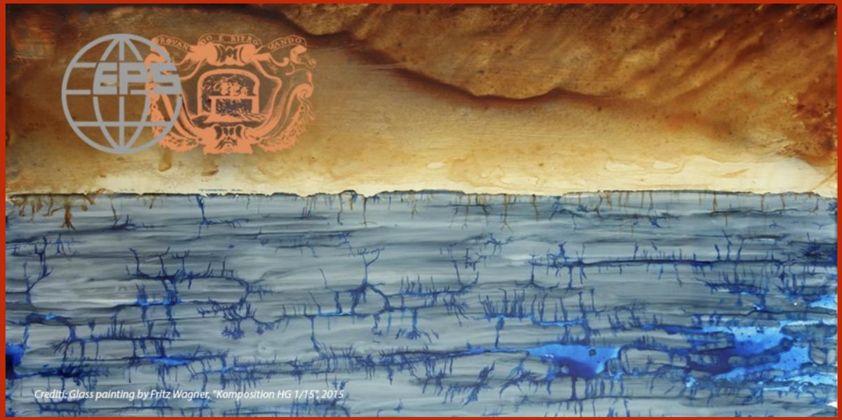
Climate Neutral and Smart cities: Towards the Energy Transition

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Joint EPS-SIF International School on Energy 2023



Carlo Alberto Nucci

University of Bologna – DEI

National Representative
EU Mission Climate Neutral and Smart Cities

July 19th, 2023 - 9:00-10:00

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Smart City

Smart city: definition

EU: A smart city is a place where traditional networks and services are made more efficient with the use of **digital solutions** for the benefit of its **inhabitants** and **business** (<u>and less emissions)</u>

A smart city goes beyond the use of digital technologies for better resource use and **less emissions**

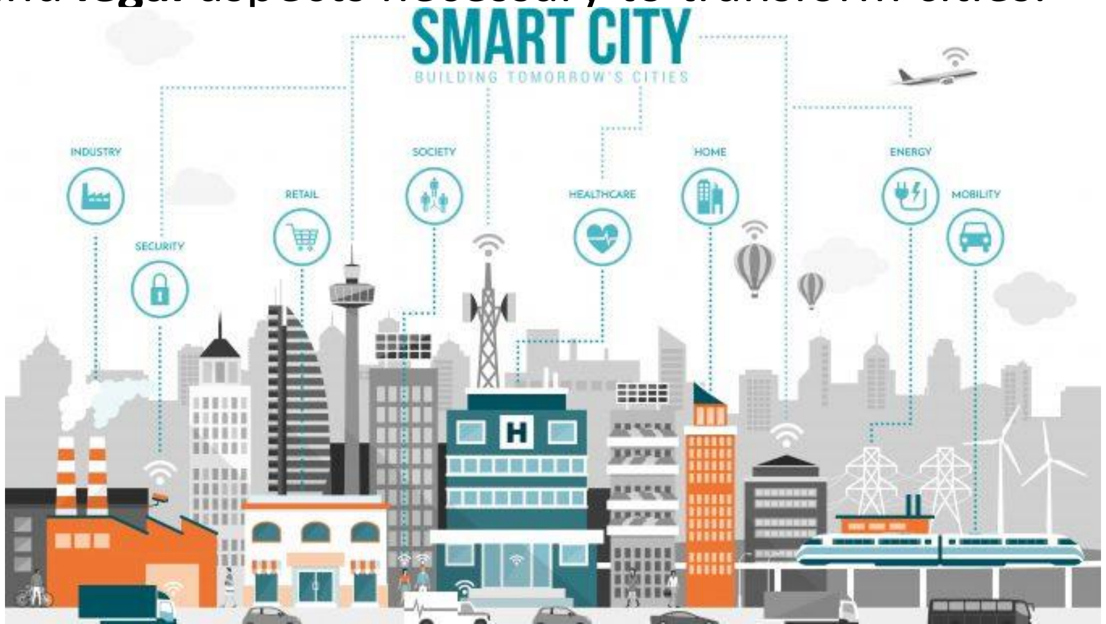
It means smarter urban **transport networks**, upgraded **water supply** and **waste** disposal facilities and **more efficient ways to light** and **heat buildings**

It also means a **more interactive** and responsive **city administration**

Use of **big data** and **IOT** technologies

Availability of **open**, interconnected and shared **datasets** throughout the city ecosystem, capable of breaking down barriers and generating greater knowledge of the city system (**Digital Twins**).

EU considers city innovation not only pertaining to technology, but also linked to the **social**, creative, organisational, **financial** and **legal** aspects necessary to transform cities.



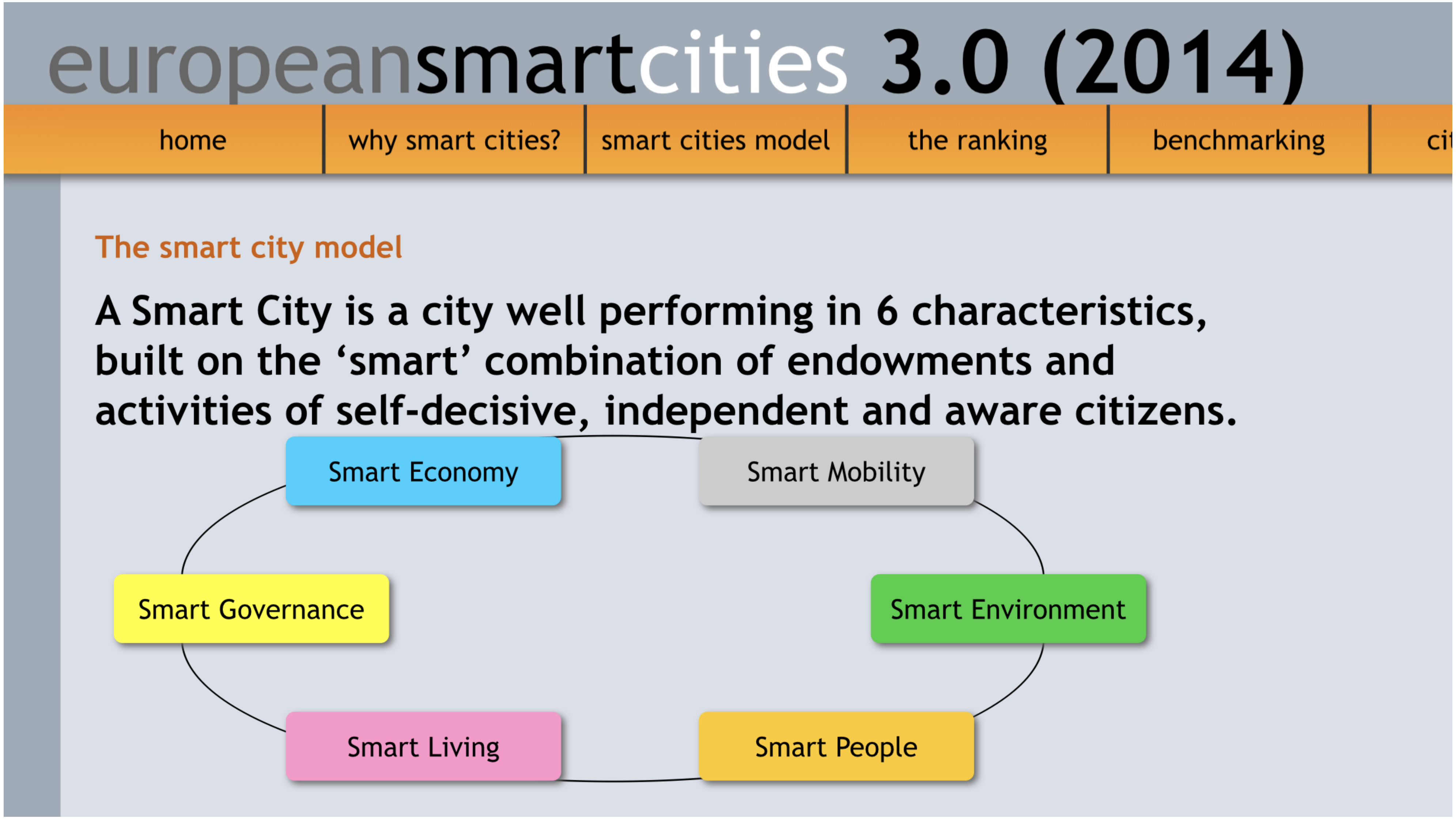
On the adjective ‘smart’

The relevant technologies are nowadays labeled with the ubiquitous word **smart**.

Technology has always been **smart** → **this adjective serves to underline the widespread use ICT, sensors and intelligence, e.g. software embedded in the various parts, components and infrastructures forming an urban area**.

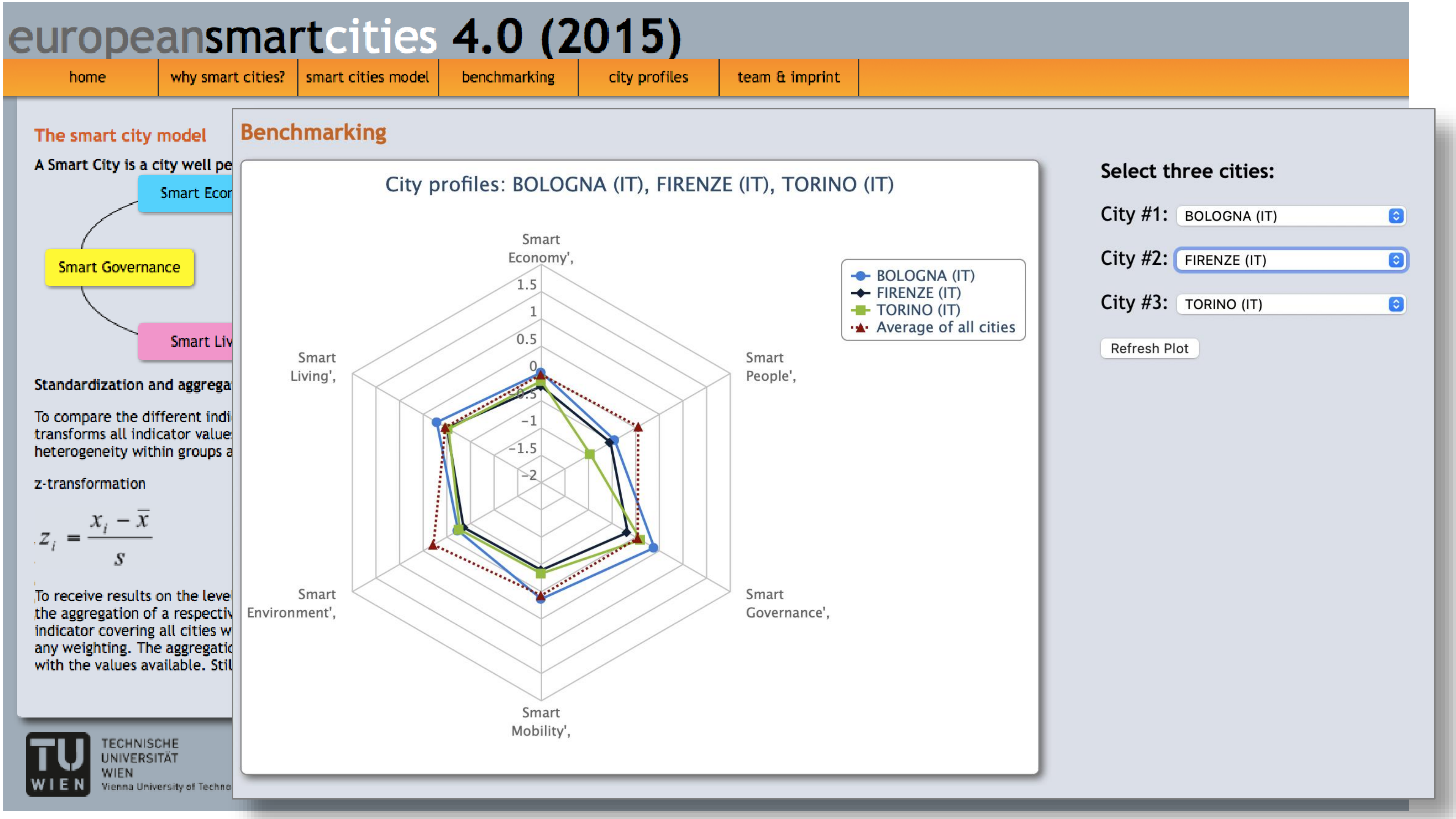
→ we label people living in the city/using its facilities as **smart** as well, in that they own portable smart **devices** and **meters** communicating with existing ICT networks

A first assessment methodology



A first assessment methodology

http://www.smart-cities.eu/?cid=-1&ver=4



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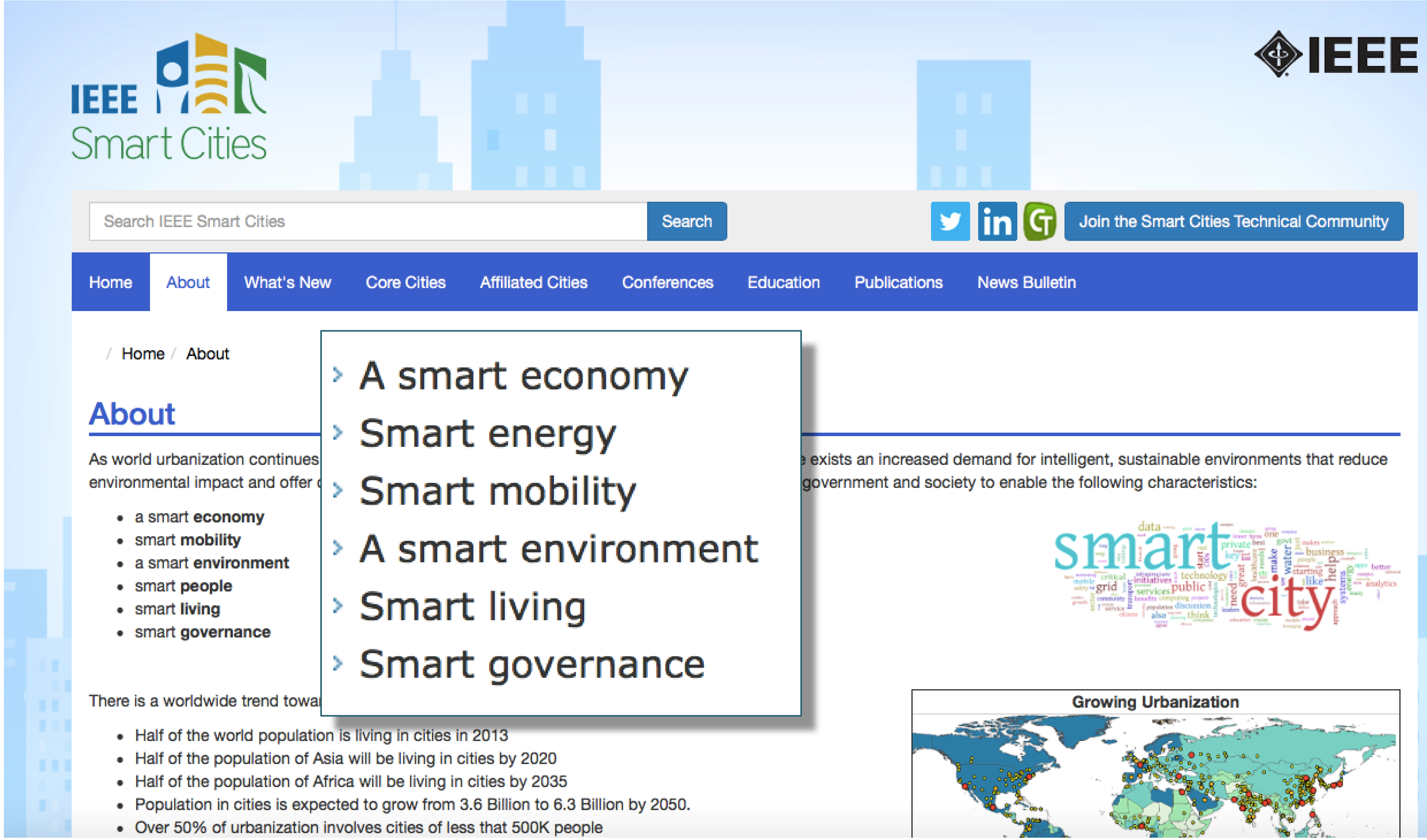
IEEE Smart City Initiative



IEEE Smart City Initiative

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About

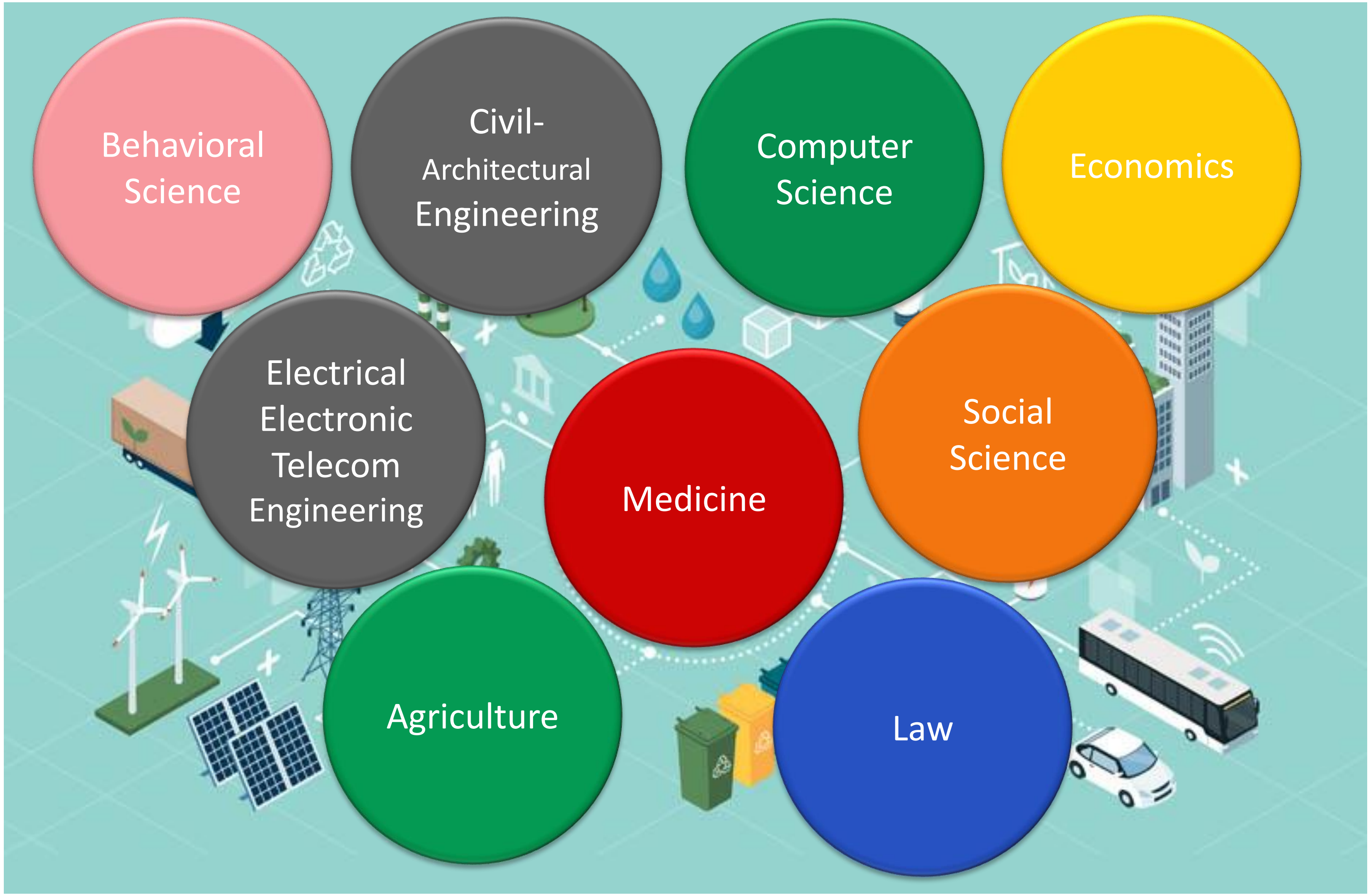
As world urbanization continues to grow and the total population expected to double by 2050, there exists an inc
environmental impact and offer citizens a high quality life. A **smart city** brings together technology, government a

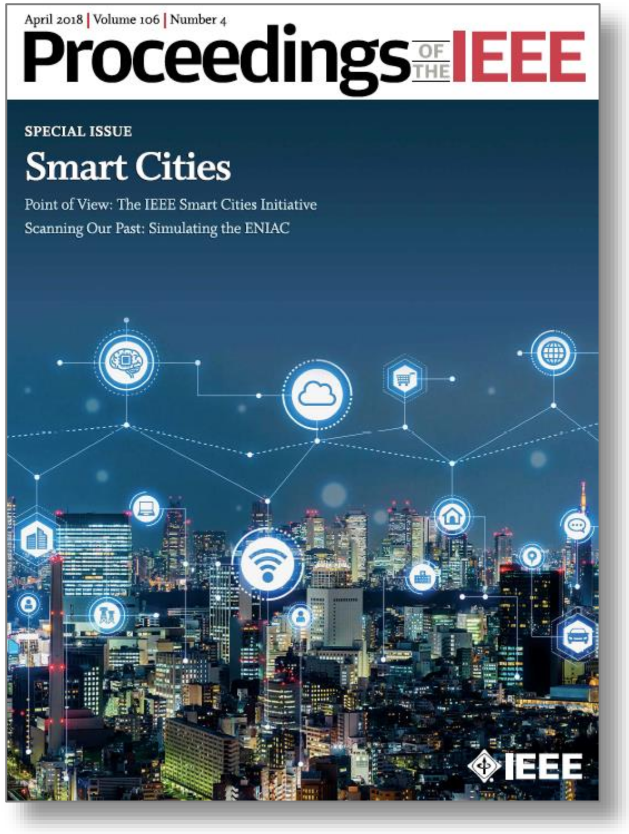
- a smart **economy**
- smart **mobility**
- a smart **environment**
- smart **people**
- smart **living**
- smart **governance**

There is a worldwide trend toward Smart Cities as shown by the following:

- Half of the world population is living in cities in 2013
- Half of the population of Asia will be living in cities by 2020
- Half of the population of Africa will be living in cities by 2035
- Population in cities is expected to grow from 3.6 Billion to 6.3 Billion by 2050.
- Over 50% of urbanization involves cities of less that 500K people

