Smart Grids for Smart Cities: the Potential of Local Energy Communities

Carlo Alberto Nucci

University of Bologna – DEI

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Greening Energy Market and Finance
First GrEnFIn Summer School

Bologna, June 10th, 2020

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Smart Cities

Adapted from https://www.tdblog.it/senseable-city-lab-mit/

Why a smart city?

The population living in urban areas is expected to double by 2050

→ any new process will require **more than just an incremental upgrading of the cities' organization, infrastructure** and the **services** provided to its citizens.

Services for a smart city

In the coming years, cities are expected to deal with an increasing number and type of services for their citizens

These services all have to do with overarching **goals**, such as

- **Sustainability**
- **Environment**
- **Quality of (working) life**
- ...

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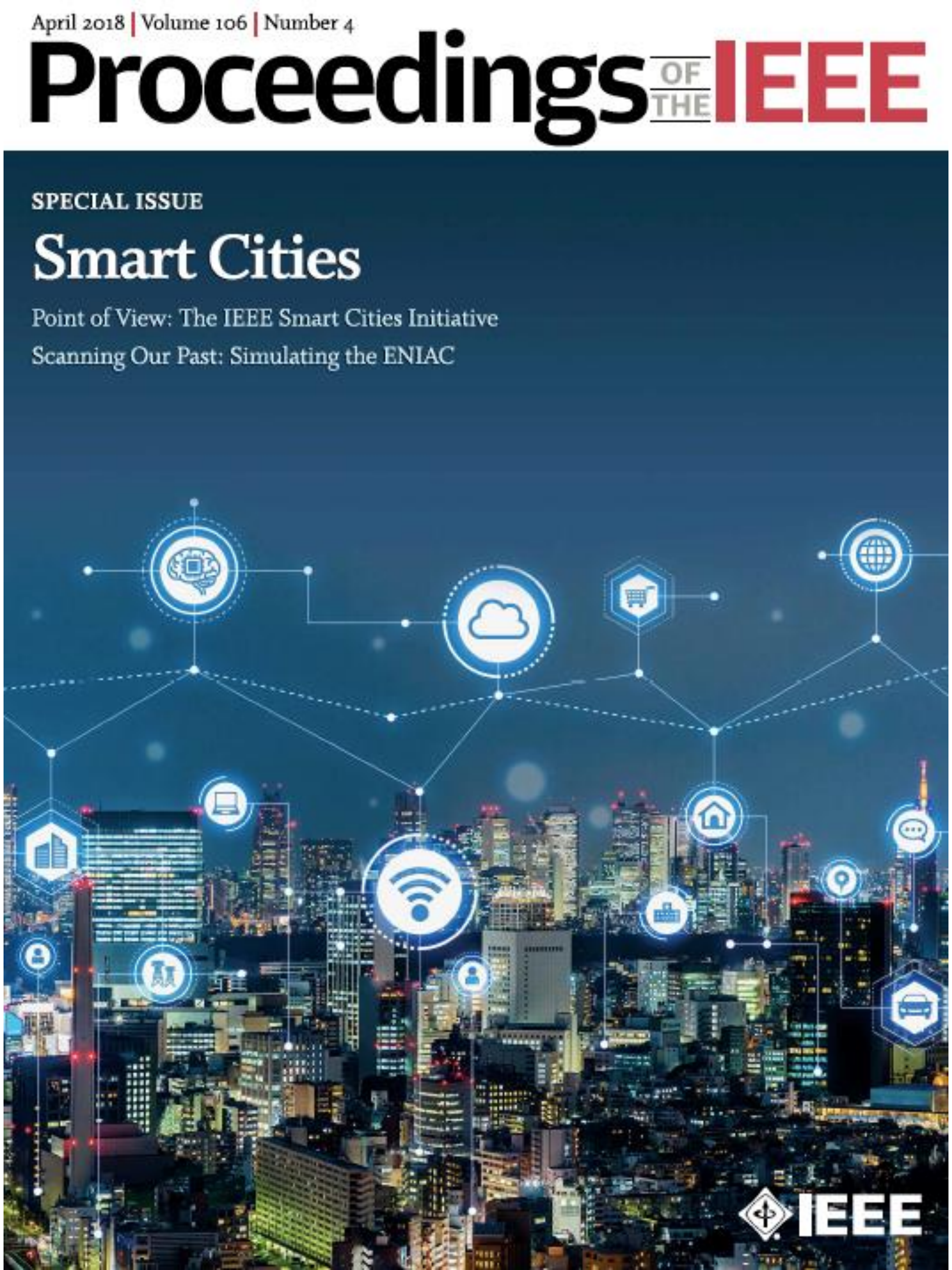

