Capacity Building Programme (CBP)

Module 2 “Integrated Energy Planning”

Ali Hainoun, Daniel Horak, Basak Falay, Sebastian Stortecky, Shokufeh Zamini (AIT)

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.
This project has received funding from the LIFE programme of the European Union under grant agreement No 101081061.

Content

1 Introduction to Energy Planning

- Role of energy system for the socio-economic development
- From energy sources to energy services
- Sustainable energy development
- implications of energy system
- Steps of integrated energy planning

Capacity Building for Energy Planning

AUSTRIAN INSTITUTE OF TECHNOLOGY

Aim:
strengthen individual and organisational skills and knowledge in energy planning process through:

Information dissemination & stakeholder involvement

Analytical tools and data analysis

Energy and policy analysis to prepare energy studies

Supporting decision making-process to formulate sustainable energy strategy in respect to national/regional conditions.

Energy and Energy Services in Our Life

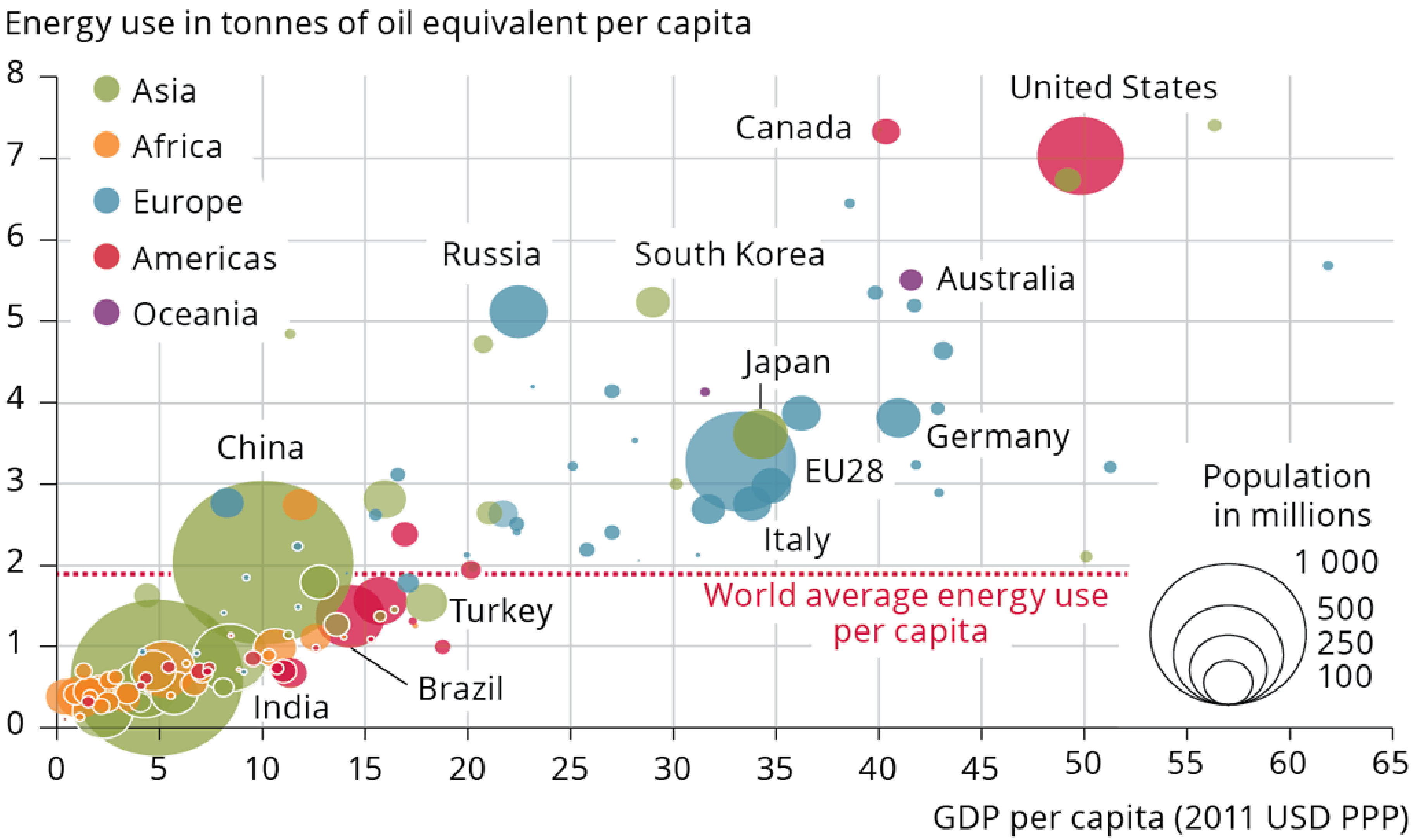
Energy is essential for meeting basic human needs and functioning of society.

It drives economic development, social progress and human well-being.

But…What we need are the **Energy Services** rather than the Energy Itself

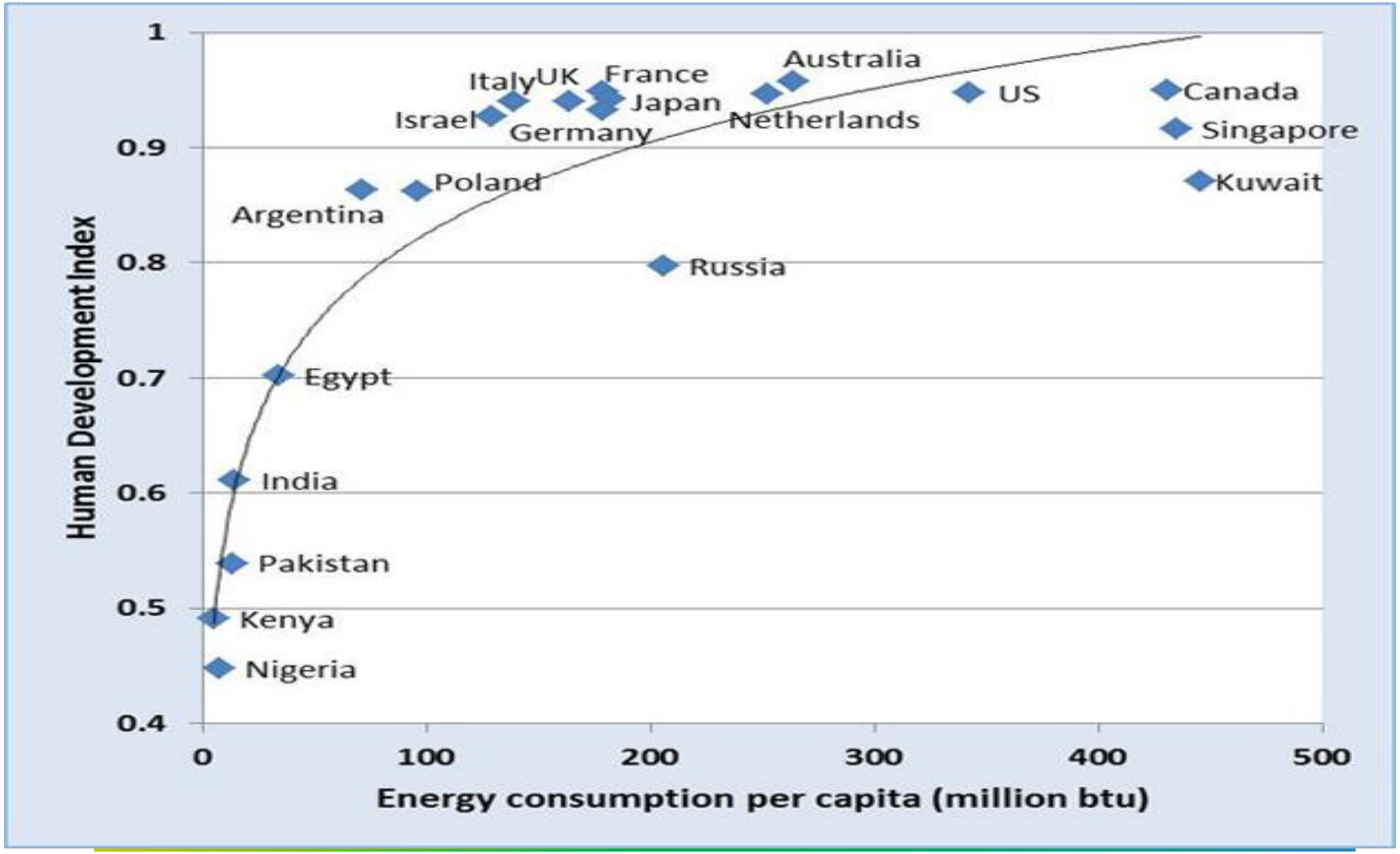
Access to modern energy services **changes** level and style of our Life.
<u>It provides:</u>
clean water, healthcare, reliable and efficient lighting, heating, cooking, mechanical power, transport and telecommunications services.

Energy Use and Income Linkage



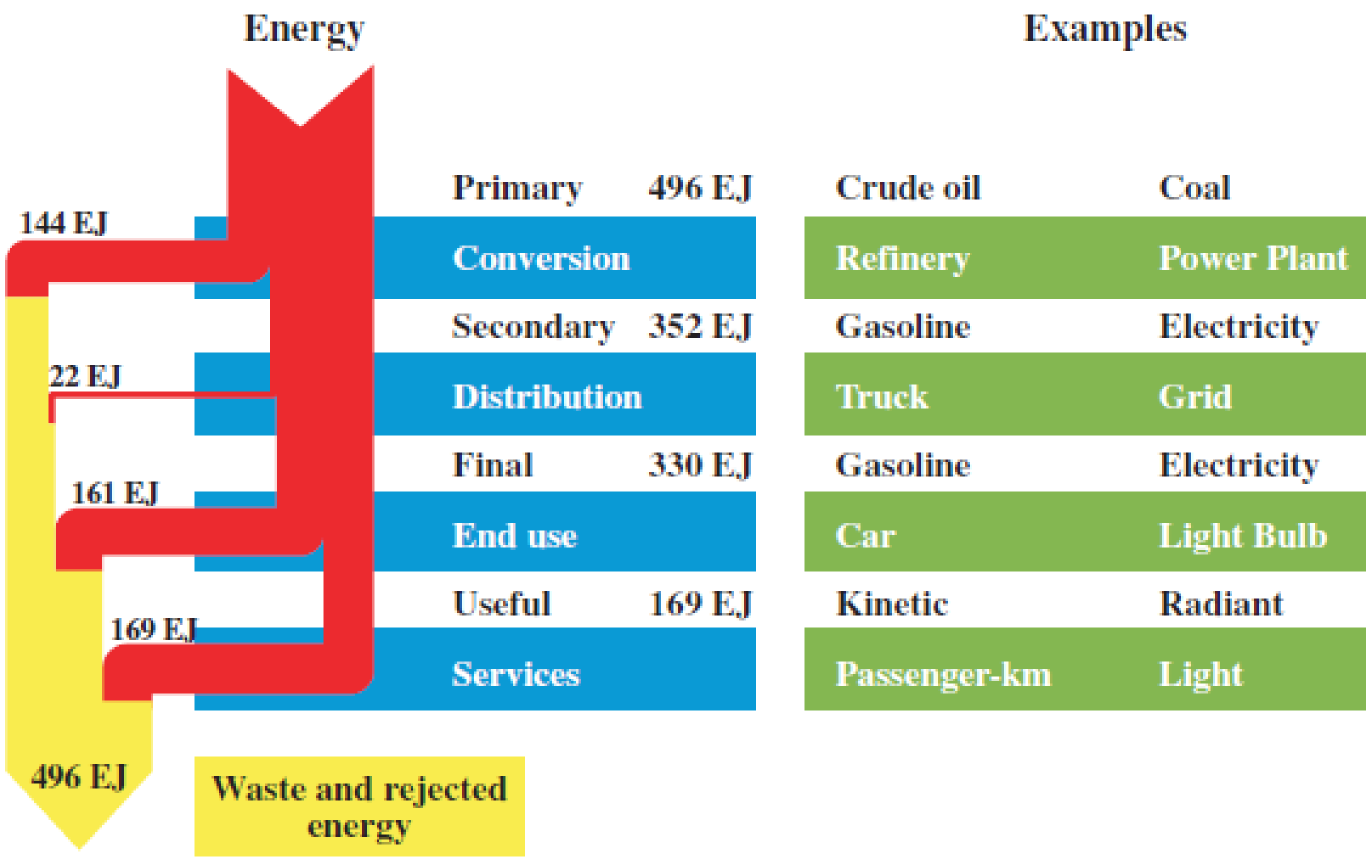
Source: EEA, 2015
https://www.eea.europa.eu/data-and-maps/figures/correlation-of-per-capita-energy

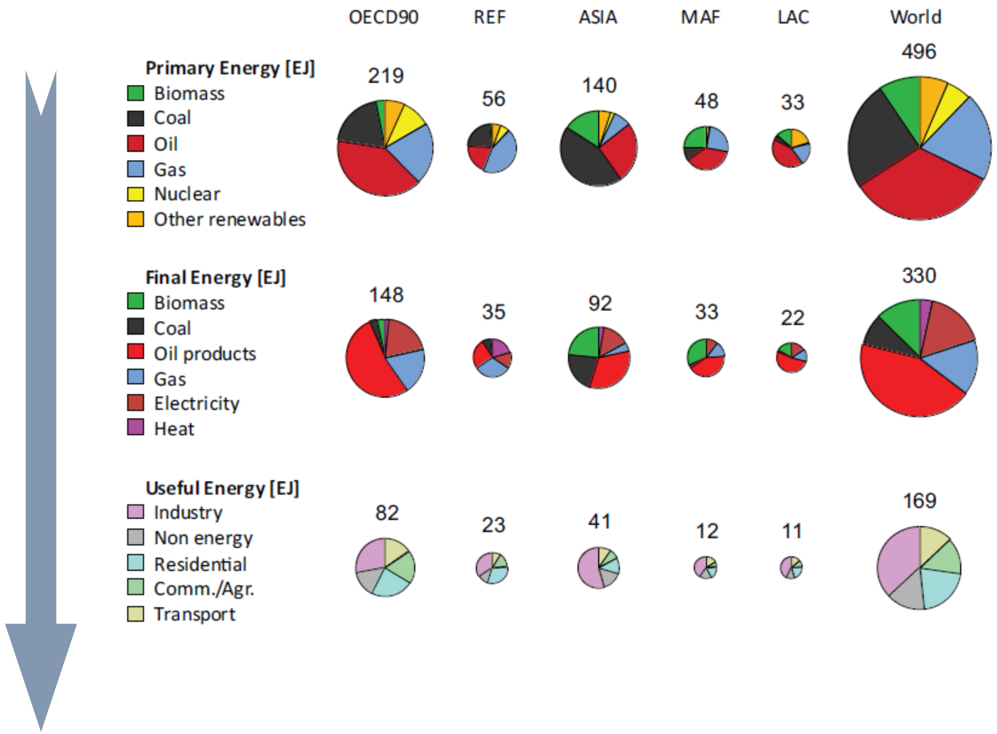
Energy and Human Development



Energy conversion and losses

-Overall energy system efficiency-





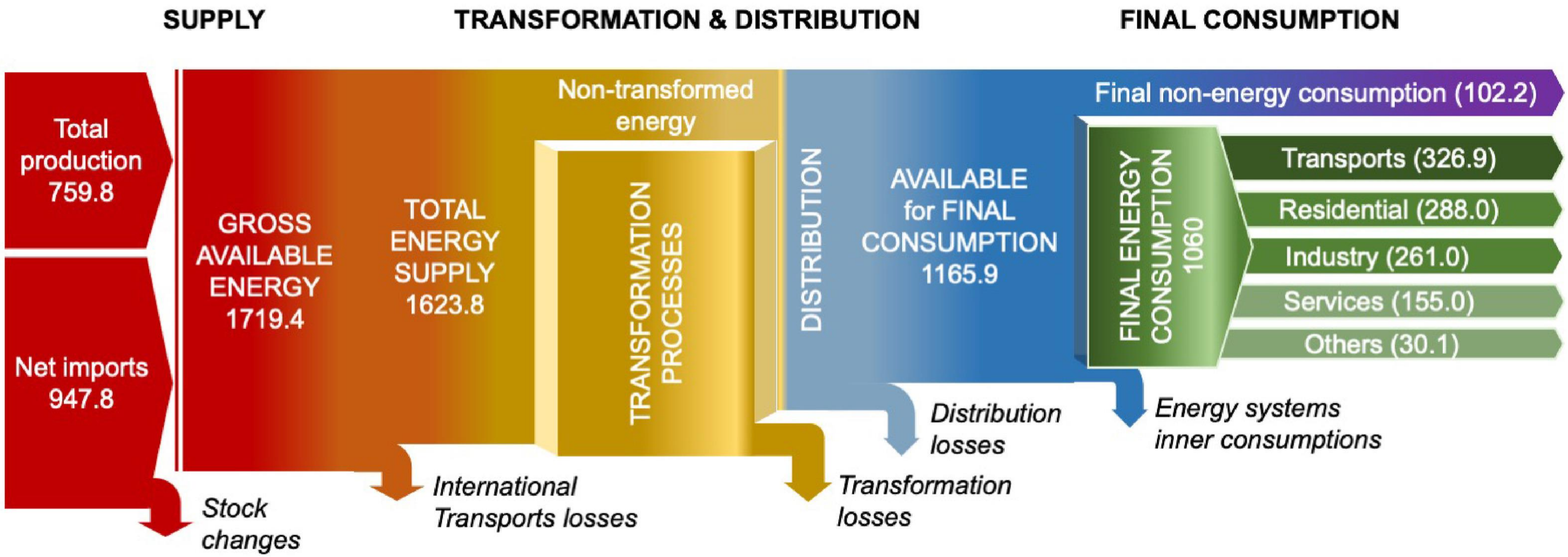
- Total energy losses account to 66%
- Only 34% reach directly the end-user

World energy use: primary energy (by fuel), final energy (by energy carrier), and useful energy (by sector/type of energy service) for the world and five GEA regions for 2005 (in EJ).