Need of a multi-disciplinary approach





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SPECIAL ISSUE

SMART CITIES

Edited by G. Betis, C. G. Cassandras, and C. A. Nucci

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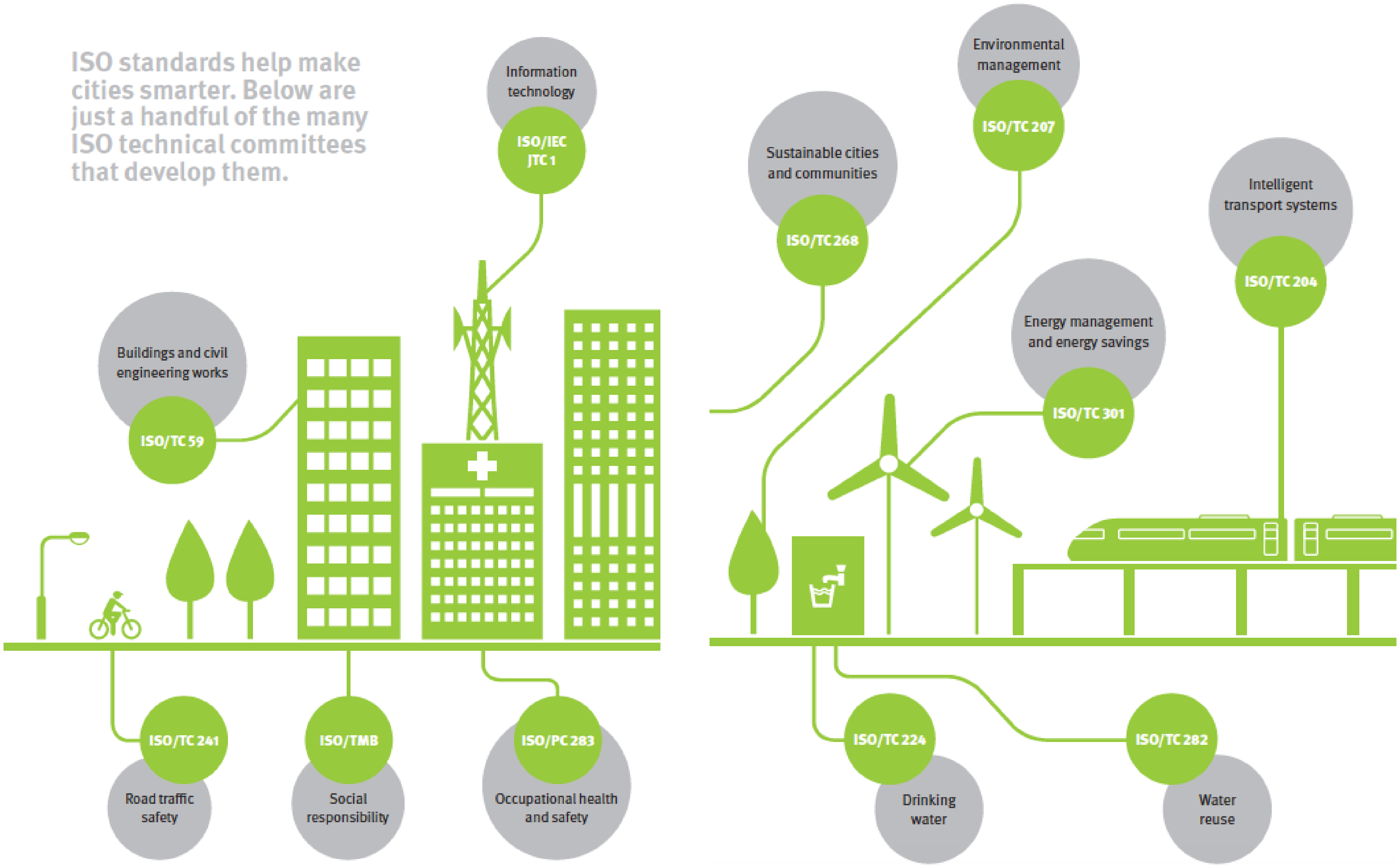

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Climate Neutrality

Crediti: Glass painting by Fritz Wagner, "Komposition HG 1/15" 2015

The IPCC

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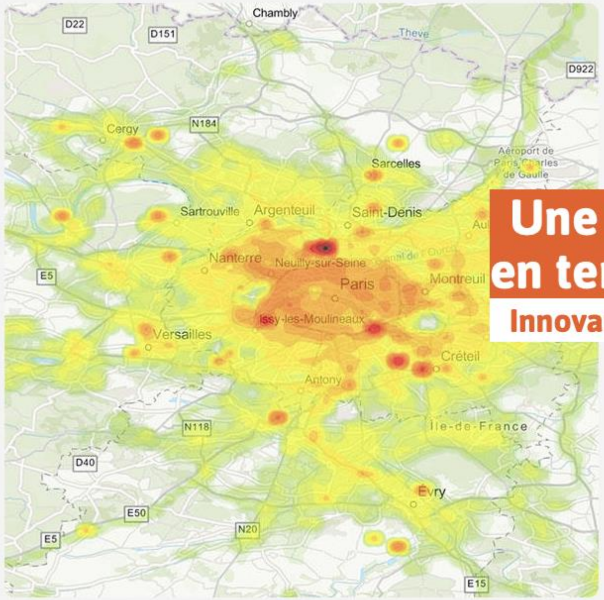


Une météo pour mesurer le carbone en temps réel à Paris

Innovation Climat

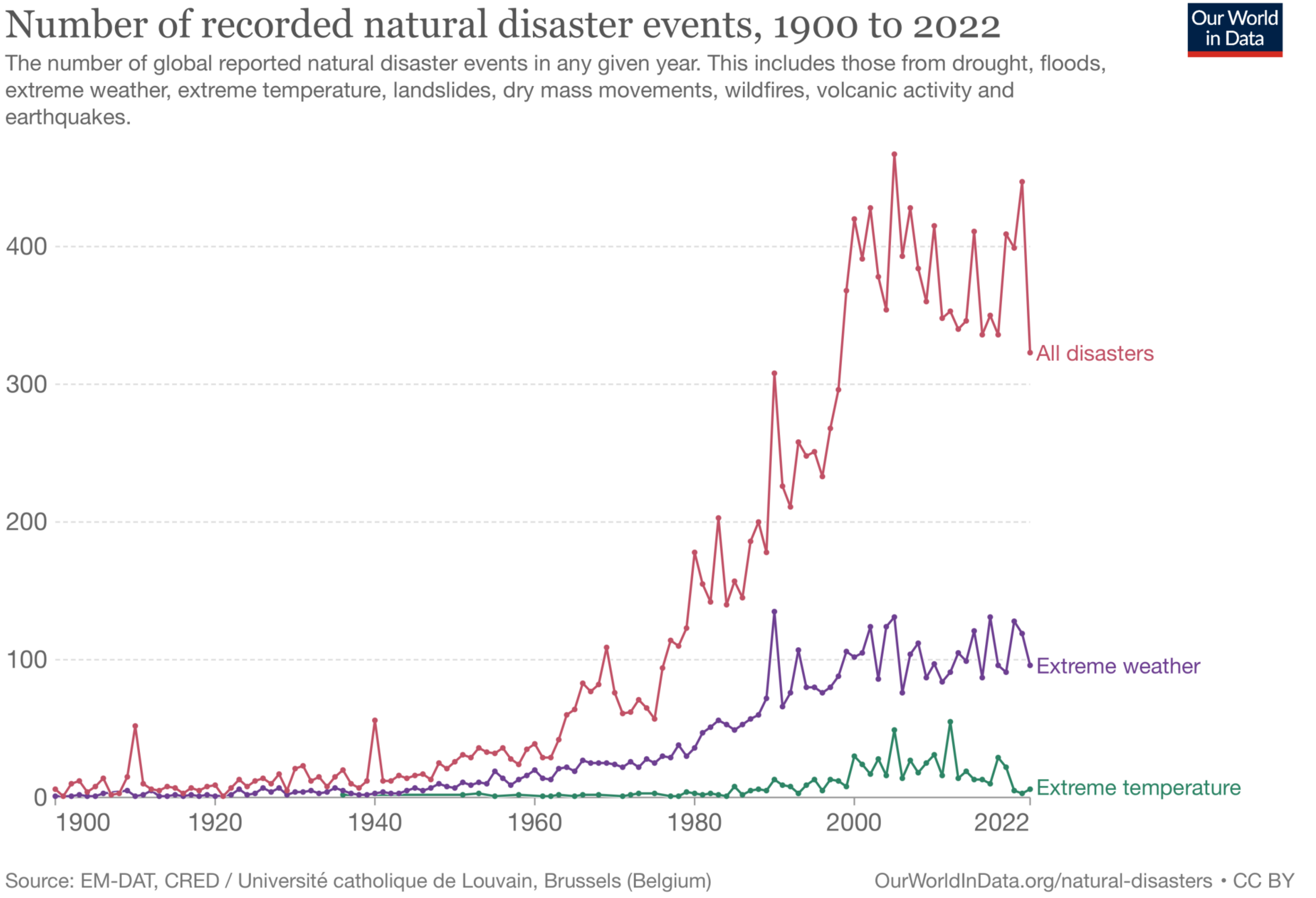
PARTICULIER
PROFESSIONNEL

Publié le 25 novembre 2019 par Agence Parisienne du Climat

La start up française Origins.earth, le Laboratoire des Sciences du Climat et de l'Environnement et la Ville de Paris lancent la Météo Carbone, pour suivre le CO2 à la trace ! Une opération soutenue par l'Agence Parisienne du Climat.



Natural disaster events



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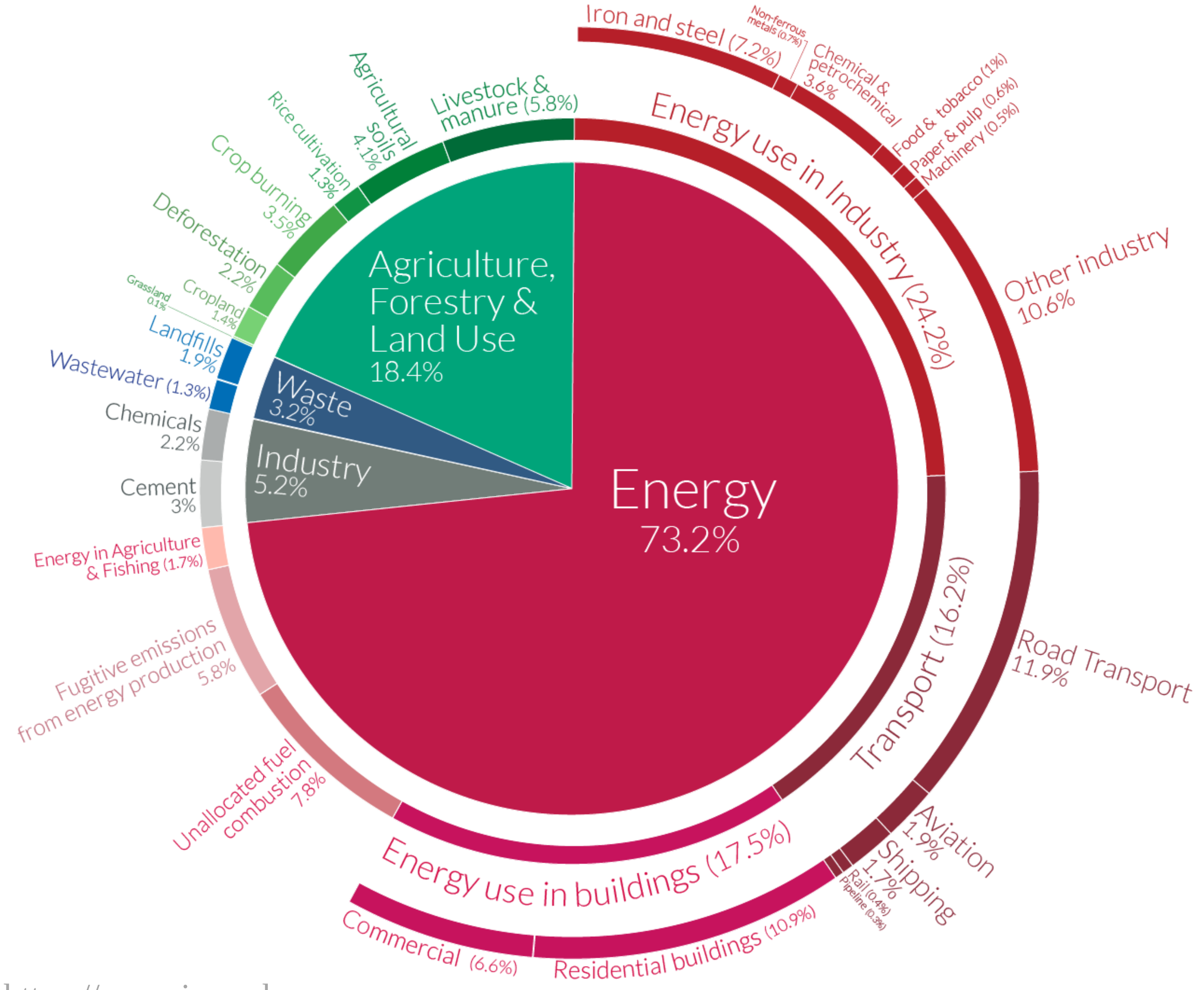
Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.

Our World in Data



https://www.ipcc.ch

OurWorldinData.org – Research and data to make progress against the world's largest problems.

https://ourworldindata.org/emissions-by-sector

Source: Climate Watch, the World Resources Institute (2020).

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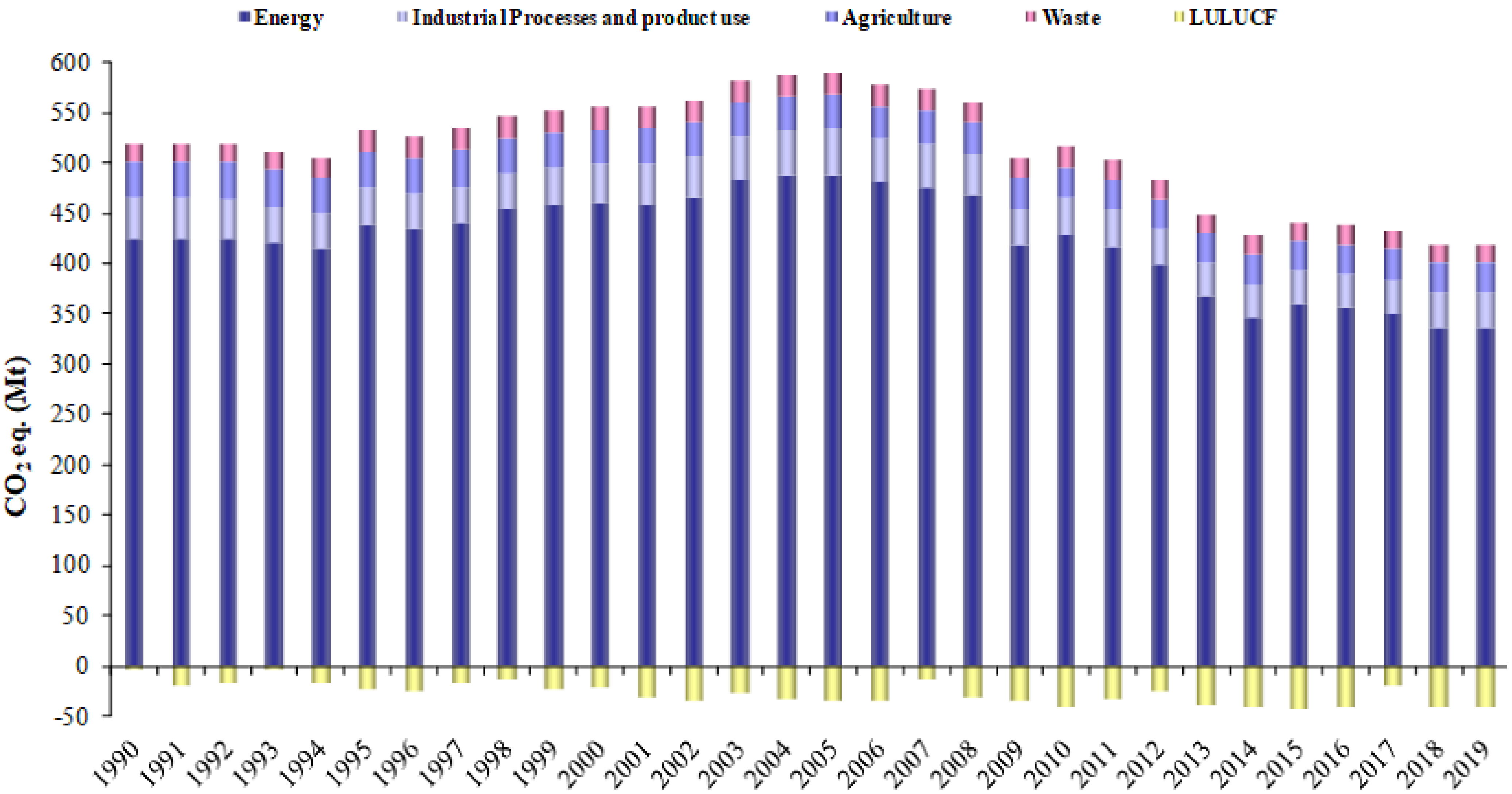
Italy GHG emissions from 1990 to 2019 by sector



https://www.isprambiente.gov.it/it/attivita/cambiamenti-climatici/landamento-delle-emissioni

Definition of climate neutrality
(EU Climate Neutral and Smart Cities Mission)

Climate neutrality → to obtain net zero emissions through the reduction of emissions, investment in green technologies and the protection / development of natural ecosystems.

The emissions must be expressed in CO2 equivalent and must cover:

Carbon dioxide (CO2),

Methane (CH4)

Nitrous oxide (N2O)

Possibly from the industrial sector also:

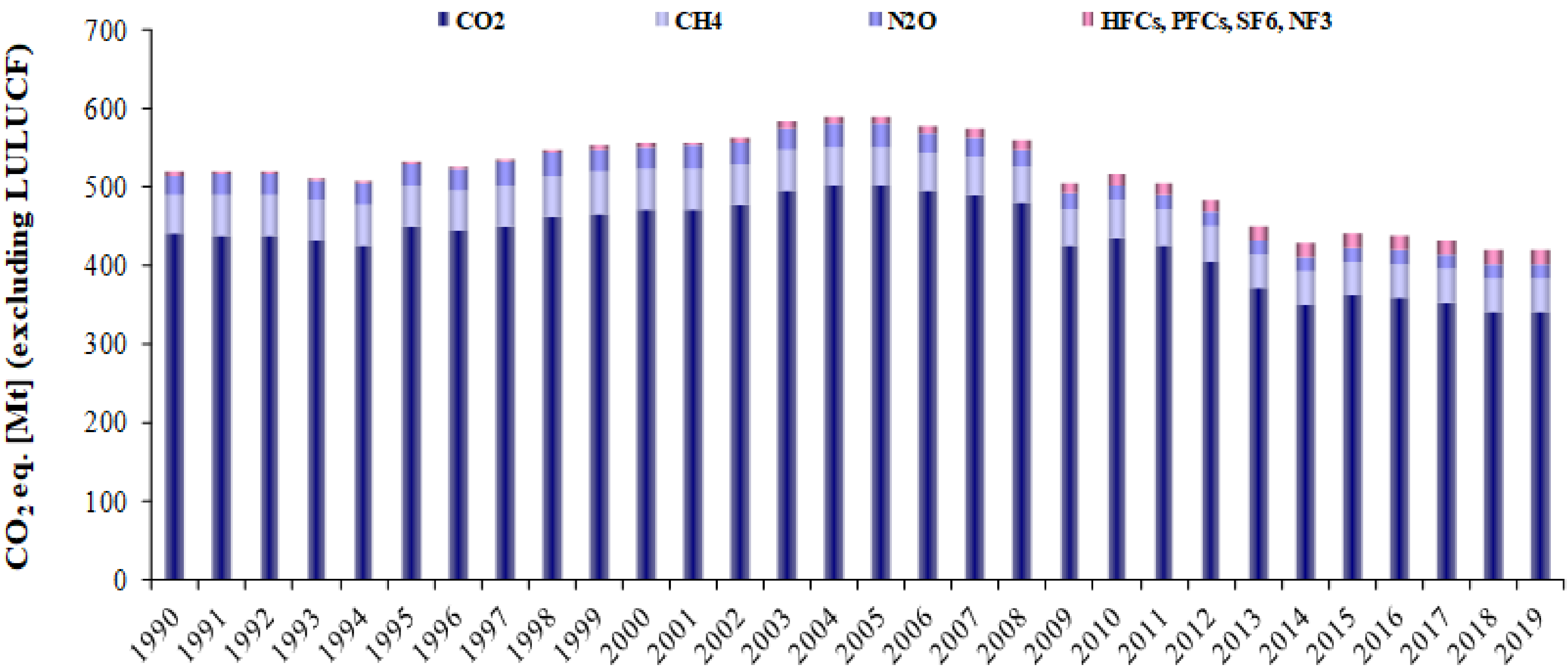
Hydrofluoro-carbides (HFCs),

Perfluorocarbons (PFCs),

Sulfo-hexafluorides (SF6)

Nitrogen trifloride (NF3)

Italy GHG emissions from 1990 to 2019 by gas



Carbon dioxide (CO_2)

Methane (CH_4)

Nitrous oxide (N_2O)

Hydrofluoro-carbides (HFCs)

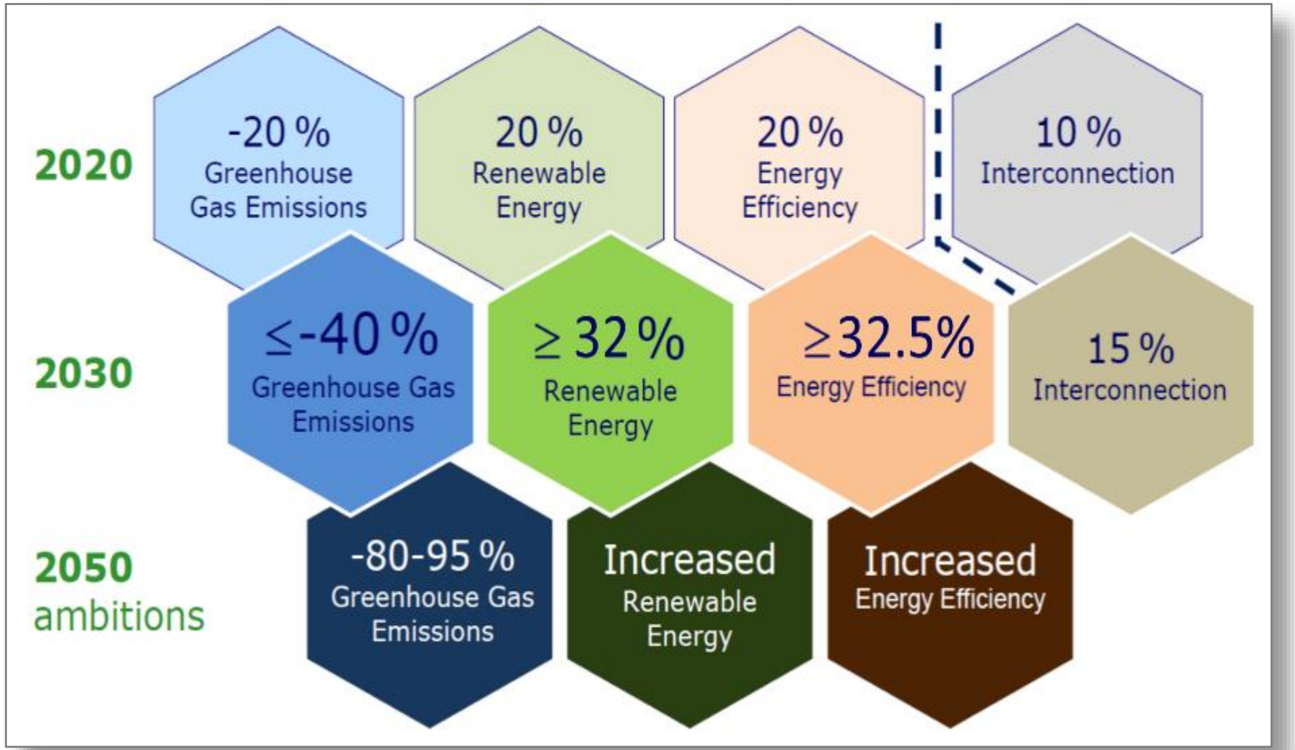
Perfluorocarbons (PFCs)