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Table of Content of the Special Issue on the Proceeding of the IEEE

SPECIAL ISSUE

SMART CITIES

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

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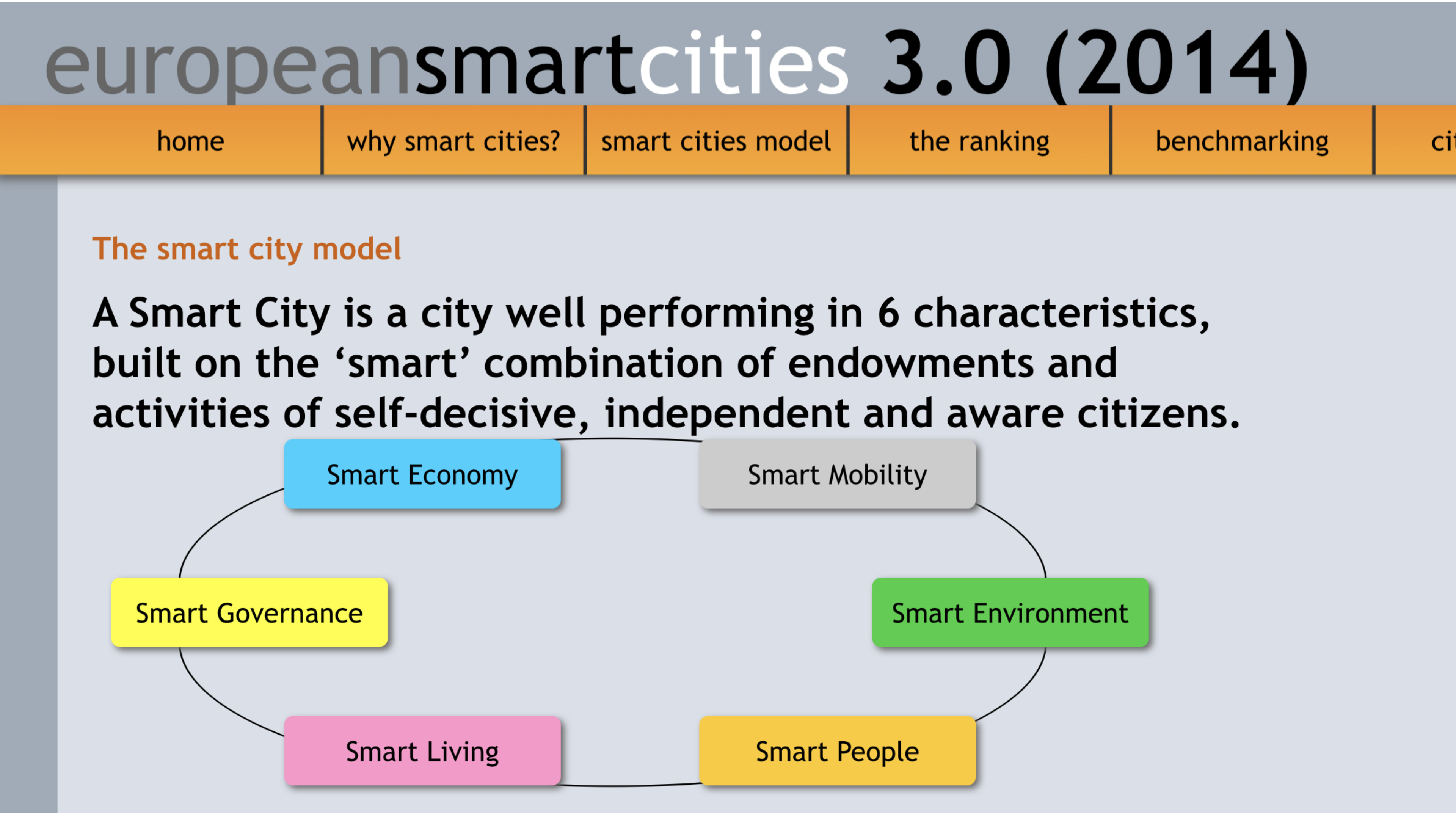
On the adjective 'smart'

