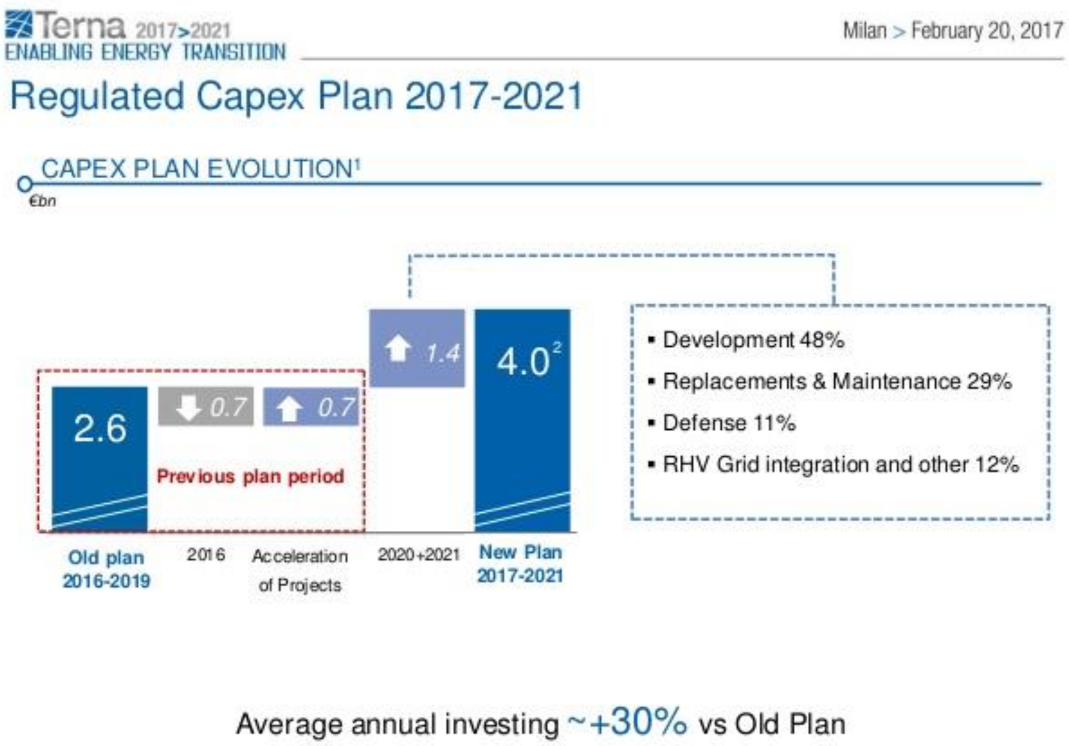
How to avoid the issue of SEP?

1) New Electric Energy System: RES electricity plants combined with Stable Output Technologies and Flexible Technologies;

Stable Output Technologies	Flexible Output Technologies
-Their outputs vary little and are predictable for extended periods of time; -These technologies are not flexible enough to follow all the peaks and lows -Run-of-river hydropower delivers steady outputs that are not typically easy to alter	- Most stock-based technologies, like gas- or oil-fired power plants, or stored hydropower, can be modulated to follow demand patterns as they emerge; -They bear no demand shortfall risk in their application;



How to avoid the issue of SEP?



2) Increasing the electricity grid capacity

The TERNA CAPital Expenditure Plan [involves investments]() in Development of new grids

How to avoid the issue of SEP?

3) New Energy System: Power-to-X strategies

SEP used to heat production: **Power-to-heat**

- Using excess electricity to feed heat pumps;
- Using electric heating by replacing heat production from CHP or biomass boilers.

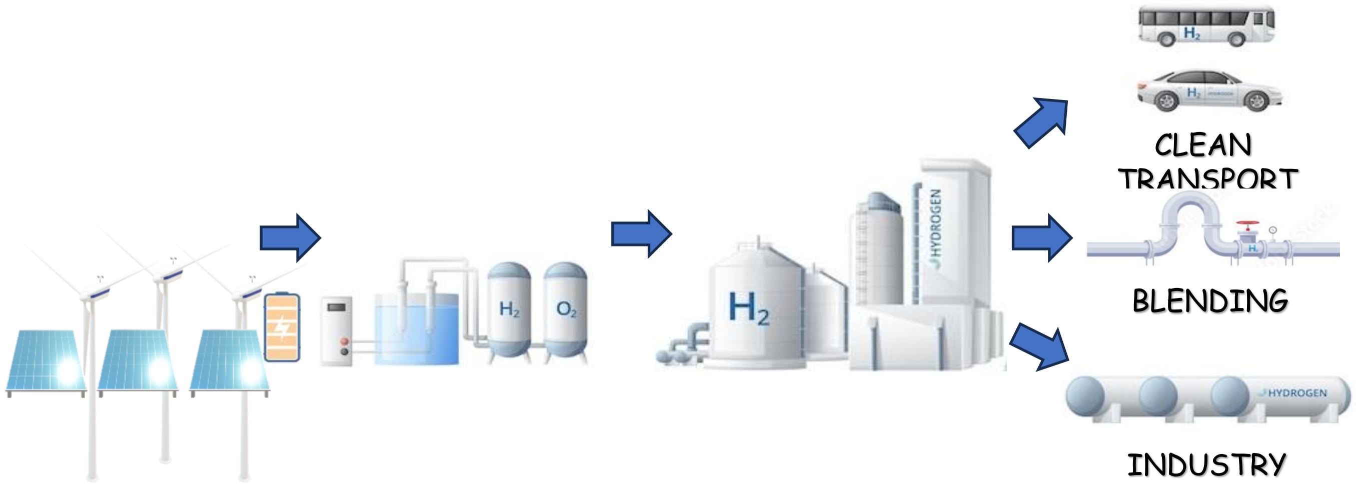
How to avoid the issue of SEP?

3) New Energy System: Power-to-X strategies

SEP used to gas production: **Power-to-Gas**

- Using excess electricity to produce hydrogen through electrolysers;
- Using hydrogen to produce other fuels.

Hydrogen Pathways



How to avoid the issue of SEP?

3) New Energy System: Power-to-X strategies

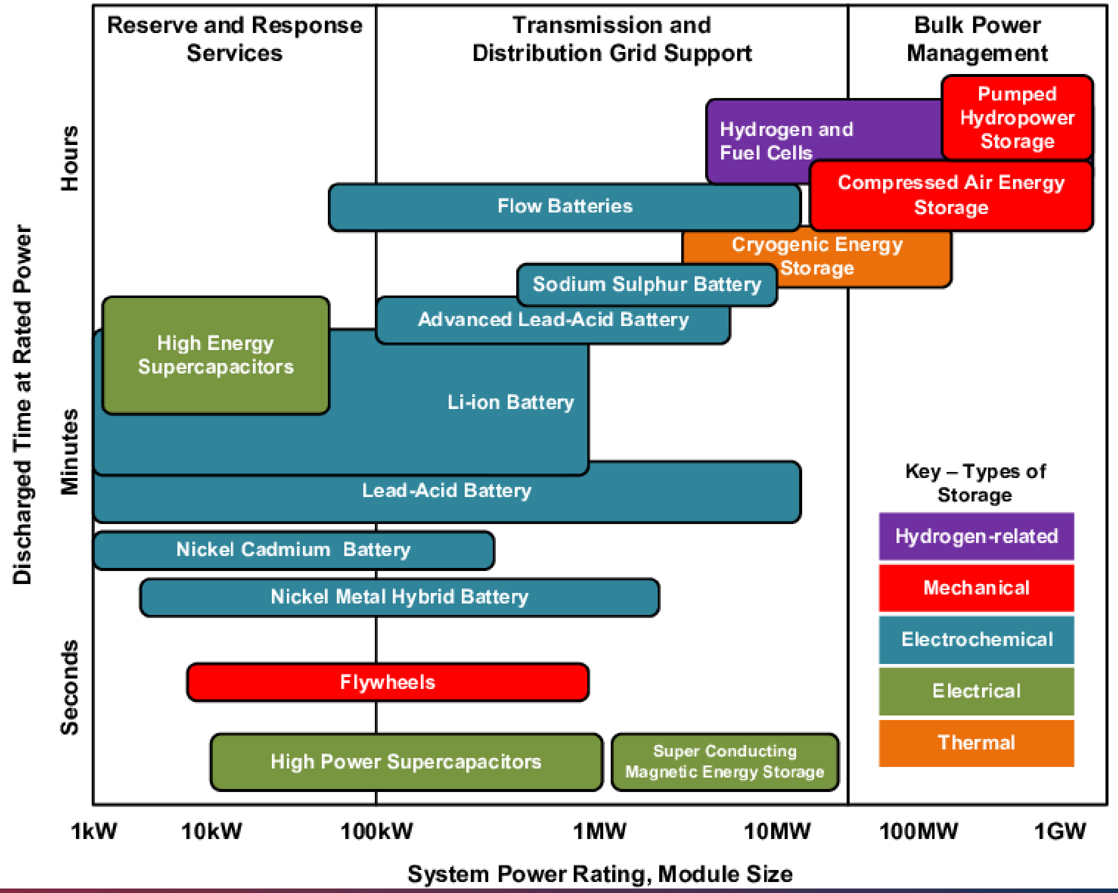
SEP stored with electric storages : **Power-to-Power**
Six main categories:

- Solid State Batteries - a range of electrochemical storage solutions, including advanced chemistry batteries and capacitors
- Flow Batteries - batteries where the energy is stored directly in the electrolyte solution for longer cycle life, and quick response times
- Compressed Air Energy Storage - utilizing compressed air to create a potent energy reserve
- Thermal - capturing heat and cold to create energy on demand
- Pumped Hydro-Power - creating large-scale reservoirs of energy with water

http://energystorage.org/energy-storage-1

How to avoid the issue of SEP?

TY - BOOK
AU - Sprake, David
AU - Vagapov, Yuriy
AU - Lupin, Sergey
AU - Anuchin, Alecksey
PY - 2017/09/12
SP -
T1 - Housing Estate Energy Storage Feasibility for a 2050 Scenario
DO - 10.1109/ITECHA.2017.8101925
ER -



How to avoid the issue of SEP?

3) New Energy System: Power-to-X strategies

SEP used in transport sector: **Power-to-Mobility**

- The technical performance of battery cars and hydrogen fuel cell cars will gradually improve in the coming decades, making it feasible for these types of cars to take over a substantial part of the transport task, particularly for passenger cars and small delivery vans below 2 t.

The barriers to the integration of electric transportation are mainly due:

- to current high technology cost (especially fuel cell vehicles),
- insufficient infrastructure, and high cost of public charging stations (especially fast-charging electricity chargers and hydrogen fuel stations)

H. Lund, E. Mu¨nster / Transport Policy 13 (2006) 426–433

How to avoid the issue of SEP?

4) Management of supply

SEP managed with production technologies
-Exploiting existing or additional heat-storage capacity in CHP units by moving production from CHP units from hours with a lot RES power to hours with less RES power;
-Replacing CHP production with biomass boiler production during hours of critical surplus production.

How to avoid the issue of SEP?

4) Management of supply

SEP managed with Renewable Energy Communities

RED II	IEM
«Jointly-acting renewable self-consumers» *Group of self-consumers* ***located in the same building or condominium*** *who, produces* ***renewable electricity*** *for its own consumption and can store or sell self-produced electricity*	**«Jointly-acting consumers»** *End customer or group of consortium end customers who consumes or stores the electricity produced or sells the electricity self-produced or* ***participates in flexibility or energy efficiency mechanisms***
REC» Renewable Energy Community *Entity located in the* ***vicinity*** *of the* ***RES plants*** *developed by the legal entity which provides environmental, economic or* ***social benefits*** *at the community level, rather than financial profits*	**«CEC» Citizen Energy Community** *Entity that offers its members or the territory in which it operates environmental, economic or social benefits at the community level and may participate in* ***providing energy services to its members*** *or partners*

These activities do not constitute the main commercial or professional activity

Europe

- Directive UE 2018/2011 (RED II)

Italy

- PNIEC
- Legislative Decree Milleproroghe (2020)
- ARERA Resolution (2020)
- Ministerial Decree
- Technical rules

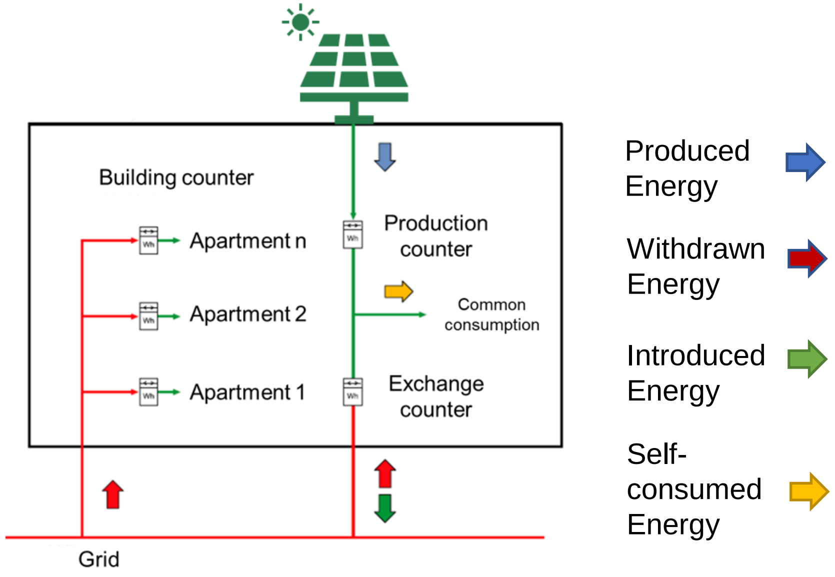
How to avoid the issue of SEP?