Sulfo-hexafluorides (SF_6)

Nitrogen trifloride (NF_3)

https://www.isprambiente.gov.it/it/attivita/cambiamenti-climatici/landamento-delle-emissioni

CEP COP Green Deal



COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

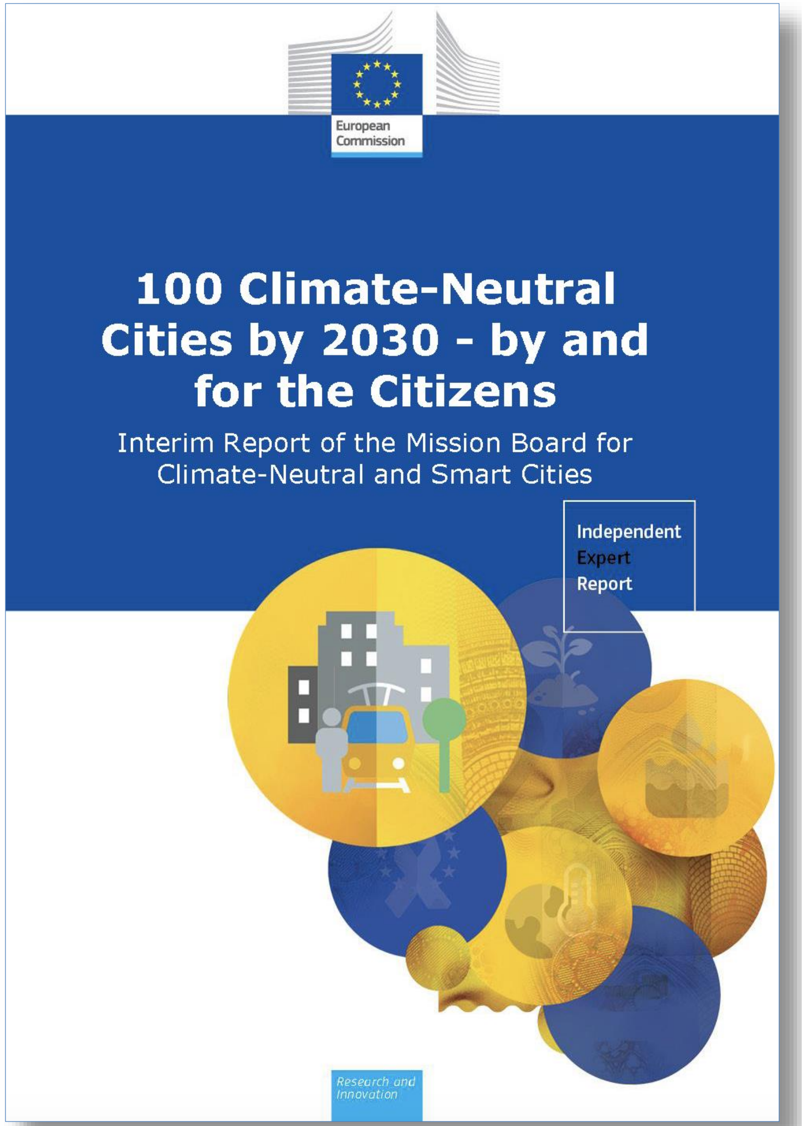
The agreement reached on 12 December 2015 commits to keeping the temperature rise below 2° and – if possible – below 1.5° compared to pre-industrial levels.

3

The EU Mission Climate Neutral and Smart Cities

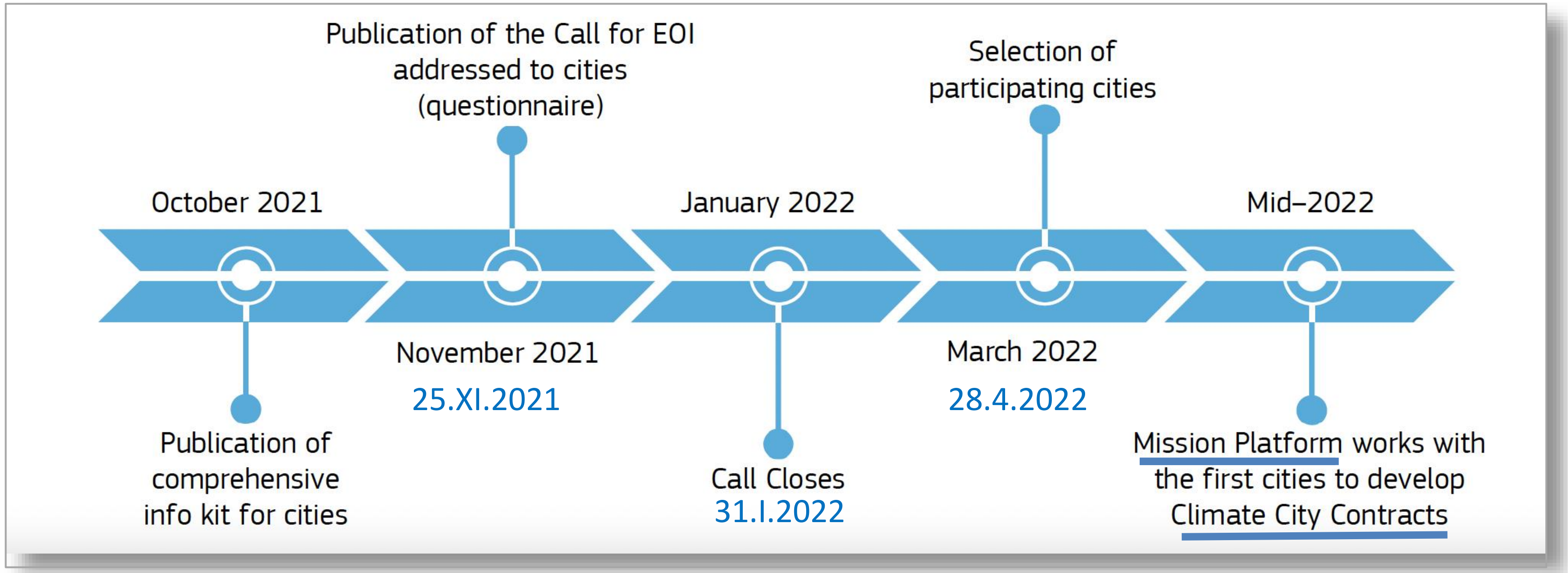
Crediti: Glass painting by Fritz Wagner, "Komposition HG 1/15", 2015

Scope of the C-N & SC Mission



1) To deliver at least **100 climate-neutral and smart cities** by **2030**

2) Ensure that these cities act as **experimentation and innovation hubs** to enable all European cities to follow suit by 2050.



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Why Cities?

4% EU land area

75% EU citizens

85% by **2050**

> 65% energy consumption

> 70% CO_2 emissions

FRANCE
Angers Loire Metropole
Bordeaux Metropole
Dijon Metropole
Dunkerque
Grenoble-Alpes Metropole
Lyon
Marseille
Nantes Metropole
Paris

LUXEMBOURG
Differdange

Leipzig
Mannheim
Munich
Münster

AUSTRIA
Klagenfurt

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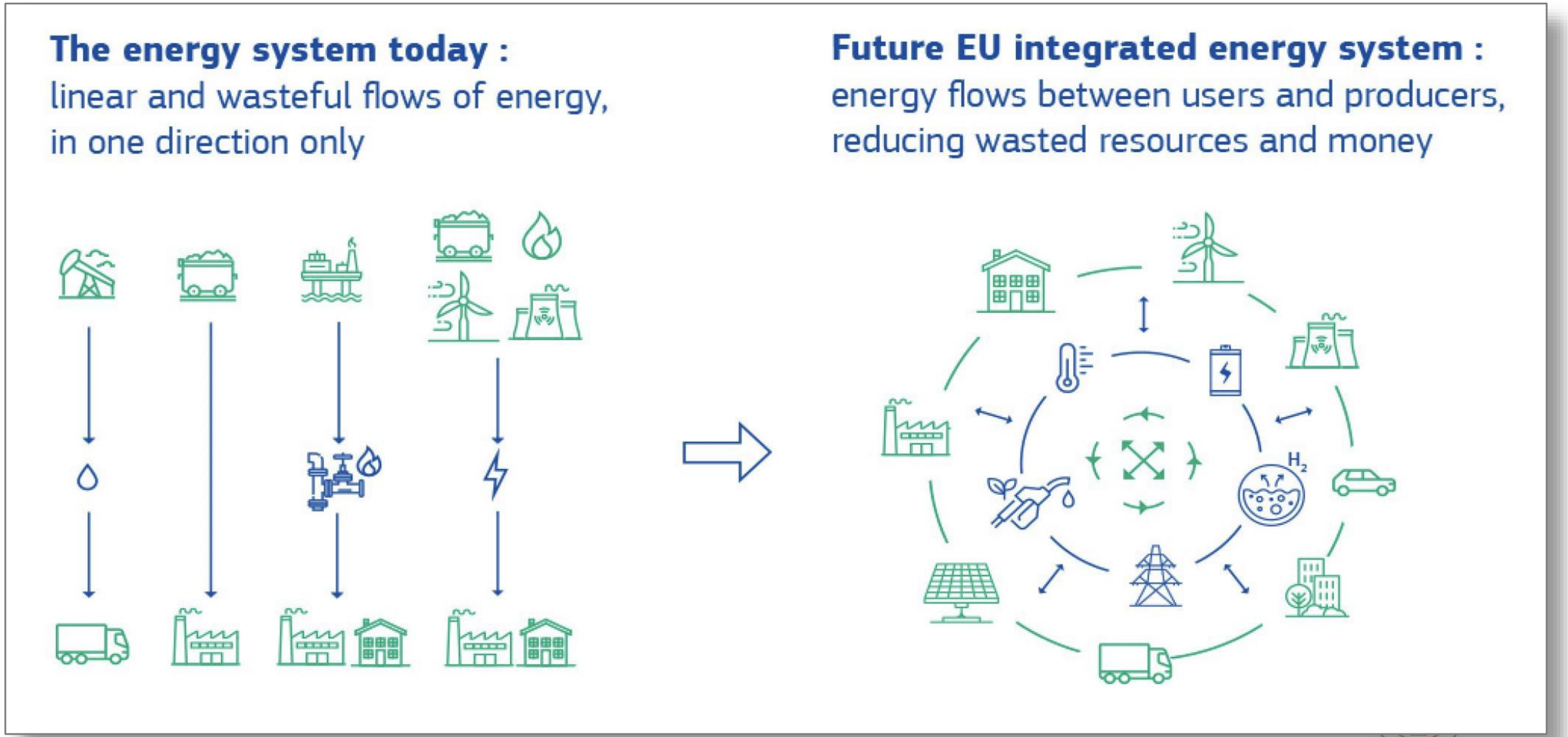


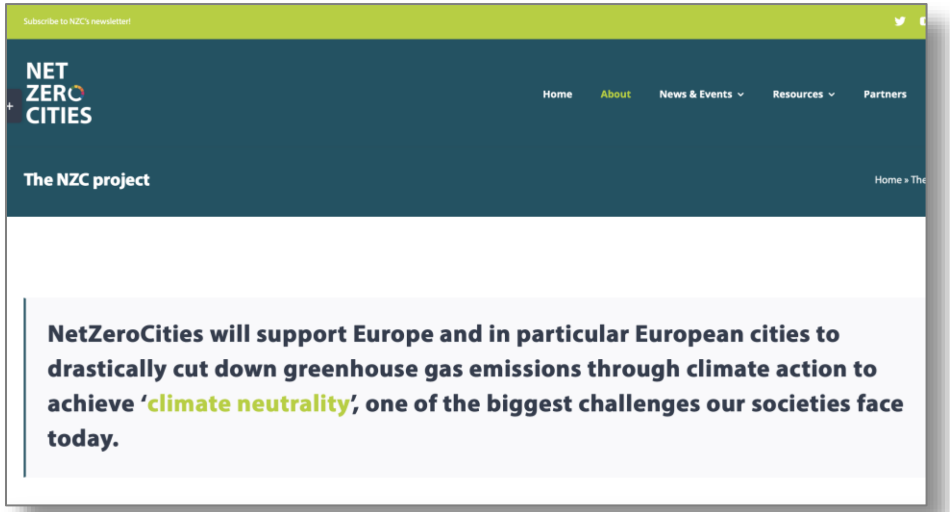
https://energy.ec.europa.eu/topics/energy-systems-integration/eu-strategy-energy-system-integration_en

Net Zero Cities – Mission Platform

Cilmate City Contract

Courtesy Francesca Rizzo, PolMi – NetZeroCities

City advisors and experts



NetZeroCities will support Europe and in particular European cities to drastically cut down greenhouse gas emissions through climate action to achieve 'climate neutrality', one of the biggest challenges our societies face today.

CapaCITIES – Mission Platform

CAPACITIES
Advancing national support
for climate neutral cities

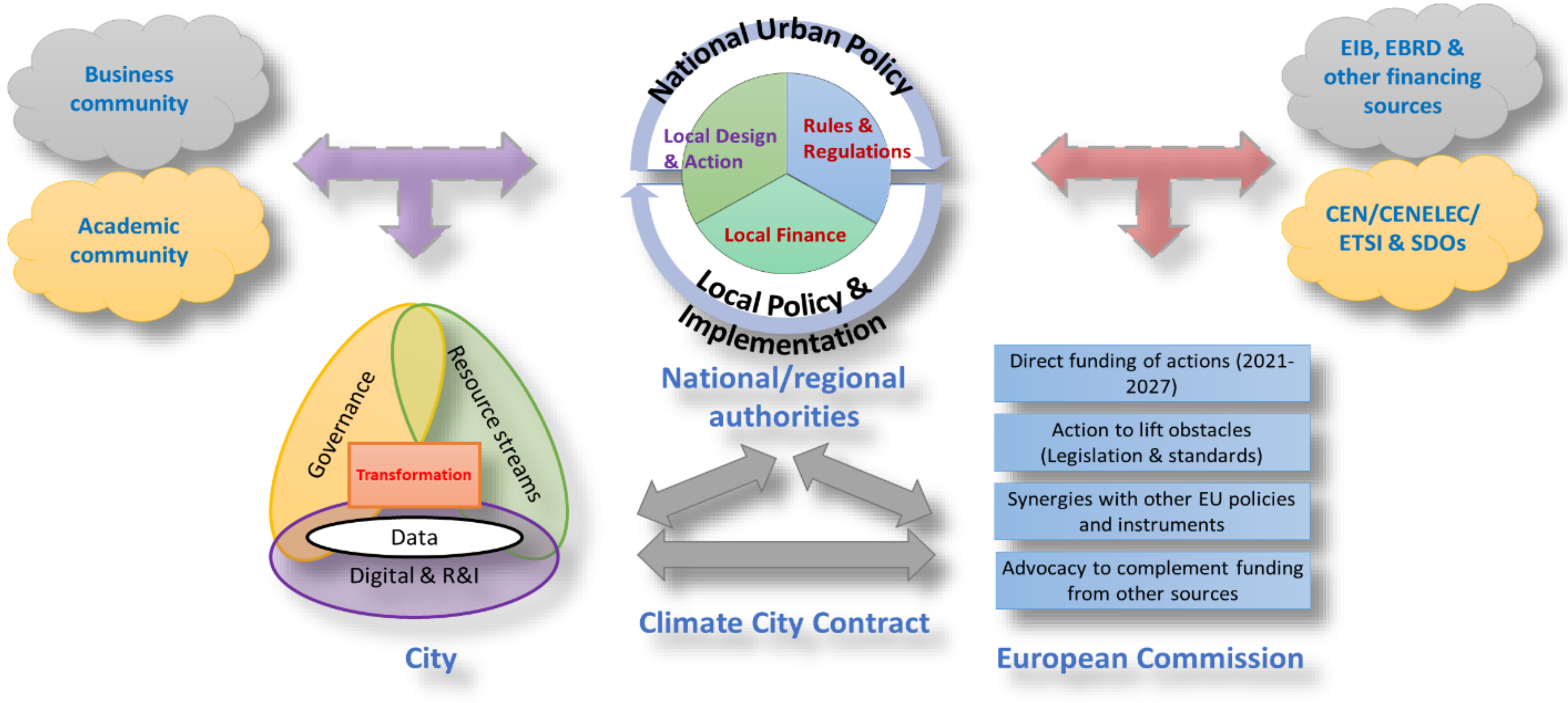
Impacts

Systemic transition towards climate neutrality within cities.

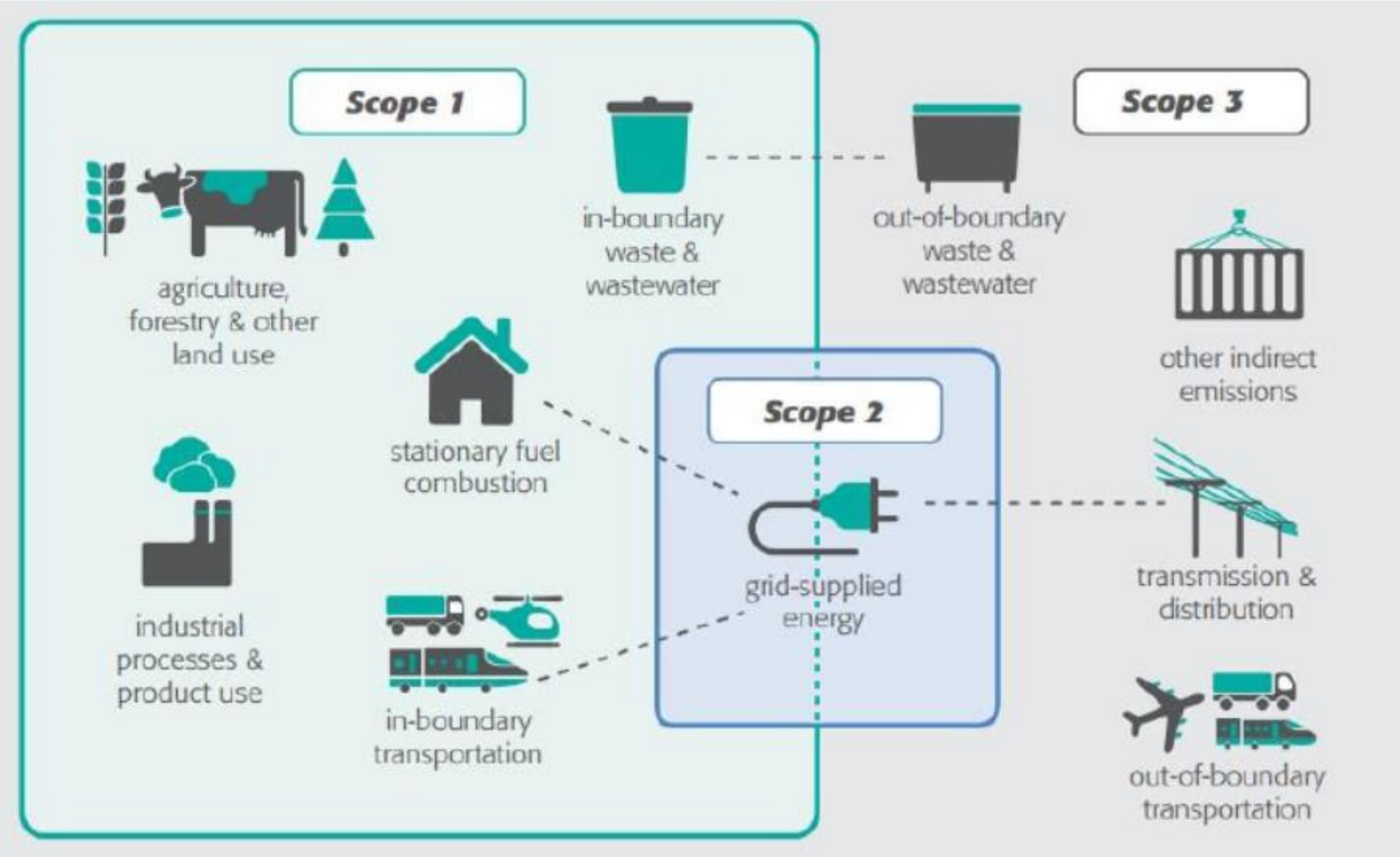
Climate neutrality and modernization of transport and mobility systems

Energy and resource efficient building renovations

Restructuring of urban spaces that combines sustainability, accessibility and aesthetics in a human-centered way (Bauhouse)



Achieving climate neutrality



1. emissions are released into the atmosphere as a direct result of a set of activities
2. indirect emissions from the generation of purchased energy, from a utility provider
3. Scope 3 emissions include all sources not within the scope 1 and 2 boundaries. An example of this is when we buy, use and dispose of products from suppliers.

Achieving climate neutrality

__will require a Mission City to reduce the GHG emissions from all sectors and sources within the city's boundary to net zero by 2030, including:

- Emissions from combustion of fossil fuels in **all buildings** and **facilities** (known as '**stationary energy').** This includes residential, commercial and industrial buildings, municipal buildings and public lighting within the city boundary;
- Emissions from combustion of fossil fuels **for all vehicles and transport** within the city boundary;
- Emissions arising from the **consumption of electricity and district heating/cooling** within the city's boundary, from power plants located within or outside the city boundary;
- Emissions arising from **waste generated within the city boundary**, treated/managed/disposed within or outside the city boundary;
- Emissions from **changes in land use** including agriculture, forestry and other land uses (collectively referred to as 'AFOLU') within the city boundary;
- Emissions from **chemical processes in industry** (collectively referred to as Industrial Process and Product Use or 'IPPU') within the city boundary.