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

Technology has always been **smart** → **this adjective serves to underline the widespread use of Information and Communication Technologies (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, which are instrumental to the accomplishment of such a goal.

The first definition



The methodology

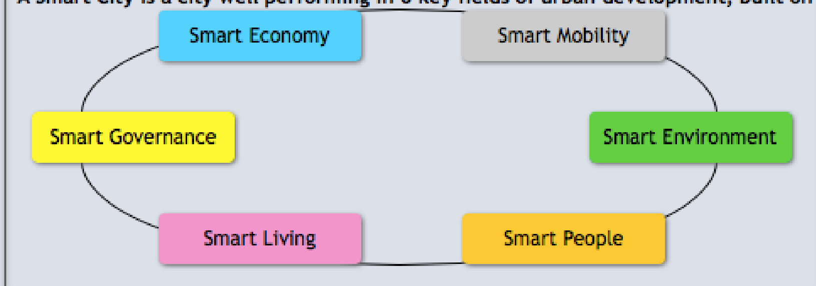
http://www.smart-cities.eu/?cid=-1&ver=4

europeansmartcities 4.0 (2015)

home | why smart cities? | smart cities model | benchmarking | city profiles | team & imprint

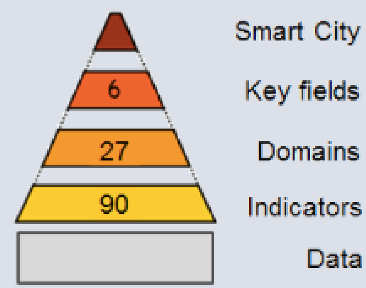
The smart city model

A Smart City is a city well performing in 6 key fields of urban development, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens.



Standardization and aggregation

To compare the different indicators it is necessary to standardize the values. One method to standardize is by z-transformation (see formular). This method transforms all indicator values into standardized values with an average 0 and a standard deviation 1. This method has the advantages to consider the heterogeneity within groups and maintain its metric information. Furthermore a high sensitivity towards changes is achieved.



z-transformation

$$z_i = \frac{x_i - \bar{x}}{s}$$

To receive results on the level of factors, characteristics and the final result for each city it is necessary to aggregate the values on the indicator level. For the aggregation of a respective group of indicators to domains we consider also the coverage rate of each indicator. A certain result from an indicator of an indicator covering all cities weights therefore a little more than from an indicator covering only for instance 60 cities. Besides this small correction the results were aggregated on all levels without any weighting. The aggregation was done additive but divided through the number of values added. That allows us to include also cities which do not cover all indicators. Their results are calculated with the values available. Still, it is necessary to provide a good coverage over all cities to receive reasonable results.