Grubler A, Nakicenovic N, Pachauri S, Rogner H.-H, Smith KR, et al., 2014: Energy Primer. International Institute for Applied Systems Analysis, Laxenburg, Austria, pp. 1-118. https://iiasa.ac.at/projects/energy-primer

Energy Flow, EU, 2017 (Mtoe)

AUSTRIAN INSTITUTE OF TECHNOLOGY

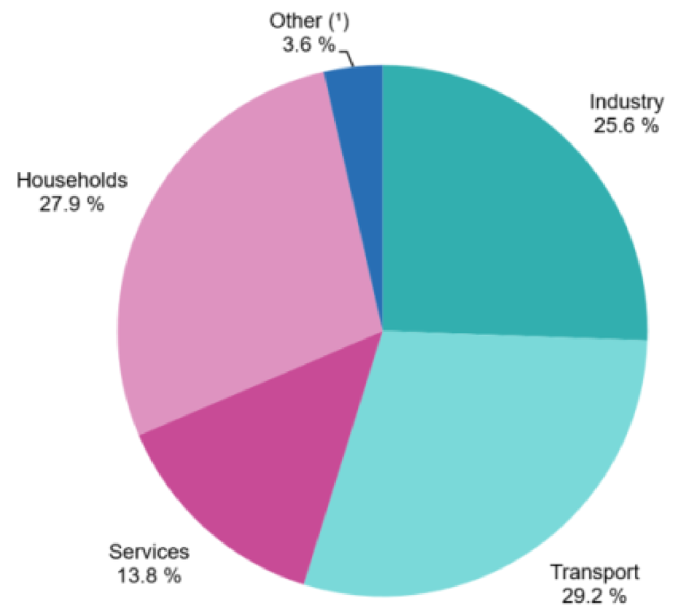


FE/PE = 68%

Source: https://doi.org/10.1016/j.energy.2022.124097

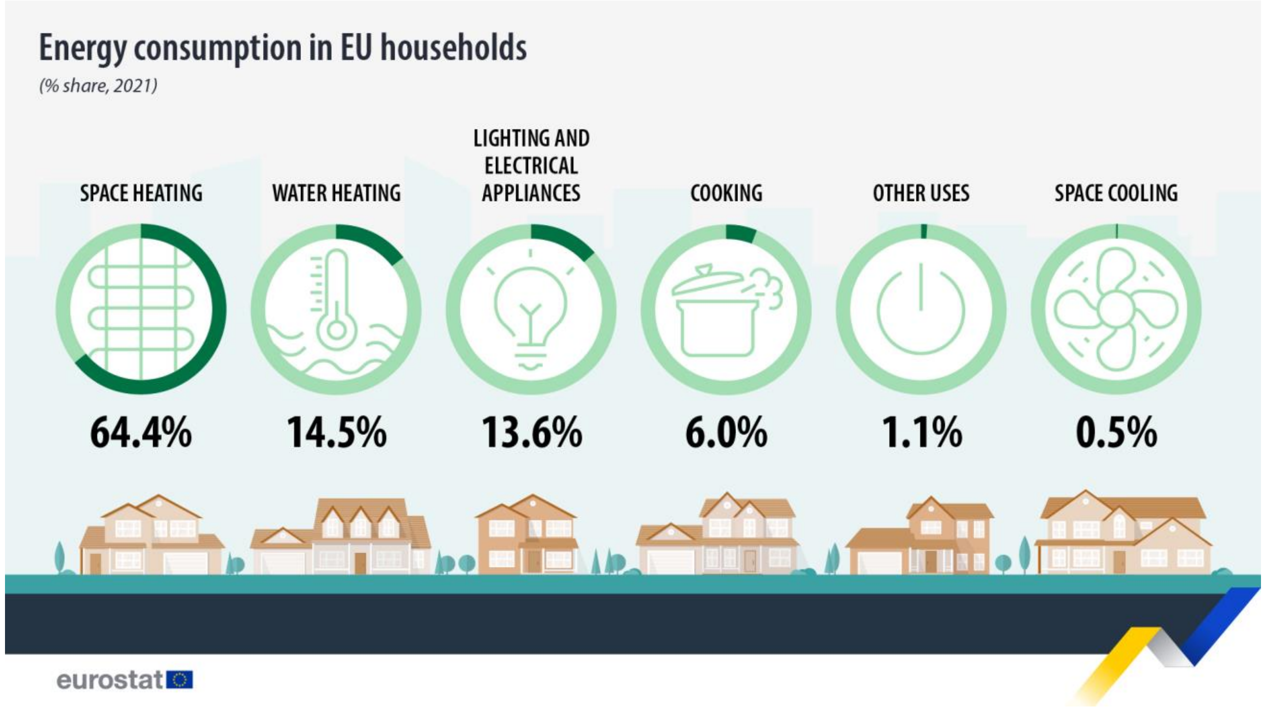
Energy consumption by sector, EU 2021

Final energy consumption by sector, EU, 2021
(% of total, based on terajoules)



(¹) International aviation and maritime bunkers are excluded from category Transport.
Source: Eurostat (online data code: nrg_bal_c)

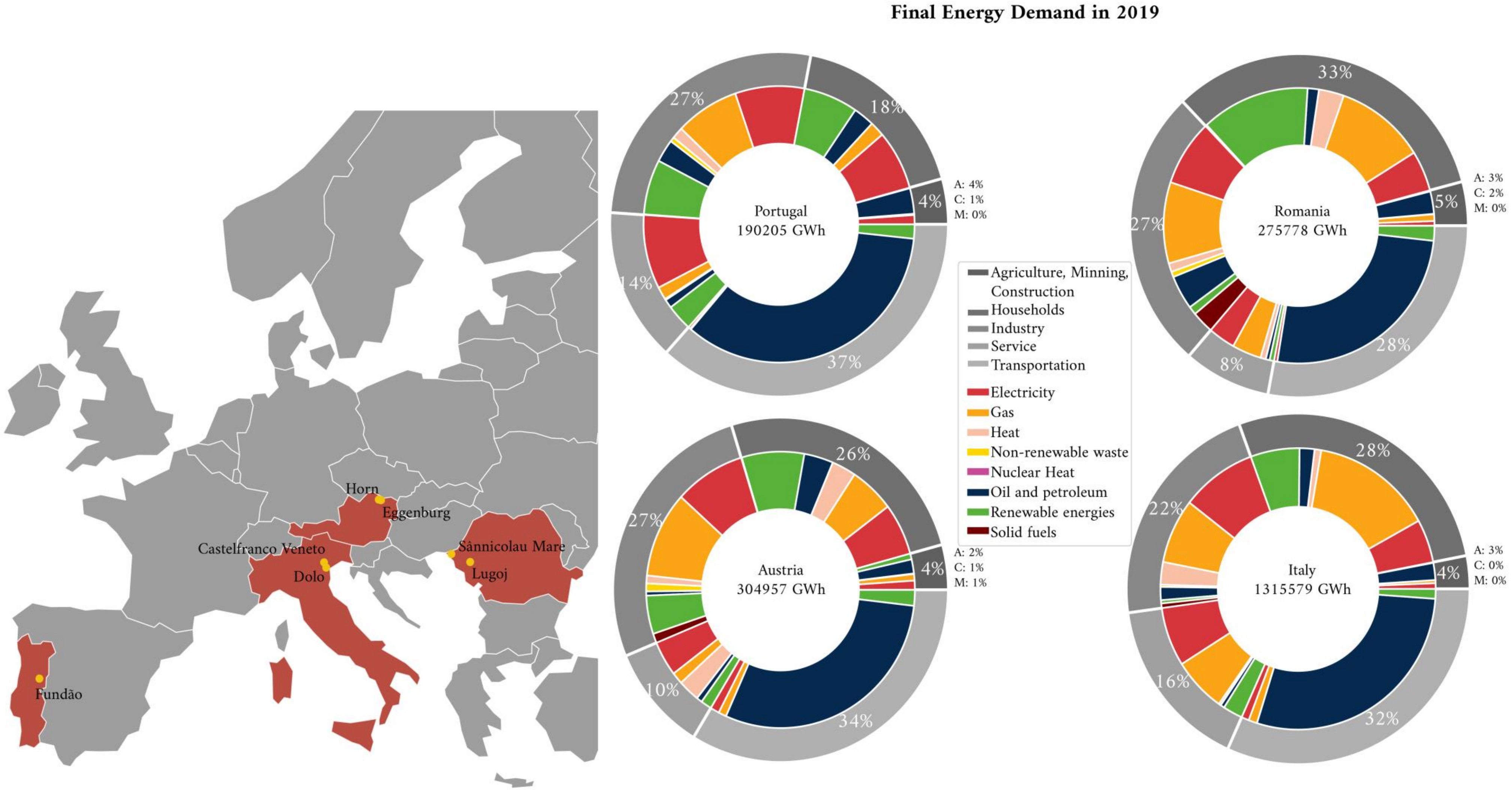
eurostat



Source: Eurostat

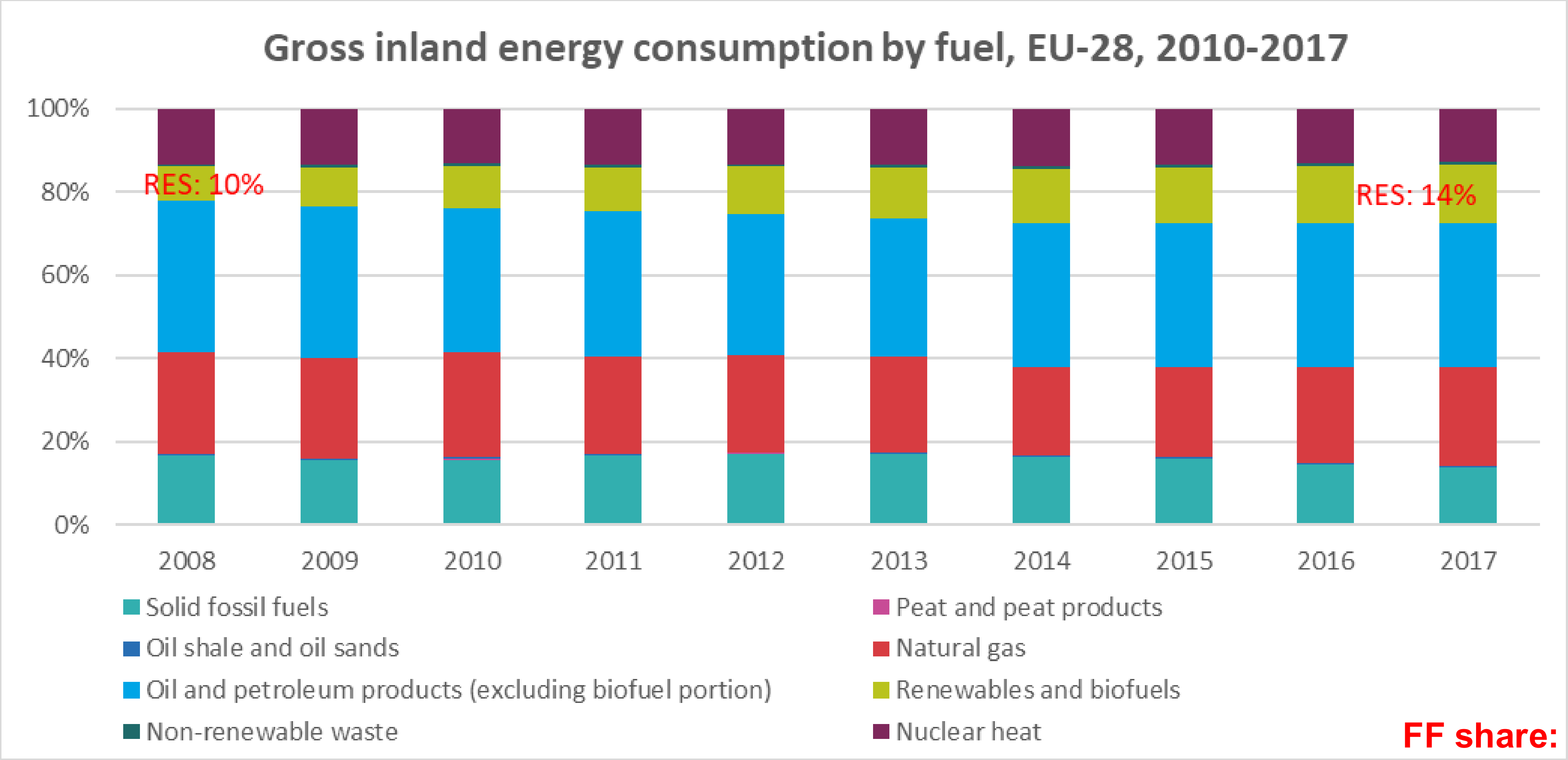
Countries of Pilot cities

-Final energy demand by sector and fuel 2019-



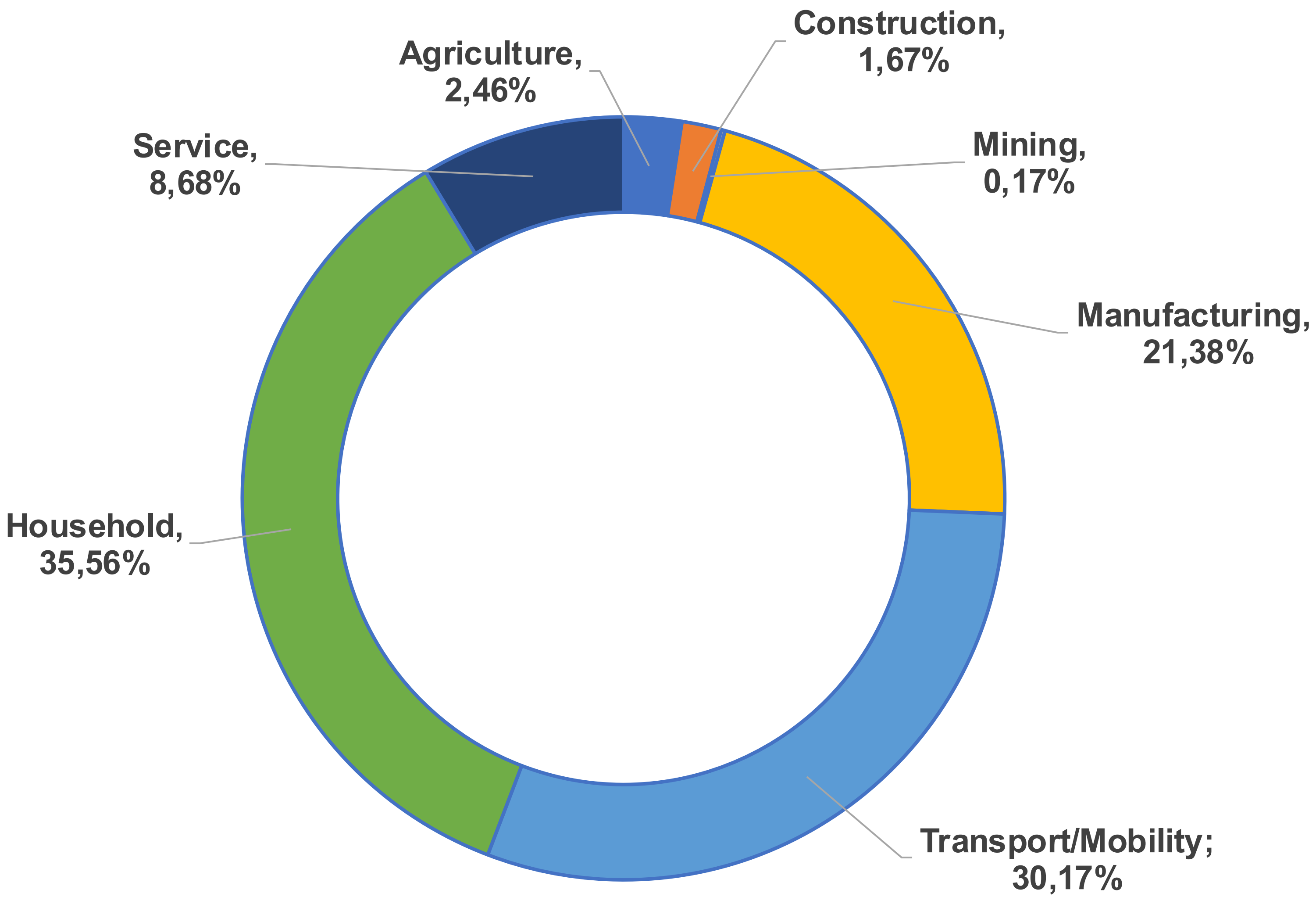
EU Energy consumption by fuel, 2017 (Mtoe)

AUSTRIAN INSTITUTE OF TECHNOLOGY



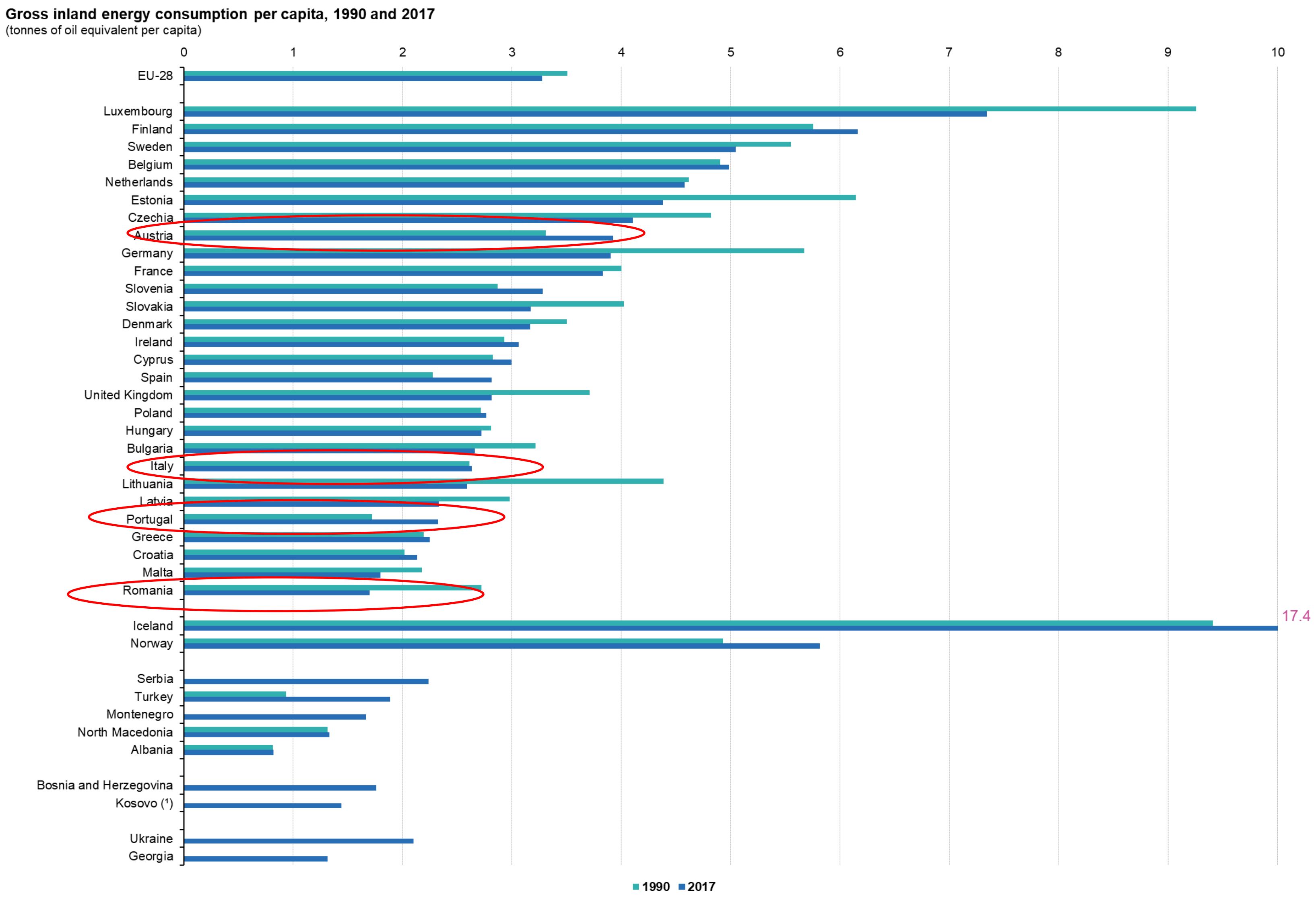
FF share: 76.7%-73.5%

Romania Final Energy Consumption by Sector, 2019
261.70 TWh



Per capita: 13.49 MWh

Gross Energy Consumption per Capita, EU 1990-2017

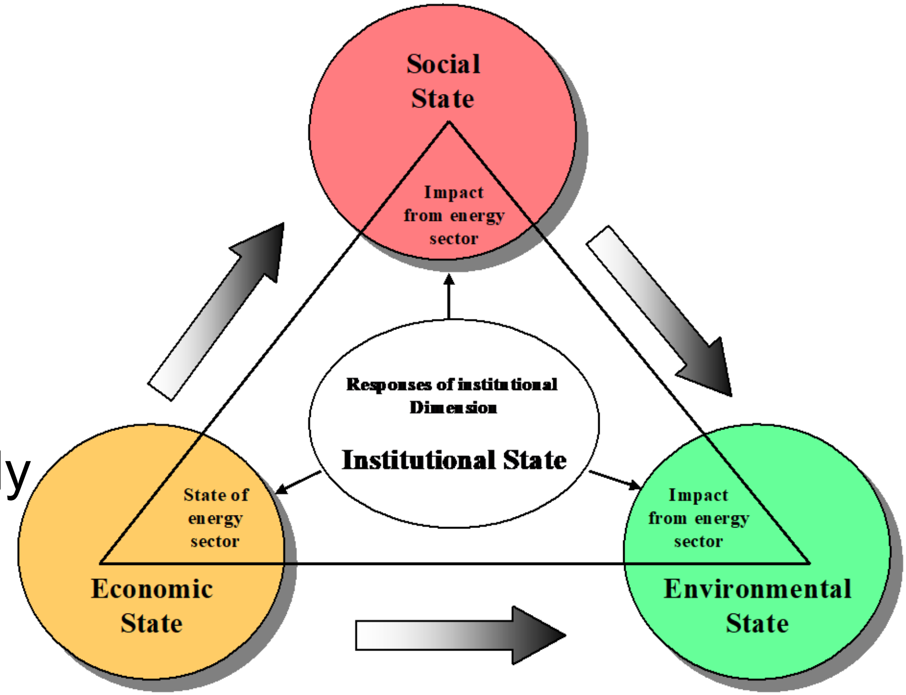


Source: Eurostat

Co-funded by the European Union

Sustainable Energy Development

- Economic dimension, Energy security- for net energy importers and exporters – including:
  - effective management of primary energy supply (domestic & external sources)
  - the reliability of energy infrastructure;
  - the ability of participating energy companies



- Social equity.
  - This concerns the accessibility & affordability of energy supply across the population.
- Environmental impact mitigation
  - This encompasses the achievement of supply- and demand-side of energy efficiencies and the development of energy supply from renewable and other low-carbon sources, while balancing environmental and social impacts.