Achieving climate neutrality through energy transition

EPBD

New Energy Performance Building Directive
Existing buildings should be carbon neutral by 2050, public buildings by 2027, all new private buildings from 2030

- **RES**

Championing local renewable energy generation

Main directions of actionable measures:
→ Centralized, utility-scale local electricity generation
→ Decentralized electricity generation by prosumers

Main directions of actionable measures:
→ District heating and cooling networks
→ Decentralized thermal energy generation

- **H_2** **Blue** and **Green**

Member States will need to add a REPowerEU (supplementary funds) chapter to their recovery and resilience plans to steer investments towards REPowerEU priorities and implement the necessary reforms. E.g. cut authorization times. Solar roofs - gradual legal obligation to install solar panels on new public and commercial buildings (2025) and new residential buildings (2029). Doubling of the diffusion rate of heat pumps and measures to integrate geothermal and solar thermal energy into modernized and municipal district heating systems.

Italian Recovery and Resilience Plan → Renewables, hydrogen, smart grid and sustainable mobility

M2C2: ENERGIA RINNOVABILE, IDROGENO, RETE E MOBILITÀ SOSTENIBILE

OBIETTIVI GENERALI:

M2C2 - ENERGIA RINNOVABILE, IDROGENO, RETE E MOBILITÀ SOSTENIBILE

- Incremento della quota di energia prodotta da fonti di energia rinnovabile (FER) nel sistema, in linea con gli obiettivi europei e nazionali di decarbonizzazione
- Potenziamento e digitalizzazione delle infrastrutture di rete per accogliere l'aumento di produzione da FER e aumentarne la resilienza a fenomeni climatici estremi
- Promozione della produzione, distribuzione e degli usi finali dell'idrogeno, in linea con le strategie comunitarie e nazionali
- Sviluppo di un trasporto locale più sostenibile, non solo ai fini della decarbonizzazione ma anche come leva di miglioramento complessivo della qualità della vita (riduzione inquinamento dell'aria e acustico, diminuzione congestioni e integrazione di nuovi servizi)
- Sviluppo di una leadership internazionale industriale e di ricerca e sviluppo nelle principali filiere della transizione

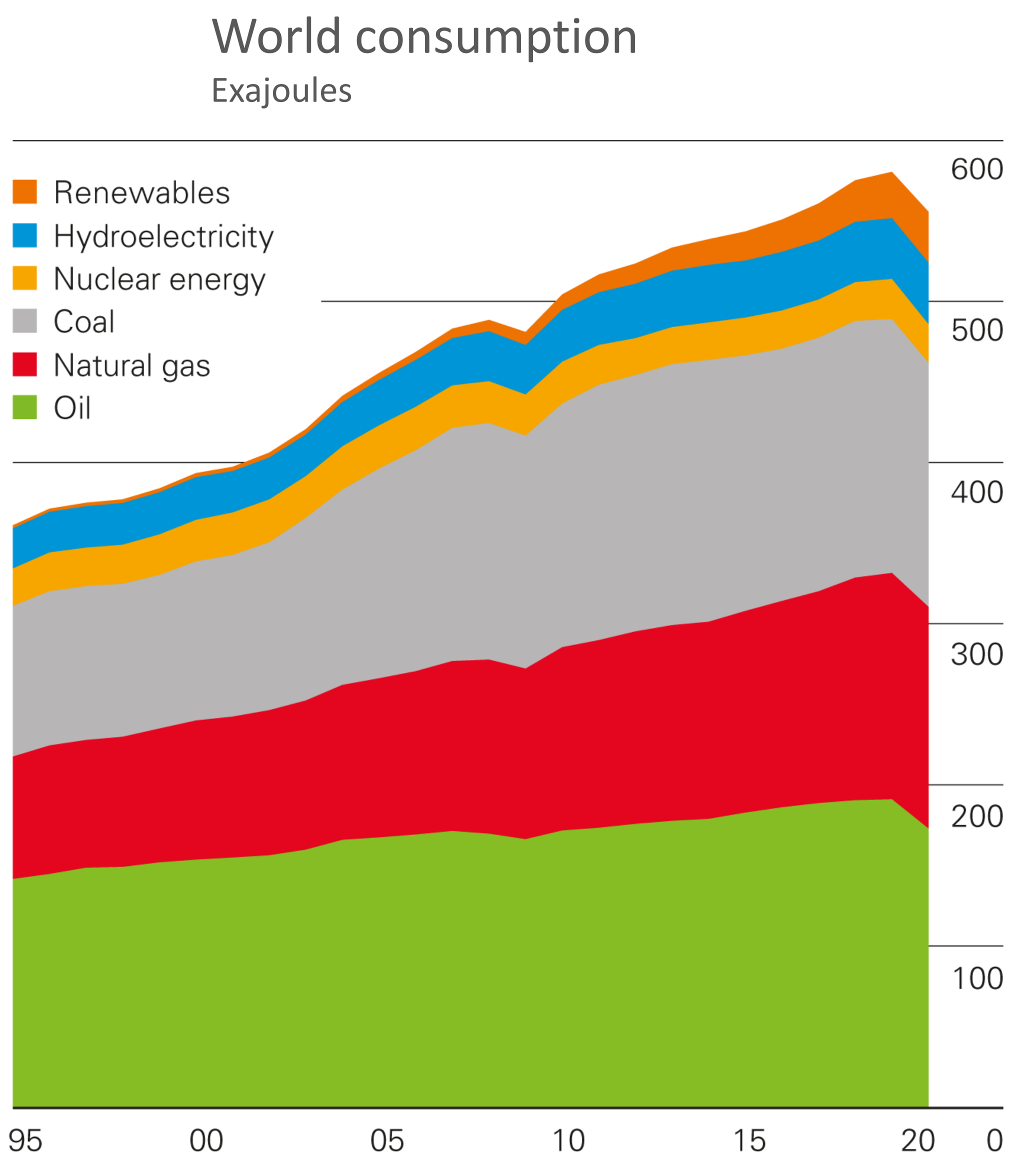
23,78 Billion

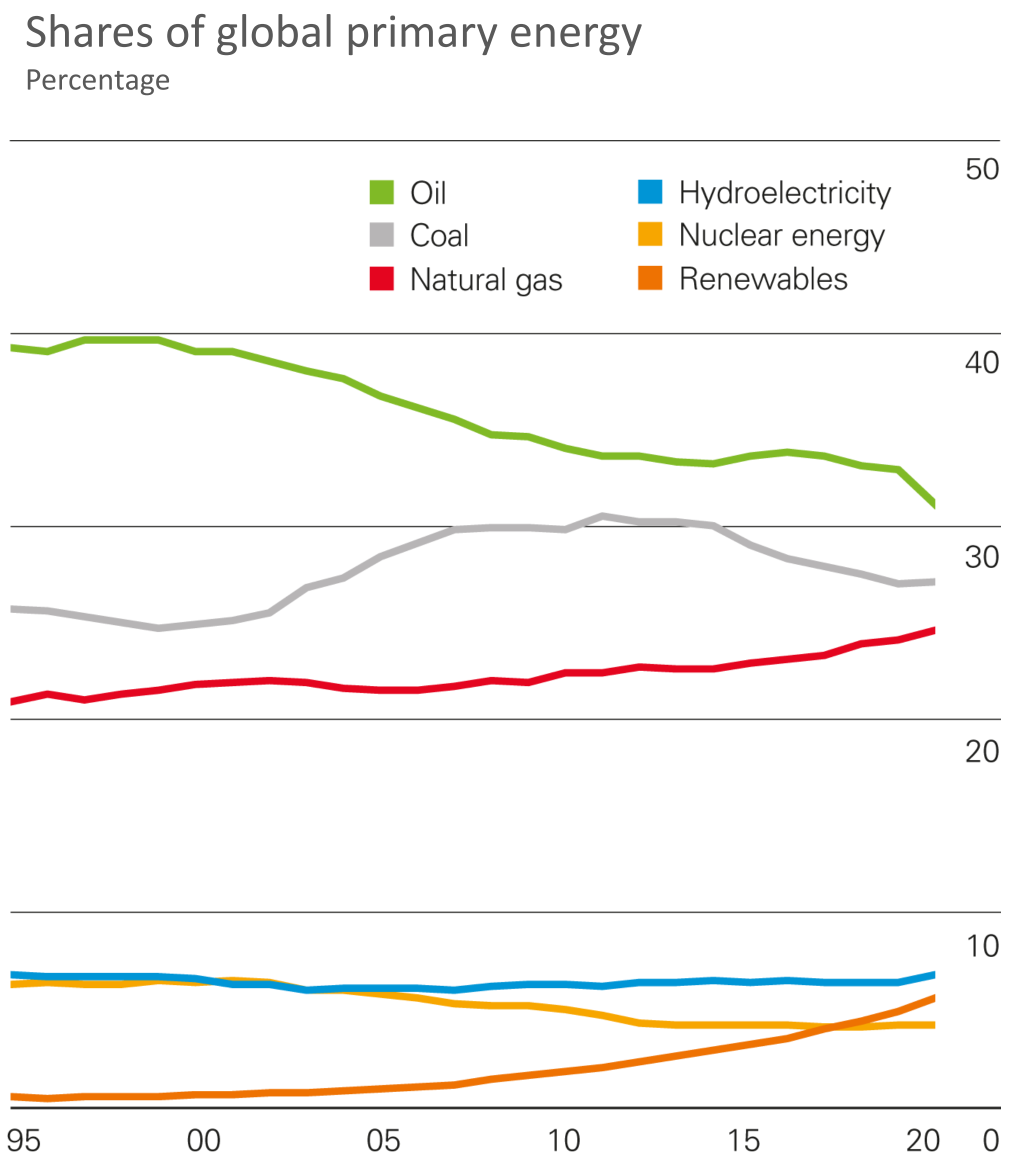
An increase in RES in energy communities and self-consumption is expected (**2.2 billion**); production, distribution and end uses of hydrogen (3.19 billion); Sustainable LPT (8.58 billion)

4

Energy Transition: the contribution of Electric Power Systems and of REC

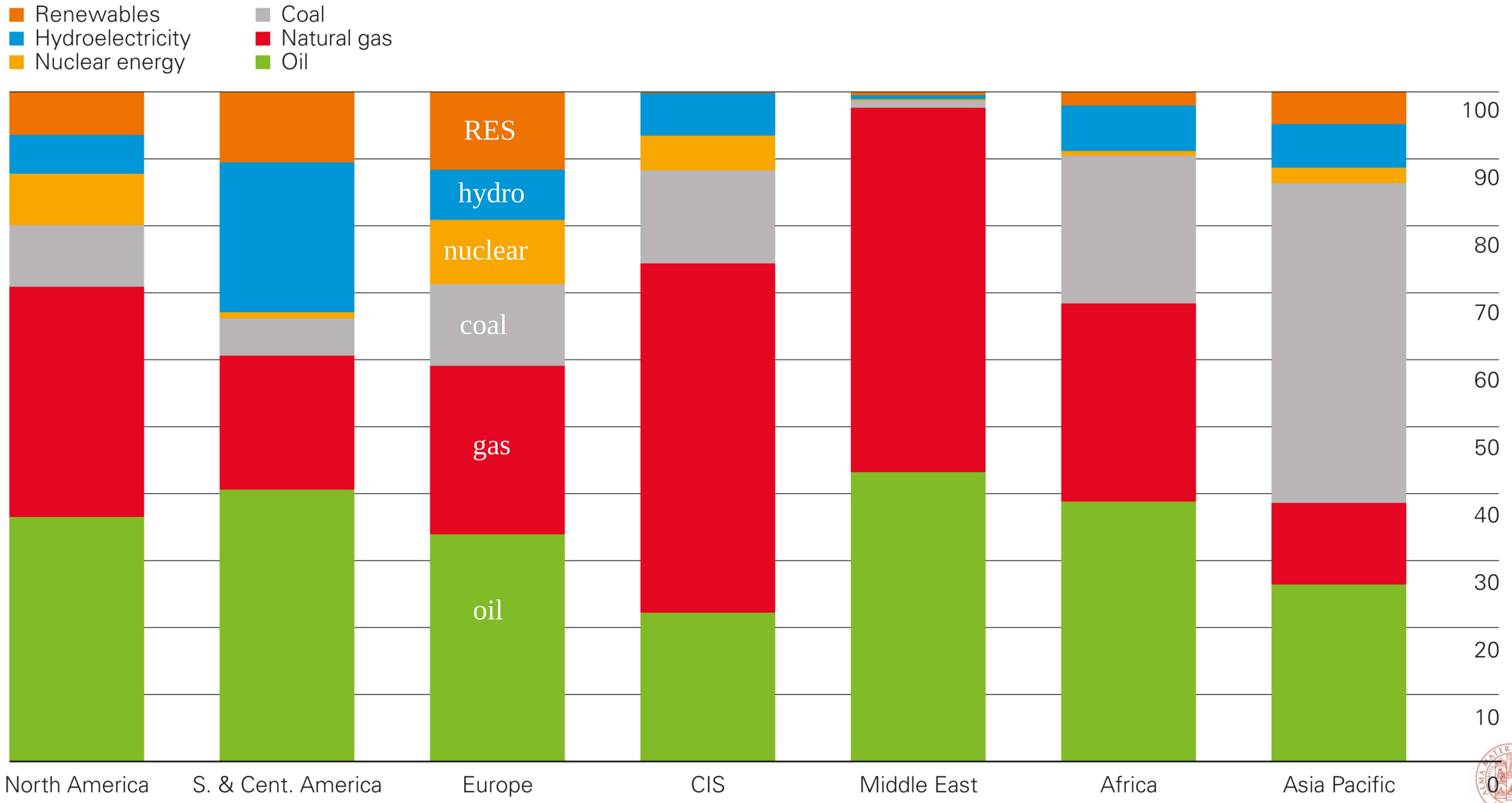
World consumption of primary energy sources





Statistical Review of World Energy 2021 © BP p.l.c. 2021

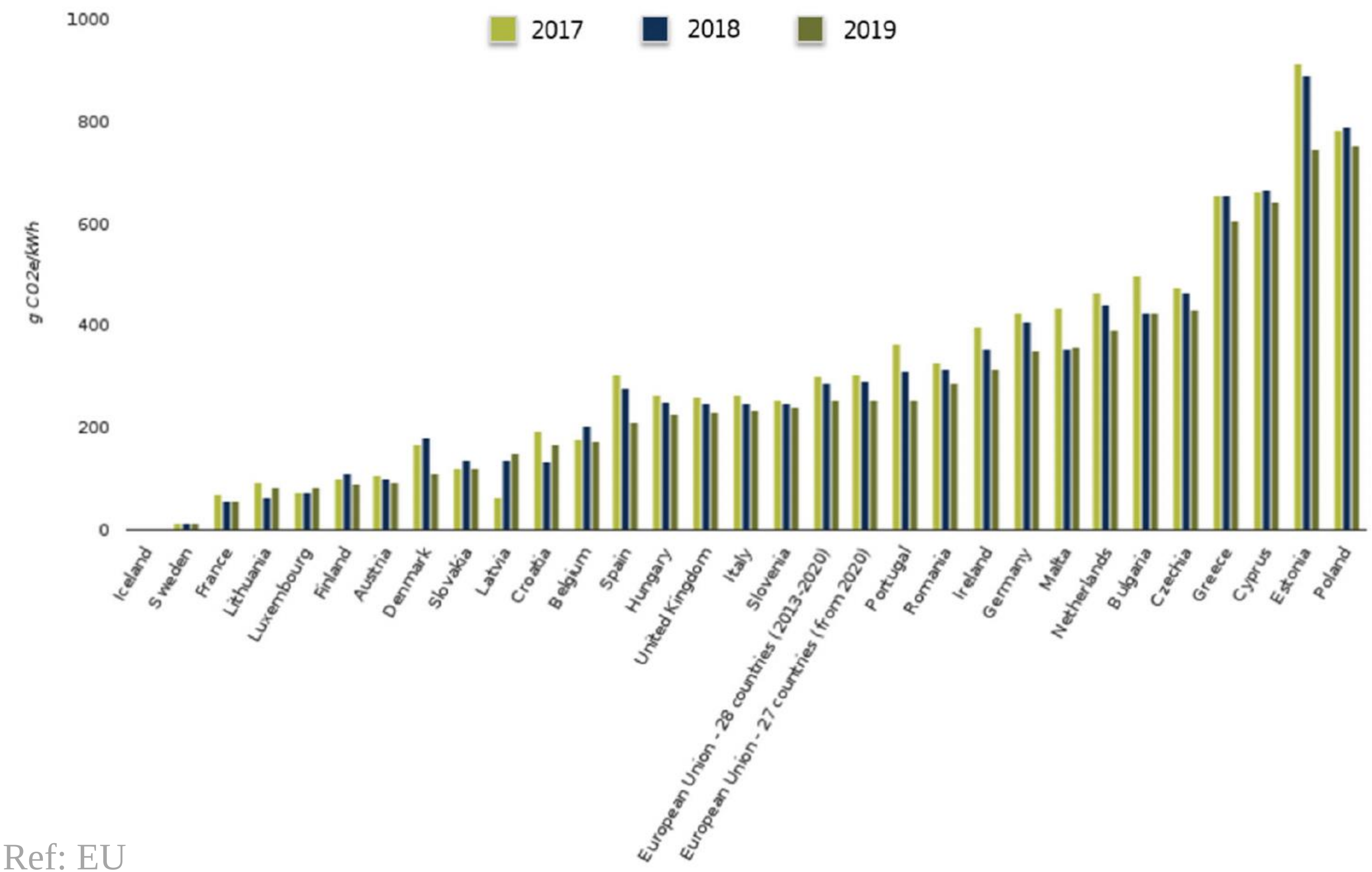
Primary energy sources Consumption % per region 2020



Statistical Review of World Energy 2021 © BP p.l.c. 2021

GHG in EU area due to Electricity

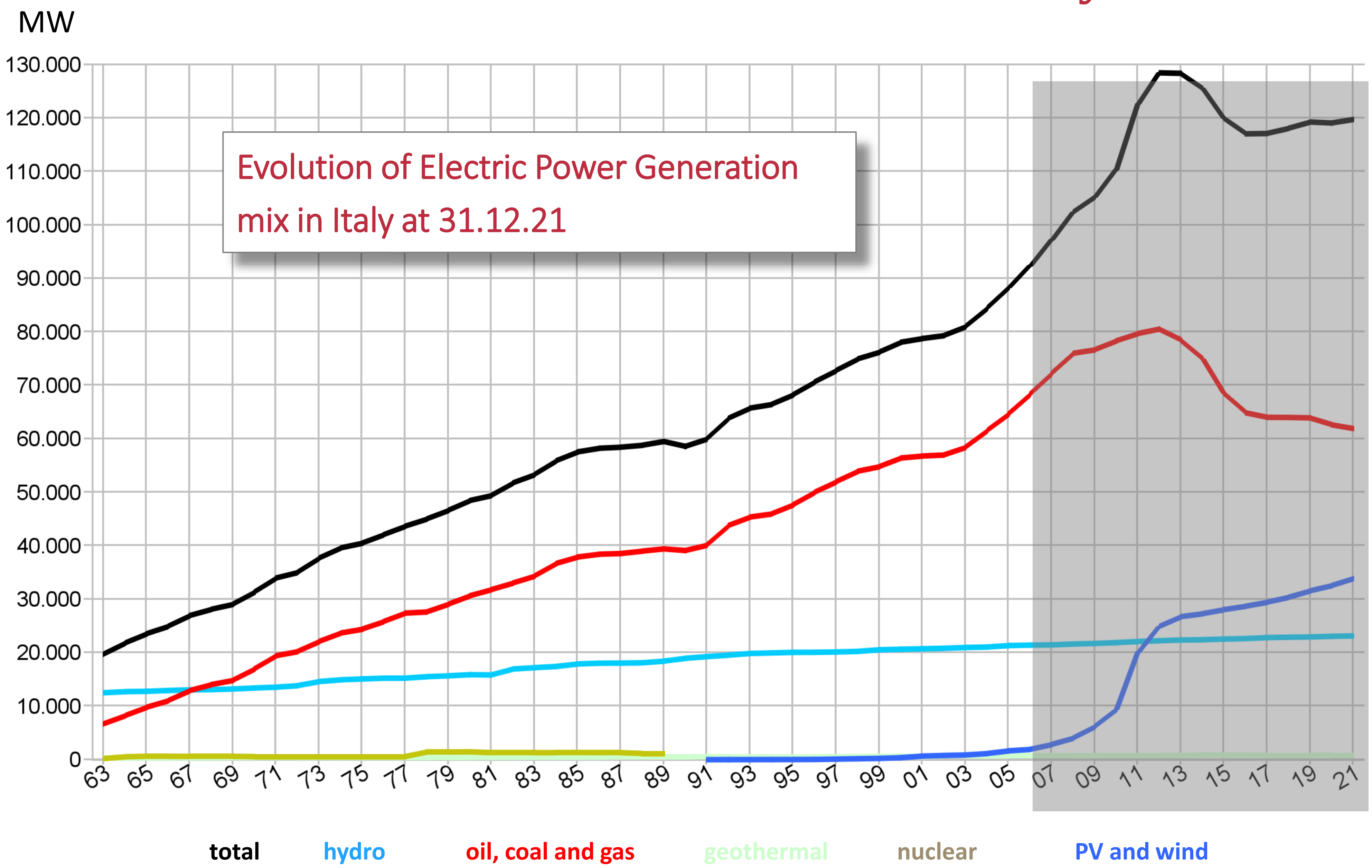
Figure 7. Country level – GHG emission intensity of electricity generation[20] for the years 2017, 2018, 2019