4) Management of supply

SEP managed with Renewable Energy Communities

Extention and scope	Plant characteristics
Communities: same primary cabin	P<1 MW
Self-consumption: same building or condo	Communities: same primary cabin Self-consumption: same area near the building or condo

The participating subjects share the energy produced using the existing distribution network



SHARED ENERGY:
In every hour is the minimum between the sum of the electric energy entering the grid and the one imported

How to avoid the issue of SEP?

4) Management of supply

SEP managed with Renewable Energy Communities

RECs economic benefits:

- Avoided bill costs due to physical self-consumption
- Refund of tariff components
- Incentives from shared energy
- Electric energy sold to the grid

Return of tariff components
- $C_{CE}=CU_{Af,m}*E_{AC}$
- Product between the monthly flat-rate self-consumption fee (8 €/MWh) and the shared energy

Incentive for shared energy
- $I_{CE}=TP_{CE}*E_{AC}$
- Product between the put premium rate of 110 €/MWh for the EC and shared energy

Energy withdrawal
- $R_{CE}=PR*E_{input}$
- Product between the selling price of energy and the energy fed into the network

Innovative technologies with novel attributes valued by end users

novel attributes?

pay per use
service-based

multiple uses
choice variety

relational

ease of use

control, autonomy

active involvement

clean at point of use

mobility

electric vehicles

mobility-as-a-service

car-sharing

cities & housing

net zero-energy building design

internet-of-things

building energy management systems

food & agriculture

reduced meat diet

vertical farming

greenhouses + LED lighting

energy supply & distribution

large-scale electricity storage

solar PV

smart grids

EnergyPLAN

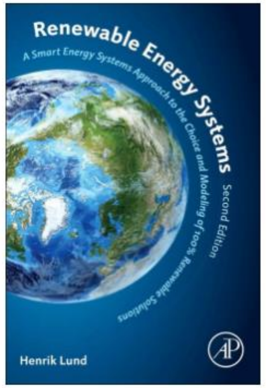
https://www.energyplan.eu/download/

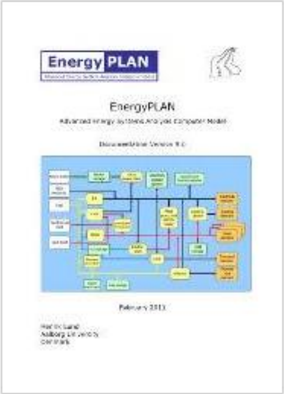
www.EnergyPLAN.eu

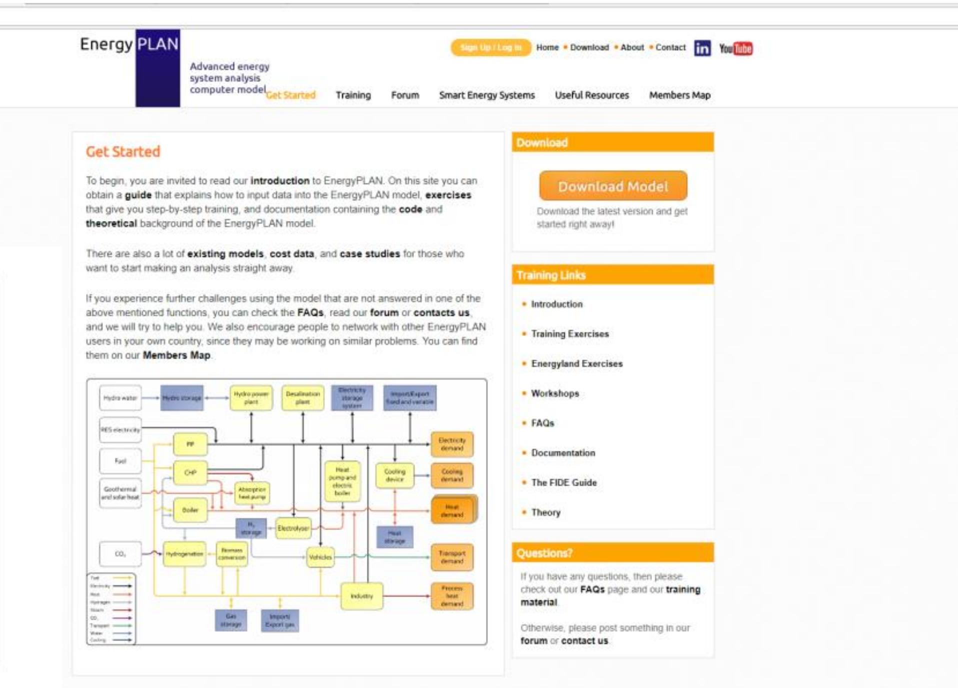
Energy PLAN
Advanced energy
system analysis
computer model

- Download EnergyPLAN
- Download documentation
- Links to journal articles
- Links to research reports
- The FIDE guide


Energy
A renewable energy scenario for Aalborg Municipality based on low-temperature geothermal heat, wind power and biomass
Poul Alberg Østergaard, Brian Vad Mathiesen, Bernd Möller, Henrik Lund







EnergyPLAN

https://www.energyplan.eu/download/

The EnergyPLAN Model:

- Energy System Analysis Model - Excel~Visual Basic~Delphi Pascal
- Main focus: Compare different regulation systems and the ability to integrate and trade RES (Wind)
- Simplified modelling of energy system.

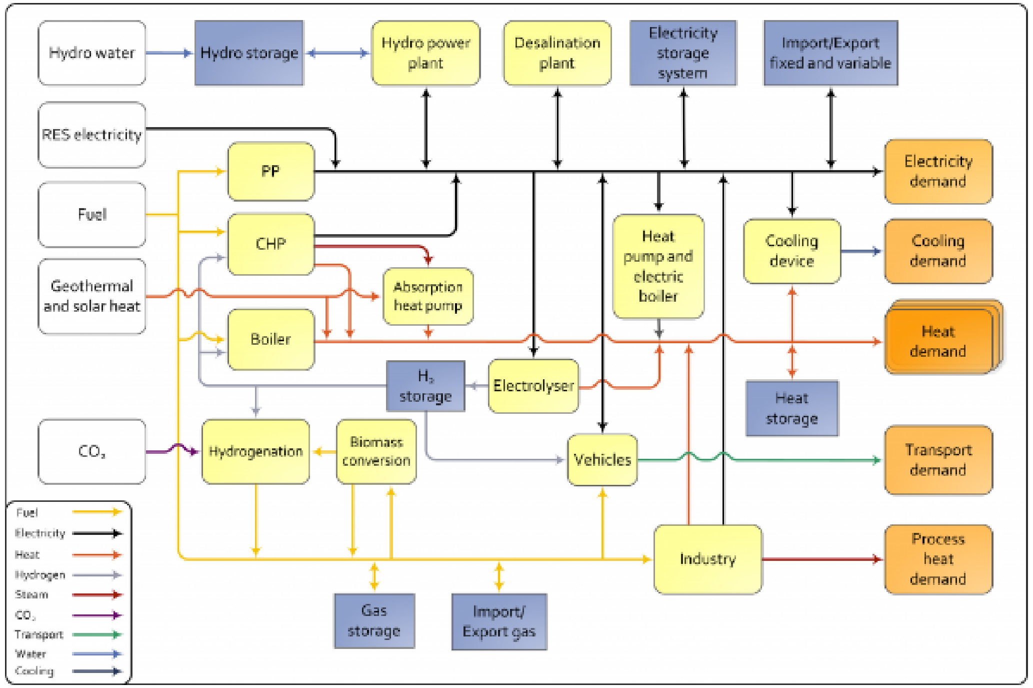
EnergyPLAN

https://www.energyplan.eu/download/

Main features

The main purpose of the EnergyPLAN model is to analyse the energy, environmental, and economic impact of various energy strategies. The key objective is to model a variety of options so that they can be compared with one another, rather than model one 'optimum' solution based on defined pre-conditions.

- **A sole focus on renewable electricity production leads to storage solutions!**
- **Looking at renewable electricity as a part energy systems including heating, industry and transportation opens for cheaper and better solutions…**

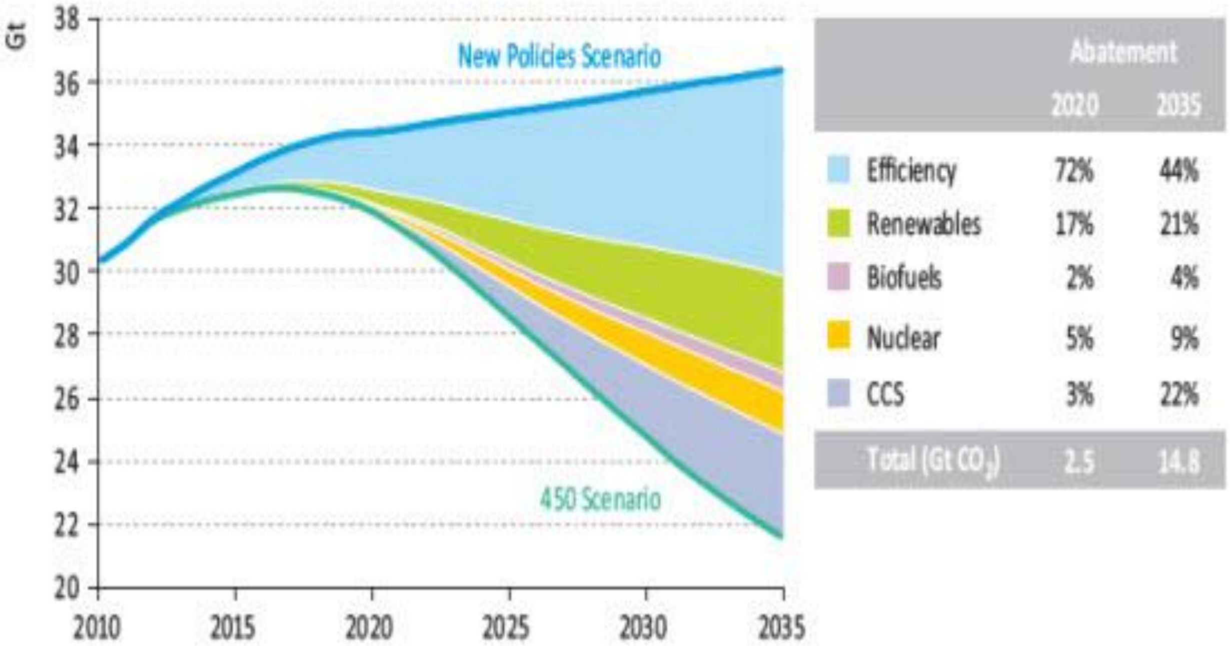


EnergyPLAN

https://www.energyplan.eu/download/

Main features

Furthermore, the aim of EnergyPLAN is to model the **'finishing point'** of the energy system rather than the starting point. The focus is placed on the future energy system and how that will operate, rather than on today's energy system. The focus is on the future rather than the present.