SDGs: Sustainable Development Goals

AUSTRIAN INSTITUTE OF TECHNOLOGY

Adopted by the UN Sustainable Development Summit on 25-27 September 2015, New York that was convened as a high-level plenary meeting of the General Assembly

Sustainable Energy Development

GOAL 7

Ensure access to affordable, reliable, sustainable and modern energy for all

Targets	Main Indicators
Accessibility: Ensure universal access to affordable, reliable and modern energy services	• Share of population with electricity access • Percentage of population with primary reliance on non-solid fuels - rural energy services – modern transportation for all, – effective public trans. and traffic infrastructure
RES: Increase substantially the share of renewable energy in the global energy mix	• Renewable energy share in the total final energy consumption • Enable legislations and framework to promote penetration of renewables (by 2020)
EE: Double the rate of energy efficiency improvement	• primary energy intensity improvement • Energy efficiency by consumption sector

Compatibility of energy sources and technologies

AUSTRIAN INSTITUTE OF TECHNOLOGY

Economic and Financial Compatibility

- Energy services must be affordable. Their prices must cover the full cost to society, including external costs.
- If a technology, or the service provided by it, is not economically competitive – in a holistic sense – it is NOT sustainable.

Socio-political Compatibility

- Energy technologies must be acceptable to the general public. They should not defy the societal values.
- Transparency and easy access to information can be instrumental in influencing public perceptions and attitudes

Environmental Compatibility

- Each step of an energy system chain should have minimally disruption for nature's flows and equilibria. The environmental burdens should not overload the carrying capacity of ecosystems.
- Temporary environmental damage may be acceptable as long as restoration is feasible later on

Environmental Implications of Energy System

There is no energy technology without risks, wastes or interaction with the environment

- **Fossil fuel:** CO_2, SO_2, NO_x, Particulates, Liquid and solid wastes
- **Nuclear Energy:** Low & Medium Level Rad. Wastes, High Level Waste
- **Hydro:** Land submergence, water logging, seismic activity, flora & fauna, people displacement
- **Solar:** Toxic wastes from production of PV systems, land-use
- **Wind:** producing noise and causing visual pollution, impacting local wildlife (**b**irds and bats), located in remote area, need for fossil fuel for material production

GLOBAL
Greenhouse effect leading to global warming

REGIONAL
Acid rain, Hydro dam induced seismic activity, Oil spills in sea, Radioactive releases in a major nuclear accident

LOCAL
Urban smog, Land disruption, Deforestation, Radiation exposure

Integrated Energy Planning

-informing decision making-

AUSTRIAN INSTITUTE OF TECHNOLOGY

Providing decision-makers with information about actions to be implemented

Information

Strategies & plans

Implementation

Information gathering
- Data collection
- Survey
- Analysis
- Policies and regulations

informing decision makers
- Government agencies
- Cities authorities
- Energy companies
- Investors

Actions
- Projects
- Policies
- Further study

2 Energy and Climate Policy Framework

- Energy and Climate Policy
- Policy and Policy Instrume
- European Policy Instrum
- European Policy Instrur

Policy and Policy Instruments

AUSTRIAN INSTITUTE OF TECHNOLOGY

Policies can be seen as a set of principles and long-term goals that

- form the basis of making rules and guidelines, and to give overall direction to planning and development of a nation or other organization.
- build the foundation to develop strategies and action plans to achieve certain targets.

Policy instruments:

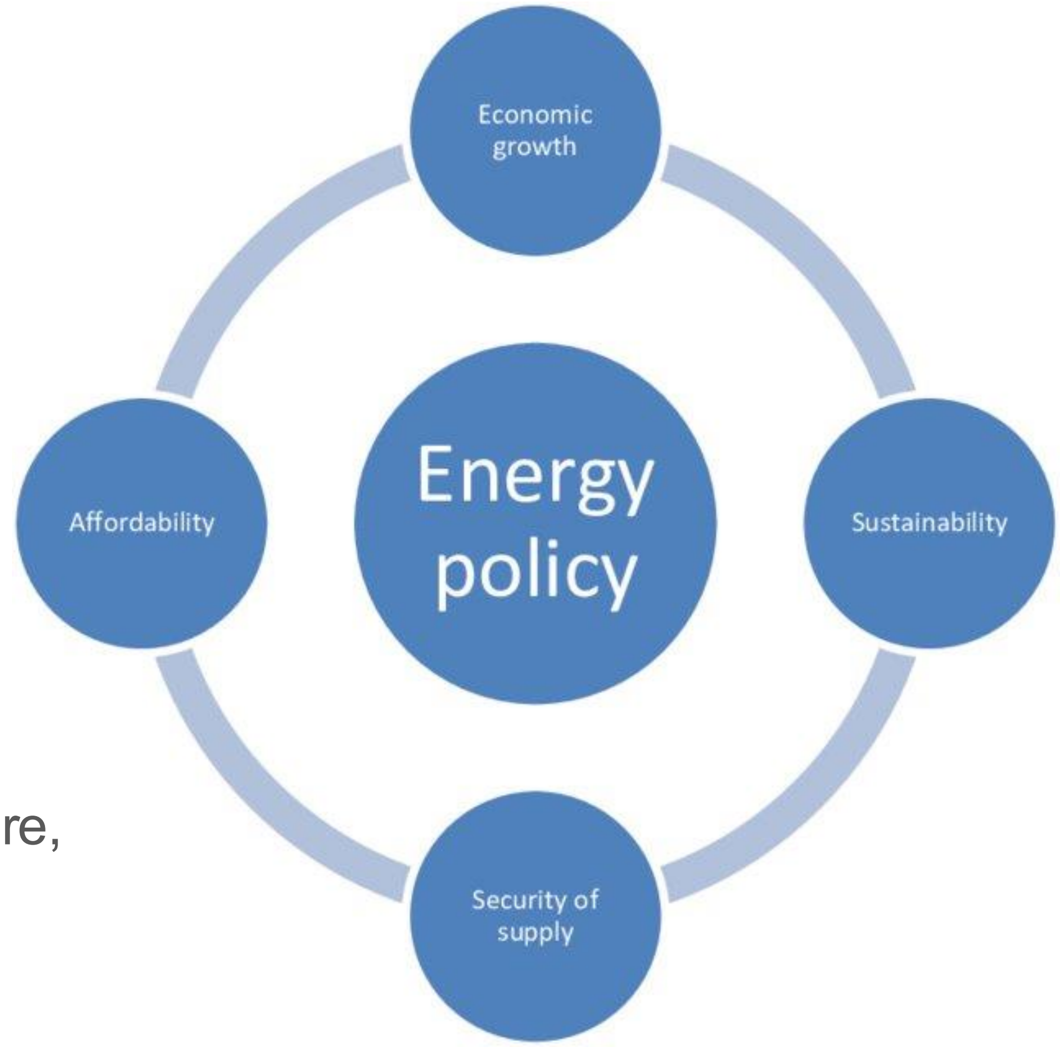
are interventions - measures and methods – applied by governments/decision makers to achieve a desired effect.

Main types of policy instruments are:

- Regulatory instruments: Legislation (laws), Licenses, (technical) Standards
- Economic instruments: taxation, price regulation, tariffs, subsidy, grant, penalties
- Information and communication: white papers, guidelines, Awareness campaigns, Public discourse, Propaganda, Lobbying, advertising

Energy and Climate Policy

Energy policy refers to a set of rules, regulations, and objectives issued by governments or organizations to provide a framework for how energy production, distribution, and consumption are conducted. The goal is to ensure security of supply and promote sustainable energy development in a socially affordable, economically viable, and environmentally sound manner



Energy policy aims at measures and corrective actions encompassing regulatory frameworks, incentives, infrastructure, technology development, international cooperation, etc.

European Energy Policy and Instruments

EU policies aim to deliver secure, sustainable and affordable energy for citizens and businesses

AUSTRIAN INSTITUTE OF TECHNOLOGY

Clean Energy for all Europeans package by 2030

*(**adopted** 2019, rev. 2023)*

- -40% GHG (compared to 1990 levels)
- 42.5% RES (share in energy consumption)
- 11.7% EE (FE reduction compared to Reference scenario projection)

https://energy.ec.europa.eu/index_en

Other energy policy targets

- Enhancing energy security
- Promoting energy market integration & power grid interconnection
- Diversification of supply, and
- Reforming the EU emissions trading scheme (ETS)

EU Climate Neutrality by 2050

EUROPEAN GREEN DEAL

1. Increasing climate ambition
2. Clean, affordable and secure energy
3. Industry for a clean and circual economy
4. Energy and resource efficient buildings
5. Sustainable and smart mobility
6. Farm to fork
7. Biodiversity and ecosystems
8. Zero-pollution, toxic-free environments

https://energica-h2020.eu/green-deal/

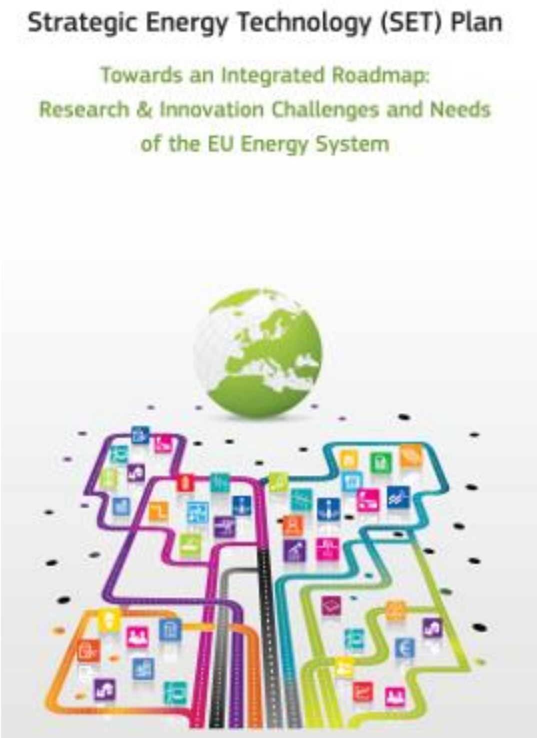
European Policy Instruments – The SET plan

- The **Strategic Energy Technologies Plan** (SET Plan), committed in 2008, set the framework for an EU energy technology policy.

The SET plan initiatives have a budget of € 71 billions:

- European Wind Initiative: focus on large turbines and large systems' demonstration (on and off-shore).
- Solar Europe Initiative: focus on large-scale demonstration for photovoltaics and solar power
- Bioenergy Europe Initiative focus on 'next generation' biofuels
- European CO2 capture and storage initiative: focus on proving zero emission fossil fuel power plants at industrial scale
- European electricity grid initiative: focus on smart grid systems, local power generation, transmission and storage

Sustainable nuclear fission initiative: focus on the development of Generation IV reactors



https://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan

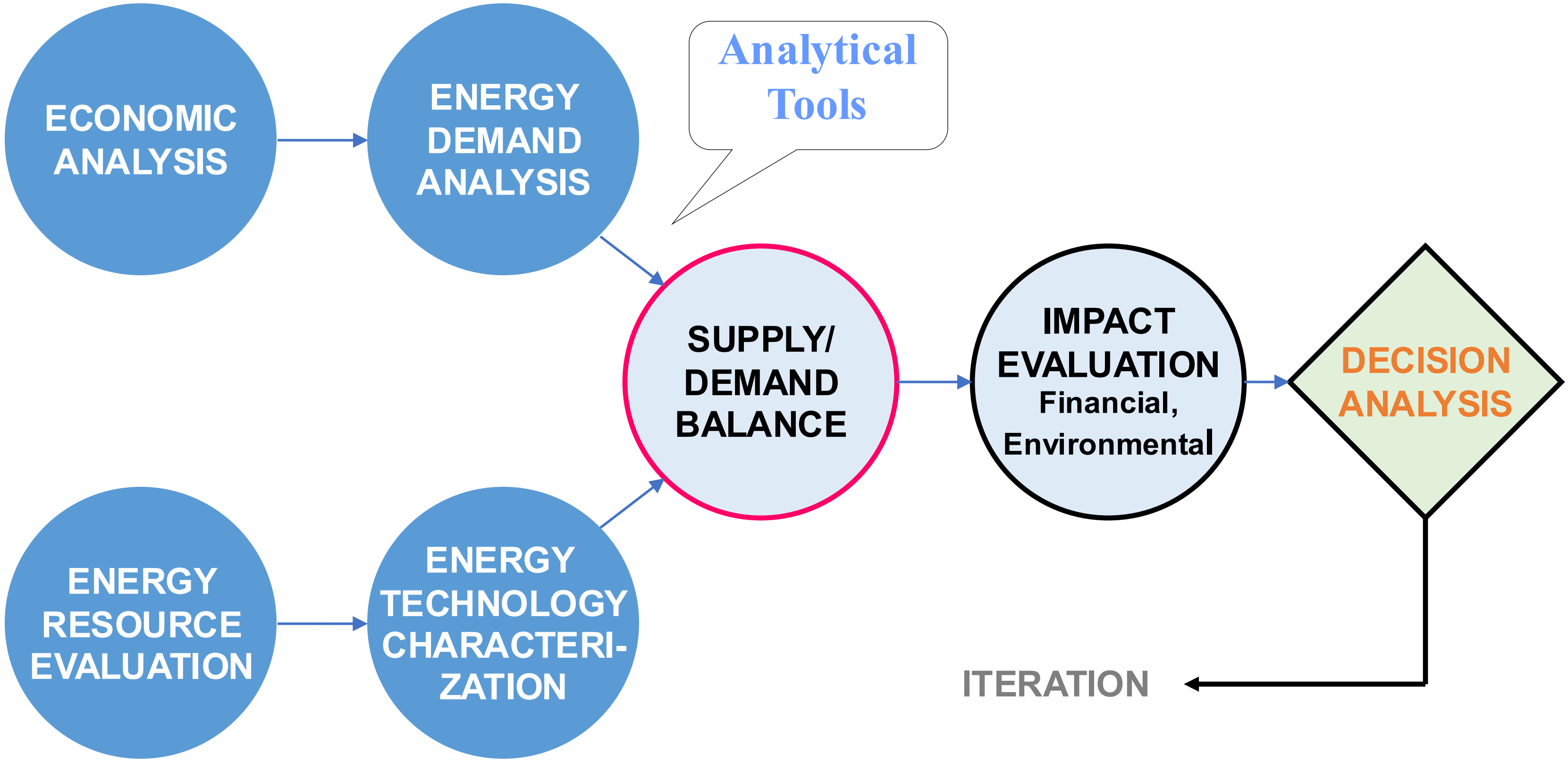
3 Integrated Energy Systems Analysis

- Energy demand-supply analysis
- Energy system modelling at national and urban scales
- Main features of urban energy systems
- Sustainable energy strategy formulation
- Energy supply security

Integrated Energy System Analysis (IESA)

AUSTRIAN INSTITUTE OF TECHNOLOGY

Aim: Formulating medium to long-term sustainable energy strategy that covers the expected energy need in a cost-effective, socially acceptable, economically viable and environmentally sound manner.