Ref: EU

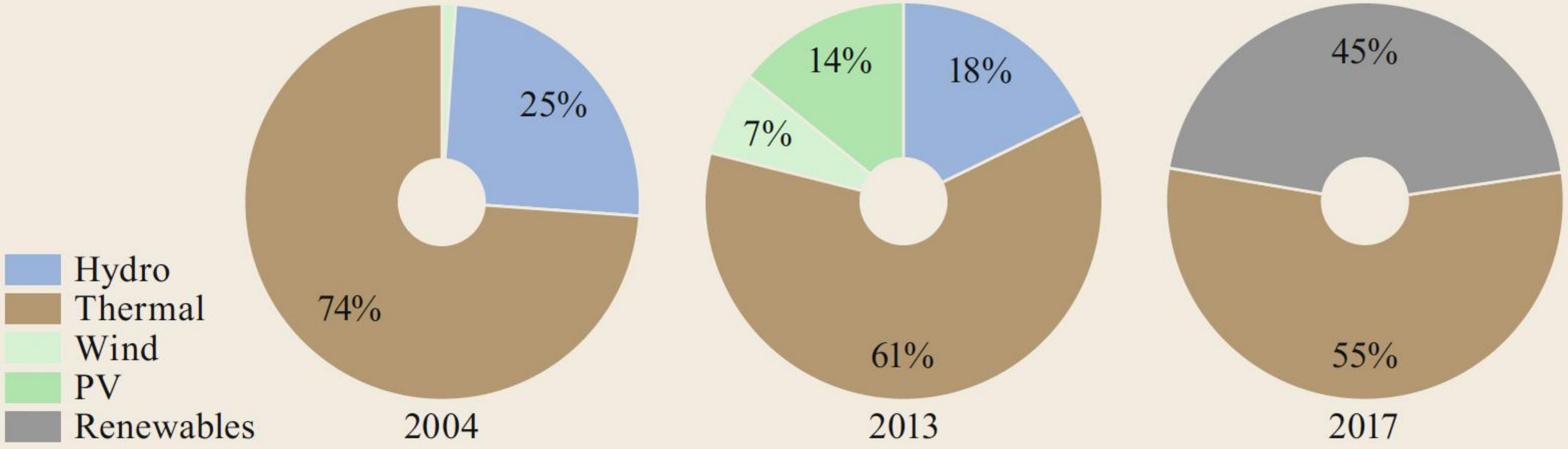
Source: Terna

Electric Power installed in Italy

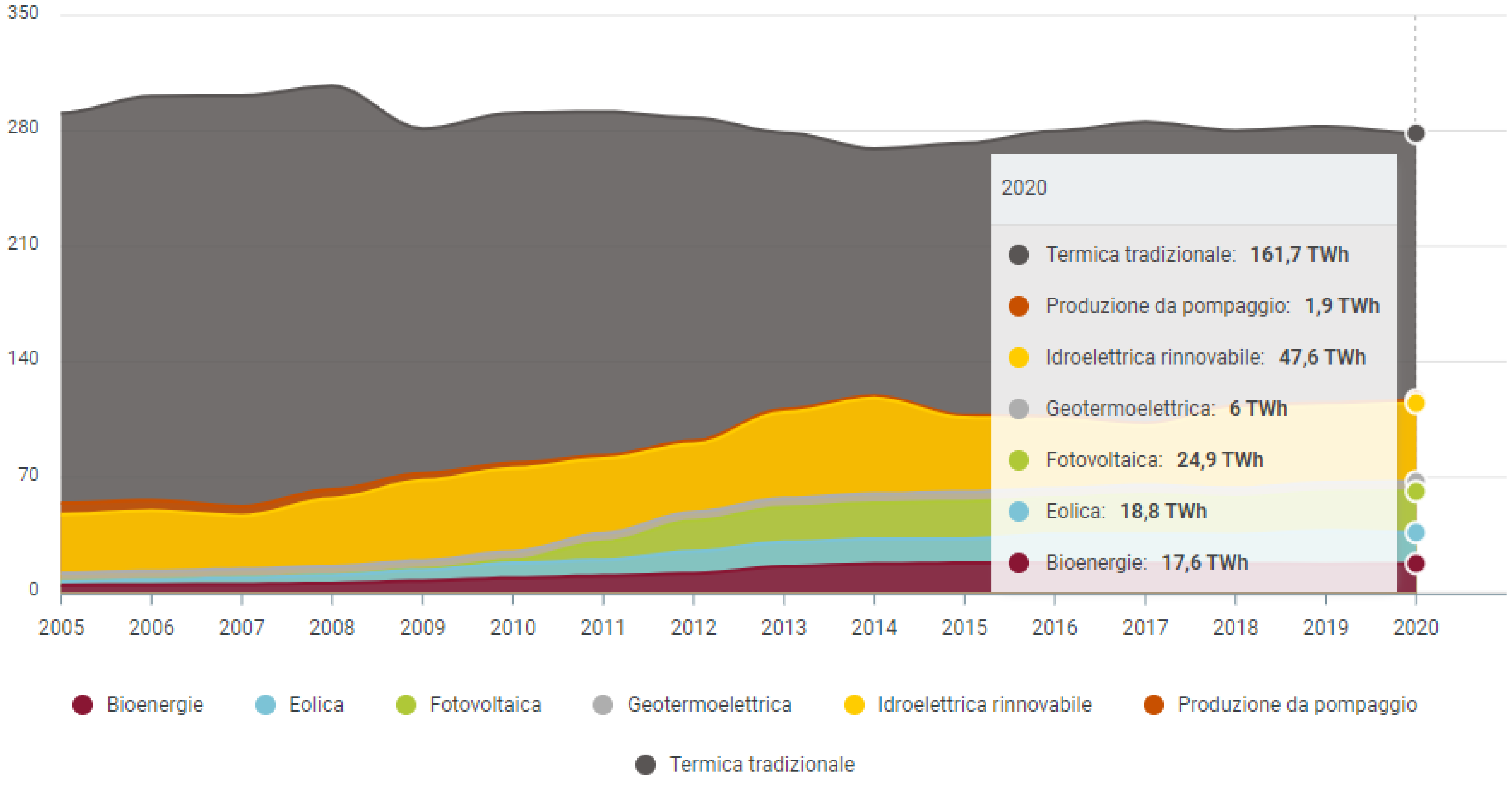


Italian Power Generation Mix

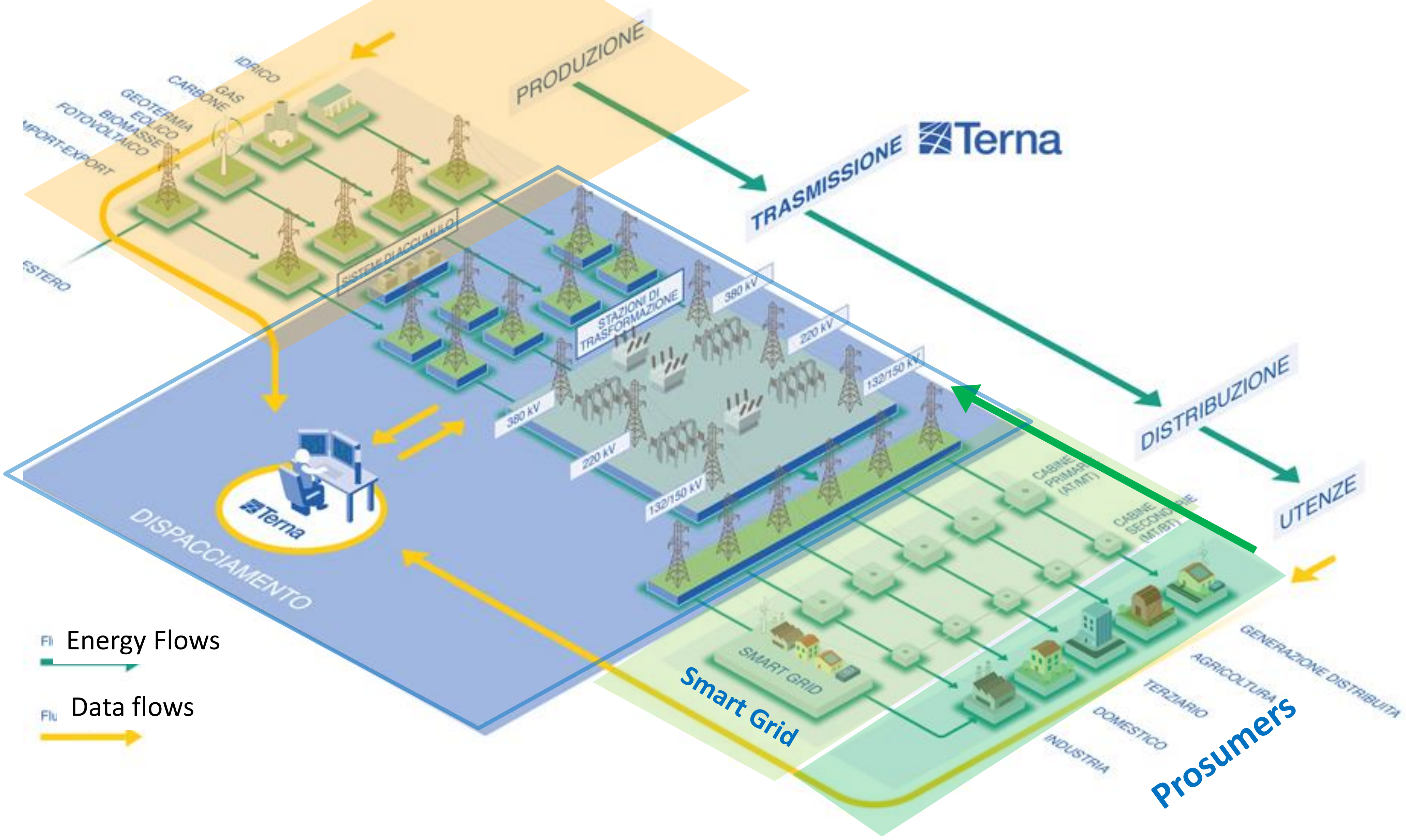
Classification	Plants (k)	Power (GW)	Plants (k)	Power (GW)
Hydroelectric	2	21.1	2.9	22.5
Thermal power	1.9	62.2	3.9	76.9
Wind	0.1	1.1	1.4	8.5
PV	0	0	559.4	18.5
Total	4	84.4	567.6	126.4



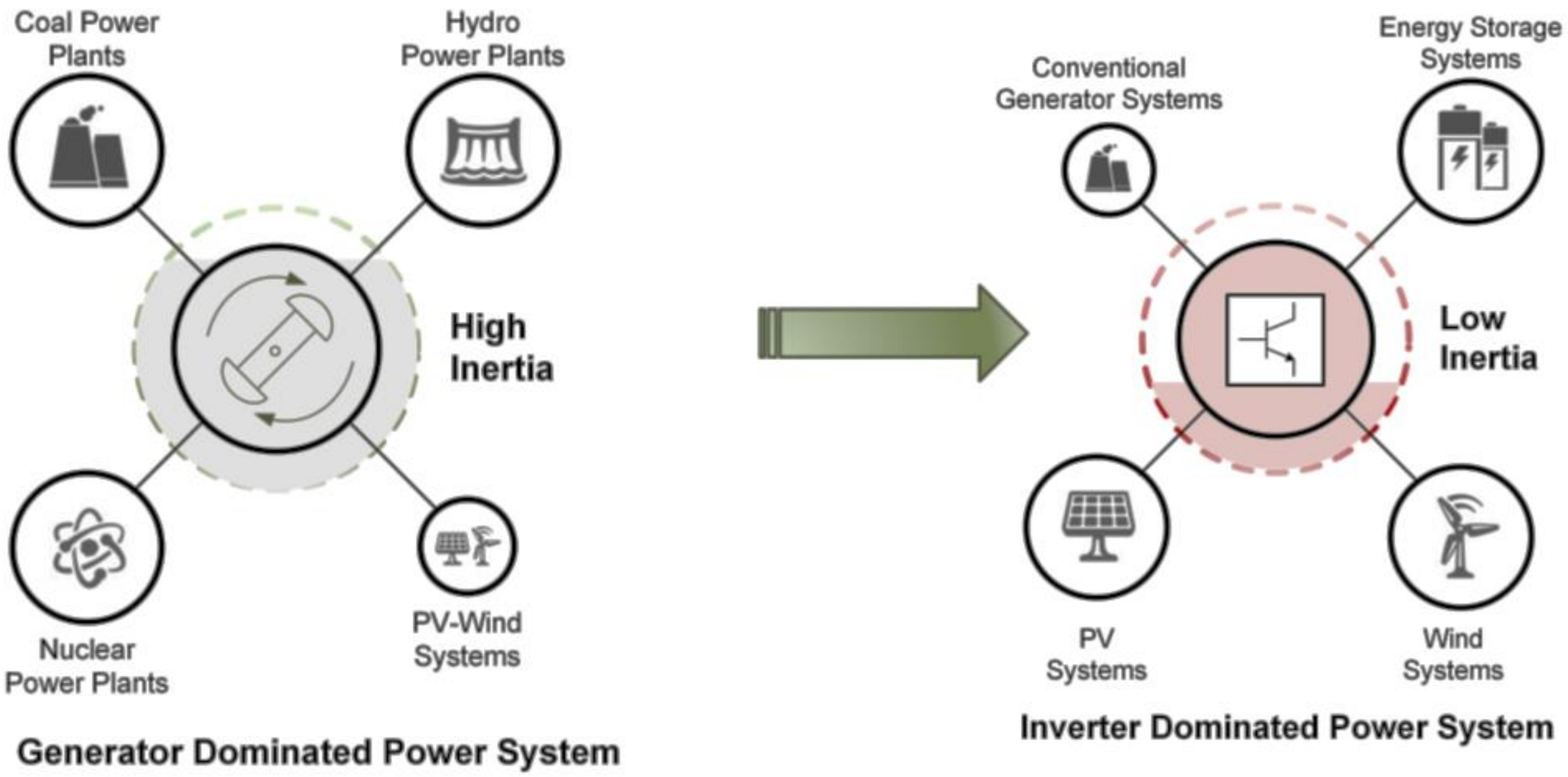
Electricity production in Italy by source



Electric Power System Configuration



Towards an inverter dominated power system



European Network of Transmission System Operations for Electricity (ENTSO-E), “Rate of Change of Frequency (ROCOF) withstand capability: ENTSO-E guidance document for national iplementation for network codes on grid connection,” 2017.

The smart grid – why it needs to be smart

Random availability of renewable sources

- *smarter* management of the system, **wide ICT deployment** (e.g. metering, co-simulation tools)
- Need for **storage resources**

Use of renewable sources

- Deployment of **converters** (which replace synchronous generators) and therefore **loss of inertia and stability**

Diffusion of electric mobility

- Network capacity needs to be assessed
- EV as potential power sources for the network

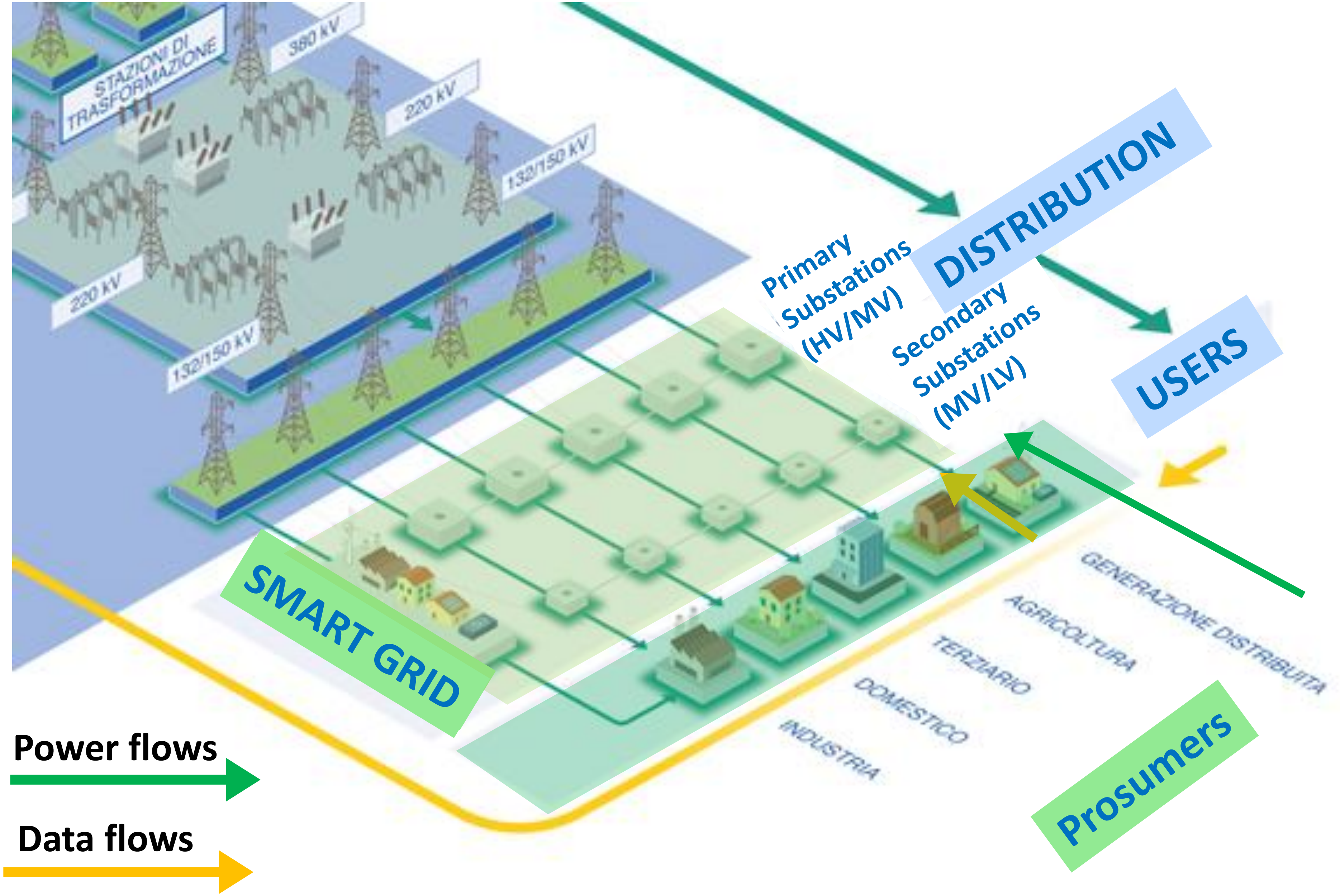
Market liberalization

- From consumers to **prosumers**

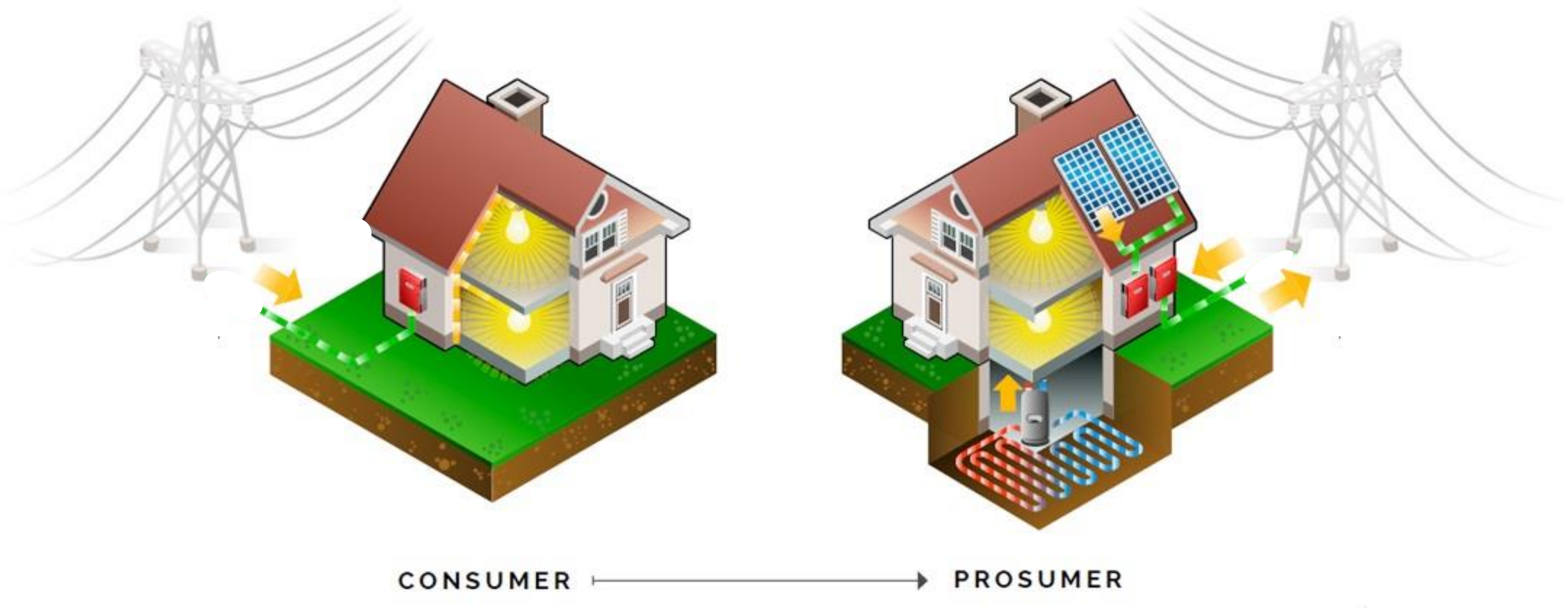
Power-flow inversion

- **Transit limits**
- **Voltage profile variation** on the lines
- Abnormal behaviour of **protections**

Electric Power System Configuration (detail)



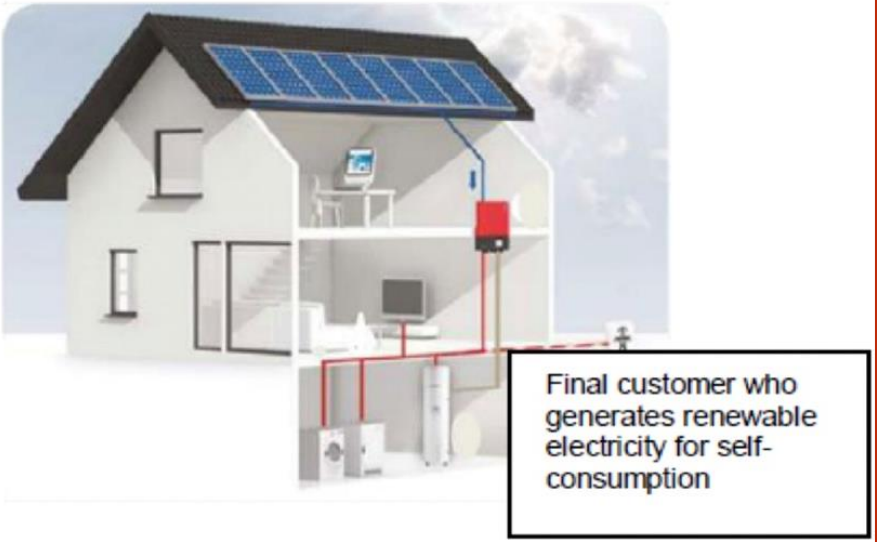
Consumer VS prosumer



(Adapted from Guida GECO, Le comunità energetiche in Italia, 2020)