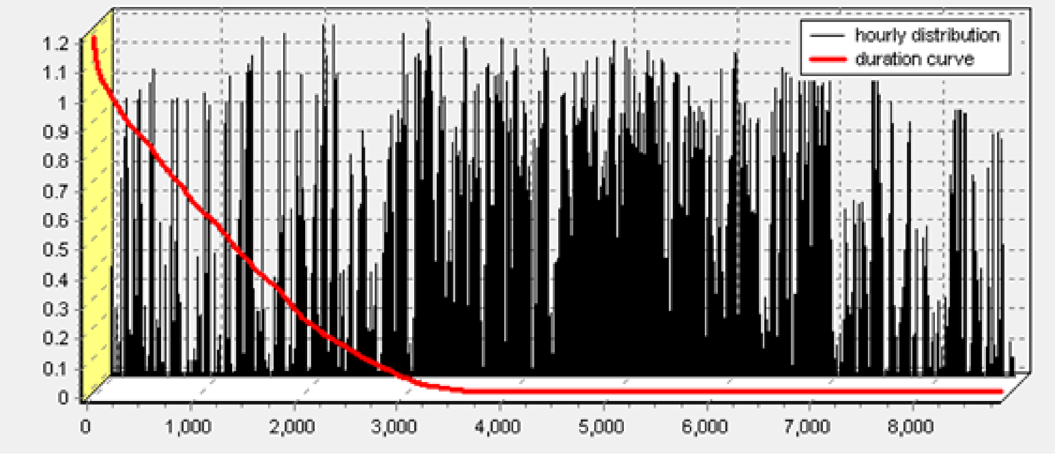
World Energy Outlook 2011© OECD/International Energy Agency 2011, figure 6.4, page 214

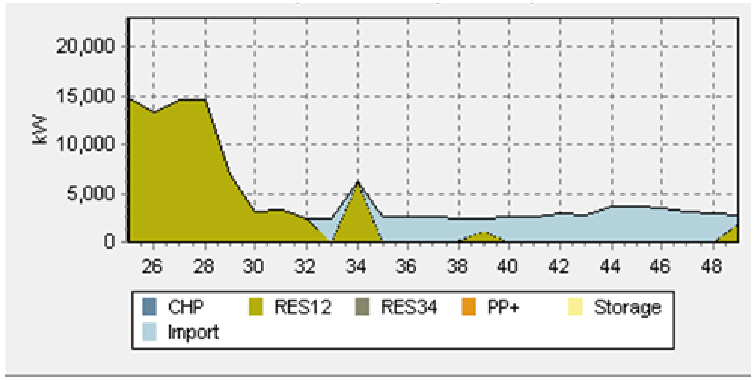
EnergyPLAN

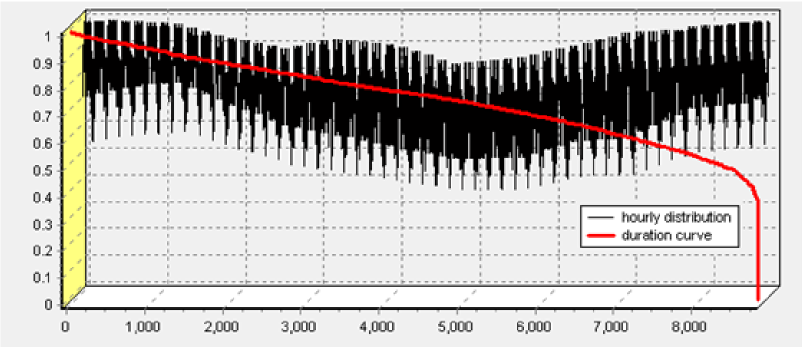
https://www.energyplan.eu/download/

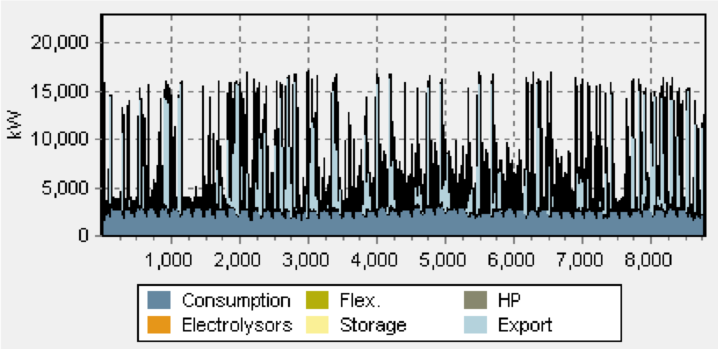
Main features

EnergyPLAN is an **hour-simulation model** as opposed to a model based on aggregated annual demands and production. Consequently, the model can analyze the influence of fluctuating RES on the system as well as weekly and seasonal differences in electricity and heat demands and water inputs to large hydropower systems.





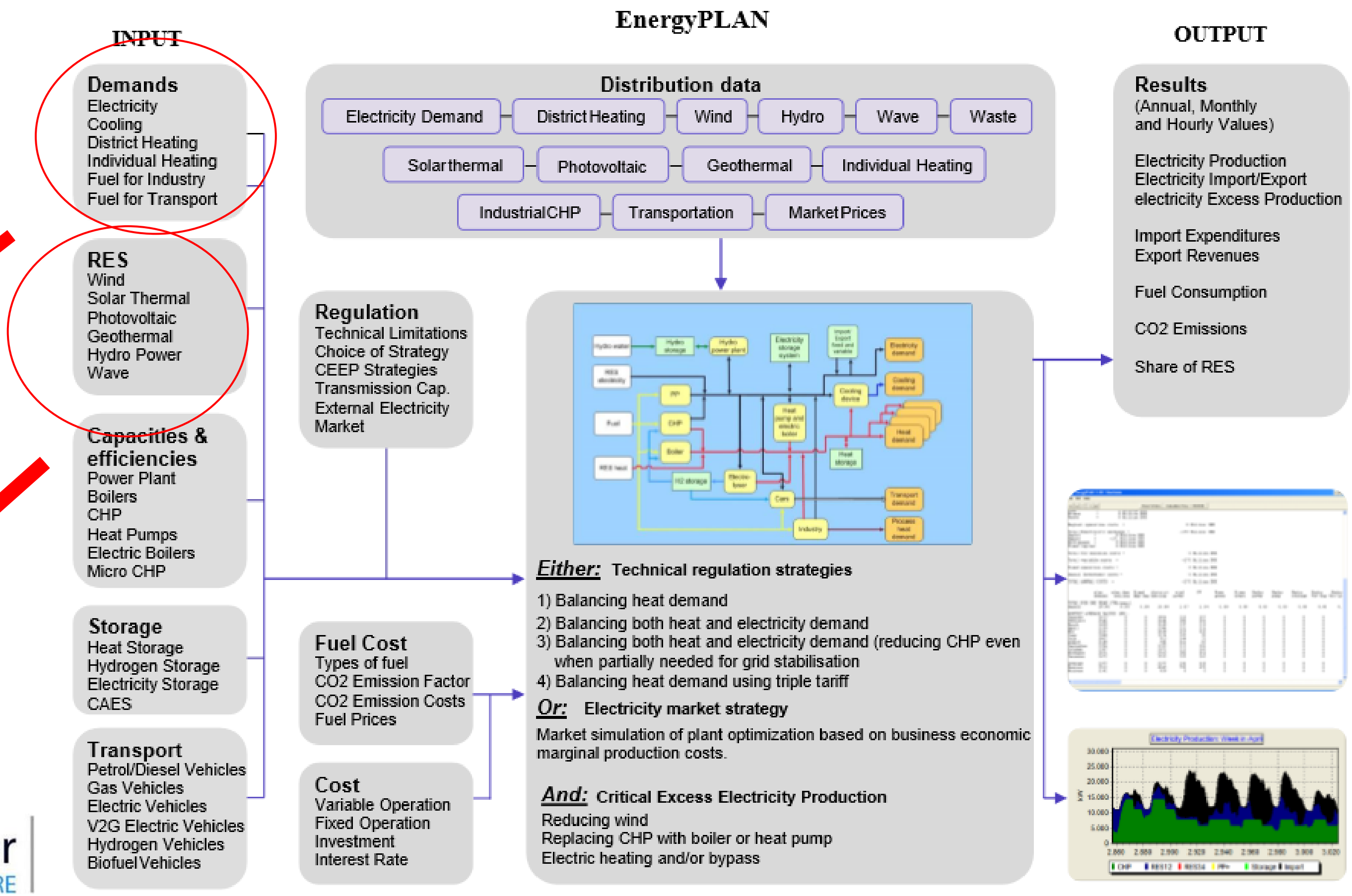




EnergyPLAN

https://www.energyplan.eu/download/

Main features



EnergyPLAN

https://www.energyplan.eu/download/

Main features

Different kinds of studies:

- Technical system studies in closed and open systems (Results are energy balances, CO_2-emissions and Excess electricity productions)

- Market exchange studies (Results are optimal exchange strategies and costs)

- Feasibility Studies (Results are socio economic costs including CO_2 trade costs)

EnergyPLAN

https://www.energyplan.eu/download/

Main features

Step by step:

1. Defining energy demands (electricity, individual and district heating, industry, transportation)

2. Defining a reference energy production system

3. Defining alternatives

4. Results

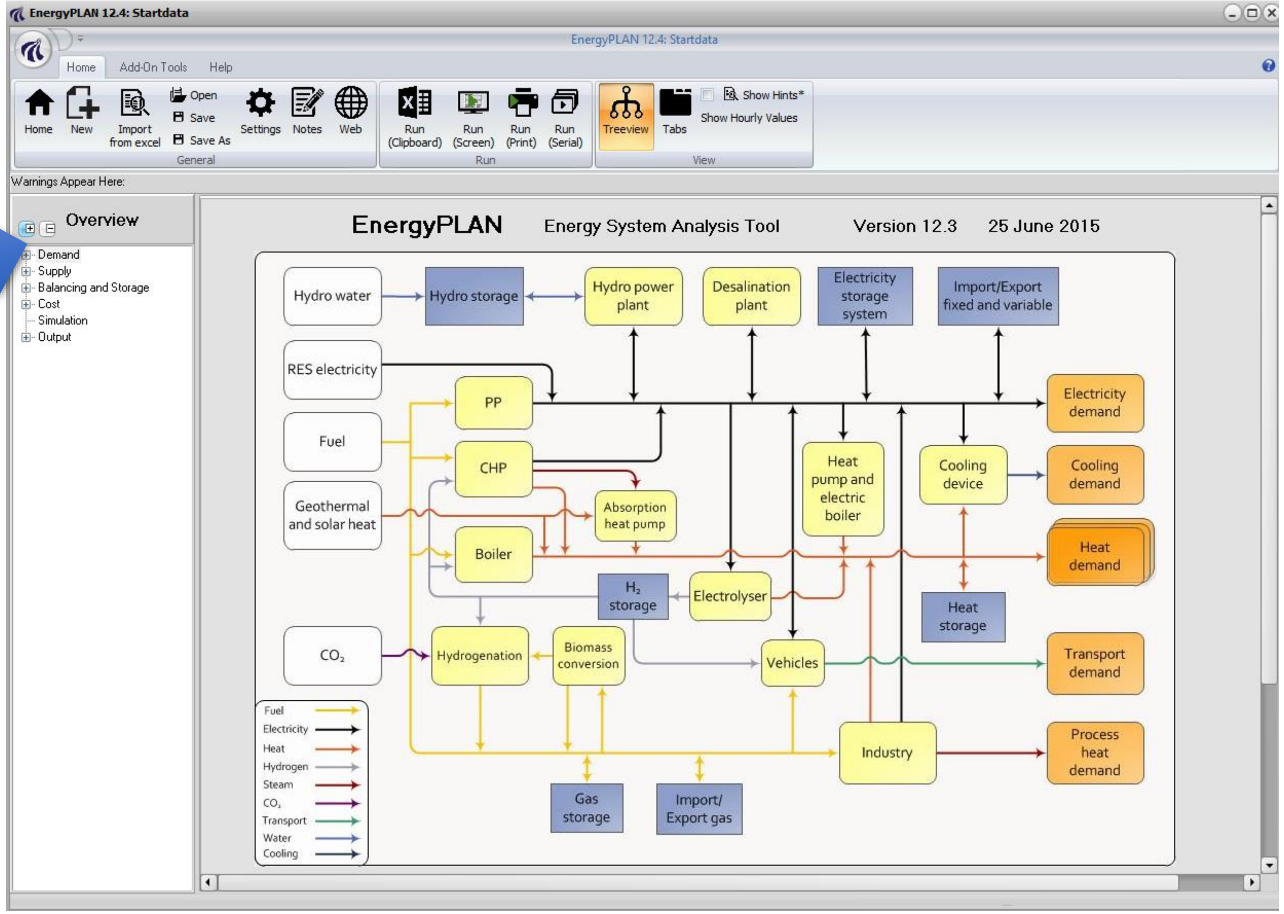
EnergyPLAN

https://www.energyplan.eu/download/

Main features

Home

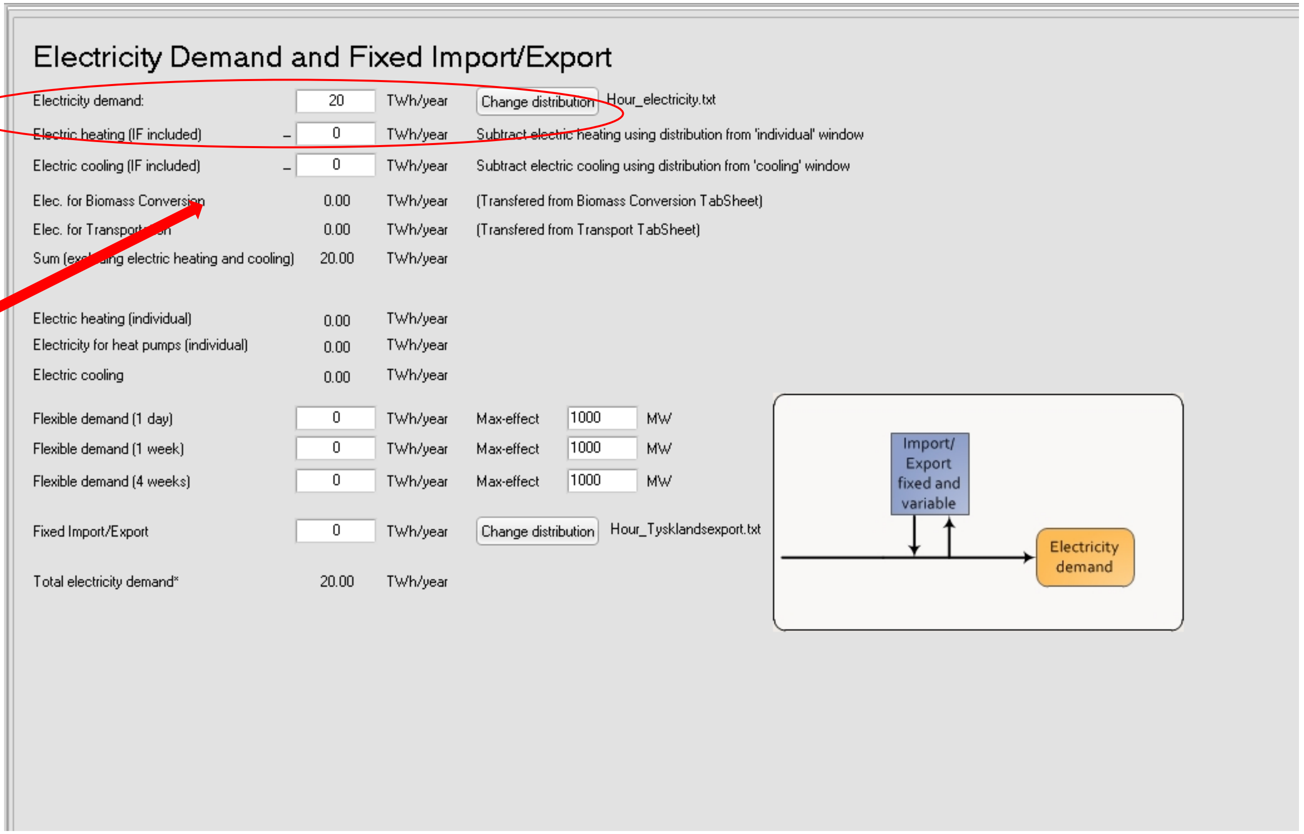
The Home button on the home menu gives the user an overview of the components and synergies included in the EnergyPLAN model



EnergyPLAN

Step 1: Defining electricity demands

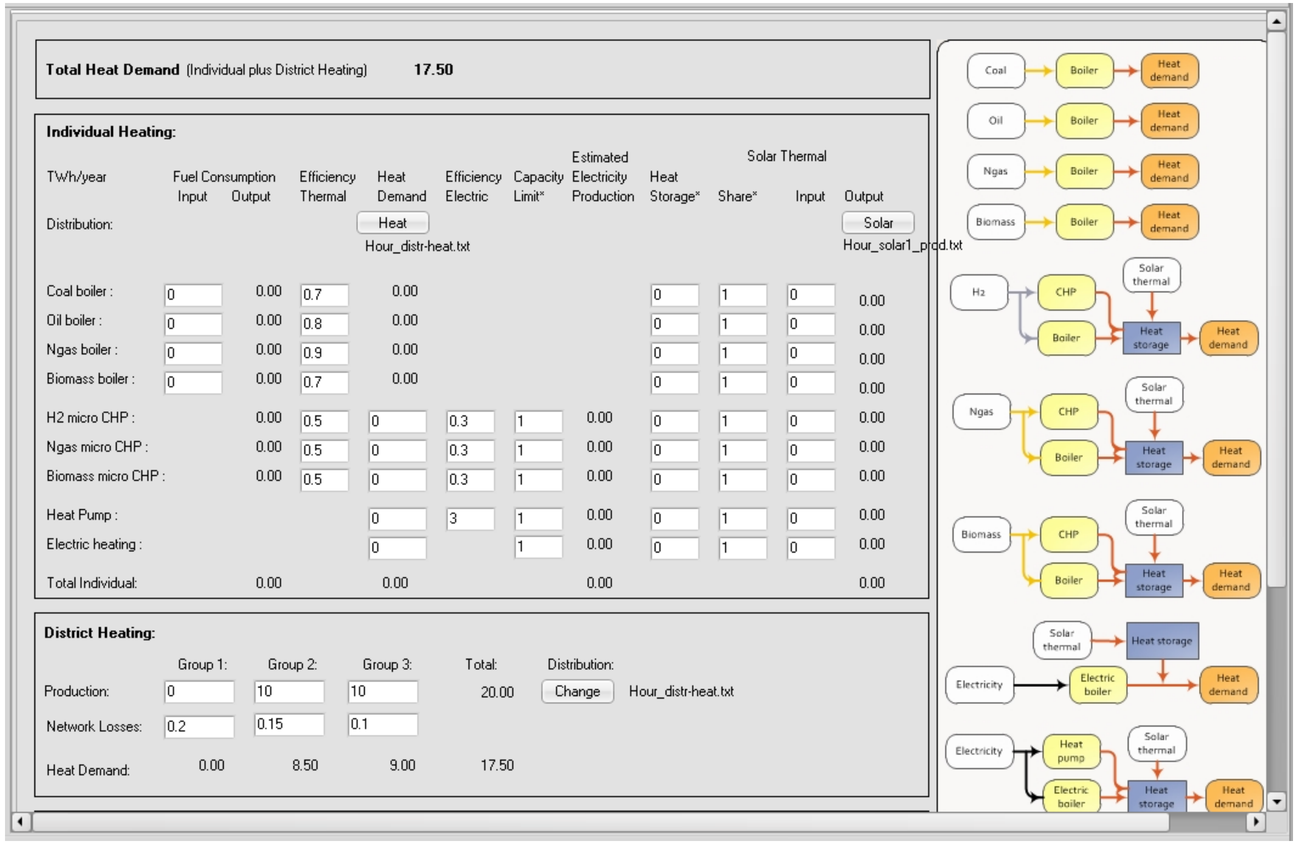
The electricity demand is defined by an annual value, (TWh per year) and it can be choosen the name of an hourly distribution data set



EnergyPLAN

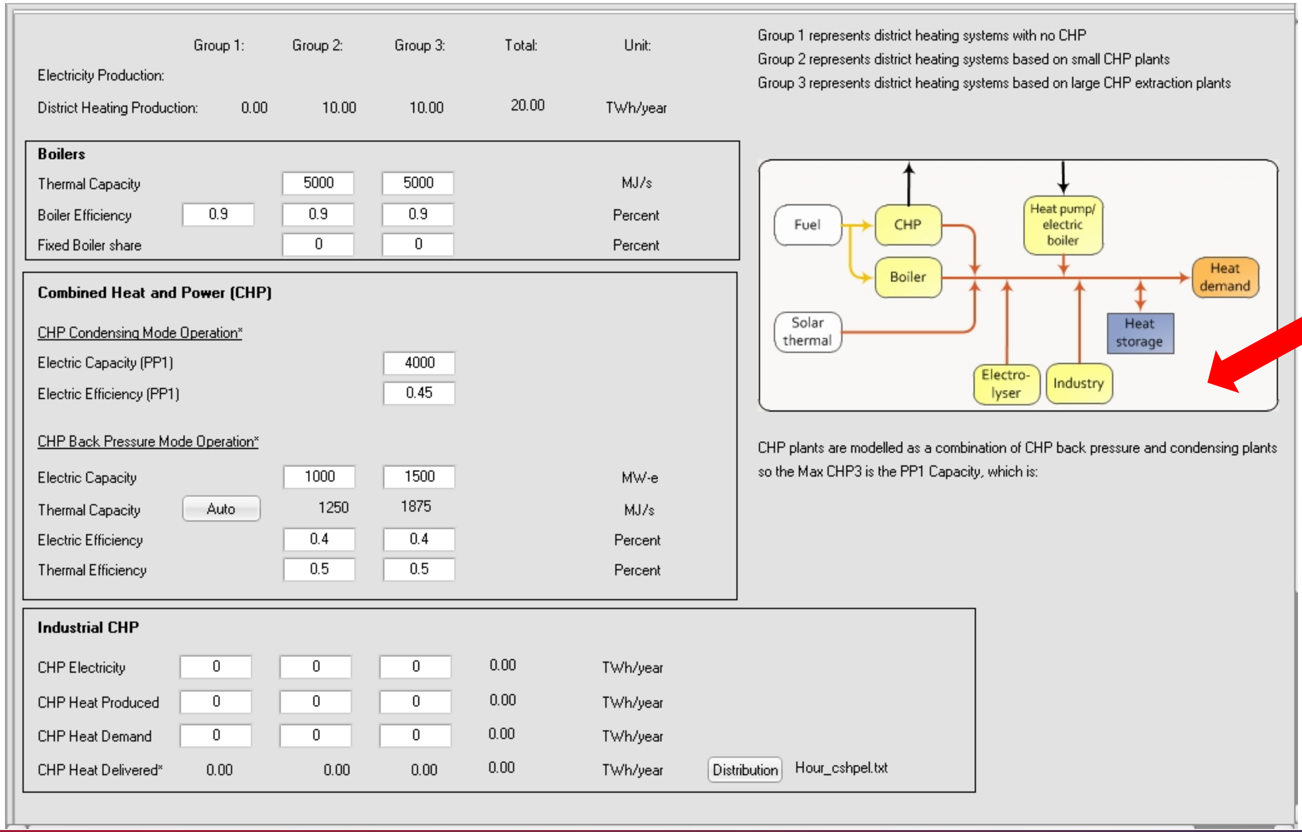
Step 1: Defining heat demands

Inputs to individual houses are basically defined as fuel inputs, since such figures are normally basic data in statistics. When defining the efficiencies of boilers, heat demands are calculated. Electric heating is defined as electricity consumption. The same hourly distributions are used for all heat demands.



EnergyPLAN

Step 2: Defining energy system (reference system)



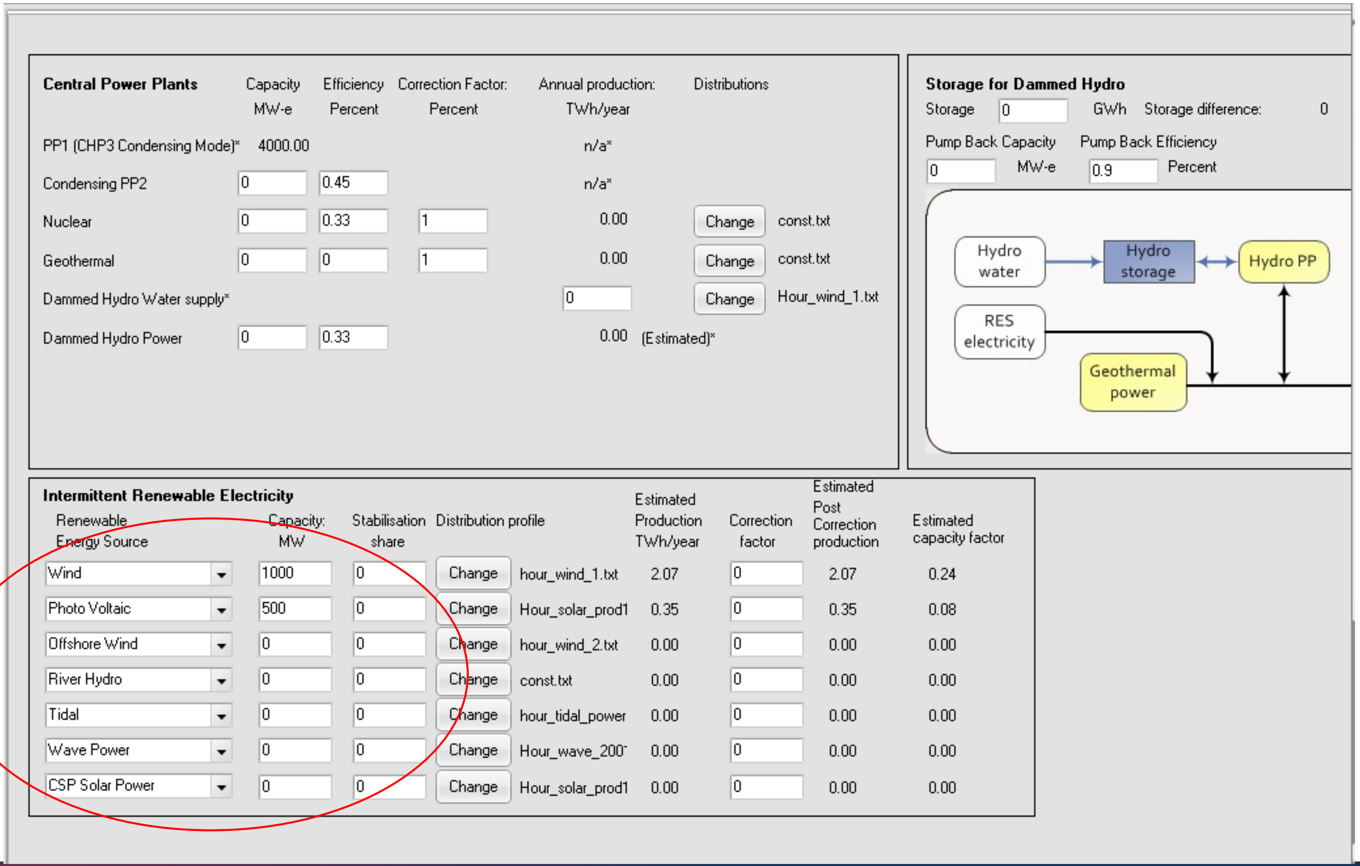
Capacities and operation efficiencies of CHP units, power stations, boilers and heat pumps are defined as part of the input data. The size of heat storage capacities is also given here