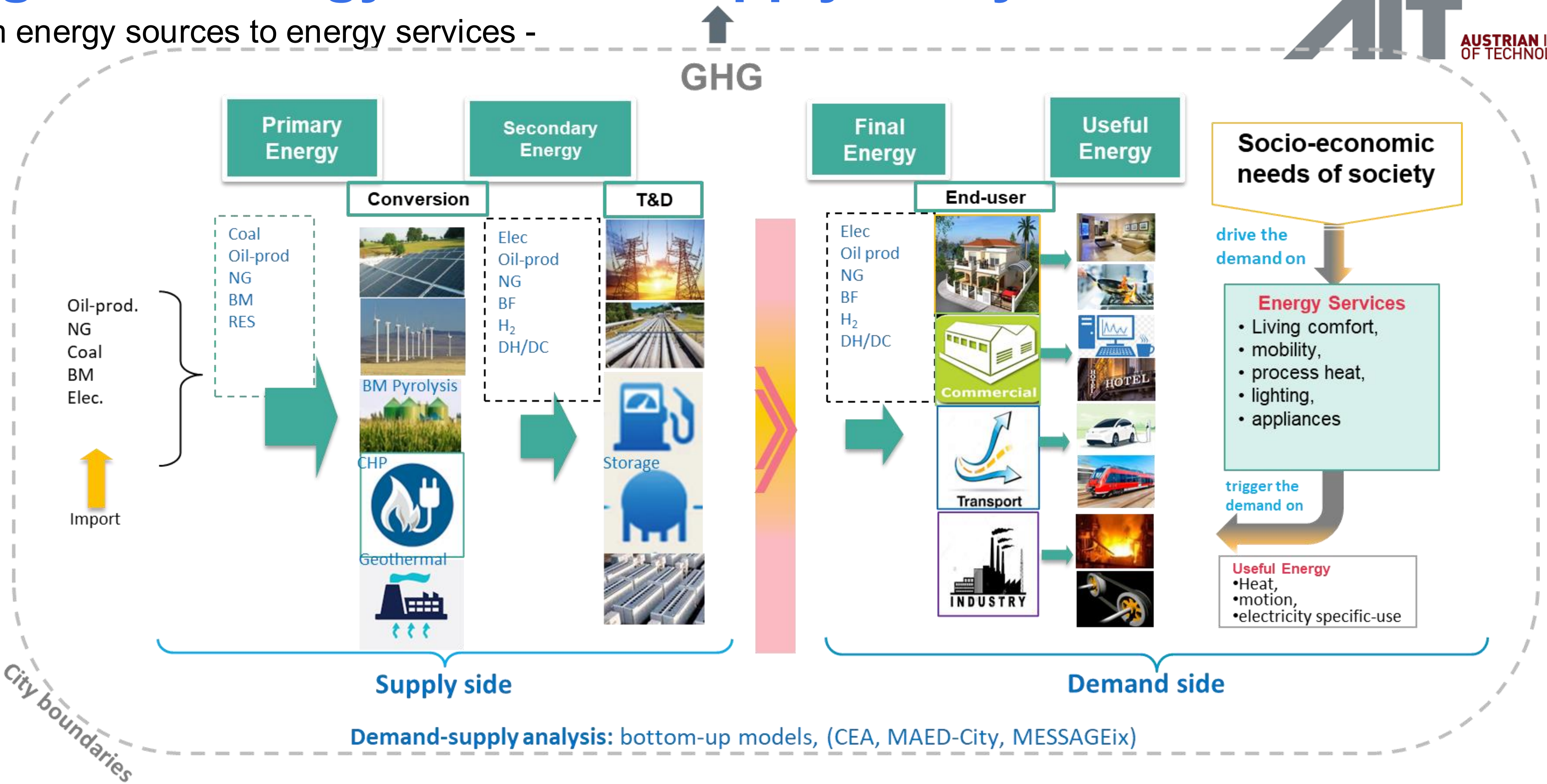
IESA integrates various disciplines such as engineering, economics, operations research, and management science

It relays on the fundaments of:

- Knowledge and commodities,
- Resources and technologies,

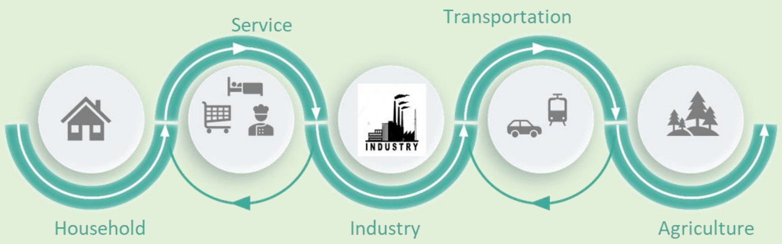
Integrated Energy Demand-Supply Analysis

- From energy sources to energy services -



Demand-supply analysis: bottom-up models, (CEA, MAED-City, MESSAGEix)

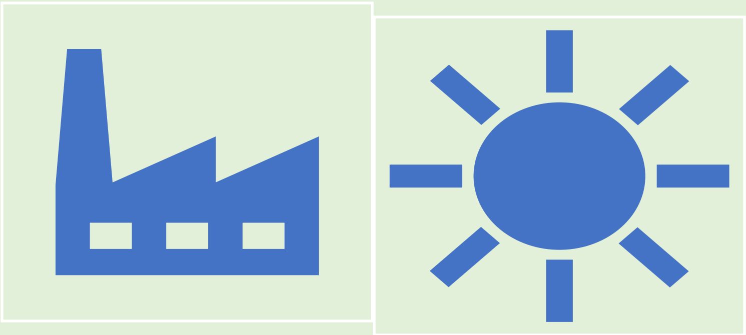
Energy Demand-Supply Analysis



Energy Demand modelling

bottom-up simulation approach to model current energy demand by sector and fuel and project future development following socio-economic and technical development of the sectors

- Industry: MAN, AGR, CON
- Building: HH and Service
- Transportation



Energy Supply modelling

bottom-up approach to simulate (or techno-economically optimise) energy supply adequate to cover the current and projected future demand, encompassing:

- Sources: RES, fossil, others
- Primary energy: fossil fuels (oil, gas, coal), RES (wind, solar, BM, hydro)
- Plants specification: Power, heat, NG, storage
- Energy infrastructure: network for power, gas and heat
- Policy constraints

Energy Supply Security

National energy supply security means having sufficient energy to meet the basic needs of the population and to make possible a certain level of development aspirations.

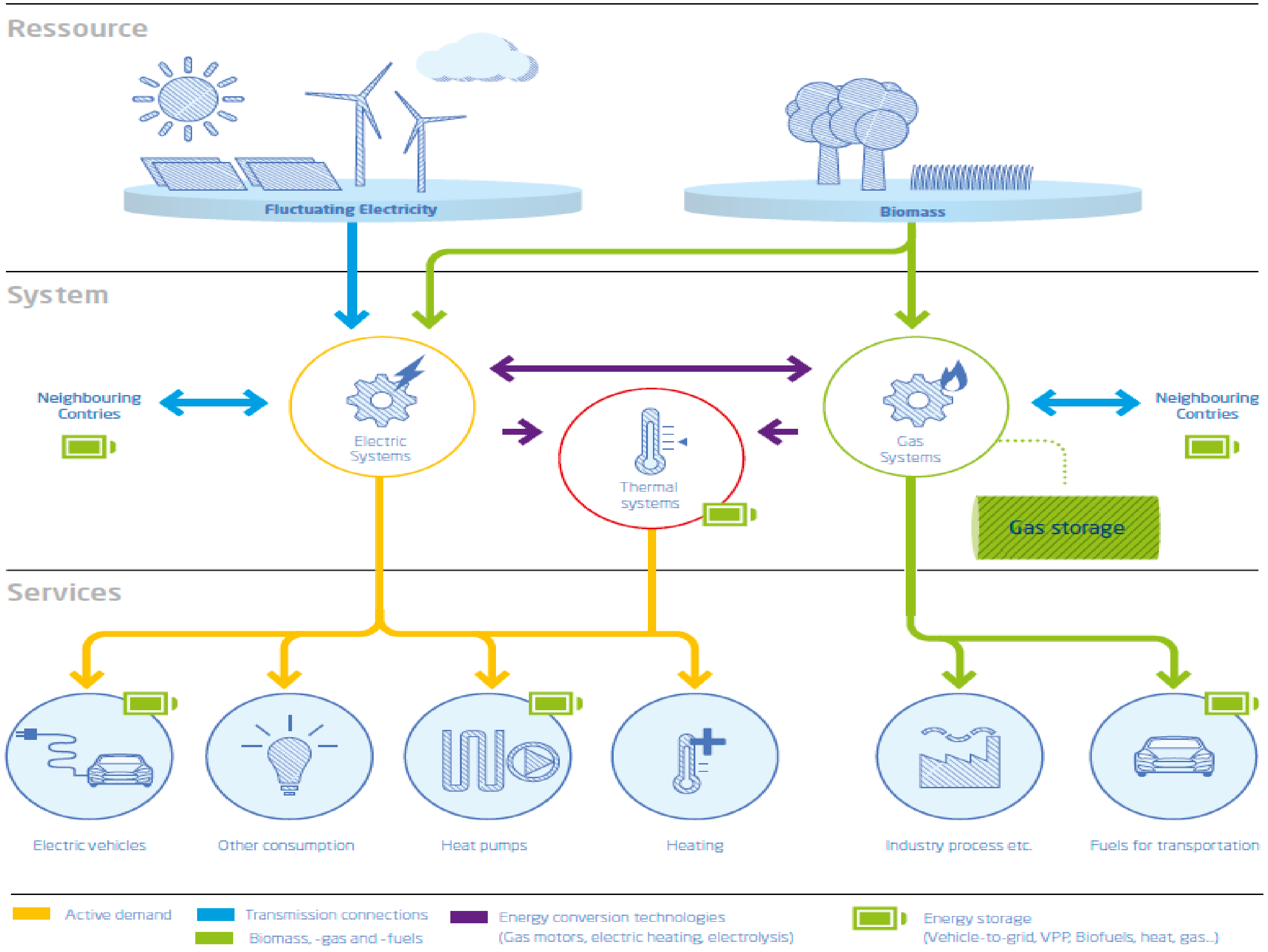
Main goals of secure energy supply

- fuel import reduction
- technology self sufficiency
- protection against supply disruptions
- protection against price volatility
- diversity of technologies and sources
- reducing threats to or from neighbouring states
- well-functioning energy markets
- environmental sustainability

Analysis of Clean Energy Transition: a future vision

Innovation needs

- integrating clean energy transition into spatial planning: to insure sustainable and resilient cities and energy infrastructure
- Optimising the use of urban space: through integrated spatial energy planning
- Improving spatio-temporal resolutions: to capture the emerging flexibilization need



Source: Karlson et. al (2015). Integrated energy systems modelling

4
Clean Energy Transition

Clean energy transition (CET):

- Goals and targets
- key drivers
- clean energy options
- Implications of CET

Flexibilization needs and options

EU initiatives to city decarbonisation:

- Climate-Neutral and Smart Cities
- Positive Energy Districts
- Life-programme on Clean Energy Transition

Integrated smart solutions and LHCs projects (Smarter Together, ASCEND).

Co-funded by the European Union

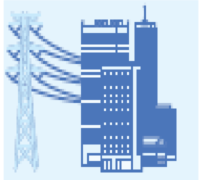
Clean Energy Transition

AUSTRIAN INSTITUTE OF TECHNOLOGY

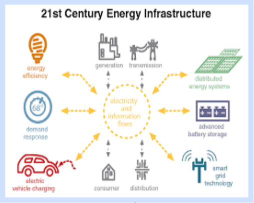
Energy systems are undergoing a transformation towards digitized, multi-integrated infrastructure, with a significant reliance on electricity sourced from intermittent renewable energy sources (RES).

→ **Ensuring sustainable and resilient energy systems**

Large share of intermittent, weather-dependant RES



Highly distributed production: low energy density (high land-use)



Multi integrated energy infrastructures: power, heat, gas and liquid fuel

Increased flexibility needs: Storage, DSM, EV, P2X, V2X

Spatio-temporal challenges and various scales (national, regional, urban)

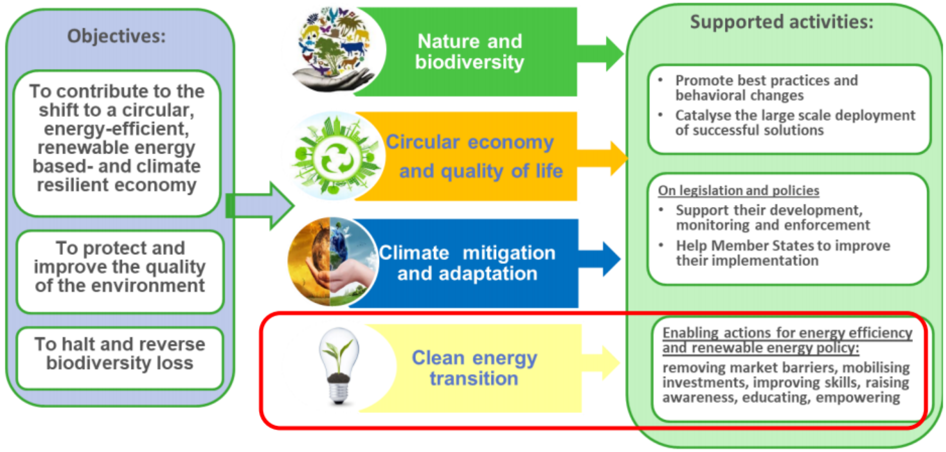
Change from consumer to Prosumer

Initiatives and programmes to support the CET and carbon neutral cities

- **H2020, HEU,**
- **LIFE-CET programe,**
- **IEA CET.**

- **EU mission:** 100 climate-neutral and smart cities by 2030
- **IEA:** Decarbonization of Cities and Communities (Cities TCP)
- **HEU** cluster 5 climate, energy and mobility
- **Eurocities:** Cities leading the way on climate action –
- **UNECE** (United Nations Economic Commission for Europe): Climate Neutral Cities –
- **C40 Cities**
- **..**

LIFE- Clean Energy Transition



Key Challenges and Constraints of Clean Energy Transition

AUSTRIAN INSTITUTE OF TECHNOLOGY

Features:

- Future energy system is dominated by **distributed** and **intermittent** RES
- Low **energy intensity** and high land-use
- Stronger intersection of demand and supply side due to **prosumer** role
- **Electrification**

Energy system analysis

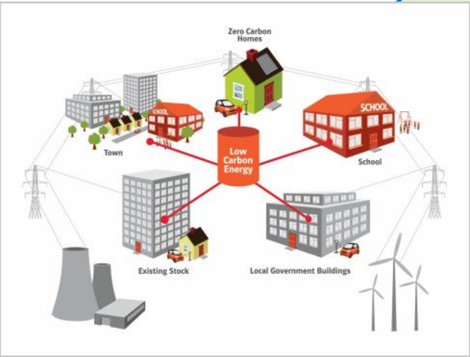
- ❖ Need for high-granularity spatio-temporal energy demand and supply analysis
- ❖ Integrated energy system: sector coupling like building/mobility, power/heat
- ❖ Increased need for flexibility options: storage, P2X, V2X, DSM,

Transitioning from fuel-based to infrastructure-based energy systems!
→ Need for high investment in new infrastructure to support the transition to decentralized RES

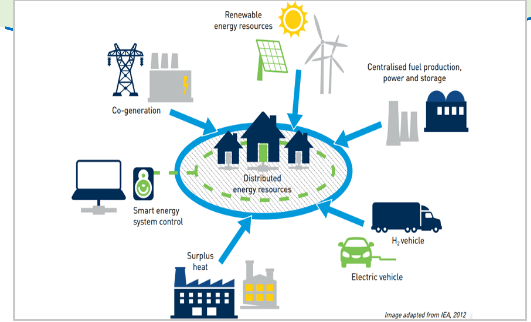
Increased System vulnerability:
→ enhanced infrastructure resilience through optimized and inherent system design to withstand external disturbances and physical threats and ensure reliable energy supply functions

Clean Energy Transition

Transformation towards secure, efficient, sustainable and resilient energy system



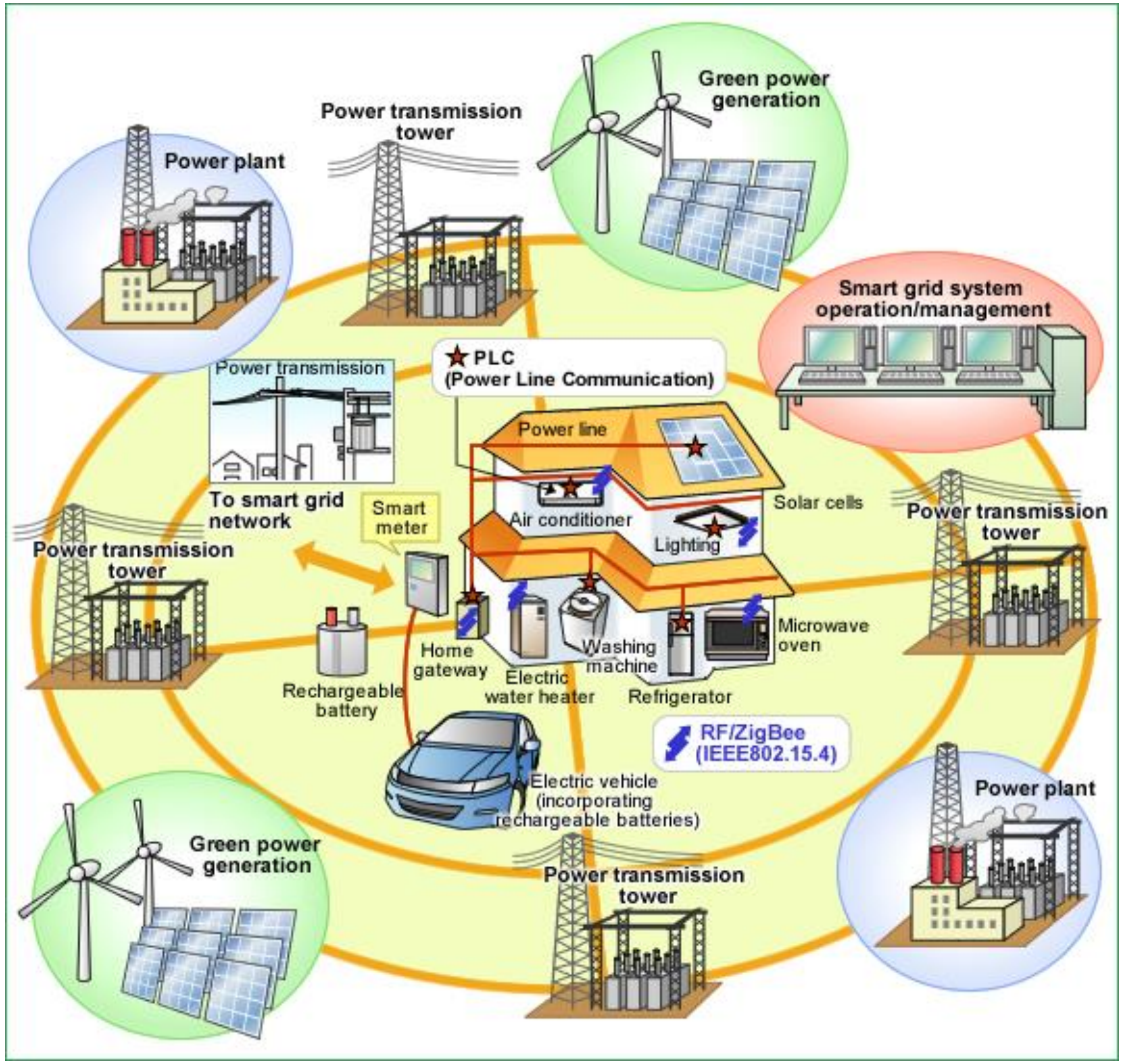
3D Transformation:
- Decentralization
- Digitalisation
- Decarbonisation



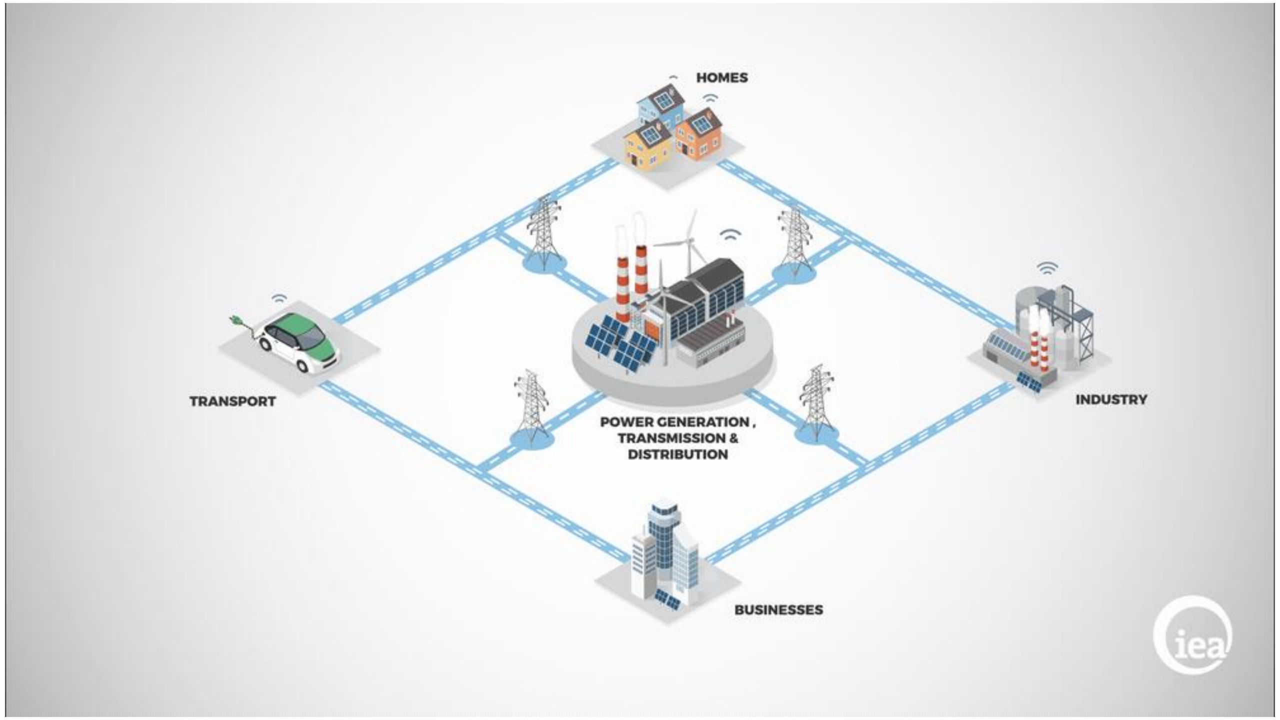
Decentralized Generation

- large number of small-capacity units connected to the power grid,
- natural gas supply network
- urban heating/cooling networks

to generate energy from local/regional renewable energy sources



Digitalization of Energy System



Utilizing digital technologies to make energy systems more connected, intelligent, efficient, reliable and sustainable, enabled by new digital applications:

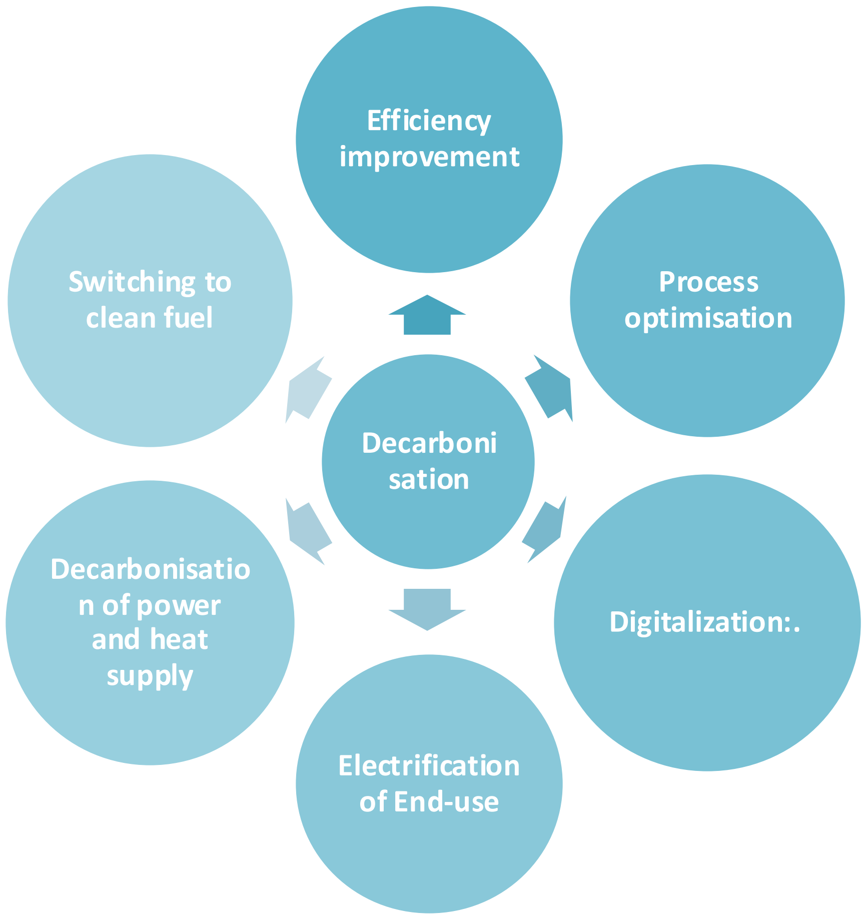
- smart appliances,
- shared mobility, and 3D printing.
- Identifying and delivering energy needs to the right time in the right place.

Clean Energy Transition

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

Key decarbonization drivers

- Energy efficiency improvement
- Fuel Switching: clean fuels (BG, H2,..)
- Promoting local/regional renewables
- Electrification of end use
- Decarbonisation of heat and power
- **Others:** Digitalization, flexibilization, sector coupling

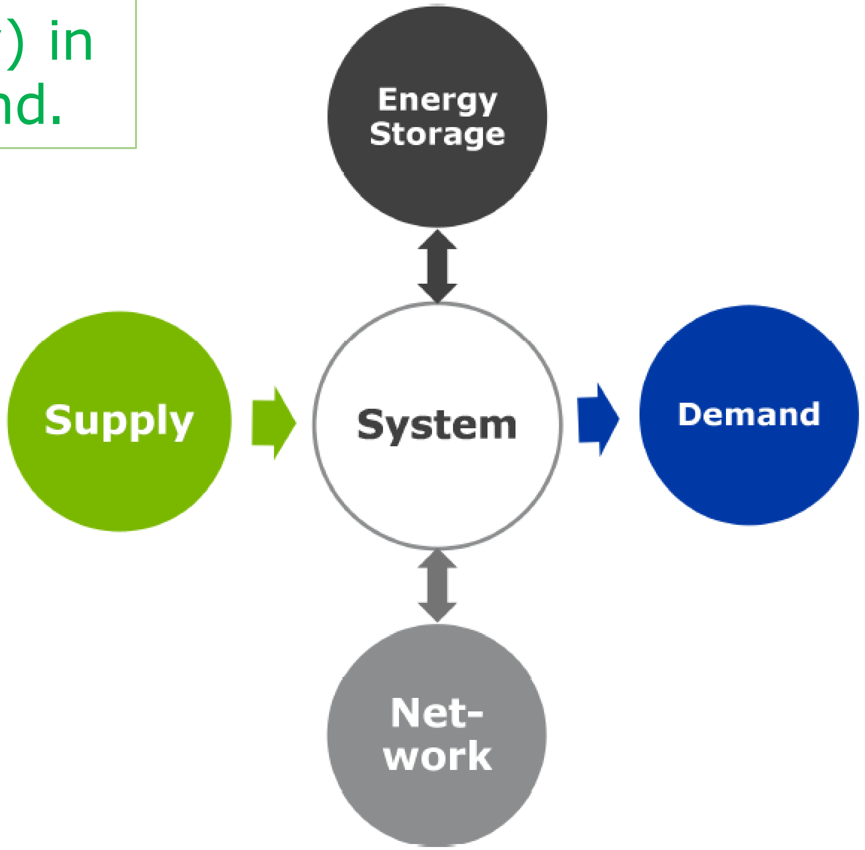


Energy System Flexibility

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

Flexibility is the ability of a power system to maintain continuous service (balancing energy demand-supply) in the face of rapid and large swings in supply or demand.

- Current flexibility is provided by fossil fuel dominated system
- Flexibility gap of future energy systems results from increased dependence on variable renewable energy sources (VRES)



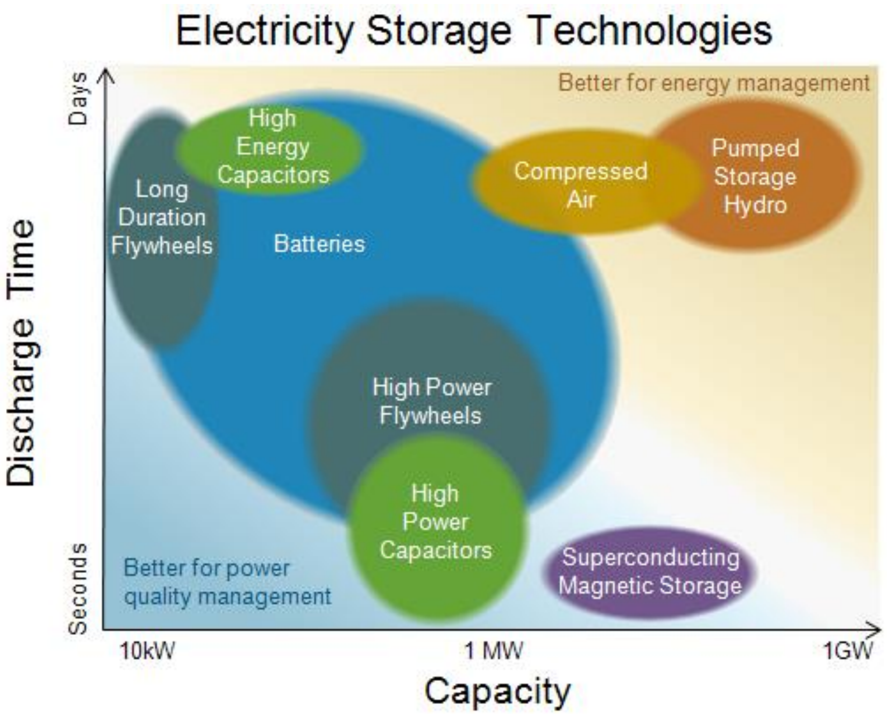
Key flexibility options:
supply, demand, energy storage, network and system.

Flexibility options

Flexibility refers to the power system's ability to maintain continuous operation despite rapid and significant fluctuations in supply or demand.

5 key categories: supply, demand, energy storage, and network and system.

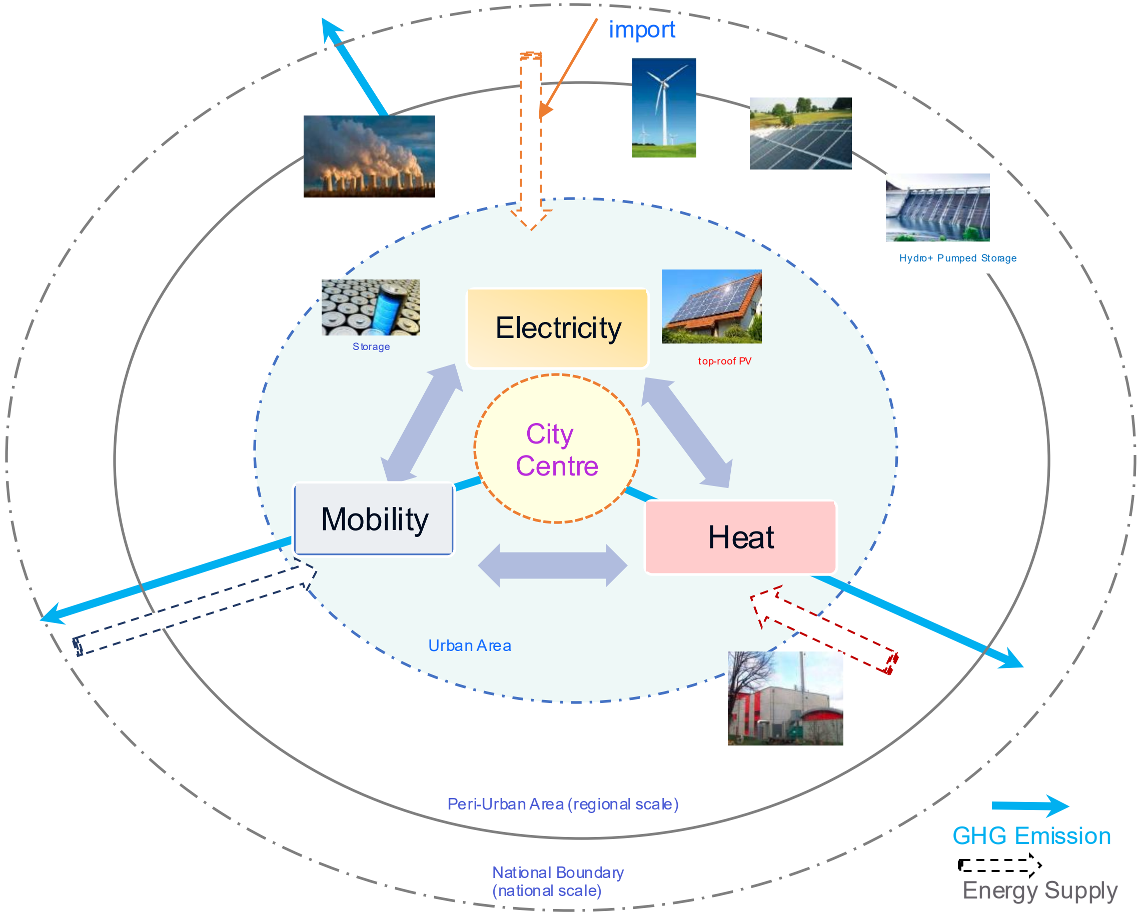
Supply: Flexible power plants (fossil, , HPP, NPP) and spinning reserves (quick-response generation).
Demand: Demand Response (DR), Demand Side Management (DSM), EVs, heat pumps, and water heating.
Storage: Pumped storage, flywheels, P2G, P2H, EV (bidirectional charging).
Network: T&D networks allowing the spatial sharing of flexibility resources T&D, power flow control devices, advanced ICT, and frequency reserves.
System: Improved operations and market integration to reduce RES variability via spatial aggregation.



Challenges of Urban Energy Systems

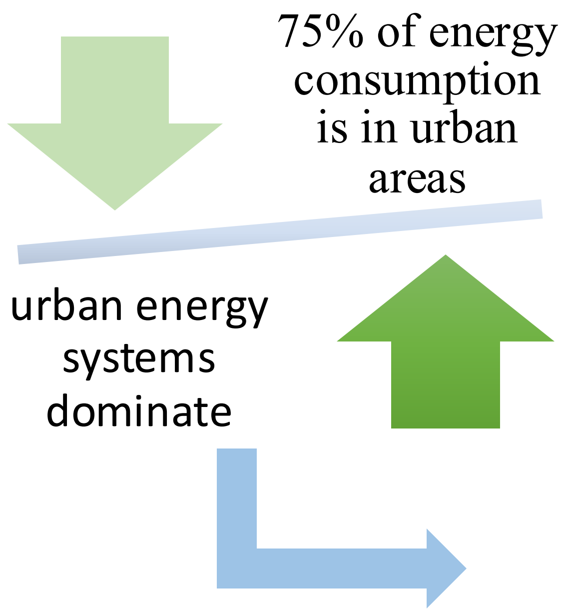
AUSTRIAN INSTITUTE OF TECHNOLOGY

- High energy demand & CO_2 emissions due to urbanisation and intensive socio-economic activities
- transition to renewable energy supply poses techno-economic, regulatory and financial challenges.
- Lack of adequate energy data by sector and end-uses
- Outdated energy infrastructure leading to vulnerable and inefficient energy supply
- Need for resilience to disruptions and extreme events
- Fragmented measures but no strategy
- Need for Decarbonisation pathways by 2040



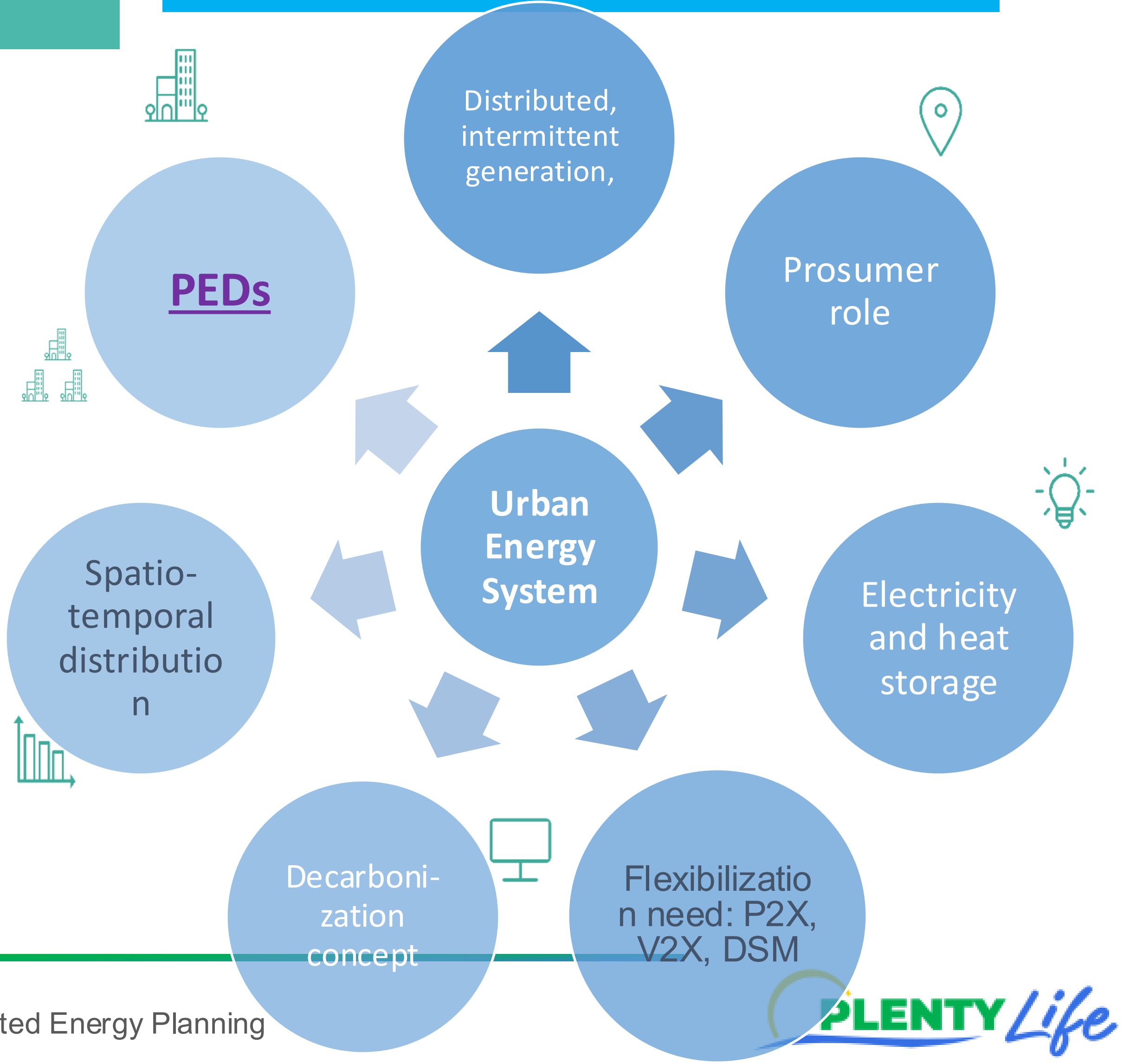
Clean Energy Transition at Urban Scale

Aim: to support city decision making process in developing sustainable clean energy transition strategies for climate neutral cities



- **SDG-Goal 11:** “Making cities and human settlements inclusive, safe, resilient and sustainable”
- **SDG-Goal 7:** “Ensure access to affordable, reliable, sustainable and modern energy for all”

Challenges of Urban Energy Systems modelling

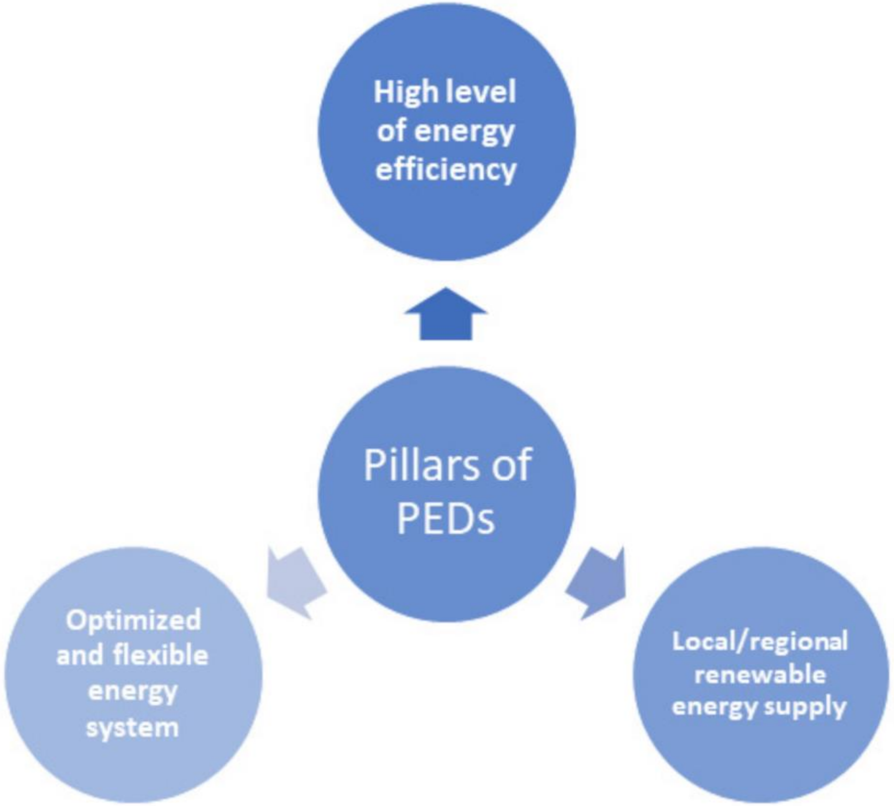


Positive Energy District (PED)

- PEDs are energy-efficient and flexible urban areas producing net zero GHG emissions and managing an **annual** local/regional **surplus renewable energy**.