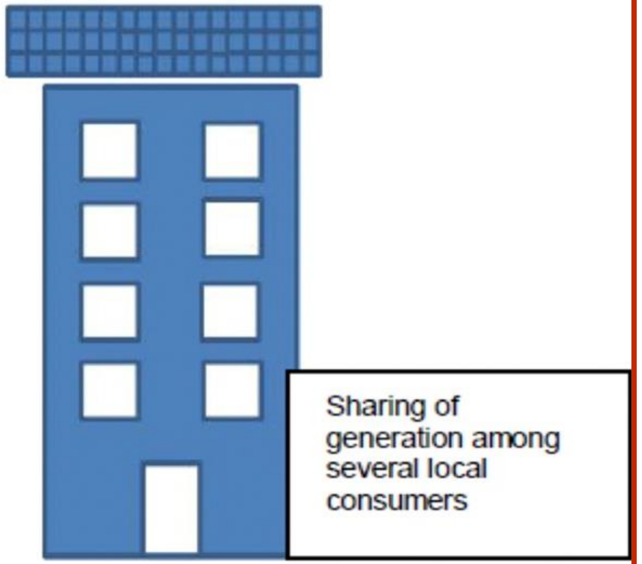
SC CSC and REC

Self-consumption



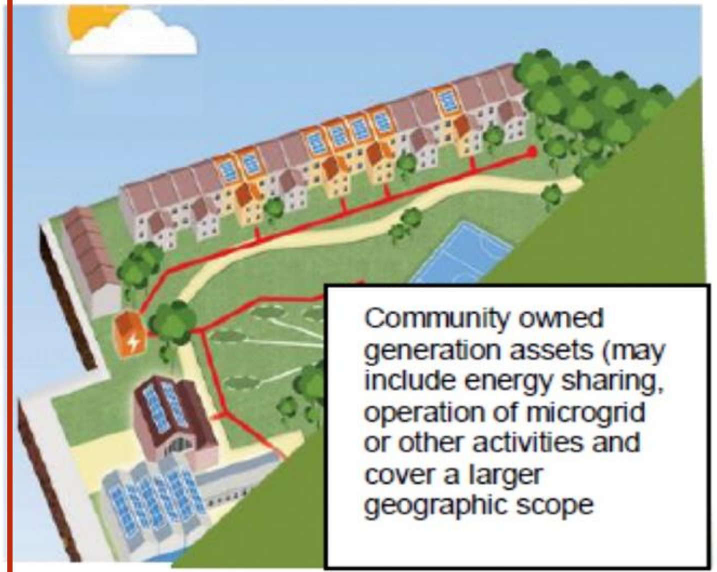
- **One-to-One** configuration: there is a unique POD with the supplier
- Energy exchange take place through the user's grid

Collective self-consumption



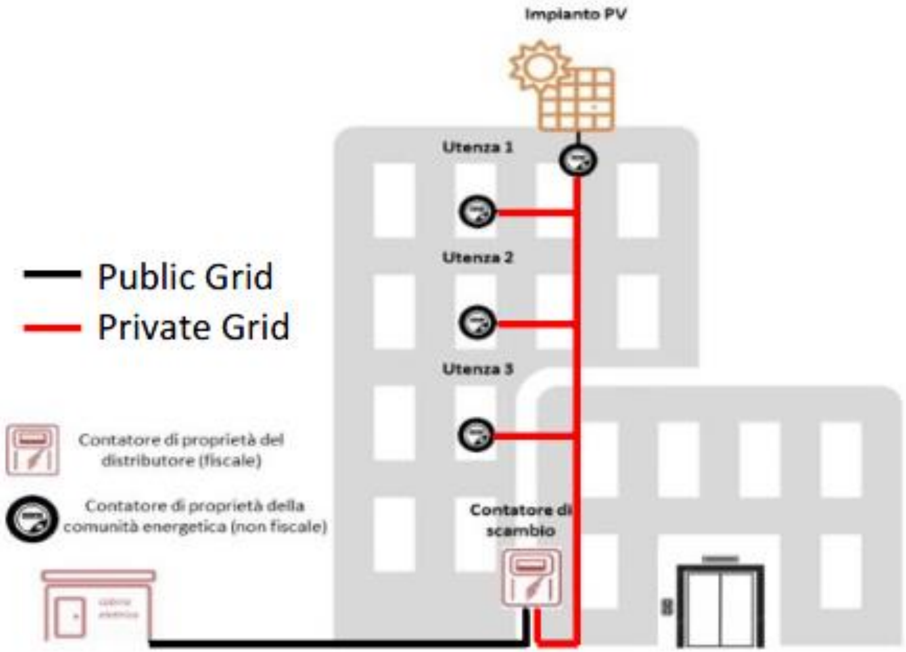
- **One-to-Many** configuration: there are many PODs with the supplier
- **Members in Same building**
- Energy exchanges take place through the **LV** public grid

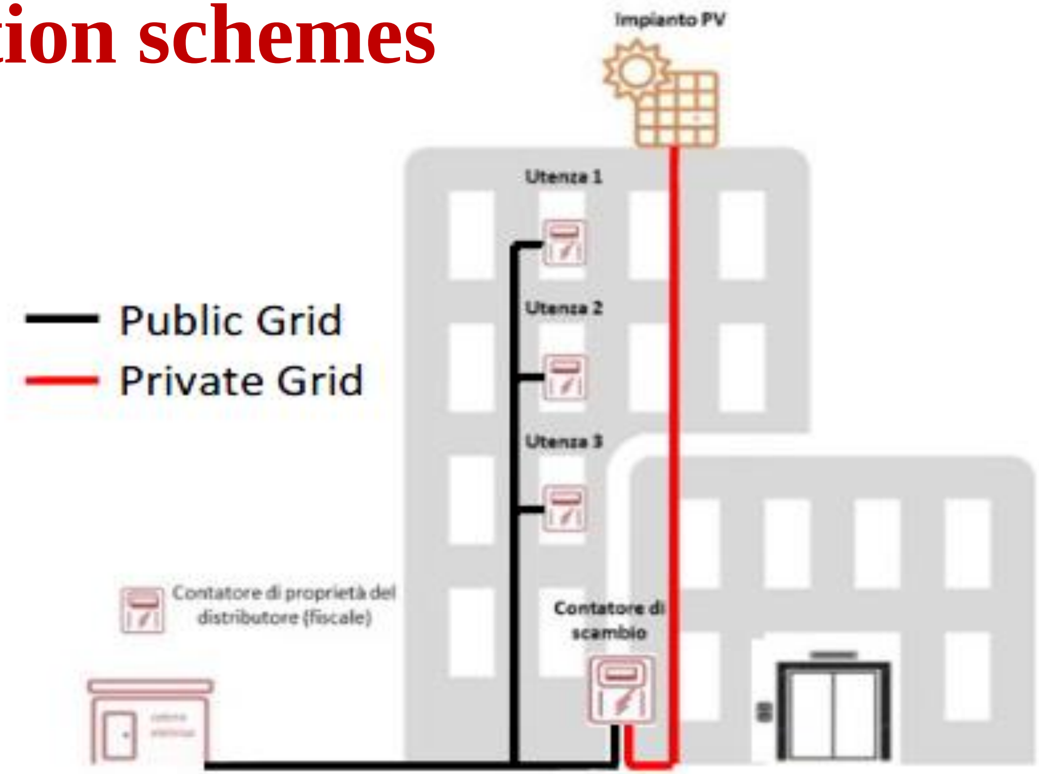
Energy Community



- Many PODS as well
- Members should be connected to the **same primary substation,** recent Legislative decree 199, **with P<1000kW (before**, Legge 8, **only to secondary substation with P<200kW)**
- Energy exchanges take place through the **LV** and **MV** public grid

Self-consumption schemes





Physical self-consumption:

- Connection among prosumers through private grid
- Unique POD (fiscal meter) and supplier
- Non fiscal meters for the users

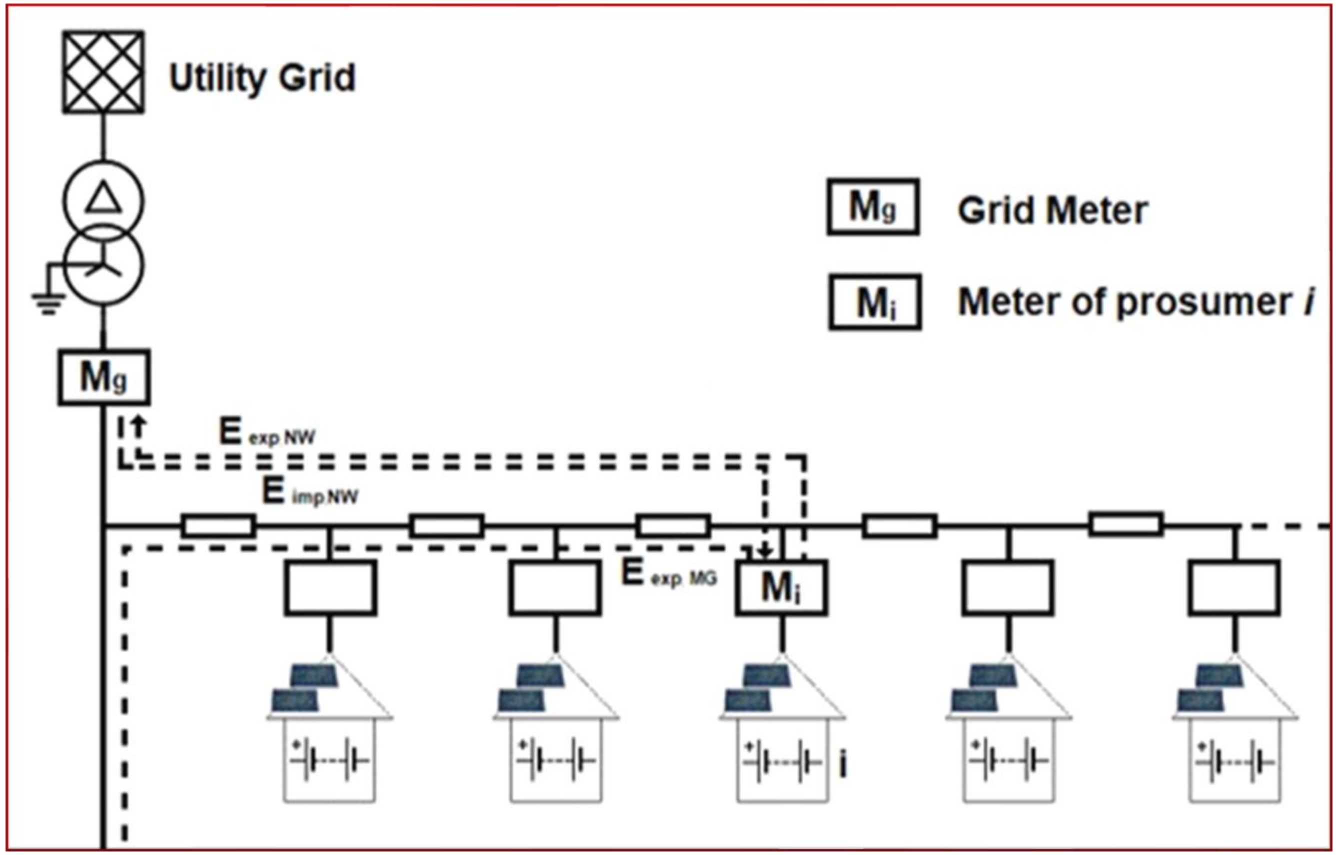
Issues:

- "Utente nascosto" Hidden user
- Users can not leave the joint activity
- Users should be free to choose a supplier

Virtual self-consumption:

- Each user has its own POD and it is free to choose a supplier
- Energy is shared through public grid
- The DSO performs the fiscal metering

EU and Renewable Energy Communities



Renewable Energy Community

DIRECTIVES

RED 2

DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 11 December 2018

on the promotion of the use of energy from renewable sources

(recast)

(Text with EEA relevance)

DIRECTIVES

IEMD

DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 5 June 2019

on common rules for the internal market for electricity and amending Directive 2012/27/EU

(recast)

(Text with EEA relevance)

Optimal Management Scheme of Energy Flows in a REC

Day ahead optimization

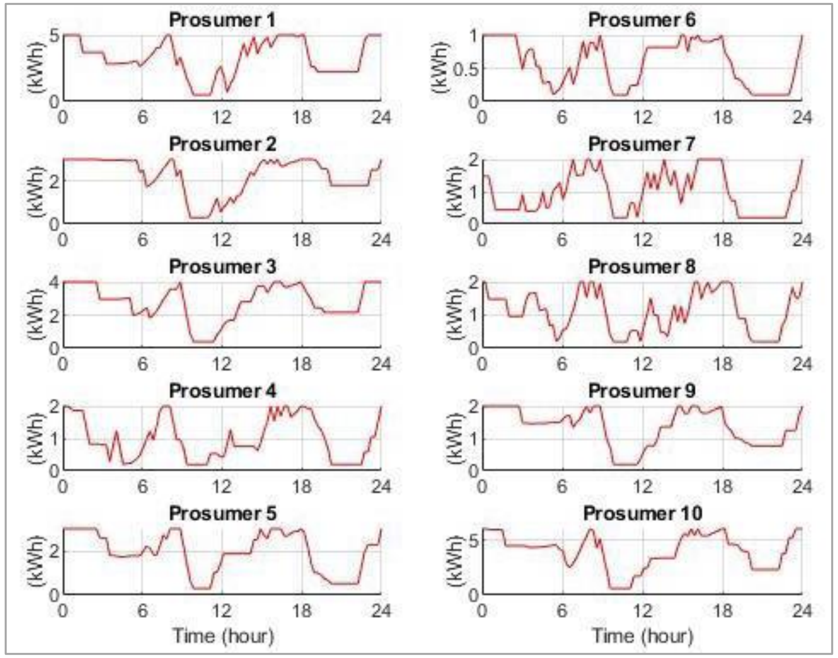
What do I manage?

- **Storage**
- Biogas
- (Loads)

1 of 14 IEEE PES Transactions on Power Systems
TPWRS-01902-2018 1

Day-ahead Scheduling of a Local Energy Community: An Alternating Direction Method of Multipliers Approach

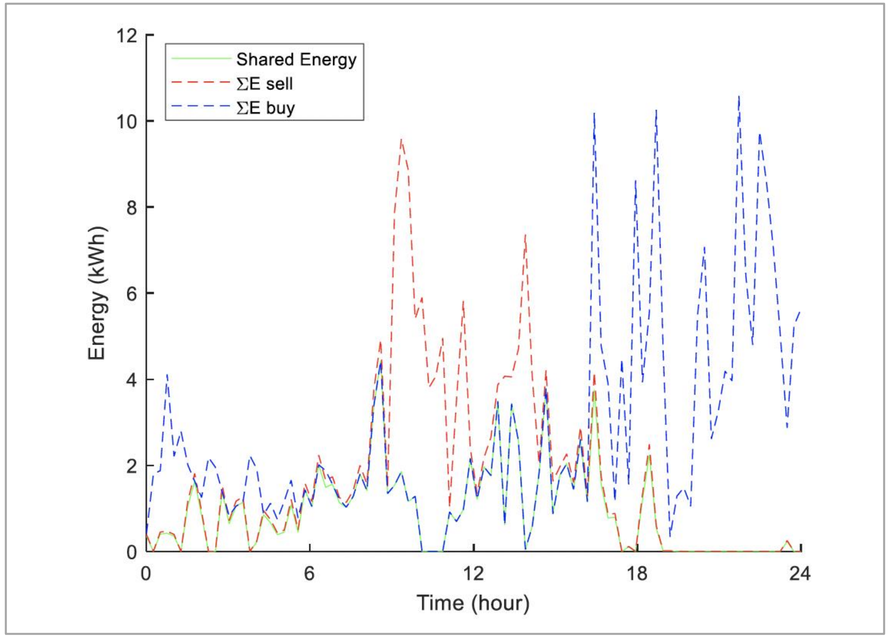
Stefano Lilla, *Student Member, IEEE*, Camilo Orozco, *Student Member, IEEE*, A. Borghetti, *Fellow, IEEE*, F. Napolitano, *Senior Member, IEEE*, F. Tossani, *Member, IEEE*



$$OF = \sum_{\substack{t \in T \\ i \in \Omega}} \left[\pi_{\text{buy}}^{t} P_{\text{buy\_Grid}\,i}^{t} - \pi_{\text{sell}}^{t} P_{\text{sell\_Grid}\,i}^{t} \right] \Delta t$$

$P_{buy/sell}$ Power withdrawn(input) from (to) the network

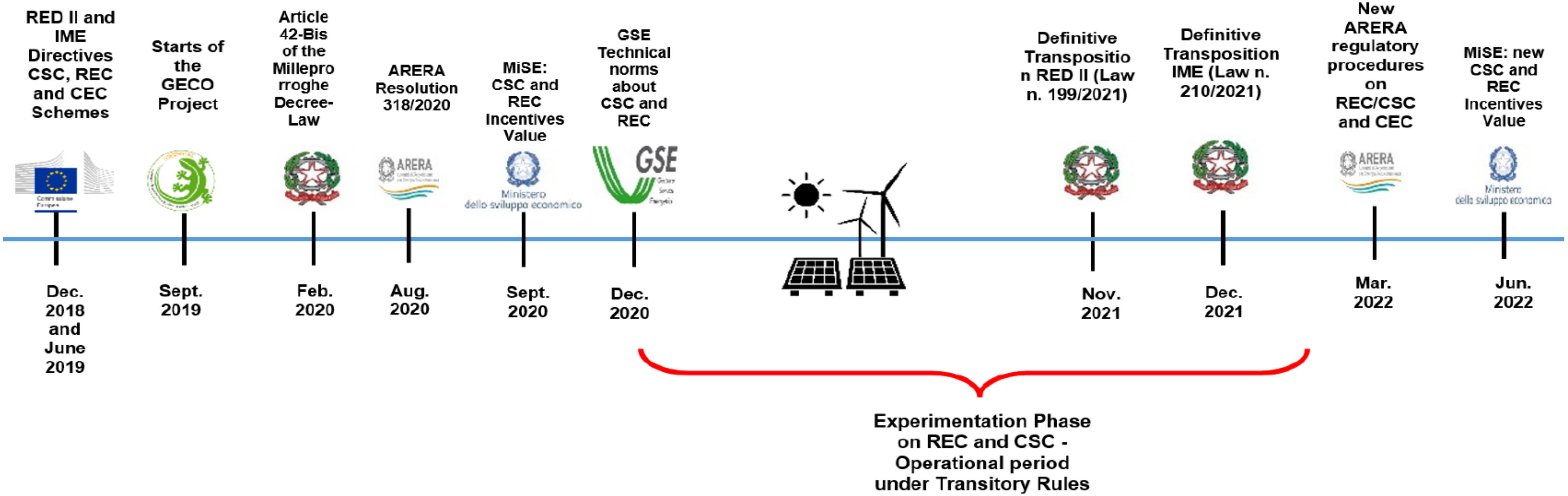
$\pi_{buy/sell}$ purchased(injected) energy price from(to)the grid



Objective function ***OF*** in compliance with **network constraints**

$$P_t^{pv} - P_t^{b} + P_t^{grid} - P_t^{load} - L_t = 0$$

Regulatory iter in Italy



Renewable Energy Communities

Law 8

Plants connected to th same secondary substation

P less than 200 kW

After March 1^{st} 2020

Legislative Decree 199

Plants connected to the same primary substation

P less than 200 kW

After December 15^{th} 2021 (30% of old plants allowed)

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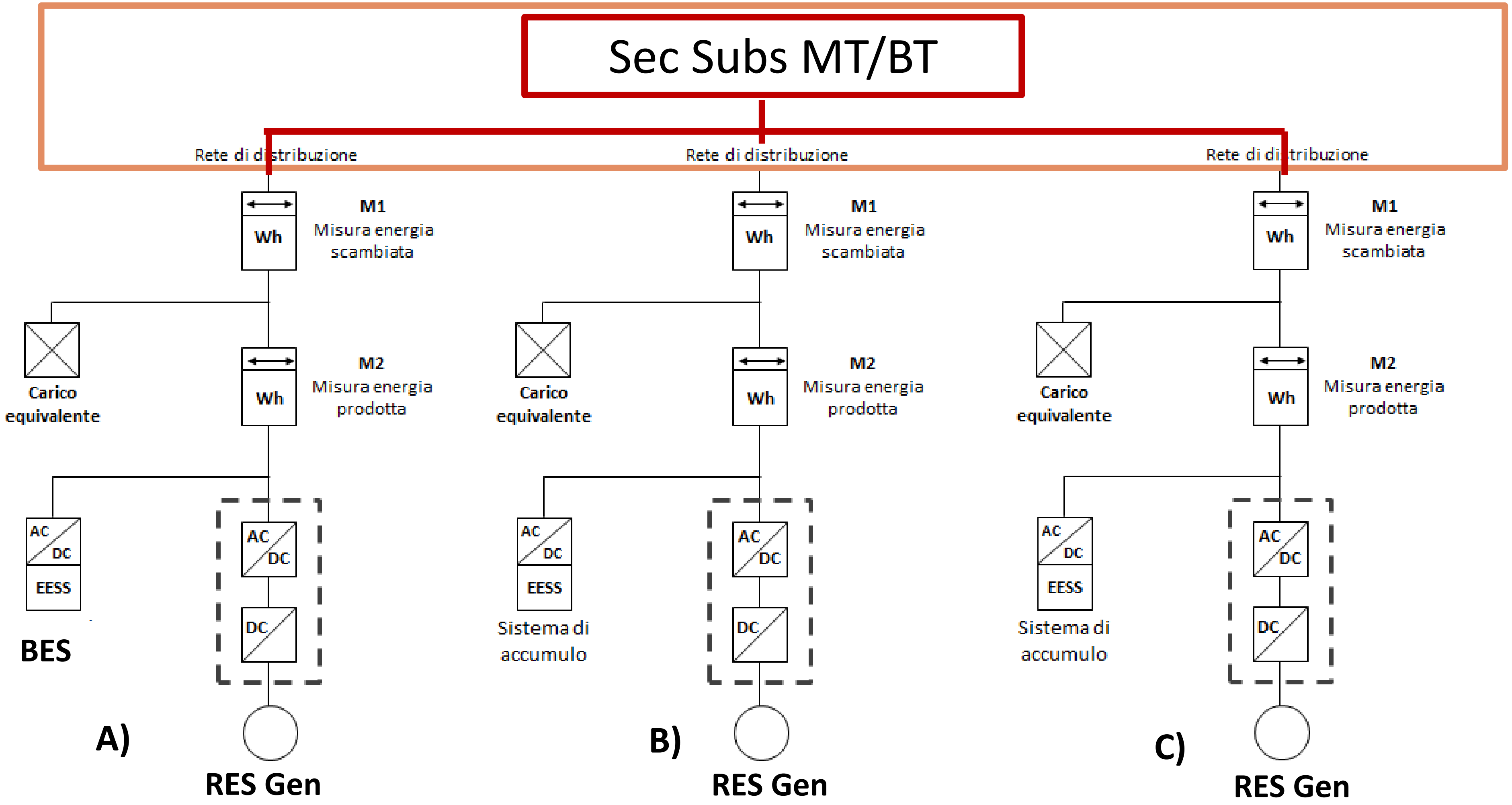
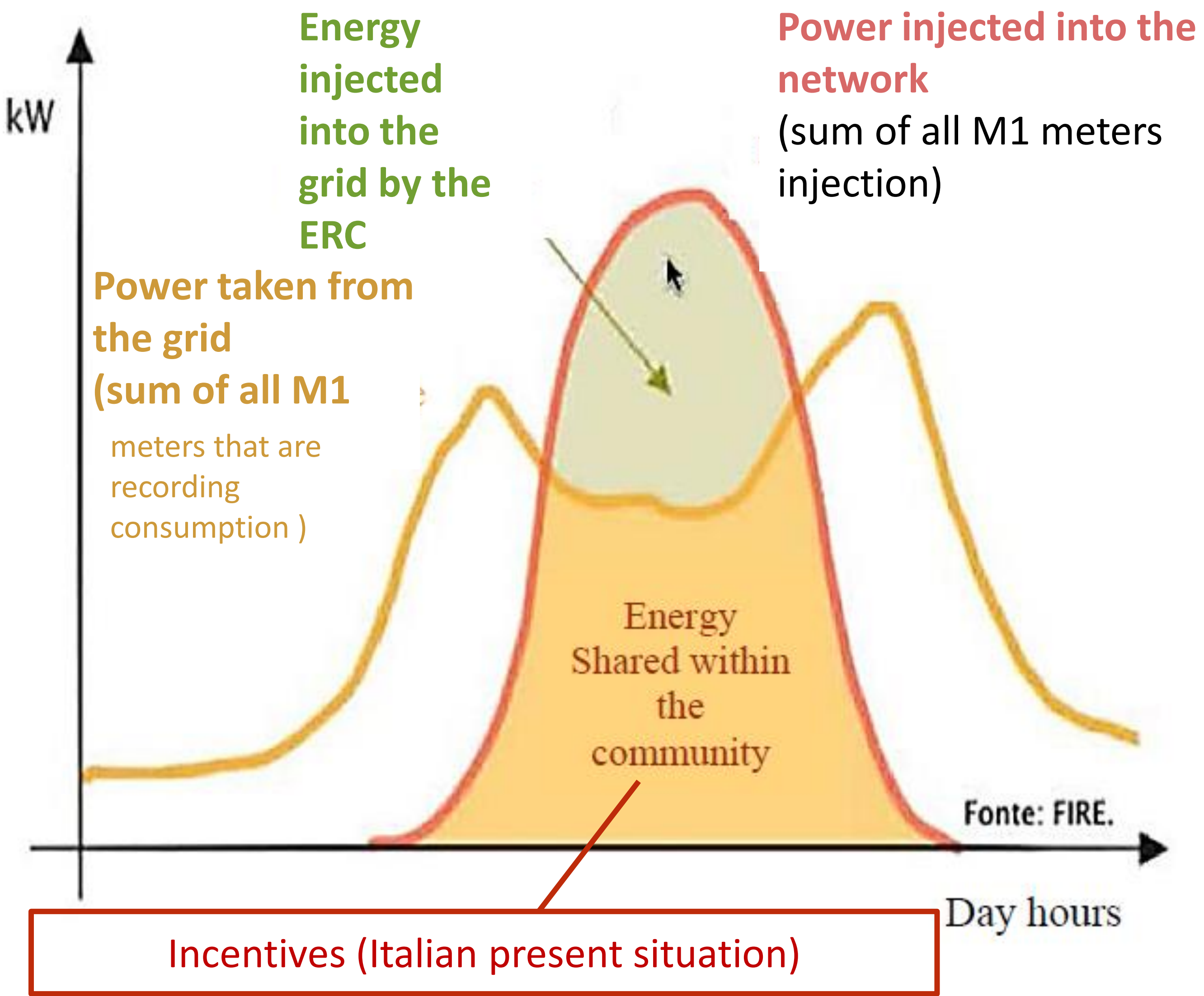
Measurement of Energy shared within the community