EnergyPLAN

Step 2: Defining energy system (reference system)

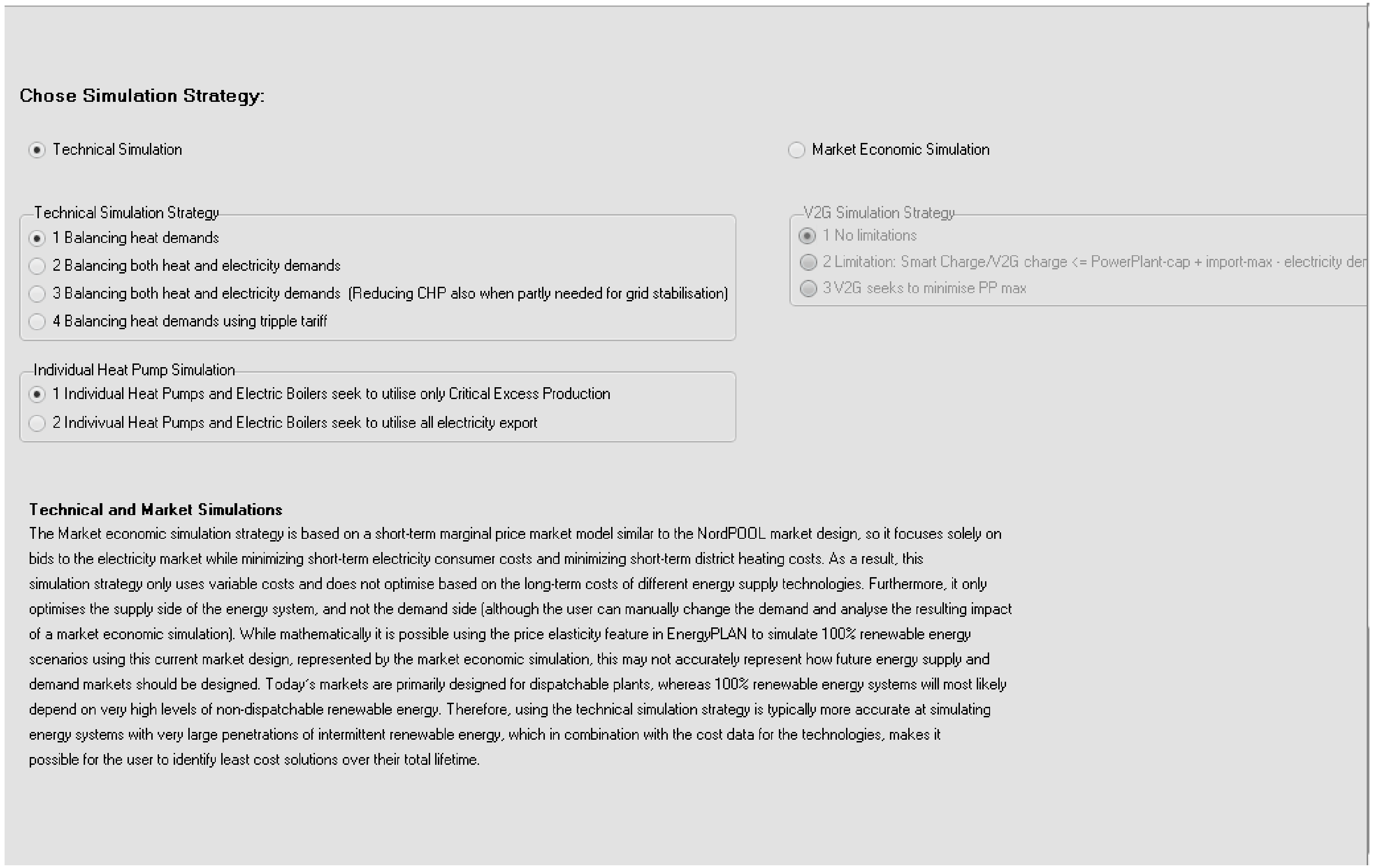
The input data set defines input from RES and hydro power. One can choose inputs from up to four different renewable energy sources. By pressing the button, the following specification can be
attached to each RES:
- Wind
- Offshore Wind
- Photo Voltaic
- Wave Power
- River Hydro

Input to the electricity production is identified by the capacity of each RES and by the name of the distribution file



EnergyPLAN

Step 3: Defining THE TYPE OF SIMULATION



Chose Simulation Strategy:

- (•) Technical Simulation
- ( ) Market Economic Simulation

Technical Simulation Strategy
- (•) 1 Balancing heat demands
- ( ) 2 Balancing both heat and electricity demands
- ( ) 3 Balancing both heat and electricity demands (Reducing CHP also when partly needed for grid stabilisation)
- ( ) 4 Balancing heat demands using tripple tariff

V2G Simulation Strategy
- (•) 1 No limitations
- ( ) 2 Limitation: Smart Charge/V2G charge <= PowerPlant-cap + import-max - electricity der
- ( ) 3 V2G seeks to minimise PP max

Individual Heat Pump Simulation
- (•) 1 Individual Heat Pumps and Electric Boilers seek to utilise only Critical Excess Production
- ( ) 2 Indivivual Heat Pumps and Electric Boilers seek to utilise all electricity export

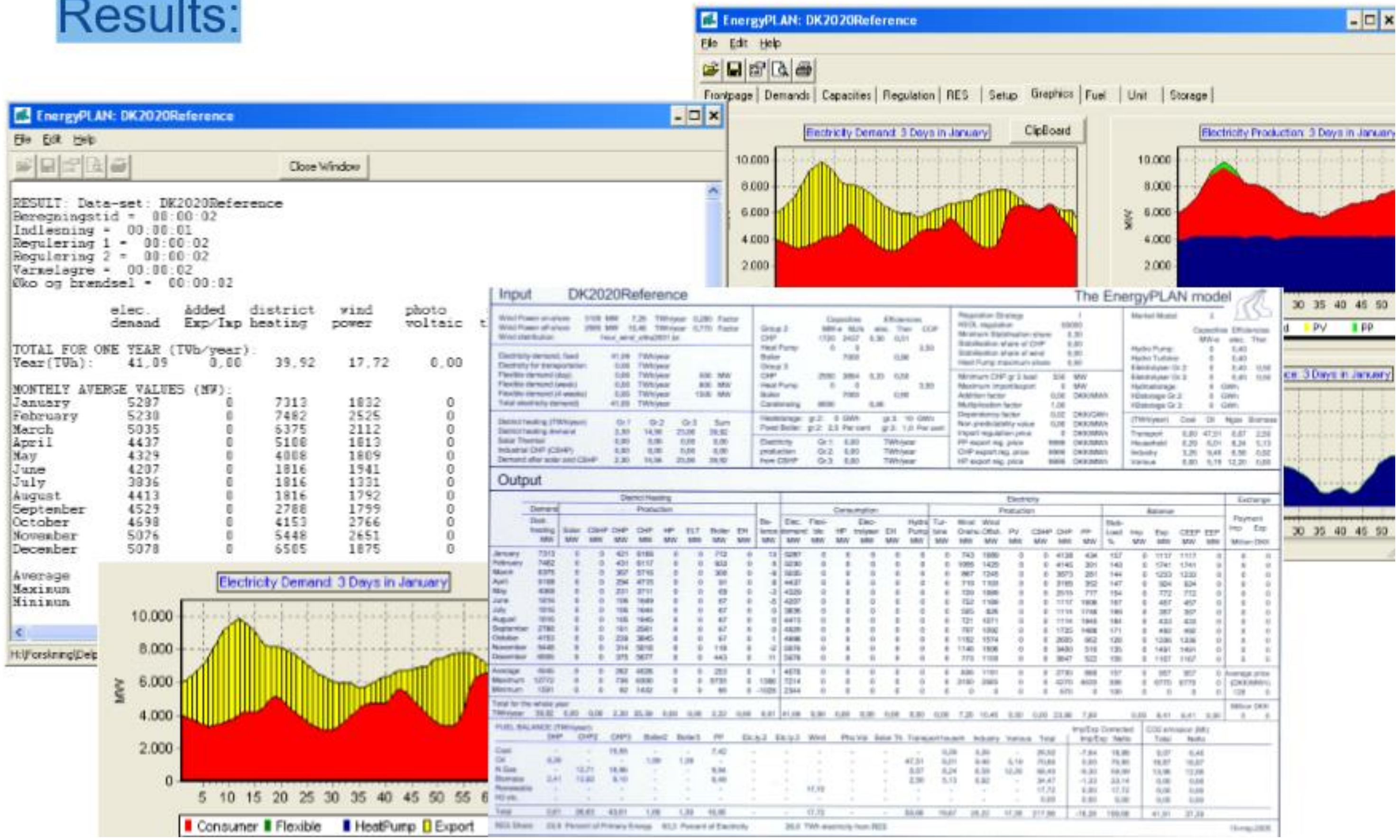
Technical and Market Simulations

The Market economic simulation strategy is based on a short-term marginal price market model similar to the NordPOOL market design, so it focuses solely on bids to the electricity market while minimizing short-term electricity consumer costs and minimizing short-term district heating costs. As a result, this simulation strategy only uses variable costs and does not optimise based on the long-term costs of different energy supply technologies. Furthermore, it only optimises the supply side of the energy system, and not the demand side (although the user can manually change the demand and analyse the resulting impact of a market economic simulation). While mathematically it is possible using the price elasticity feature in EnergyPLAN to simulate 100% renewable energy scenarios using this current market design, represented by the market economic simulation, this may not accurately represent how future energy supply and demand markets should be designed. Today's markets are primarily designed for dispatchable plants, whereas 100% renewable energy systems will most likely depend on very high levels of non-dispatchable renewable energy. Therefore, using the technical simulation strategy is typically more accurate at simulating energy systems with very large penetrations of intermittent renewable energy, which in combination with the cost data for the technologies, makes it possible for the user to identify least cost solutions over their total lifetime.

EnergyPLAN

Step 4: RESULTS

Results:



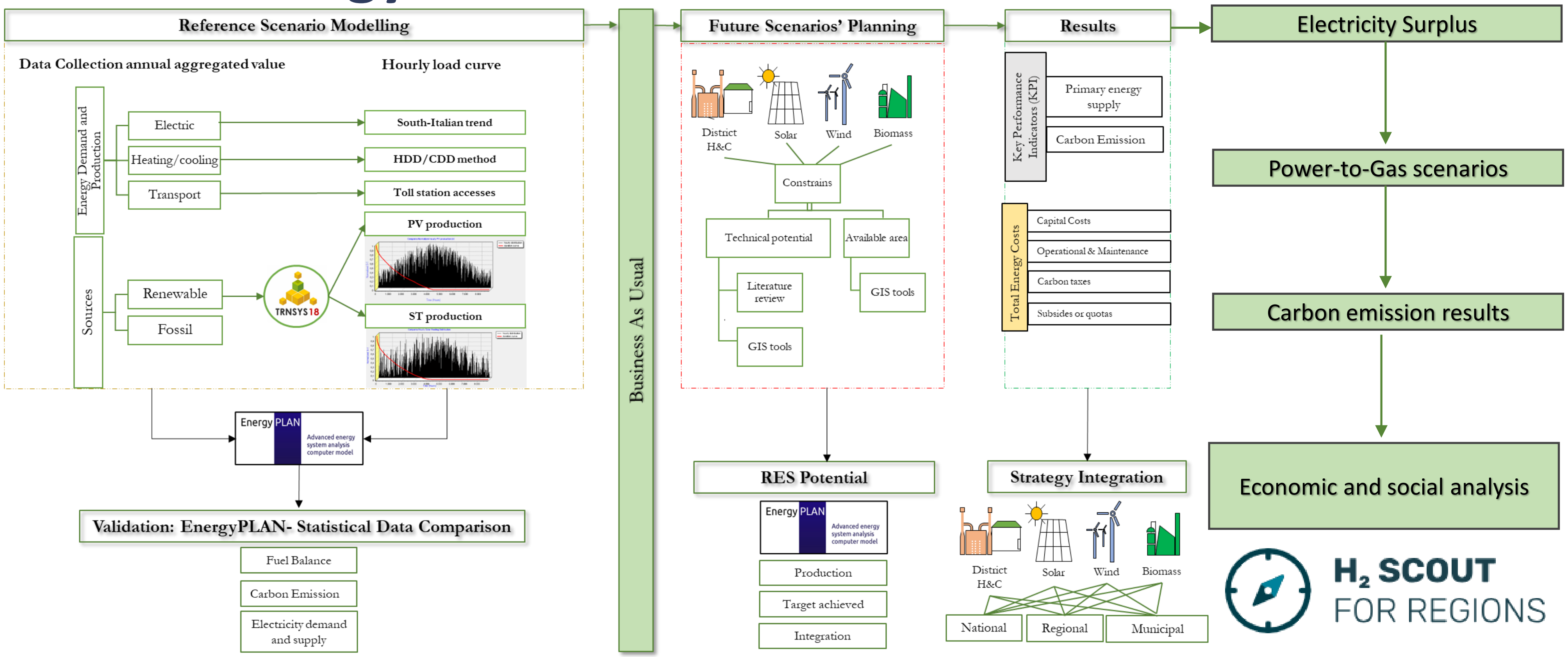
EnergyPLAN

Next step….