PEDs

- require integrated systems and infrastructure,
- fostering **interaction among buildings**, users, and regional energy, **mobility**, and ICT systems.
- This ensures sustainable living in line with social, economic, and environmental goal

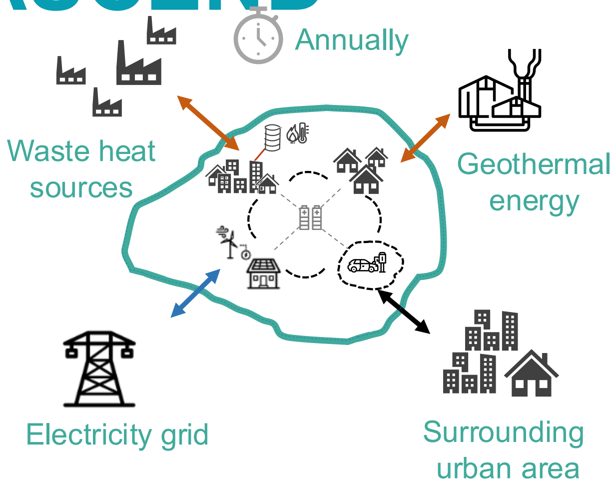


Common understanding of PED setting within ASCEND

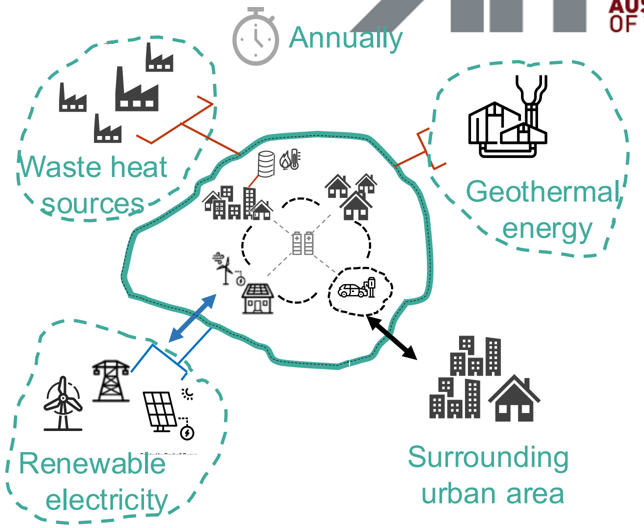
AUSTRIAN INSTITUTE OF TECHNOLOGY

EERA-Net, JPI-UE, EU SET 3.2 definition:

"PEDs are energy-**efficient** and energy-**flexible** urban areas which produce net zero GHG emissions and actively manage an annual local or regional **surplus** production of renewable energy.



Geographical district boundaries.



Virtual boundary: energy production facilities outside the district boundaries with community ownership

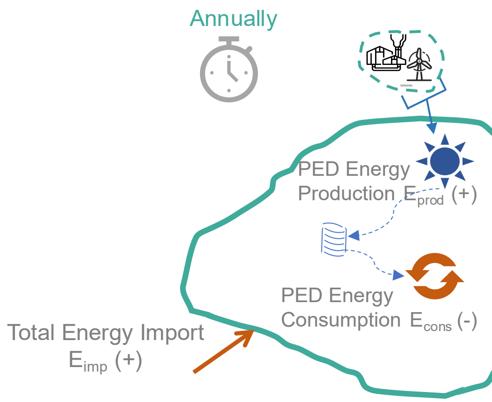
Dynamic-PED

Net positive annual energy balance **within the geographical boundaries** of the PED but **dynamic exchanges** with the hinterland to compensate for momentary surpluses and shortages

Virtual-PED

Net positive annual energy balance **within the virtual boundaries (contractual boundaries, energy system)** of the PED but **dynamic exchanges** with the hinterland to compensate for momentary surpluses and shortages

Energy balance



Geographical district boundaries.

Virtual boundary: energy production facilities outside the district boundaries with community ownership

Co-funded by the European Union

PLENTY Life

ASCEND. ACCELERATE POSITIVE CLEAN ENERGY DISTRICTS

HEU, HORIZON-MISS-2021-CIT-02-04 - Positive Clean Energy Districts

Duration: 2023 - 2027

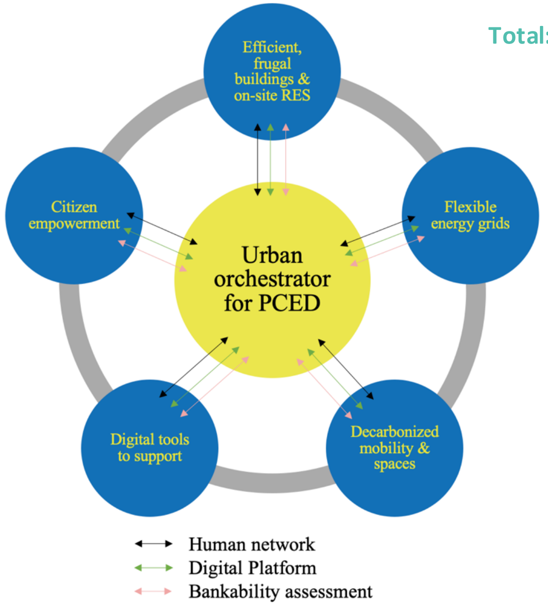
Total: 39 partners

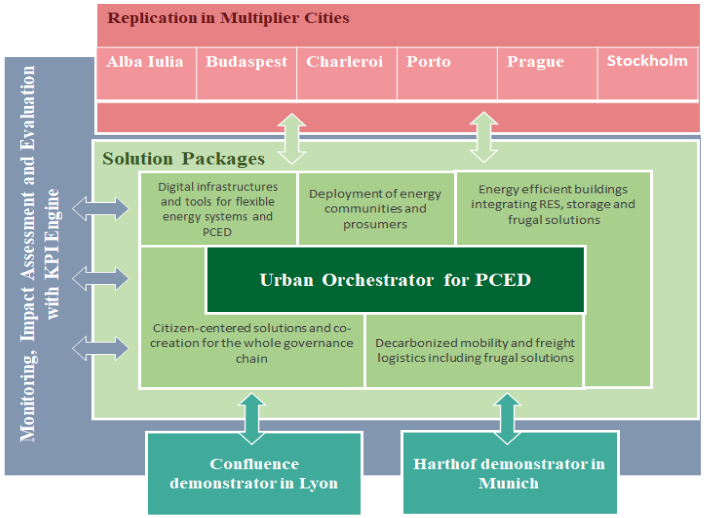
Objectives

- Deliver two inclusive, affordable PCEDs in **Lyon and Munich**;
- Successfully "bootstrap" implementation of PCEDs in the Multiplier Cities of Alba Iulia (RO), Budapest (HU), Charleroi (BE), Prague (CZ), Porto (PT), Stockholm (SE);
- Scale-up solution packages for a large community of cities and investors across Europe;
- Disseminate our results widely to the smart cities community.

Outcomes (Expected)

- Large-scale PCEDs demonstrations in 2 LHCs, using existing knowledge form Smart Cities Projects,
- Offering well-proven and cost-effective 5 solutions packages, scalable by design to cities across Europe.
- Replication and Upscaling strategy for LHCs and MCs
- outcome-driven collaboration with EC initiatives (Climate-Neutral and Smart City Mission, CoM, Scalable cities)





VILLE DE LYON

AUSTRIAN INSTITUTE OF TECHNOLOGY

DKSR Daten-Kompetenz für Städte & Regionen

UNIVERSITÉ DU LUXEMBOURG

ENERTECH SCOP

..

Accelerating PCEDs deployment for cities' transition toward climate neutrality

https://www.ascend-project.eu/

https://cordis.europa.eu/project/id/101096571

CBP, Integrated Energy Planning

European Commission

Funding scheme: HEU, EU, SCC

Total budget: 24.7 Mio€

PLENTY Life

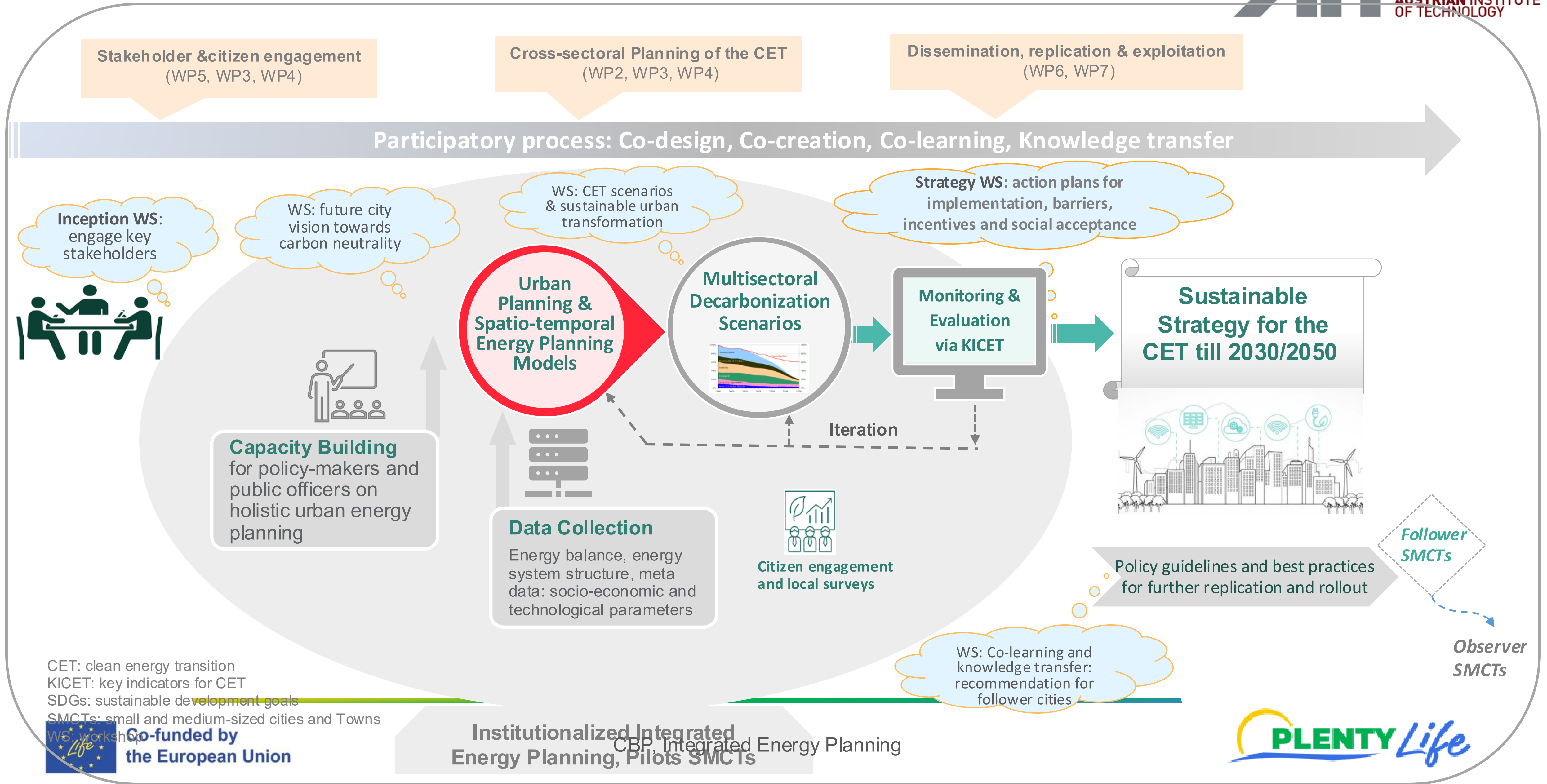
5
Formulation of Clean Energy Transition Strategy

Demonstration of city case studies

- Participatory process
- Data collection
- Storylines and scenarios construction
- Results evaluation and refinement
- Extraction of Key performance indicators

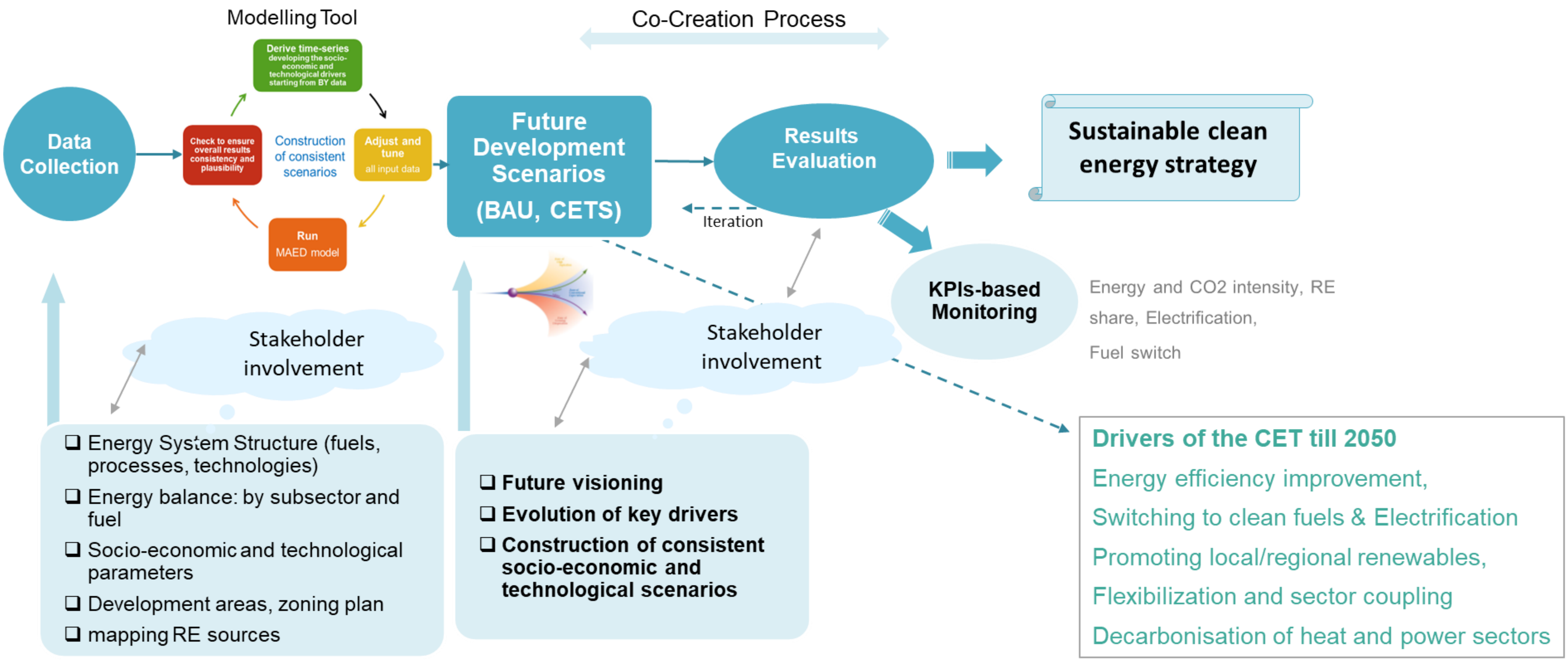
Participatory process of PLENTY-LIFE Project

HISTEP: Holistic Integrated Spatial-Temporal Energy Planning methodology



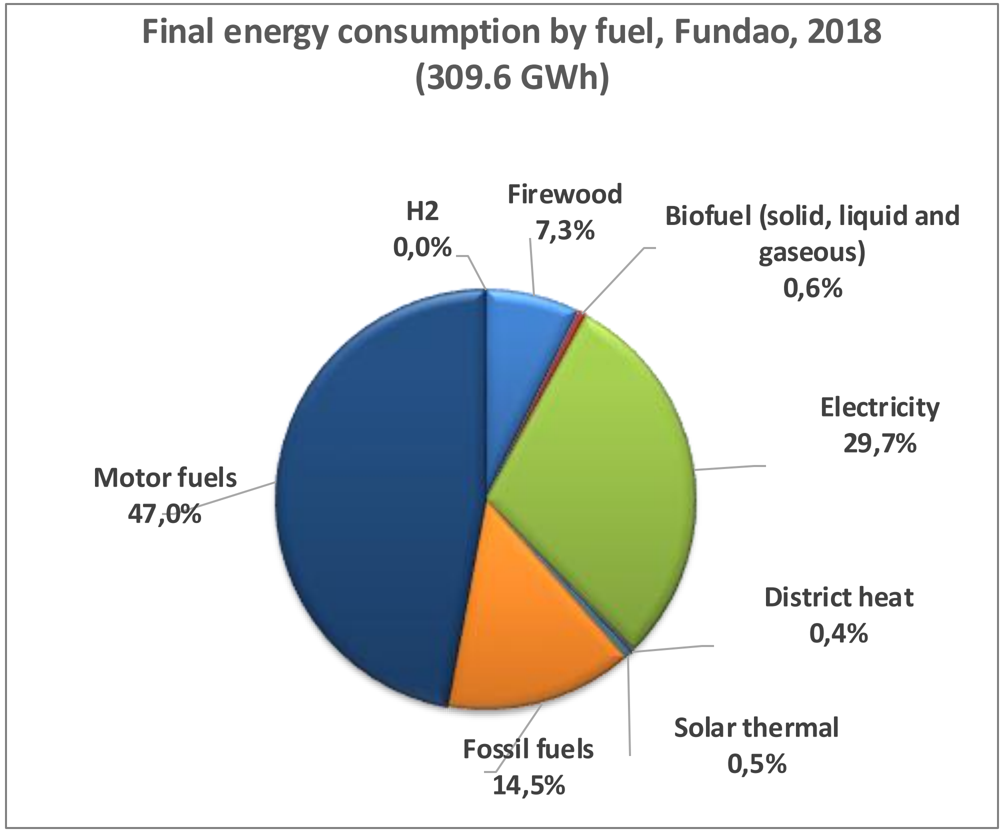
Formulation of cities' clean energy transition strategies