M1: energy exchanged with network

M2: energy by Gen and EEES (Pgen. + Pdischarge – Pcharge)

Energy shared within the Community



Shared Energy for self-consumption: in each hour, the minimum between the sum of the electricity actually injected and the sum of the electricity withdrawn through the POD (M1) that identify a group of self-consumers acting jointly, or a CER

Valorization of Shared Self-Consumed Energy

GSE is the entity entitled to calculate and provide incentives on the shared energy. Incentives are formed by two components:

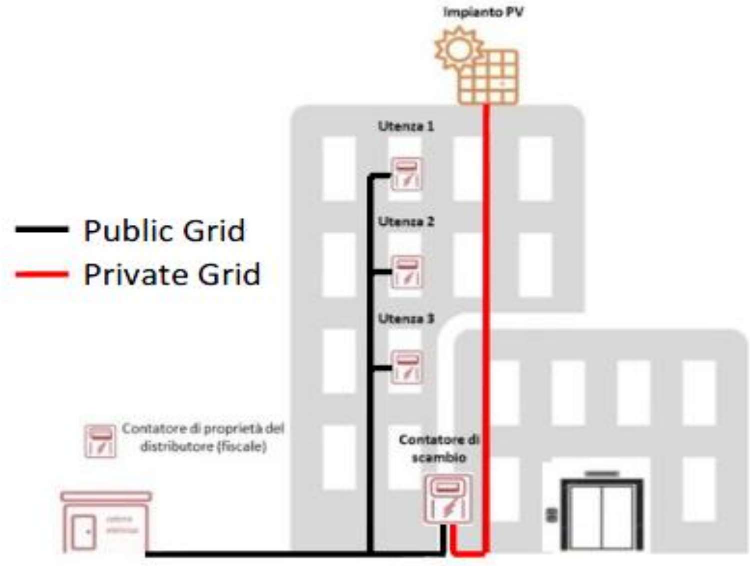
1. **MInistry of Economic Development** (**MISE**) incentives, for 20 years. (Decreto Ministeriale 16 settembre 2020)
2. **ARERA** refunds: these refunds are related to ''fair network charges for the shared energy'' and typically range between 8-10€/MWh, and in principle for each year need to be calculated using a number of coefficients and fees. These coefficients/fees are part of those ones used for the calculation of distribution/transmission/losses components in the bill (previously seen). Such a calculation needs to be performed, i.e. we cannot use the same coefficients and values used for the classical bill, since the energy shared use only a small part of the electric network (see the following slide for the relevant calculation)

MiSE

- REC: 110 €/MWh
- CSC: 100 €/MWh

ARERA

- REC: ≈ 8 €/MWh
- CSC: ≈ 10 €/MWh



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Valorization of Shared Self-Consumed Energy

MiSE

- REC: 110 €/MWh
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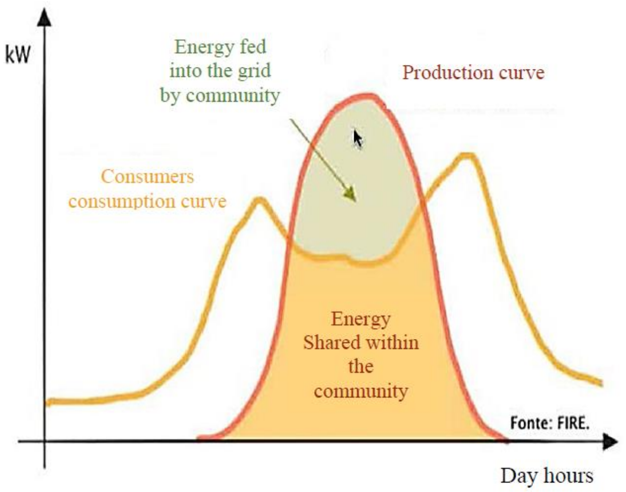


$$CU_{Af,m} = TRAS_E + BTAU = 8{,}22 \left[{}^{€}/_{MWh}\right]$$

For **REC**

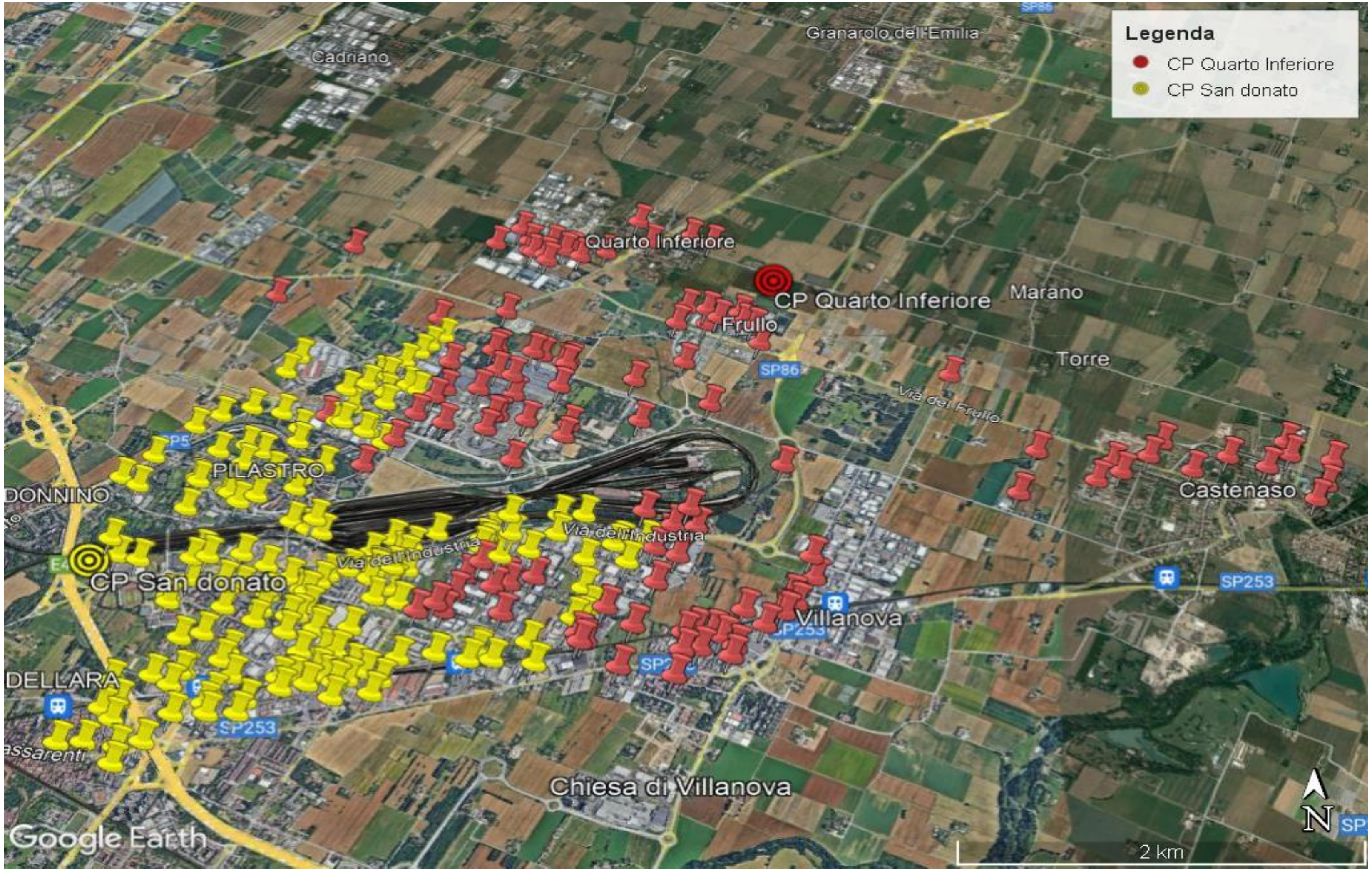
$$C_{AC} = CU_{Af,m} \times E_{AC} \; [€]$$

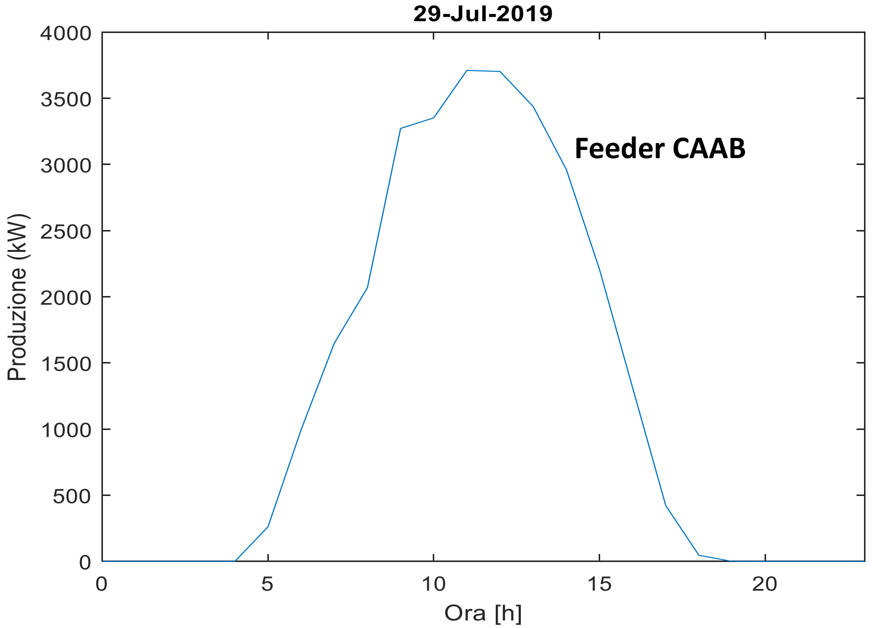
For **CSC** (use less grid respect to REC so there is an additional component)

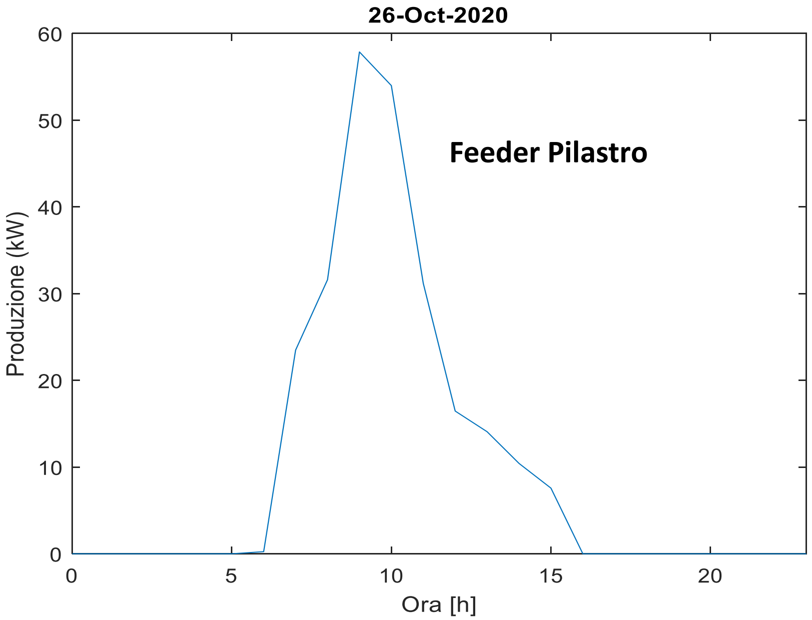
$$C_{AC} = CU_{Af,m} \times E_{AC} + \sum_{i.h} \left(E_{AC} \times C_{PR,i} \times Pz\right)_h \; [€]$$

$CU_{Af,m}$ monthly flat-rate unit fee
$TRAS_E$ transmission fee variable part for low voltage consumer
$BTAU$ distribution variable component for low voltage consumer
C_{AC} shared energy ARERA refunds
$C_{PR,i}$ grid avoided losses coefficient
Pz hourly zonal price

Pilastro and Roveri districts







Estimation of PV production for each primary substation/ feeder.

GECO
Green Energy COmmunity

GECO project

- GECO is a **pilot/demonstrator project** financed by **Climate-KIC**
- Partners: **AESS** (coordinator. Contact: Claudia Carani ccarani@aess-modena.it), **Enea** (Contact: Francesca Cappellaro francesca.cappellaro@enea.it) and **UniBo** (Contact: Carlo Alberto Nucci carloalberto.nucci@unibo.it)
- Area of interest**: Pilastro-Roveri district of Bologna**

https://italy.climate-kic.org/projects/geco-green-energy-community/
https://magazine.unibo.it/archivio/2019/10/07/a-bologna-nasce-geco-la-prima-comunita-energetica

- Residential area with 7.500 inhabitants (1400 in social housing buildings)
- Commercial a…
  Meraville and…
- Industrial are…
  Roveri).
  - **CAAB** / FIC…
    (210 kWh)…
    biogas with…
  - Roveri 2 M…
  - Pilastro Ag…
  - Residential…

Green Energy COmmunity

agenzia per l'energia e lo sviluppo sostenibile

National Agency for New Technologies, Energy and Sustainable Economic Development

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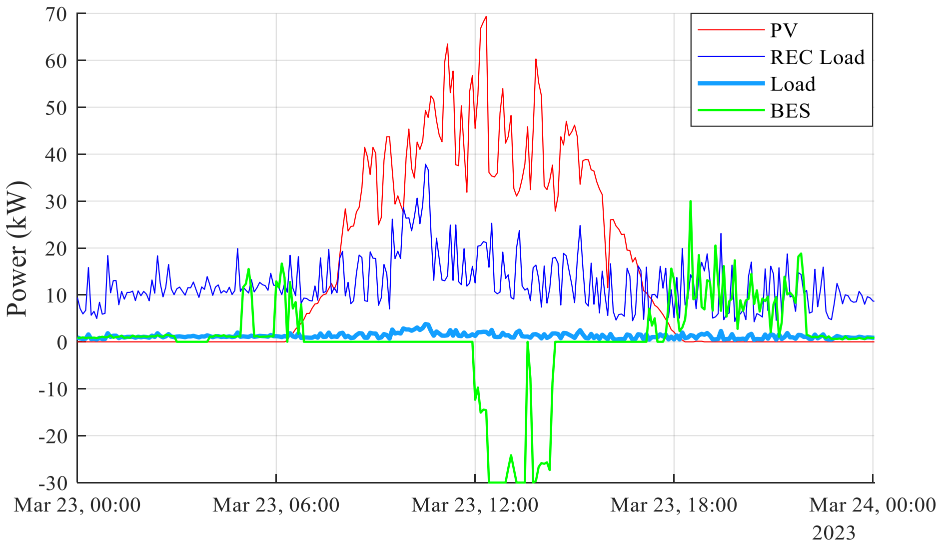
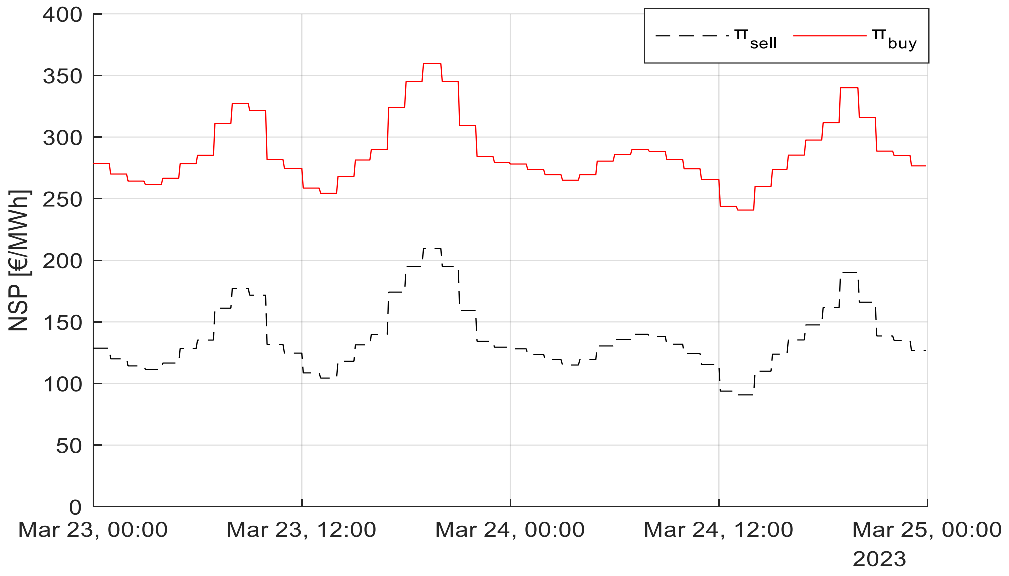
Optimal EMS

Objective of the rolling approach model–> minimization of the community’s overall cost for energy procurement considering the economic incentives for the shared energy, in the next 48 hours by controlling the battery energy storage systems.



$$OF = \sum_{\substack{t \in T \\ j \in J}} (\pi^{-}_{t,j} P^{-}_{t,j} - \pi^{+}_{t,j} P^{+}_{t,j}) \Delta t - \sum_{h \in H} I_E E^h_S$$

P^- / P^+	power withdrawn/fed from/into the grid
$\pi_{buy/sell}$	purchase/selling price of the energy
I_E	economic incentives for the shared energy
E_s	shared energy in hour *h*



The algorithm tends to charge the BES when the price is lower while share energy when the price is greater

In the proposed scenario:

Selling price = NSP

Purchase price = NSP + spread

Spread = 15c€/kWh

Why a rolling model?