Try yourself…!!!

Campania case study

Methodology: scheme



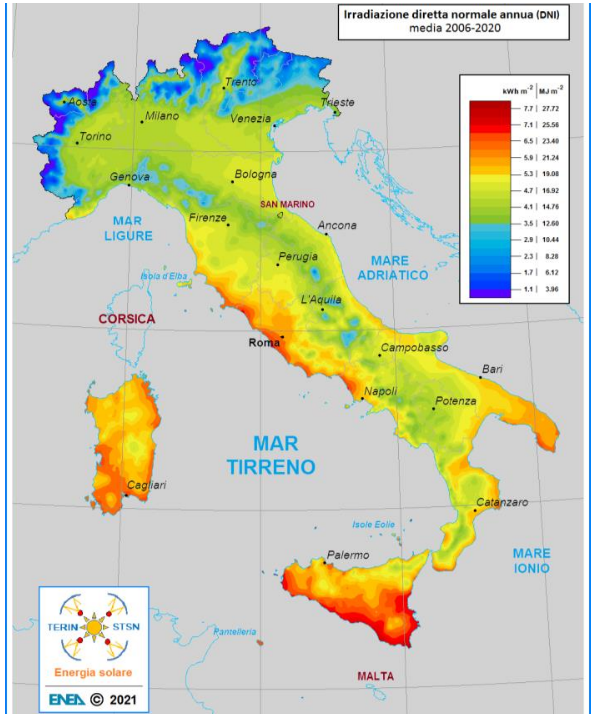
V. Battaglia, G. De Luca, S. Fabozzi, H. Lund, and L. Vanoli, "Integrated energy planning to meet 2050 European targets: A Southern Italian region case study," Energy Strateg. Rev., vol. 41, no. March, p. 100844, 202210.1016/j.esr.2022.100844.

Methodology: RES potential evaluation

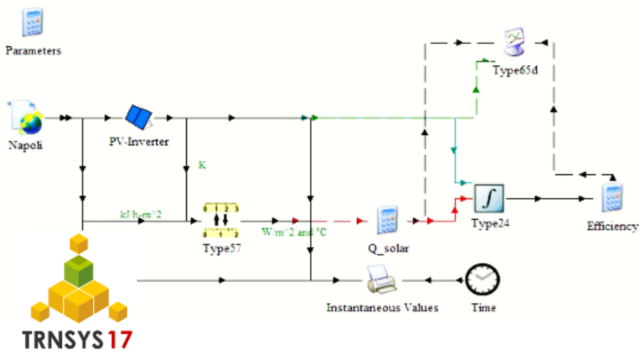
RES potential evaluation

- RES penetration constrains
  - Technical potential in the area
    - Literature review
    - GIS tools
  - Available area
    - GIS tools

PV potential



QGIS

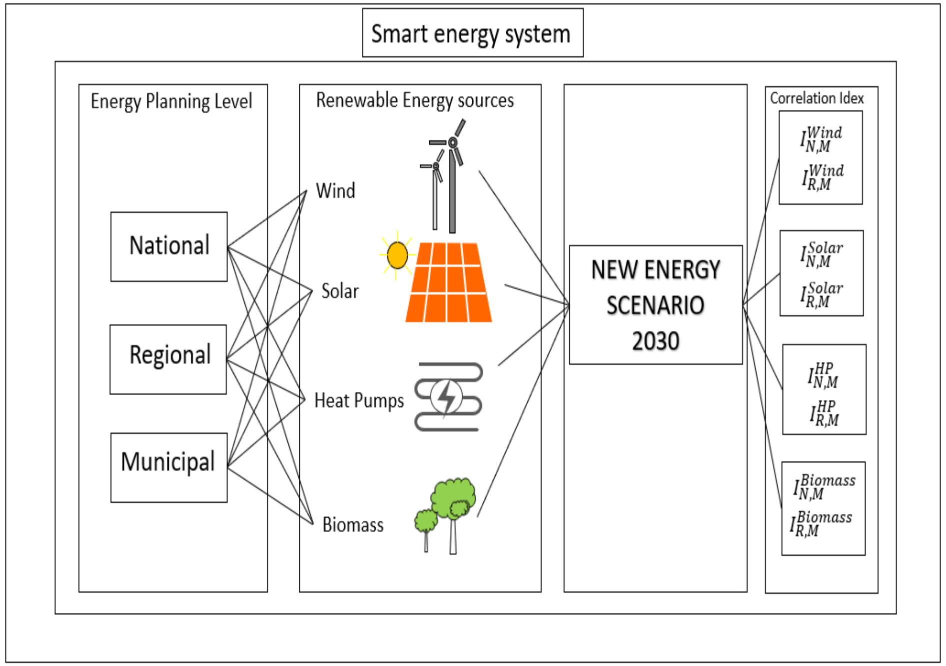


Methodology: coherence analysis

Coherence analisys

Definition parameters for multi-scale comparison through potential indexes

Coherence analysis among different-scales energy plans



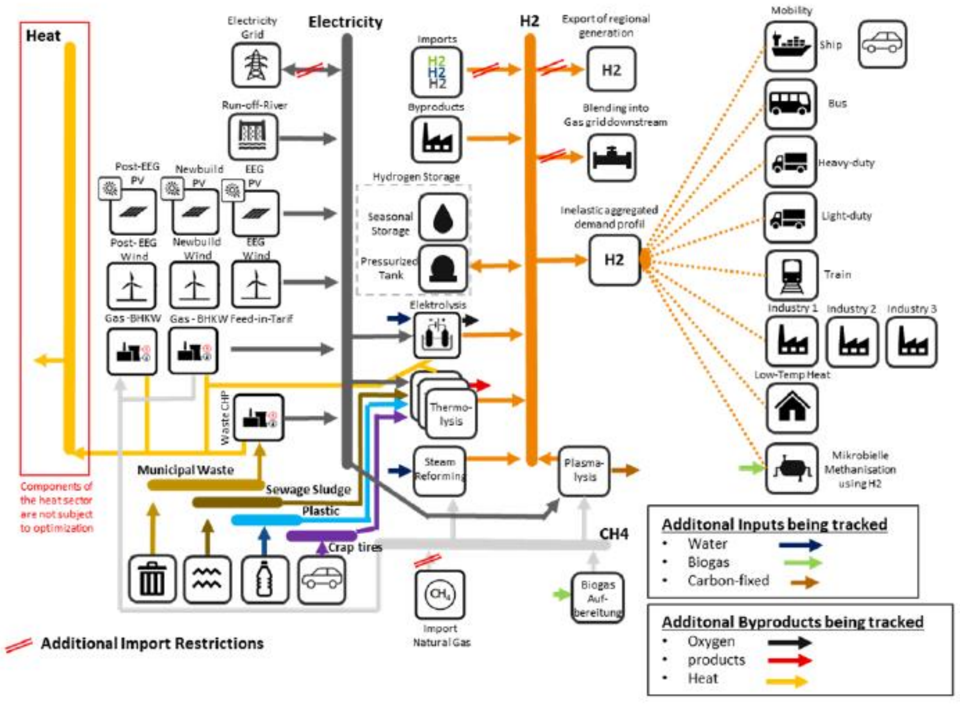
$$I_{solar} = \frac{Global\ yearly\ irradiation\ * Surface\ for\ PV\ installation}{Inhabitant}$$

$$I_{wind} = \frac{Producibility\ at\ 100\ m\ * Area\ for\ capacity\ installed * Agricoltural\ Area}{Total\ surface}$$

$$I_{biomass} = \frac{Biomass\ energy\ potential}{Total\ UAA}$$

Methodology: optimization

H_2 SCOUT
FOR REGIONS



Optimization of hydrogen value chain

USER INPUT

- Hydrogen production process and storage
- Available resources
- annual demand per sector
- Export/import
- Electricity and fuel price/taxes

OUTPUT

- Energy and mass balances
- Optimized capacities of transformation plants
- Key performance indices
- Costs and Revenues

SOFTWARE PROPERTIES

- Hourly resolution
- Dataset for CAPEX and OPEX

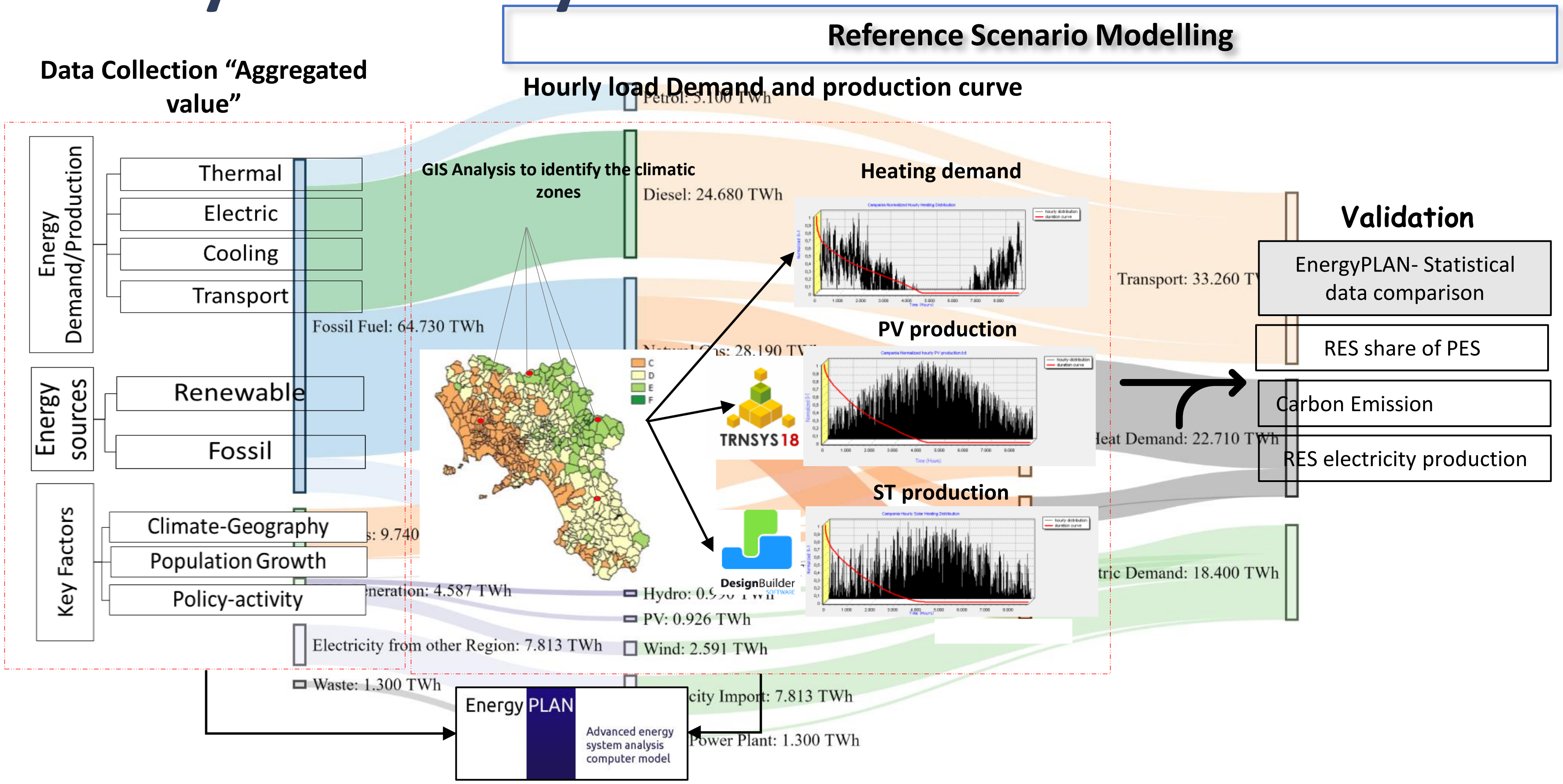
Campania case study: baseline year

2030 Target

40% reduction in the CO_2 emissions of Campania by 2030 compared to the 1990 levels

2050 Target

80% reduction in the CO_2 emissions of Campania by 2050 compared to the 1990 levels