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

IEEE Smart City Initiative

- A smart economy
- Smart energy
- Smart mobility
- A smart environment
- Smart living
- Smart governance

IEEE Standards Help Enable Smart City Technologies for Humanity

Smart City

Smart Grid
IEEE 1547™ Series DER
IEEE 1815™ Distributed Network Protocol
IEEE 2030™ Series Interoperability
IEEE C37™ Series Grid Critical Infrastructure

Learning Technologies
IEEE 1484™ Series eLearning Technologies
IEEE 1278™ Series Distributed Interactive Simulation
IEEE 1516™ Series Modeling and Simulation
IEEE 1730™ Series Distributed Simulation Engineering and Execution Process

Intelligent Transportation
IEEE 1609™ Series Wireless Access Vehicle Environment
IEEE 1901™ Series Power Line Communications (PLC)
IEEE 802.15.4p™ WPAN Rail Communications and Control
IEEE 1512™ Emergency Management System

Smart Home
IEEE 802® LAN/MAN
IEEE 1901™ Series PLC
IEEE 1905.1™ Home Network for Heterogeneous Technologies
IEEE 2030.5™ Smart Energy Profile

eHealth
IEEE 11073™ Series Medical Devices
IEEE 139™ RF Emission from ISM Equipment
IEEE 602™ Healthcare Facilities
IEEE 1363™ Series Encryption

eGovernance
IEEE P7002™ Data Privacy Process
IEEE P7004™ Child and Student Data Governance
IEEE P7005™ Transparent Employer Data Governance
IEEE P7006™ Personal Data Artificial Intelligence (AI) Agent

Energy Efficiency
IEEE 1801™ Low Power, Energy Aware Electronic Systems
IEEE P1889™ Electrical Performance of Energy Saving Devices
IEEE P1823™ Universal Power Adapter for Mobile Devices
IEEE P1922.1™-IEEE P1929.1™ Series for Energy Efficient Systems

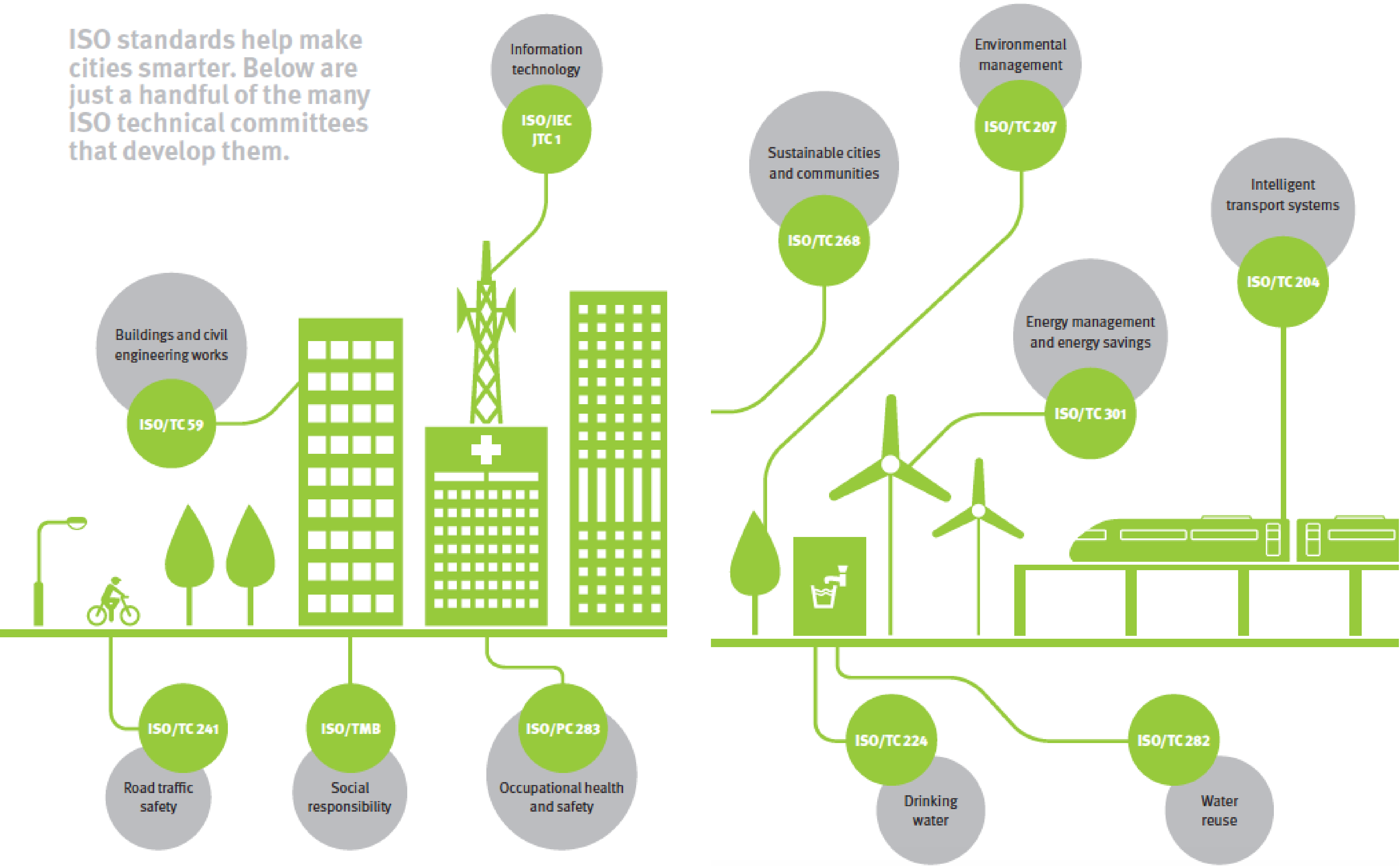
Internet of Things (IoT)
IEEE P2413™ IoT Architecture
IEEE 1588™ Precision Time Stamp
IEEE 1451™ Series Sensor Networks
IEEE P1451-99™ Harmonization of IoT Devices and Systems