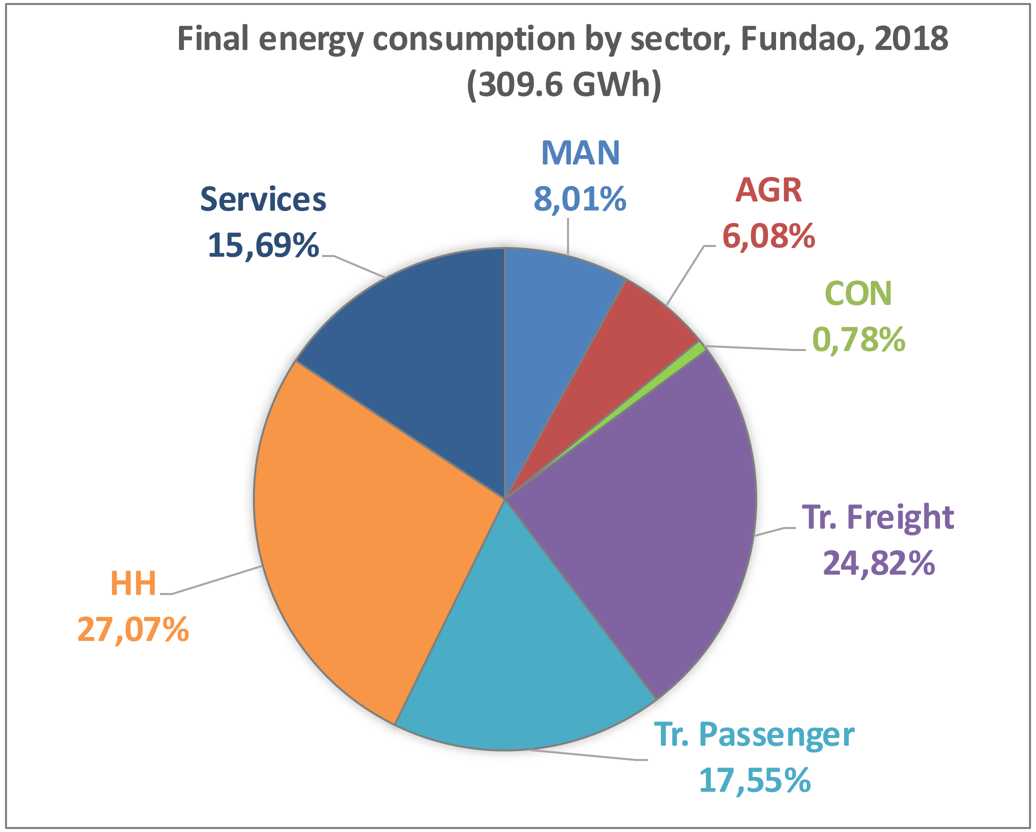
-Co-creation with the key city stakeholders-



Fundão current energy consumption and CO2-emission

-for the base year 2018-



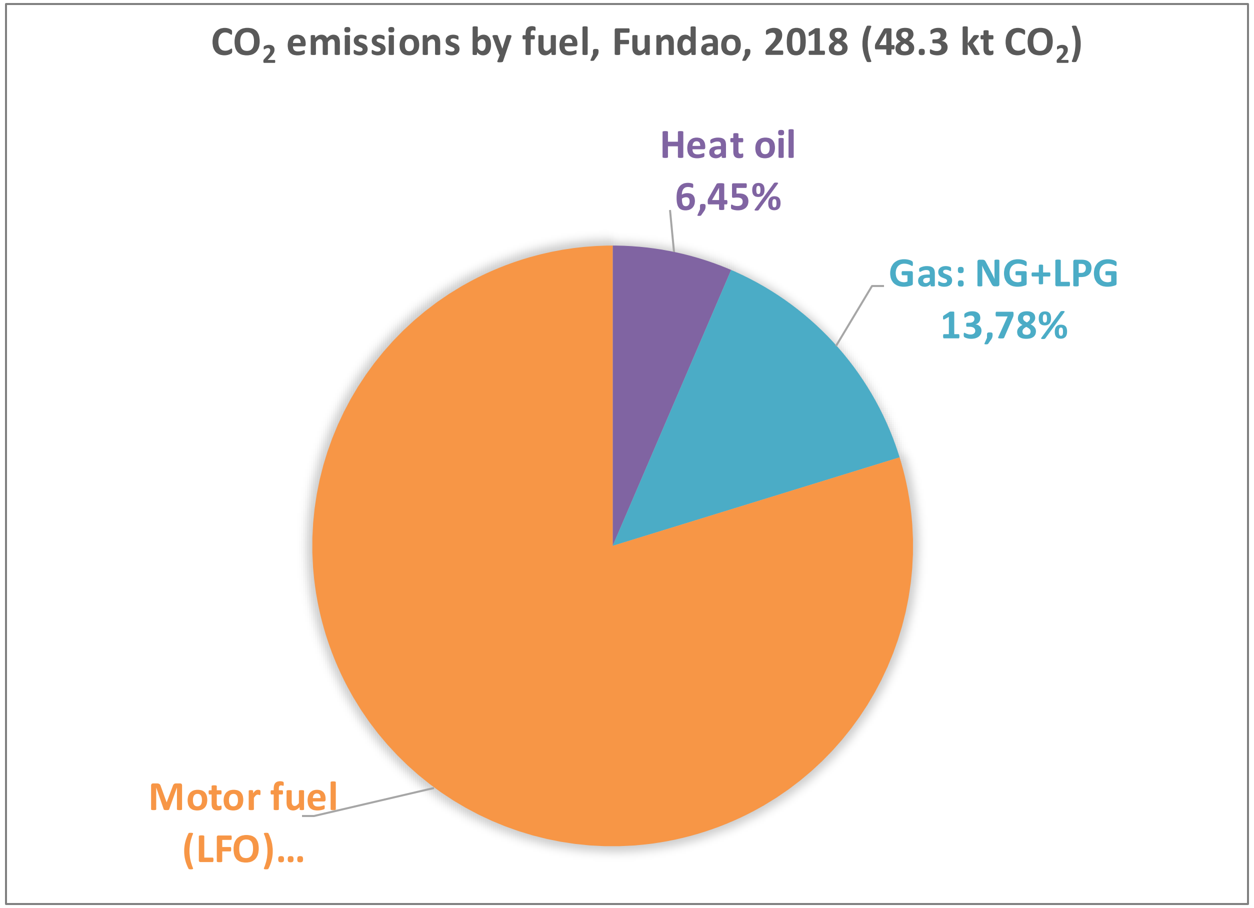


Fundao, Final energy per Capita: 11.6 MWh/Cap

Portugal, national average: 29 MWh/cap

Fundão current energy consumption and CO2-emission

-for the base year 2018-



CO2-emission per capita: 1.8 t-CO2

Main groups of input data for energy demand-supply modelling

AUSTRIAN INSTITUTE OF TECHNOLOGY

Energy

- Base year Energy consumption by sector, fuel, and end-use category
- Potential of local RES
- Current energy supply structure
- Official energy policies enacted and conceived to achieve energy and climate goals

Economy

- GDP
- GDP growth rate
- Fractions of sectors (VA)

Demography

- Population Growth rate
- Urbanization
- Labor Force

Lifestyle

- Household type
- Dwelling size
- Area per employee in service sector
- Mobility: pkm, tkm
- Car ownership
- Electrification
- Appliances
- Transport modes

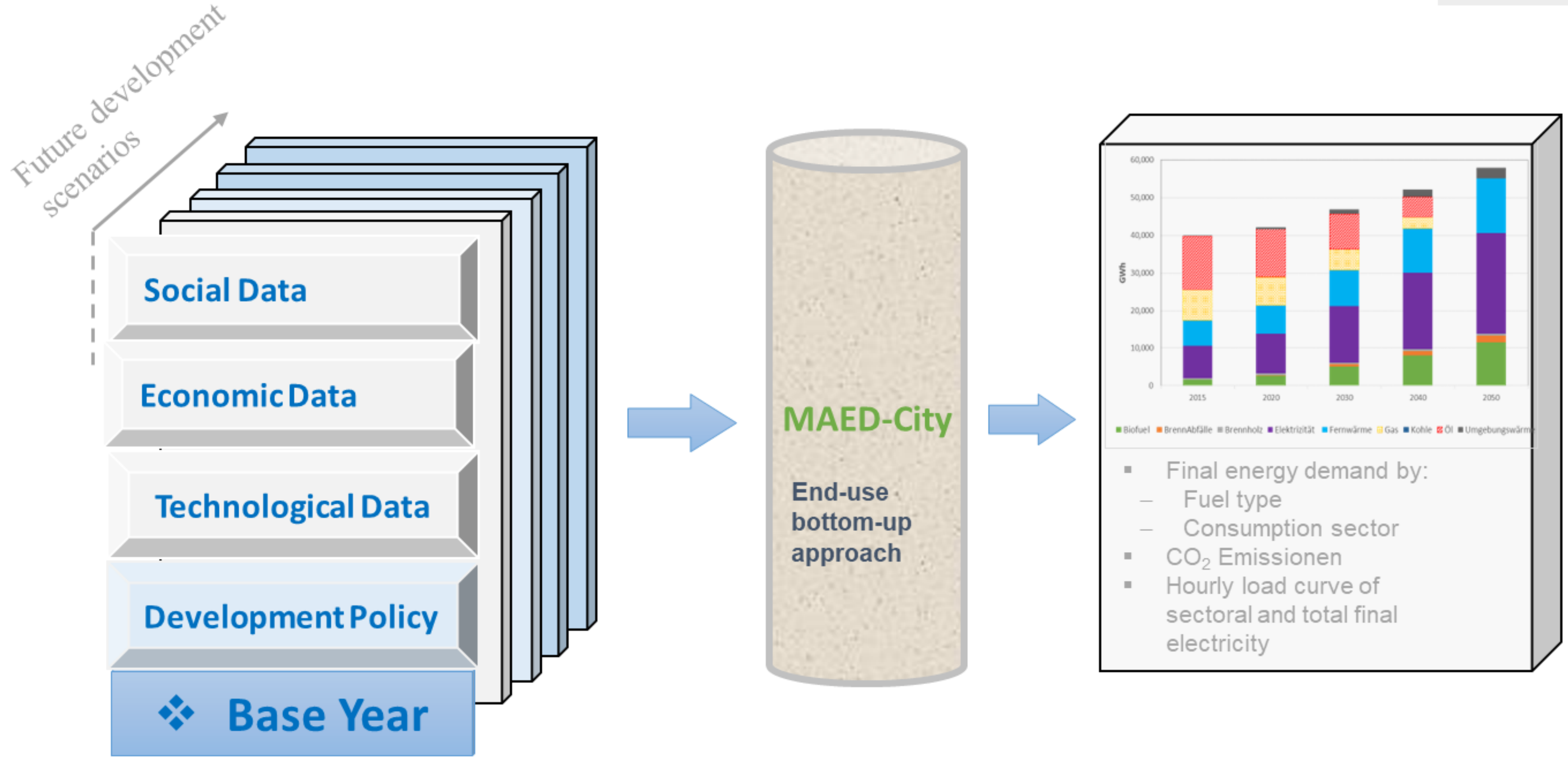
Technology

- Type of space heating
- Building insulation
- Energy intensity
- Efficiency
- Mileage
- Technology Penetration rates

MAED-City: Model for Analysis of Energy Demand of City

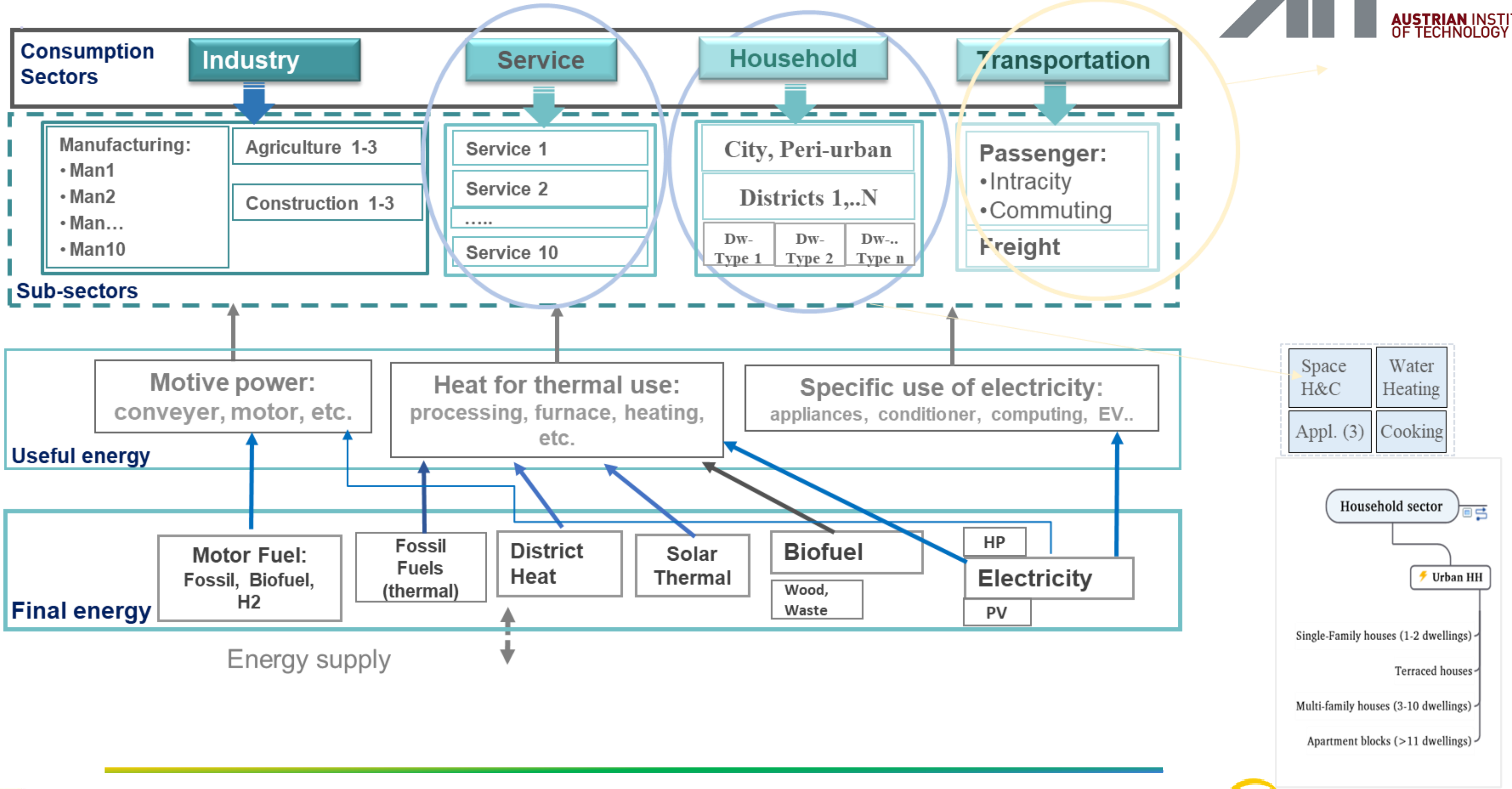
In cooperation with IAEA

AUSTRIAN INSTITUTE OF TECHNOLOGY



A scenario is a set of consistent parameters describing possible long-term pattern of socio-economic, demographic, and technological development of a country/region

MAED-City: sectoral energy demand modelling



Co-funded by the European Union

Input data, Reconstruction of Base Year

BASE YEAR STATISTICS

Industry statistics

Transport statistics

Household statistics

Service statistics

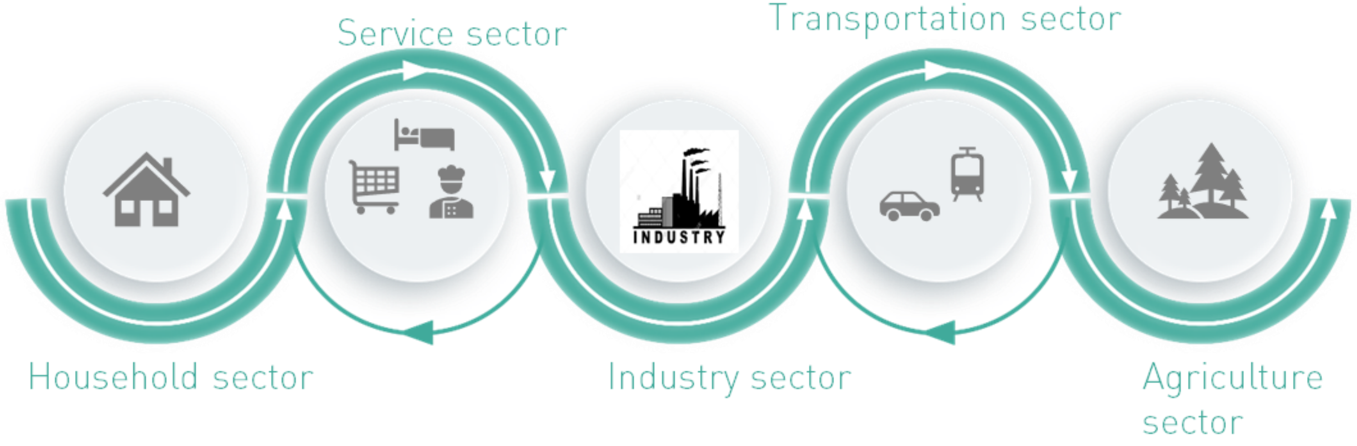
GDP by sector and subsector

Demography

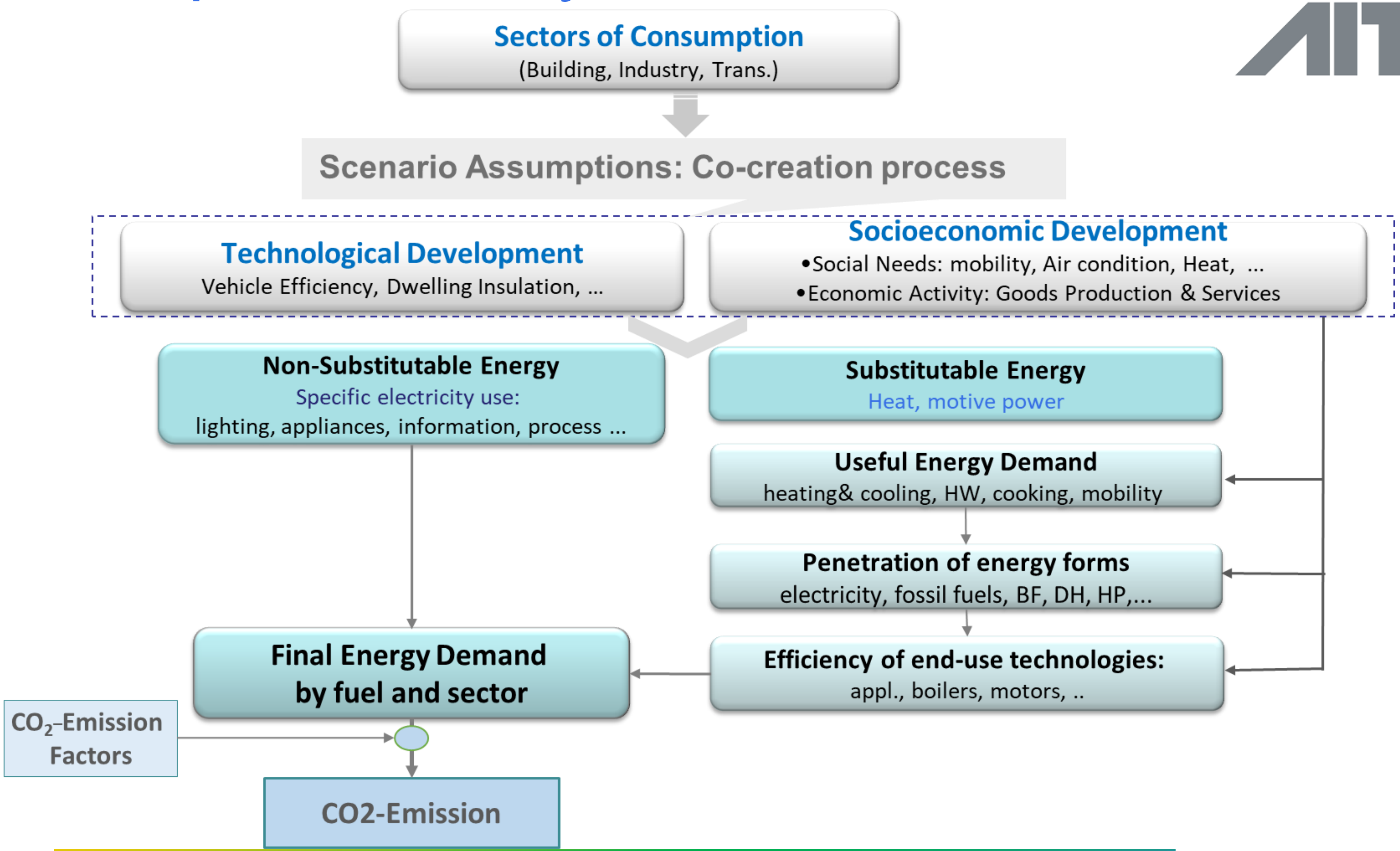
Energy balance by sector and fuel

INPUT DATA FOR THE BASE YEAR

- ***Macroeconomy***
- ***Demography***
- ***Lifestyle parameters***
- ***Technology parameters:***
  - ***Energy intensities***
  - ***Penetration rates***
  - ***Efficiencies***