Campania case study: 2030 scenario

BAU future scenario

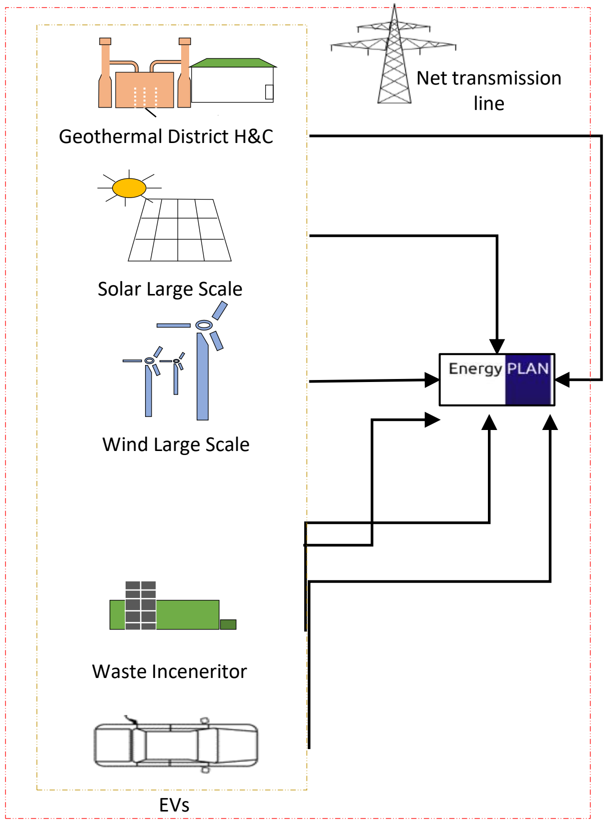
Future scenarios' Planning

DEMAND

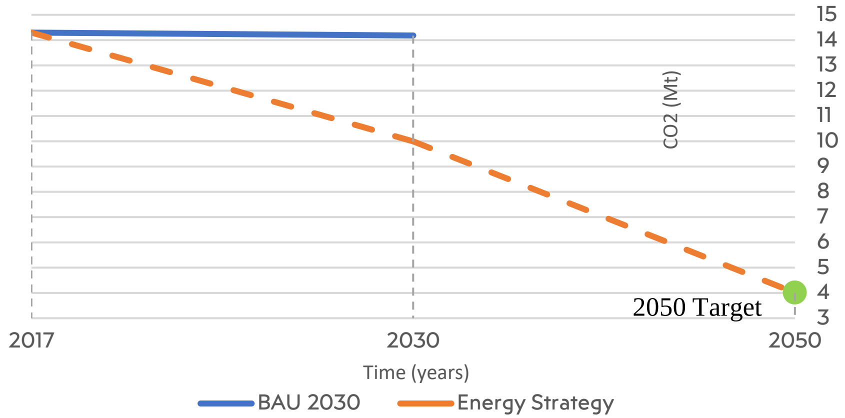
- Electrification of the transport sector in smart charge
- Heating and cooling demand variation
- Industrial production

BAU ACTIONS

- Reduced traditional PP capacity with the addition of combined heat and power CHP plants
- A potential expansion of the wind and solar energy is envisioned

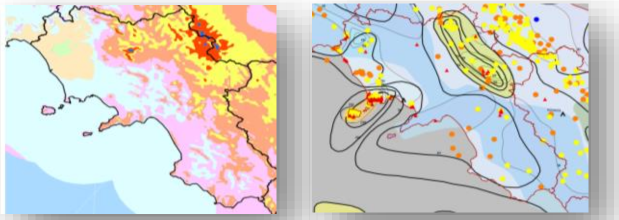


2030 BAU Results



New actions

- Multi-Level District Heating (MLDH) system



Campania case study: 2050 scenario

BAU future scenario

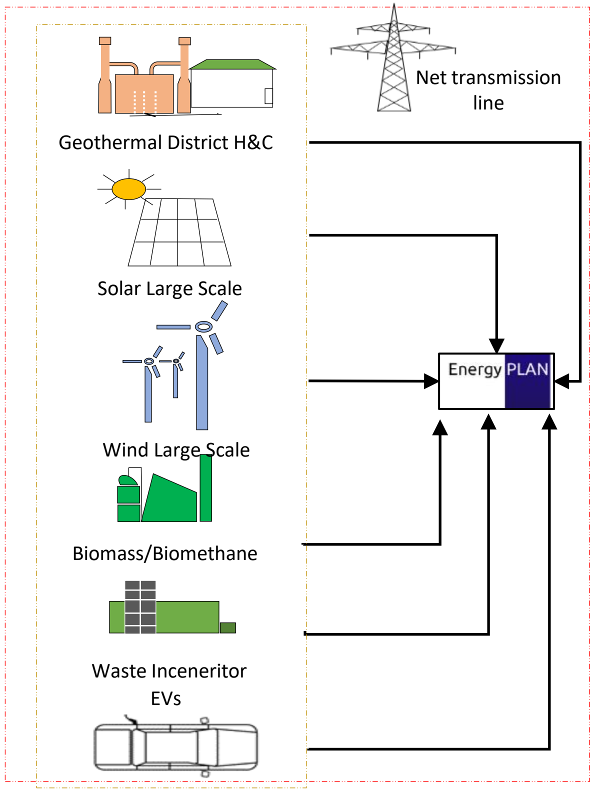
Future scenarios' Planning

DEMAND

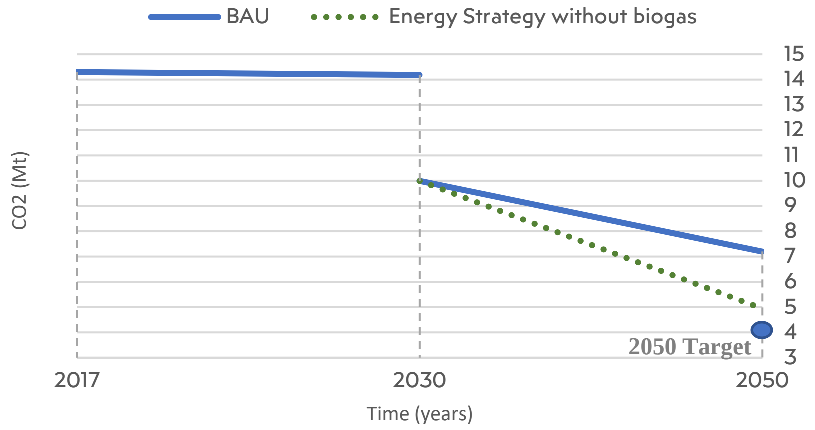
- Further electrification of the transport sector
- Heating and cooling demand variation
- Industrial production

BAU ACTIONS

- DHC powered by CHP plants fueled by natural gas and RES, geothermal energy from compression heat pumps and for absorption machines, solar thermal collectors, and biomass
- Increase wind and PV installed capacity

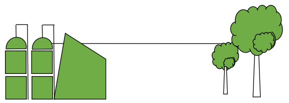


2050 BAU Results

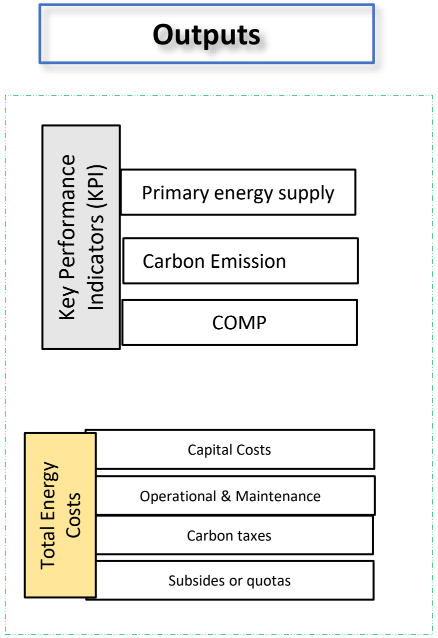


New actions

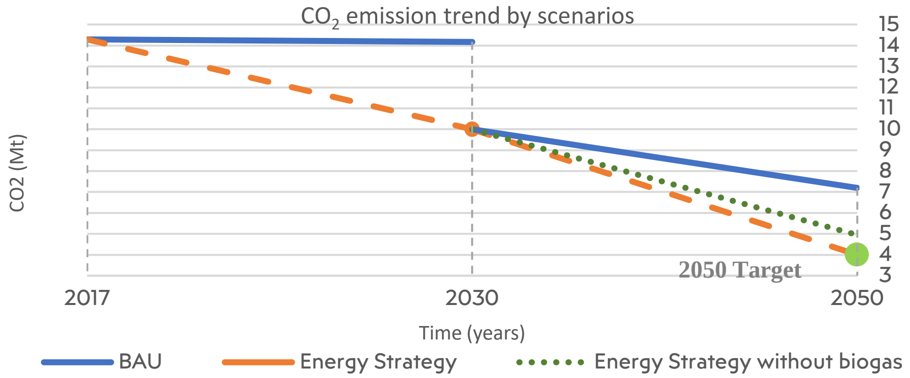
- Biomethane production

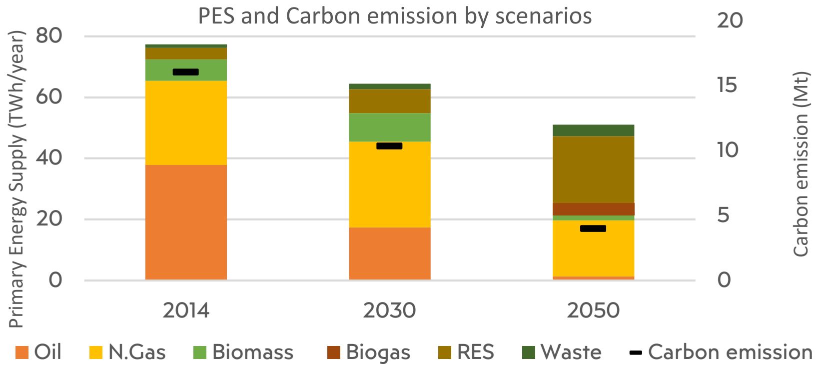


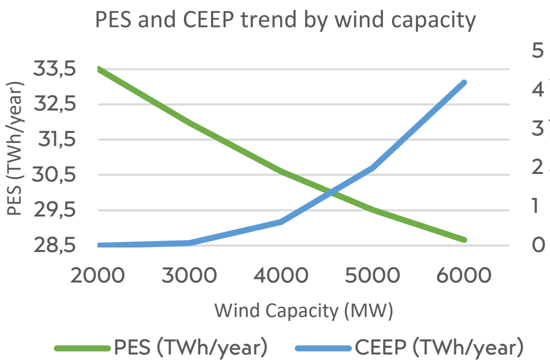
Campania case study: results

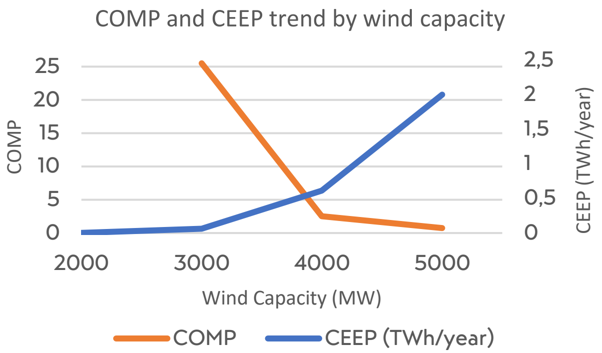


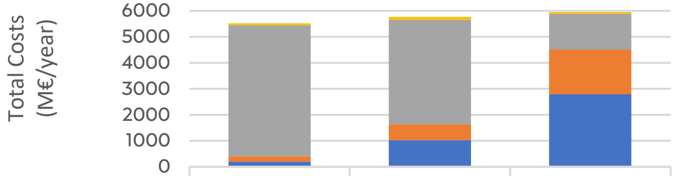
$$COMP = \frac{\Delta PES}{\Delta CEEP}$$







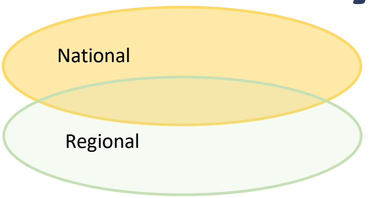


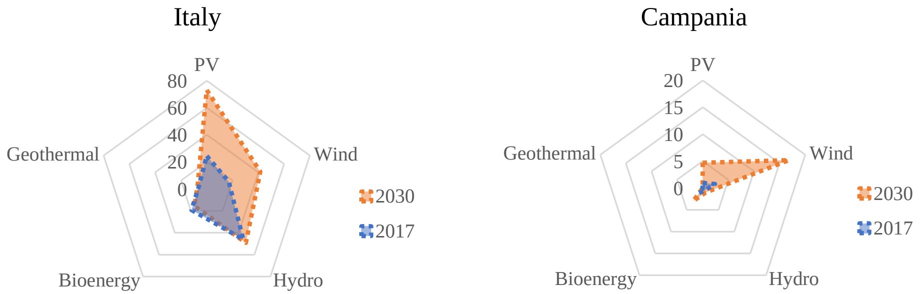


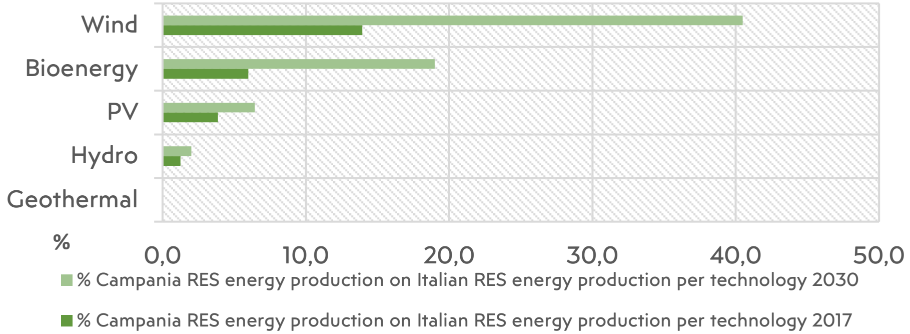
	2014	2030	2050
CO2 emission costs	79	111	66
Fuel	5042	4018	1380
Fixed O&M	208	617	1718,2
Investment	197	1019,7	2789,2