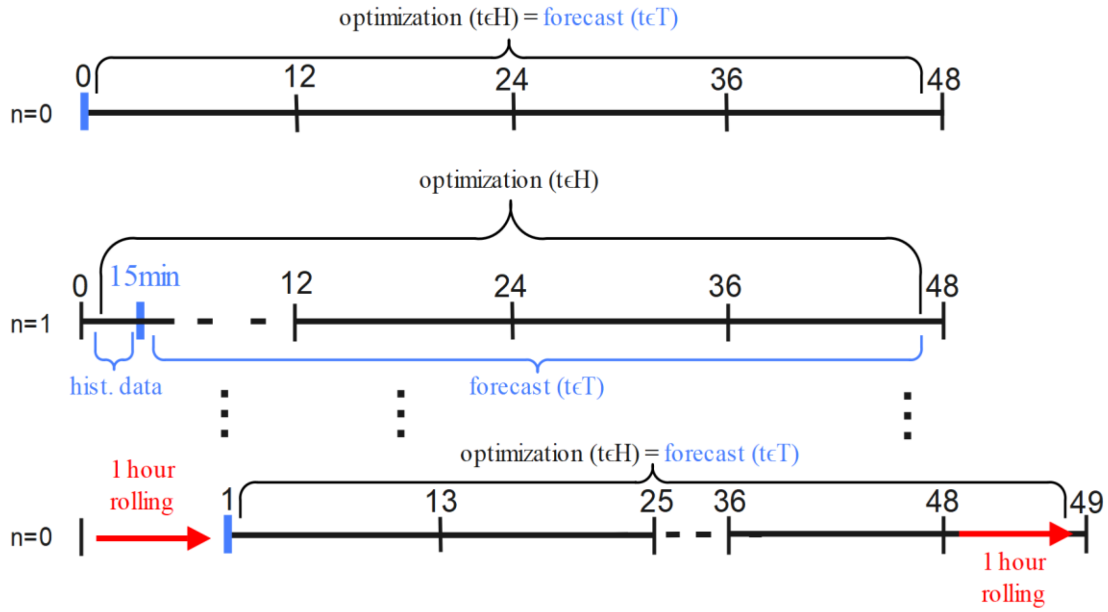
A rolling approach, which executes the optimization algorithm each 15 min, benefits of:

- Updated **load** and photovoltaic **production** forecast
- Updated energy prices, as soon as they are available (www.mercatoelettrico.org)
- Possible adjustment on energy sharing within the same hour to cope with forecasts error. This is possible acquiring the measurements of smart meters.
- Real time acquisition of the BESs SOC

Shared Energy computation

$$E_s^h \leq \sum_{\substack{j \in J \\ t \in Th}} (P_{t,j}^- + P_{t,j}^{hist-})\Delta t \qquad \forall h$$

$$E_s^h \leq \sum_{\substack{j \in J \\ t \in Th}} (P_{t,j}^+ + P_{t,j}^{hist+}) \times (1 - R^j)\Delta t \qquad \forall h$$



R is a factor which accounts for energy fed not coming from a renewable source; this is the case of batteries charged from the grid

Main constraints

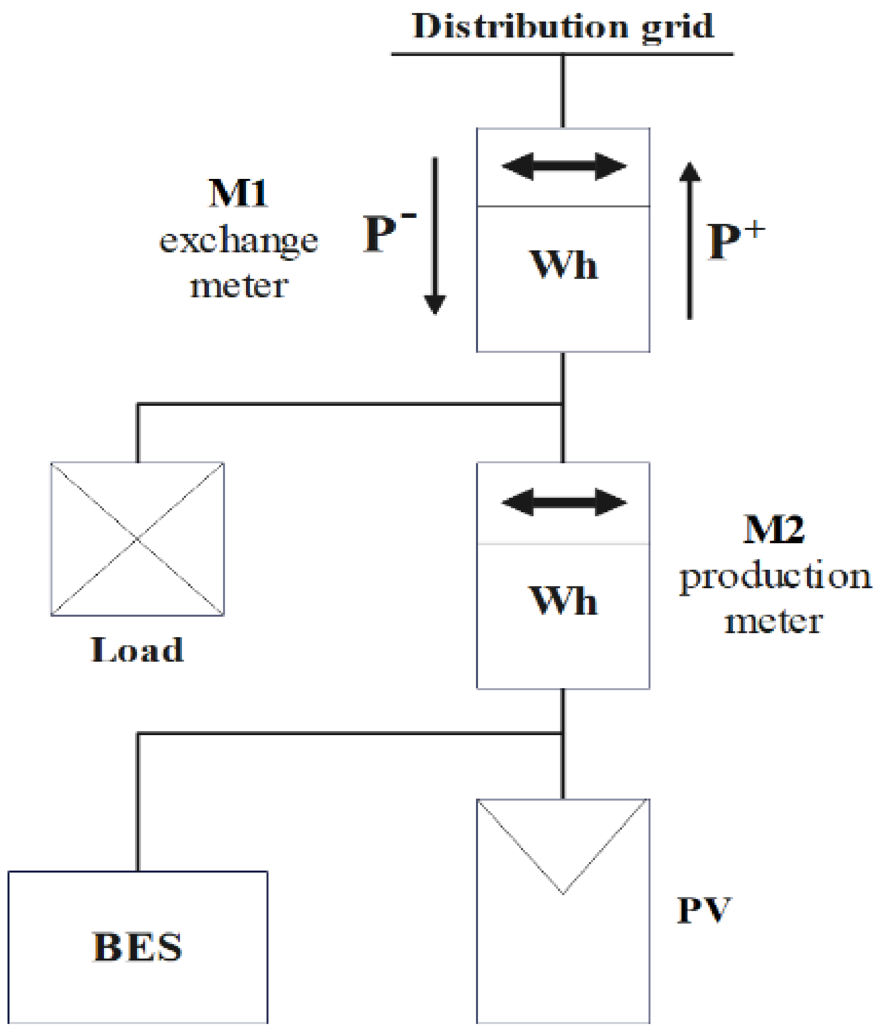
- Power balance

$$P_{t,j}^{PV} + P_{t,j}^{BES+} - P_{t,j}^{BES-} - L_{t,j}^{S} = P_{t,j}^{+} - P_{t,j}^{-} \quad \forall t, j$$

- BES charge/discharge cannot be simultaneous

- Energy withdrawn from/fed into the grid cannot be simultaneous

- BES efficiency and SOC limits

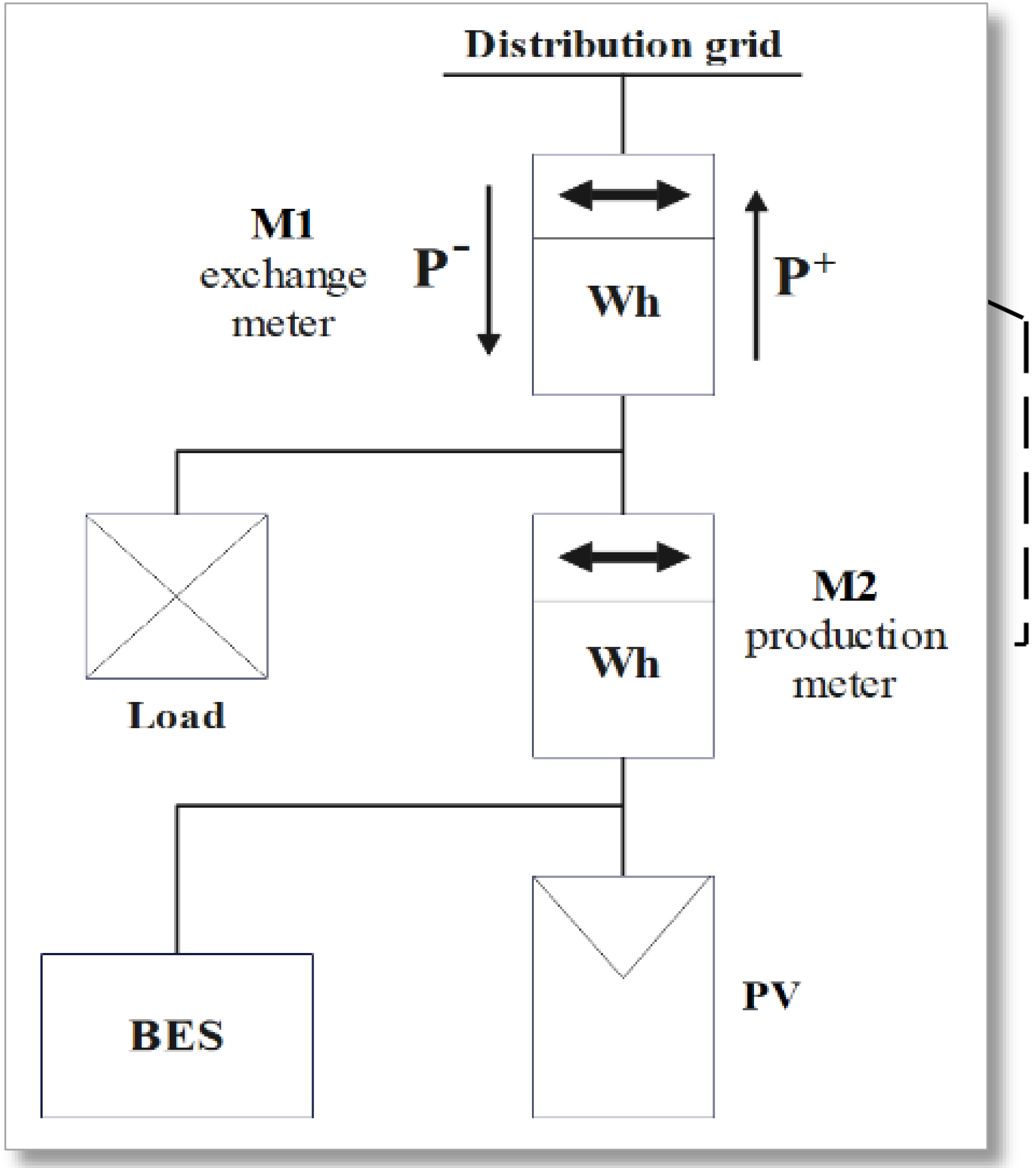


$$E_{t,j}^{\mathrm{BES}} = E_j^{\min} \le E_j^{\mathrm{BES,0}} + \left(\sum_{t=1}^{t} P_{t,j}^{BES-} \eta^j - \sum_{t=1}^{t} P_{t,j}^{BES+} / \eta^j \right) \Delta t \le E_j^{\max} \quad \forall t, j$$

Real Time REC Simulator

Energy Management System (EMS) architecture

- Smart meters measure consumption/production. Measurements are sent to a database.
- The database makes available the data to the community members and to optimization algorithm
- Historical data are used to perform load forecast; production forecast is based on meteorological prediction
- The EMS calculates the optimal batteries power profile and sends it to the virtual batteries
- The OPAL-RT simulates the battery behaviour and sends the storage data to the database



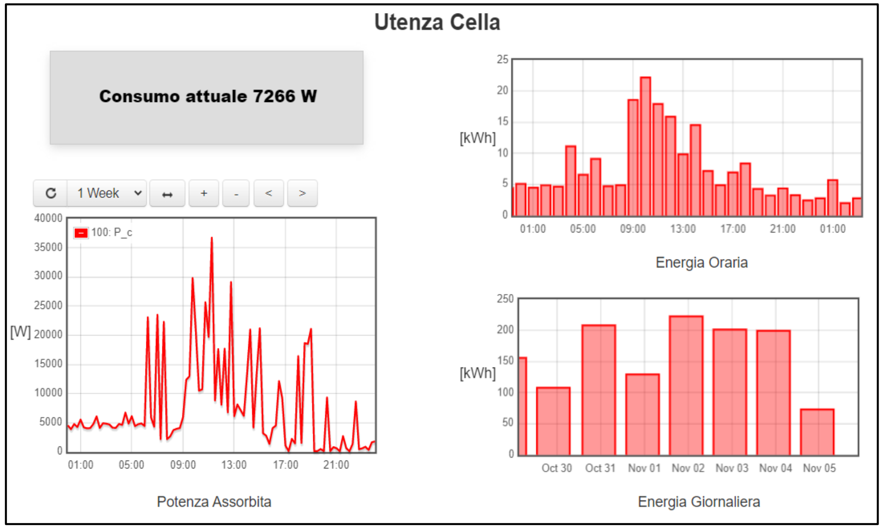
Energy Community manager dashboard

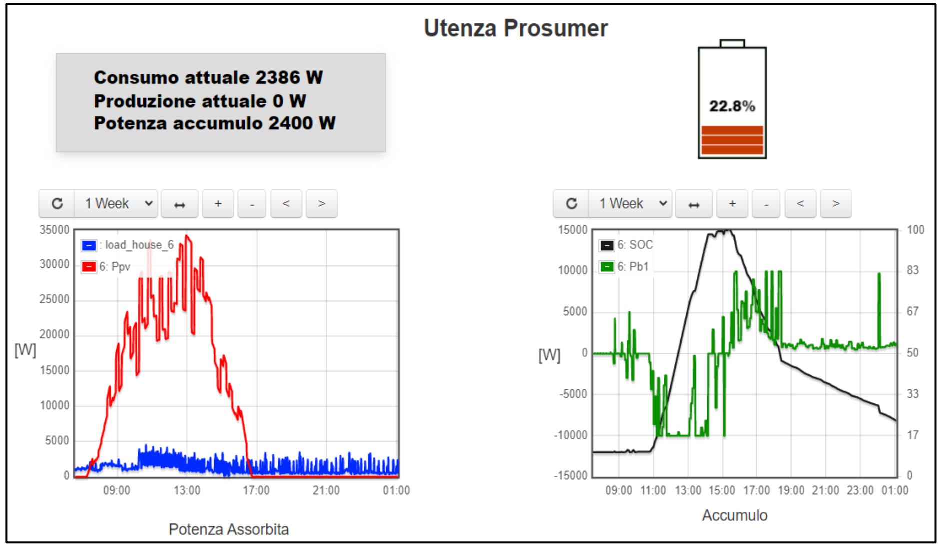
- Real-time values of:
  - Production and consumption
  - Power fed into the grid or withdrawn from the grid
  - Battery energy storages (BESs) state of charge (SOC)

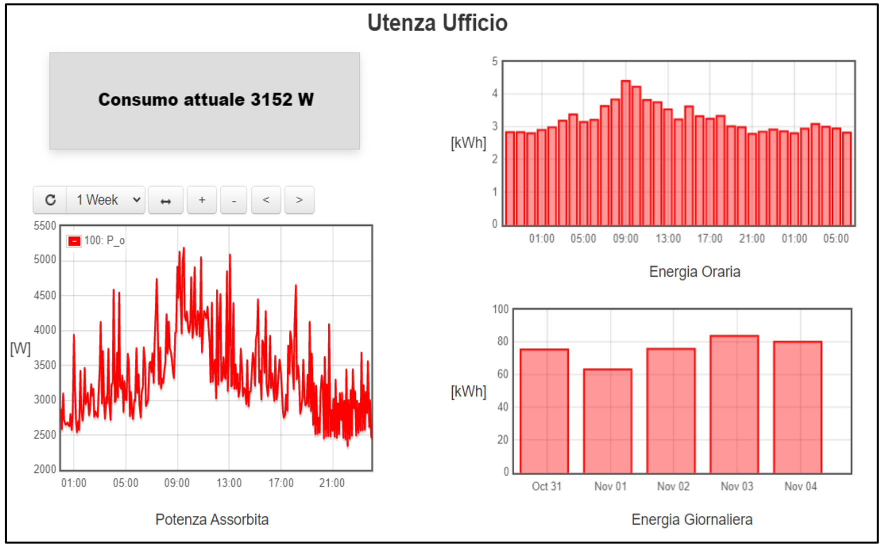
- Possibility to access to historical data

User dashboard

- Real-time measurements visualization
- Historical data visualization or download







[Open dashboard]

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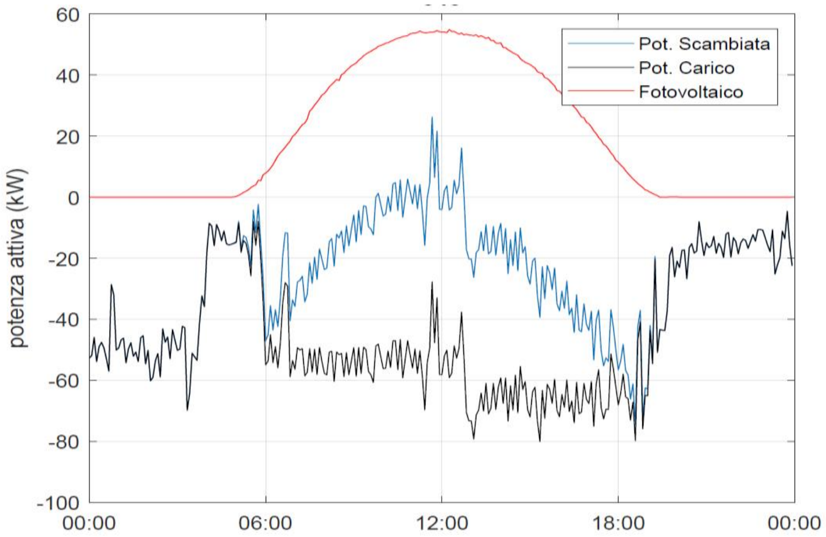
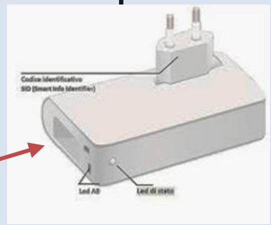
Smart metering

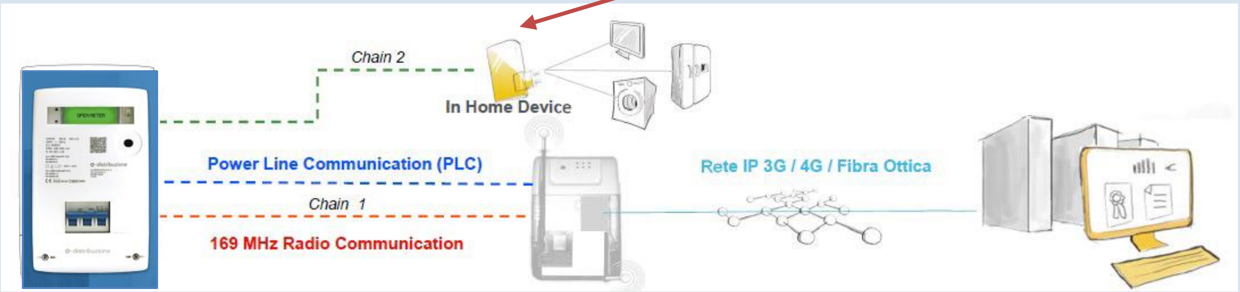
For the acquisition of **production** and **consumption data**, two types of **smart meters** were installed in various users at the CAAB (Centro AgroAlimentare di Bologna)

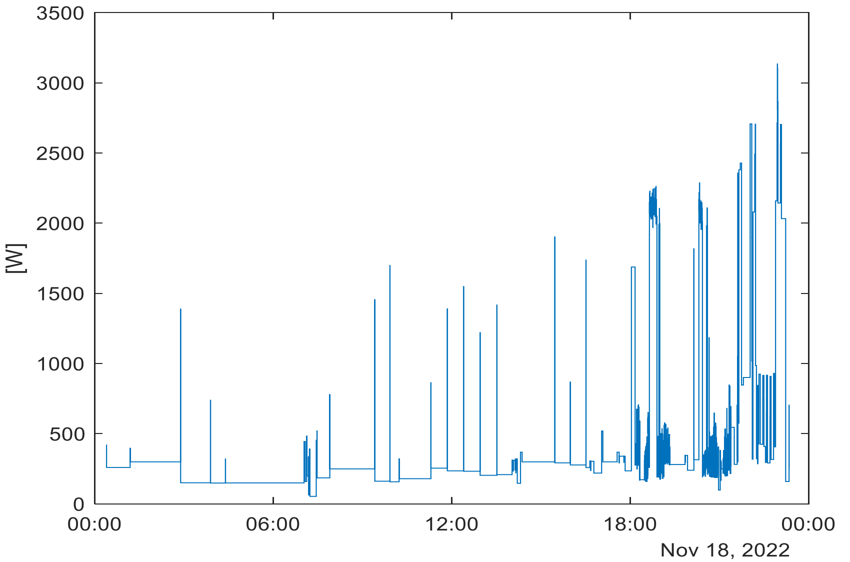
NILM (Non-Intrusive Load Monitoring) **instruments** →
direct power measurement by TA (amperometric transformer)
- data acquisition every few seconds (2-5s)



User Devices: use the PLC-chain2 protocol to acquire the measurements made by the fiscal counter
- data acquisition every 15 minutes
- each variation of ±10% power







Concluding Remarks

- Smart cities are crucial **systems of systems** where to accomplish the **CN** mission.
- This will require **a**) appropriate **smart sector integration** towards the **energy transition**
- **b**) **decades** and **c**) appropriate/reasonable differentiation of primary energy sources (solar, wind, hydro, nuclear – increasing – and fossil – decreasing)
- **Examples** coming from the **100 cities** (**2030**) are expected to be helpful for **all others** (**2050**)
- The **progressive electrification** of consumption in various sectors needs to be accompanied by adequate diffusion of electric generators powered by renewable sources
- EU is pushing towards a **user-centric** way to support self-consumption through **CEP**
- The push towards the creation of **energy communities** envisaged by the European directives **RED II** and **IEM**, underline the importance that the **electricity system** and **smart grids** will play more and more in this context.
- **Climate neutrality** cannot be accomplished through **energy communities** only, but it is reasonable to conclude that it **cannot be accomplished without them**.

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Post doc

PhD. **Diego Rios Penaloza**

PhD students

Eng. **Tadeo Pontecorvo**

Eng. **Andrea Prevedi**

For further reading

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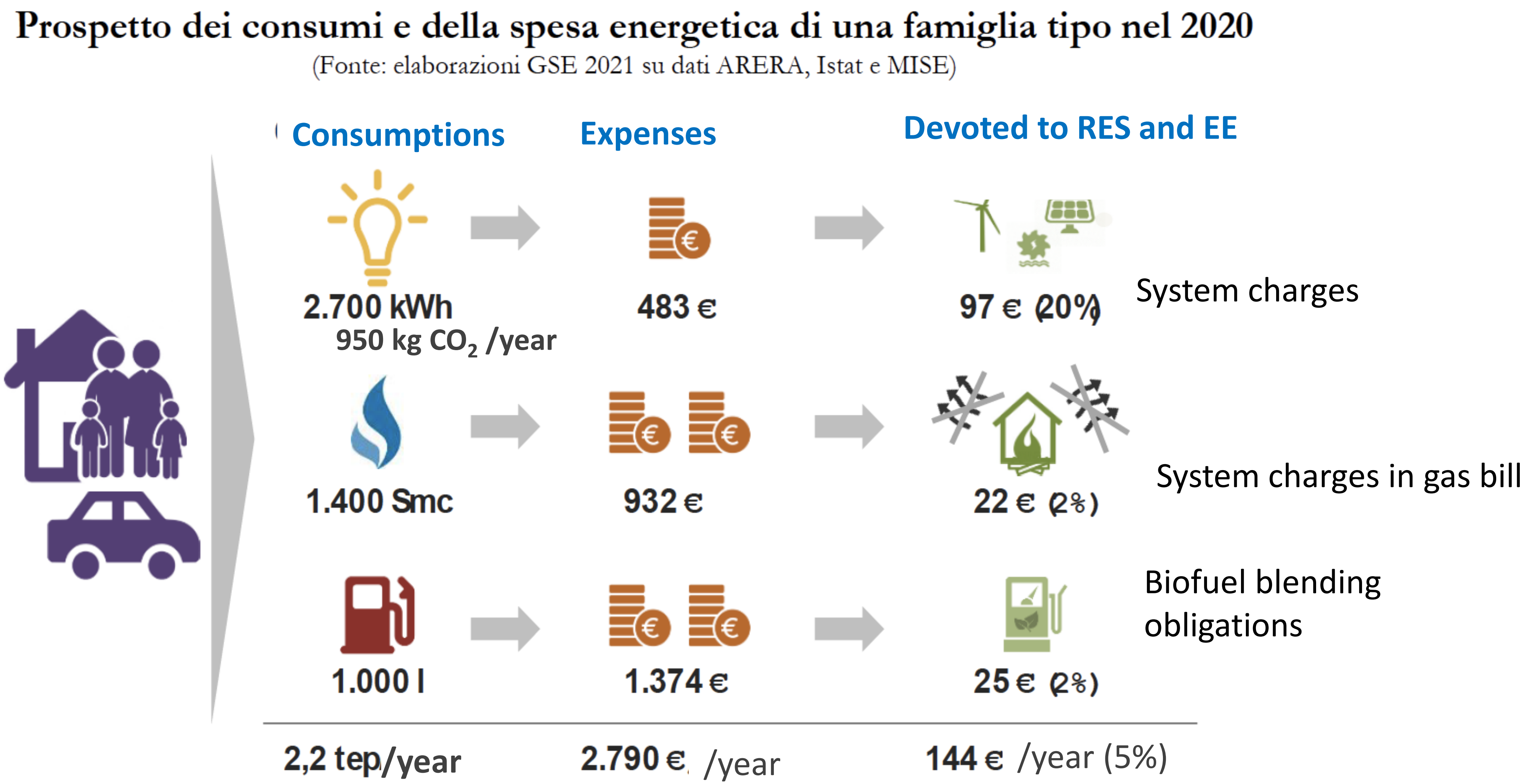
Appendix - Energy expenditure per typical household in Italy (2020)



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