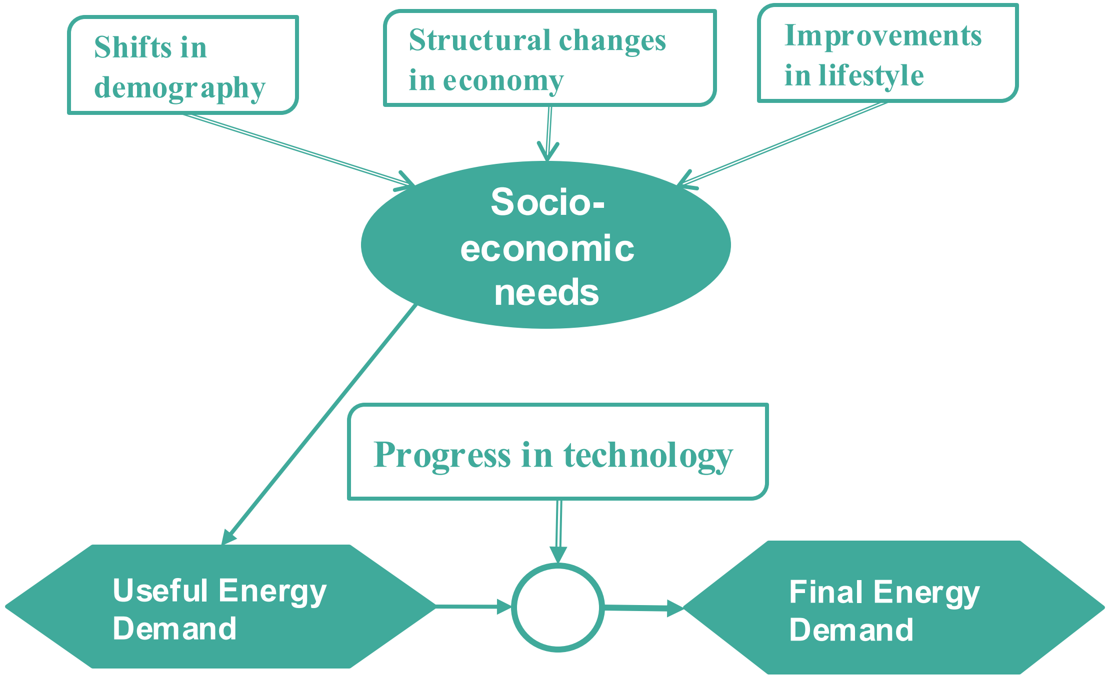
Scenario Development, MAED-City



MAED-City Methodology

- Concept of constructing future development Scenarios -

AUSTRIAN INSTITUTE OF TECHNOLOGY



City's possible future transformation should be described with respect to:

- Demographic changes
- Economic development
- Technological development
- Social progress and life-style changes

Essential features of scenarios

- **Transparency**
- **Consistency**
- **Plausibility**

Key Objectives of Scenario Development

AUSTRIAN INSTITUTE OF TECHNOLOGY

- To help imagine a range of possible futures, explore alternative development trends and address their related challenges and opportunities to achieve the desired prospects
- Help articulate or think through key considerations and assumptions
- Identify gaps, inconsistencies, dilemmas, uncertainties and interdependencies
- Blend quantitative information and qualitative knowledge
- Extract useful information for decision-making.

MAED Methodology:
-scenario-based simulation-

AUSTRIAN INSTITUTE OF TECHNOLOGY

- Evolution of energy demand is analyzed by constructing future development scenarios
- Each scenario can be regarded as the future values of a set of economic, technological and social factors which directly affect the energy demand. (based on the expected evolution of a country/region and its society)
- Scenarios should be based on *internally consistent sets of assumptions* about driving forces of energy demand (demography, economic growth, technology) and their relationships
- Construction of contrasting scenarios would permit capturing:
  - Possible evolutions of energy demand in the city, and
  - Role that electricity may play in meeting this demand

Important Aspects of MAED Methodology

The results of MAED are always of the conditional type, i.e., What would happen if …... ?

This is one of the main advantages of the model, since it allows the analysis of:

- Different socioeconomic development policies for the country/region: different economic growth, emphasis on industry/agriculture/service, on certain types of industries,
- Alternative policies for energy use (individual car vs. public transport, electricity vs. direct use of fuels)
- New policy targets of clean energy transition
- Impact of technological development (equipment efficiency)
- Effect of changes in the lifestyle of society
- The evolution of the potential markets of each form of energy carrier: electricity, fossil fuels, solar, district heat etc.

Future Development Scenarios

Scenarios differ in key assumptions; this may include more than one parameter

BAU: Reference Scenario
(current energy policy)

- reference values for all parameters: slight improvement form the current situation, limited innovative evolutions, considering historical trends

SD Scenario
(ambitious vision, G7 SDGs)

- increasing energy end-use efficiency
- accelerated penetration of renewables
- Switch to clean fuel and electrification

Example for future scenarios

Future development Scenarios

BAU:
business as usual

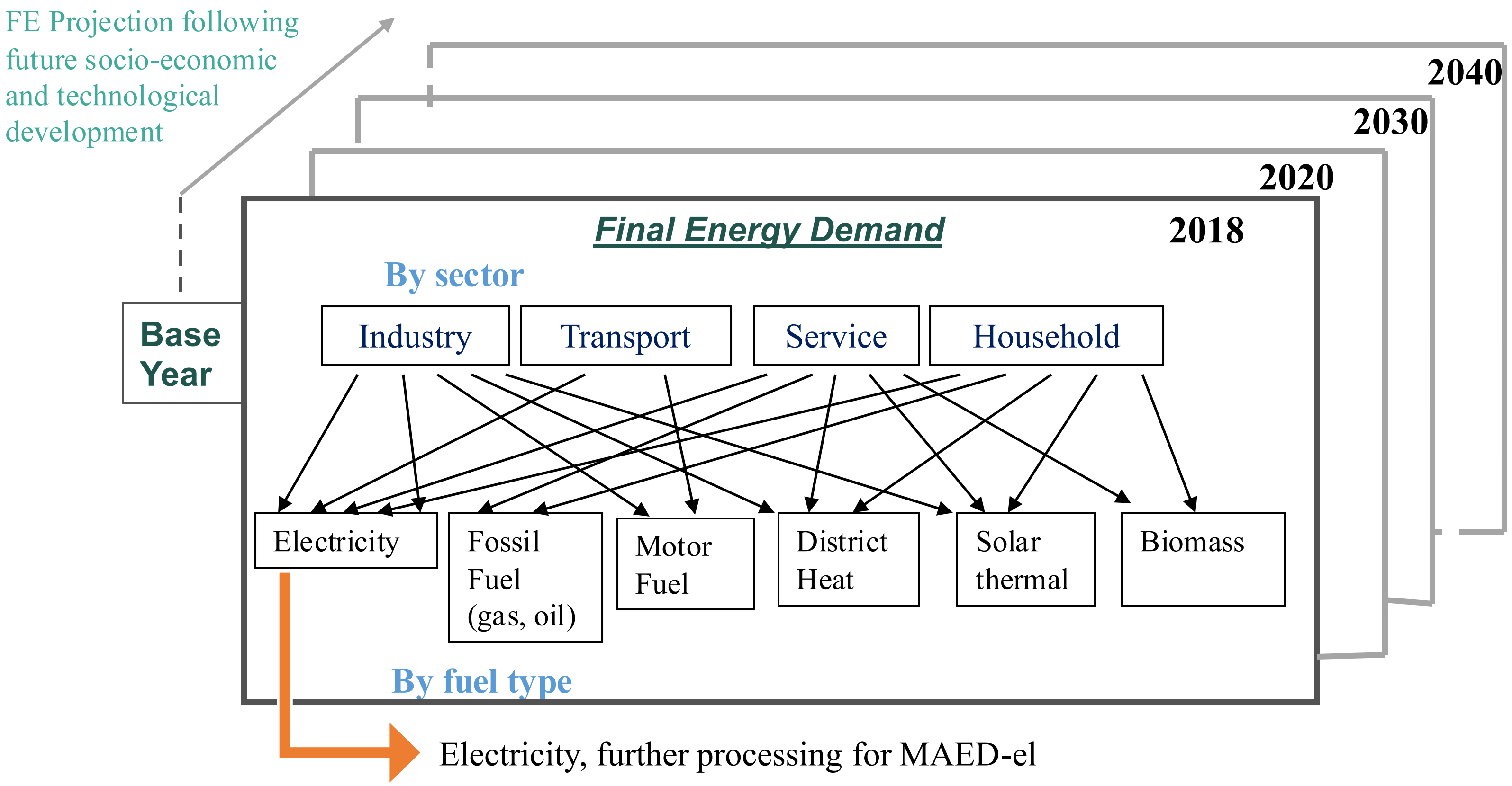
- reflects current energy policy trends
- follows historical trends.

SDS:
sustainable development scenario

- focuses on ensuring sustainable energy development
- addresses the perceived transformation towards efficient, sustainable and low-carbon energy system.

Future energy demand projection:

-annual results by sector and end-use electricity can be hourly-

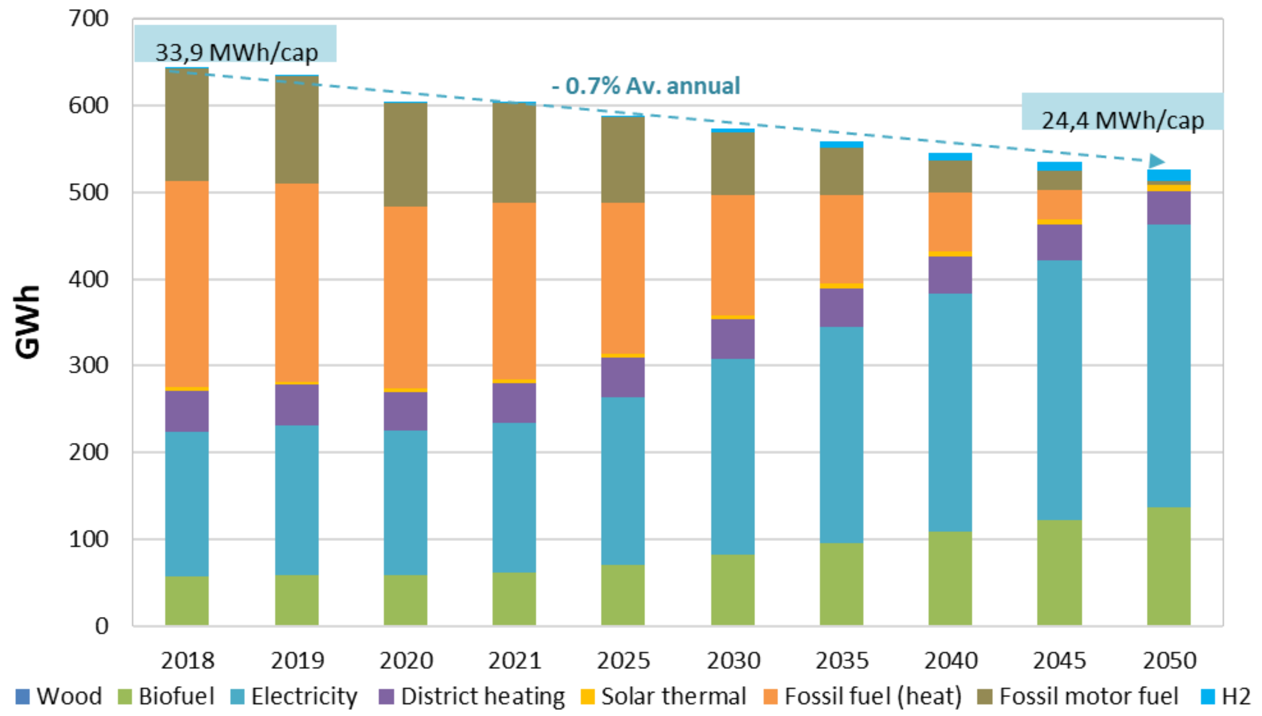


Clean energy transition pathway

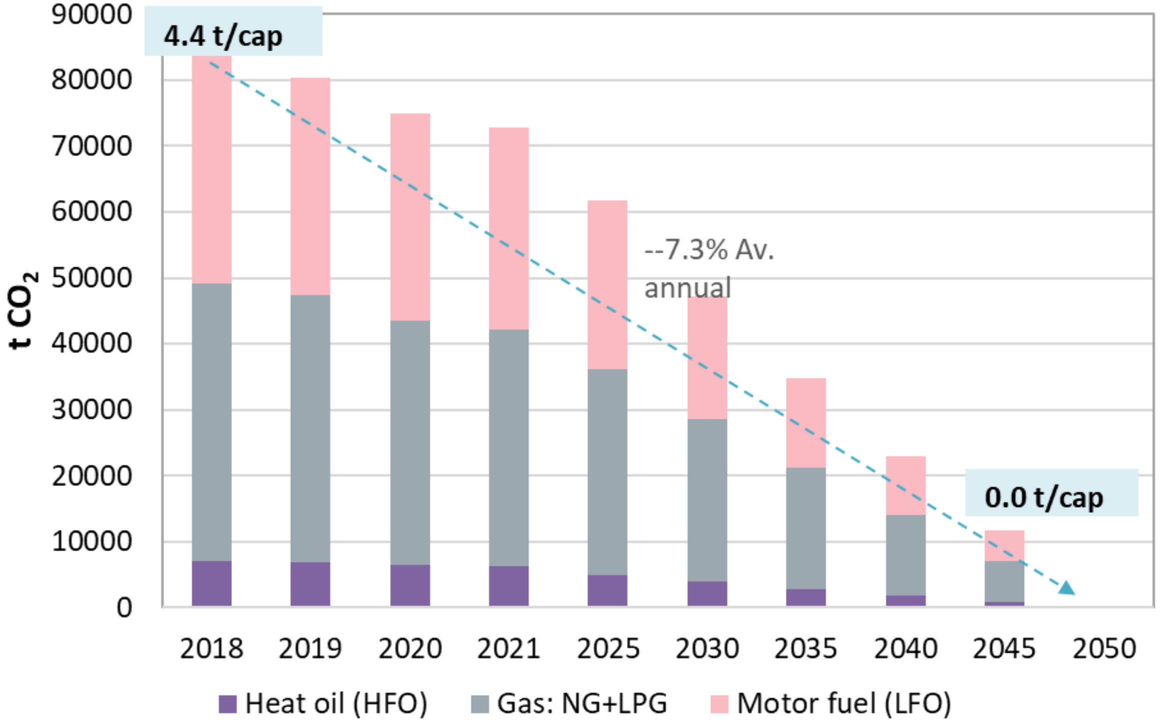
-Results of Sustainable decarbonisation scenario-

AUSTRIAN INSTITUTE OF TECHNOLOGY

Final Energy Demand, sustainable development path (example for a small city)



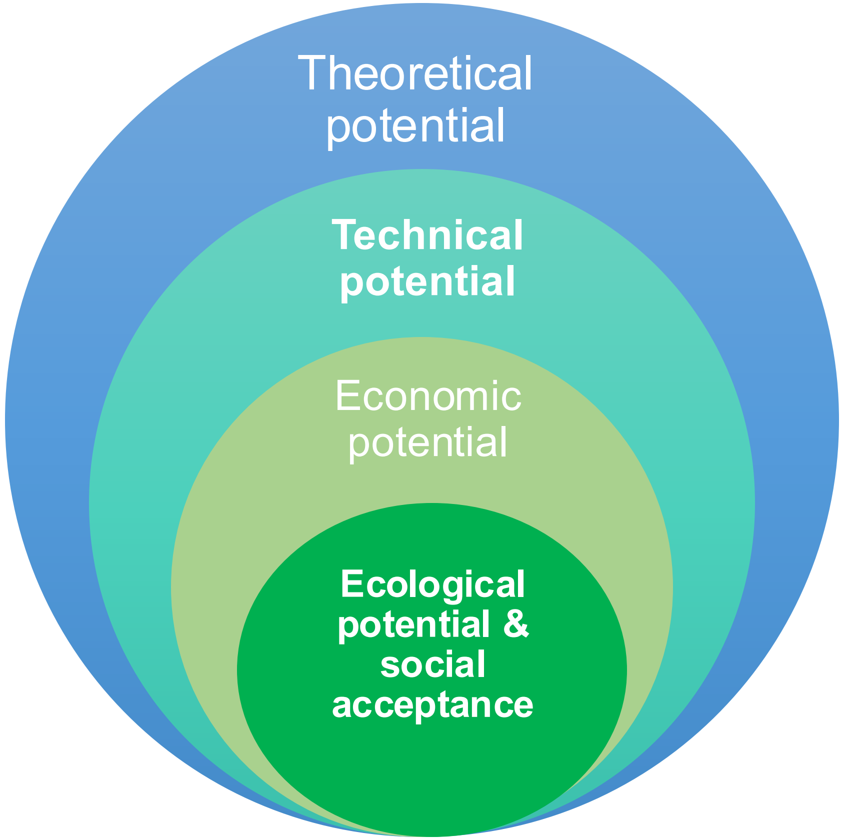
CO_2 EMISSION Decarbonisation pathway (example for a small city)



Renewable energy potentials

POTENTIAL TERMS

AUSTRIAN INSTITUTE OF TECHNOLOGY



1. **The physical/theoretical potential:**

   The theoretical potential of an energy source in the study area refers to the total available supply, without taking into account any actual usage-related restrictions.

2. **The technical potential:**

   The technical potential refers to the portion of the theoretical potential that is actually usable, taking into account technical restrictions.

3. **The economic potential:** If the overall costs of converting an energy source fall within the same range as the costs of competing systems, the determination of economic potential depends on assumptions and fluctuating influencing parameters (such as electricity market price, interest rate, depreciation period, price developments, etc.).
4. The ecological potential: will not be considered
5. Social acceptance: will not be considered

Based on Fechner, H, 2020, Ermittlung des Flächenpotentials für den Photovoltaik-Ausbau in Österreich: Welche Flächenkategorien sind für die Erschließung von besonderer Bedeutung, um das Ökostromziel realisieren zu können

Ali Hainoun

AIT Austrian Institute of Technology GmbH

Digital Resilient Cities, Center for Energy

Giefinggasse 4 | 1210 Vienna | Austria

Ali.Hainoun@ait.ac.at| http://www.ait.ac.at/city

www.plenty-life.eu

Co-funded by the European Union