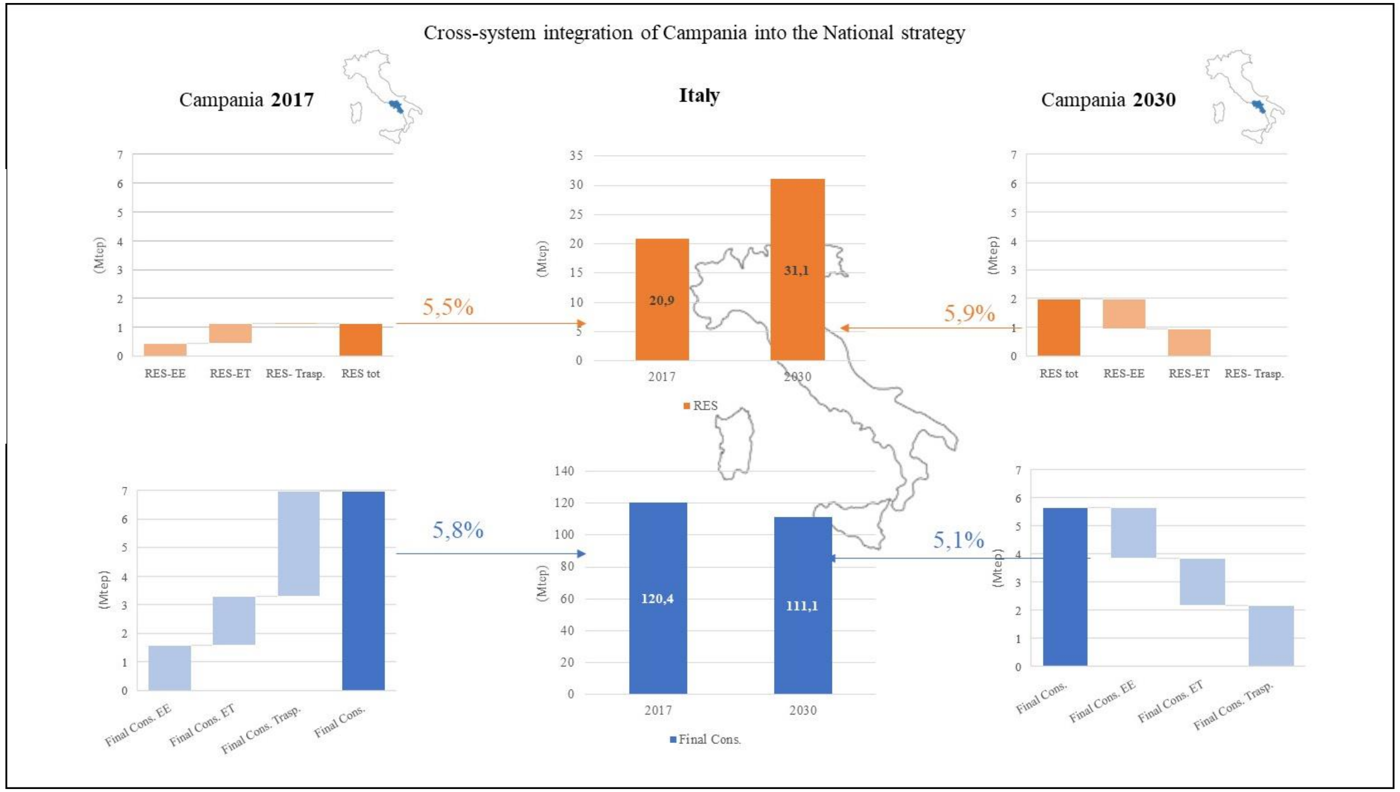
Campania case study: results

Cross-system Integration into the National Energy System



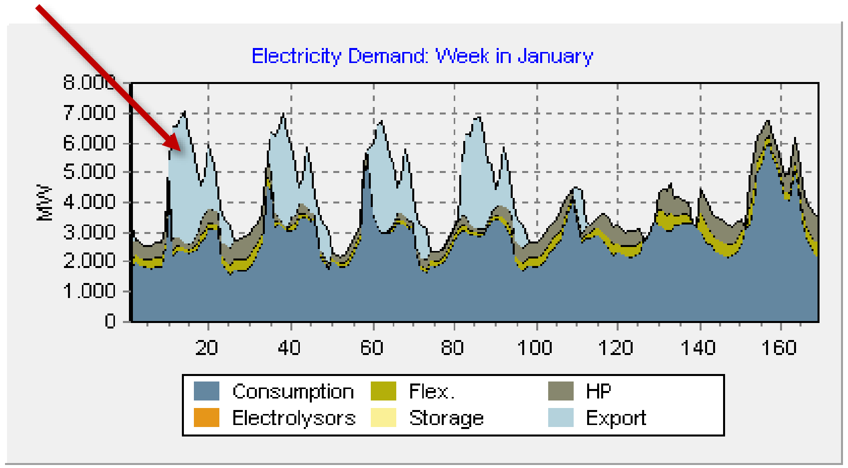




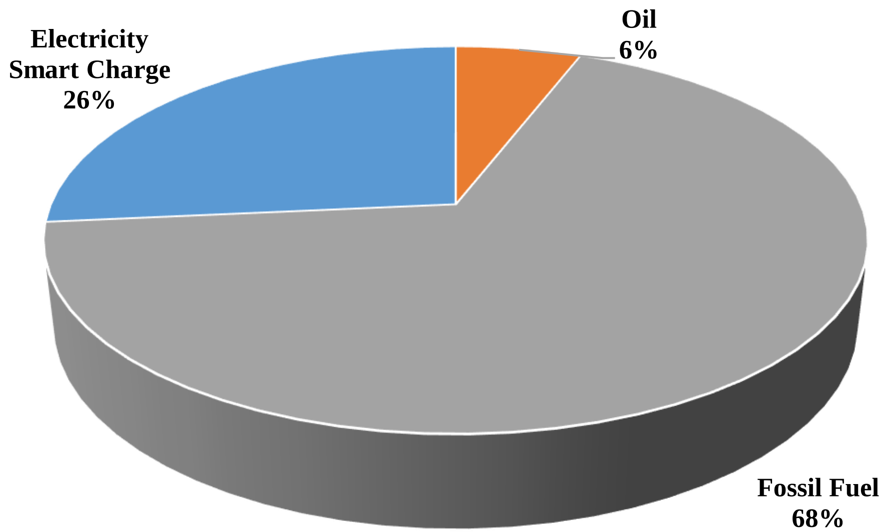


Power to Gas: Campania case study

Surplus without hydrogen



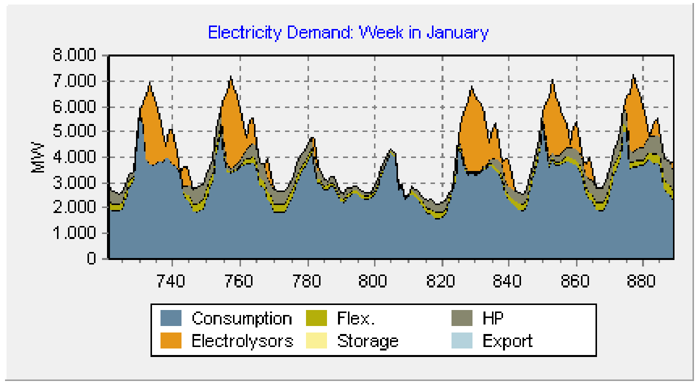
Mobility share scenario 2050 (export of surplus electricity)



- Use of the critical excess of electricity production (2.4 TWh) to supply electrolyzers
- Mobility sector is still relying mainly on fossil fuels

Power to Gas: Campania case study

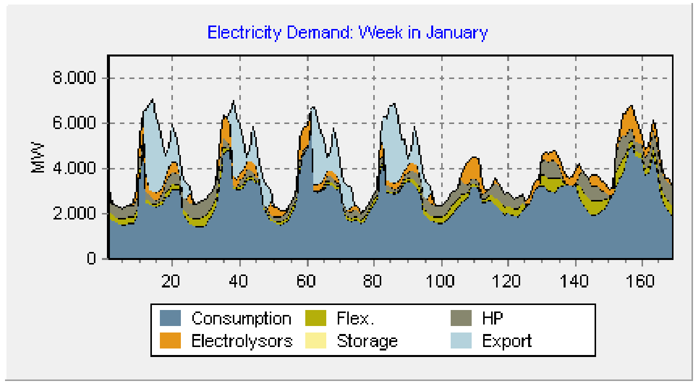
Scenario I



H_2 demand trend equal to the surplus one
Total abatement of surplus

10% share of transport sector
84% CO_2 emission reduction
Electrolyzer capacity of around 5 GW

Scenario II



Hydrogen demand based on traffic survey
10% share of transport sector

47% abatement of surplus
81% CO_2 emission reduction
Minimum electrolyzer capacity of 1,3 GW

Power to Gas: Campania case study

Assumptions

- Green hydrogen only scenario, using the new installed technology (scenario 2050)
- Hydrogen production with alkaline electrolysers (efficiency= 51,2 $kWh_{el}/kg\ H_2$, or 65%)
- Hydrogen is used in mobility, replacing fossil fuels
- Export reduction

Power to Gas: Campania case study

Parameters	Value
Hydrogen demand (kt/y)	47
Electric energy (GWh/y)	2412

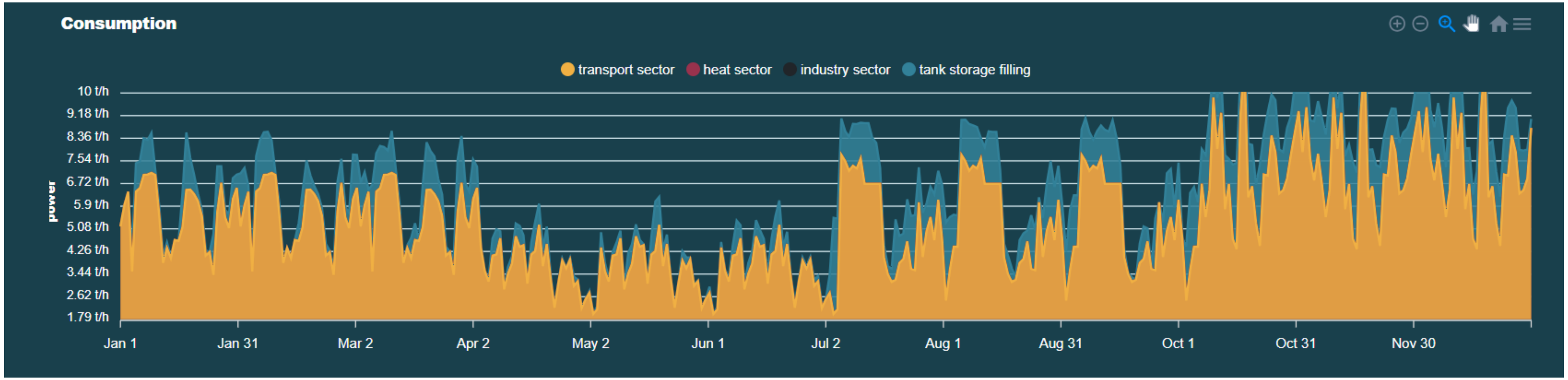
→ **Validated against EnergyPLAN results**

Parameters	Value
CO_{2eq} (kt/y) due to wind power factor emission	28
Specific emission factor (CO_{2eq} kg/H_2kg)	0.46
CO_2 emissions reduction (%)	97

Power to Gas: Campania case study

Parameters	Capacity Value	Investment costs (M€)
Electrolyzers (t/h)	8,61	270
Storage tank (t)	195	530
Wind (MW)	544	743

KPI	Capacity Value
Hydrogen supply costs (€/kg)	3,21
Pay back (y)	5



Power to Gas: Campania case study

- There is room for further emission reductions and a means to utilize surplus electricity generated by RES
- Customized dataset for Campania region
- Different types of conversion technologies and the production of electrofuels

Thank you!