Cyber Security
IEEE P802E™ ePrivacy
IEEE 1363™ Series Encryption
IEEE 1402™ Physical Security
IEEE 1686™ Intelligent Electronic Devices (IEDs)

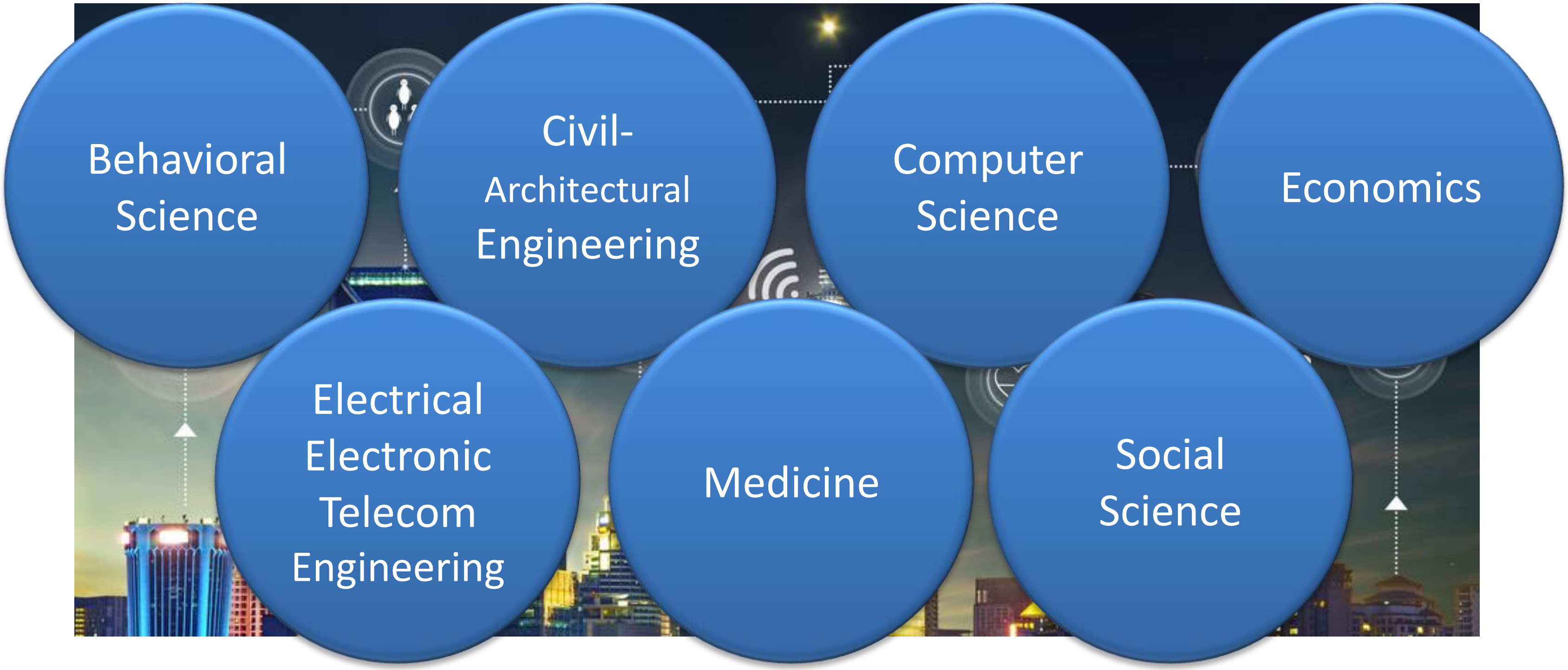
5G
IEEE P1914.1™ Fronthaul
IEEE P1918.1™ Tactile Internet
IEEE 802® LAN/MAN
IEEE P1915™-IEEE P1921.1™ Series Software Defined Networks

ISO Standards

ISO standards help make cities smarter. Below are just a handful of the many ISO technical committees that develop them.



The need for a multidisciplinary approach



To achieve the challenging **goals** mentioned above, drastic changes are required that involve a multitude of **new technologies** relevant to various disciplines e.g.

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The need in emergency situations: COVID 19

On the Coronavirus (COVID-19) Outbreak and the Smart City Network: Universal Data Sharing Standards Coupled with Artificial Intelligence (AI) to Benefit Urban Health Monitoring and Management

Article (PDF Available) *in* Healthcare 8(1):46 · February 2020 *with* 297 Reads

DOI: 10.3390/healthcare8010046

Zaheer Allam
18.29 · Curtin University

David Jones
14.64 · Deakin University

Abstract

As the Coronavirus (COVID-19) expands its impact from China, expanding its catchment into surrounding regions and other countries, increased national and international measures are being taken to contain the outbreak. The placing of entire cities in 'lockdown' directly affects urban economies on a multilateral level, including from social and economic standpoints. This is being emphasised as the outbreak gains ground in other countries, leading towards a global health emergency, and as global collaboration is sought in numerous quarters. However, while effective protocols in regard to the sharing of health data is emphasised, urban data, on the other hand, specifically relating to urban health and safe city concepts, is still viewed from a nationalist perspective as solely benefiting a nation's economy and its economic and political influence. This perspective paper, written one month after detection and during the outbreak, surveys the virus outbreak from an urban standpoint and advances how smart city networks should work towards enhancing standardization protocols for increased data sharing in the event of outbreaks or disasters, leading to better global understanding and management of the same.

The need in emergency situations: COVID 19

healthcare

MDPI

Perspective

On the Coronavirus (COVID-19) Outbreak and the Smart City Network: Universal Data Sharing Standards Coupled with Artificial Intelligence (AI) to Benefit Urban Health Monitoring and Management

Zaheer Allam [1,*] and David S. Jones [2]

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2 School of Architecture & Built Environment, Deakin University, Geelong, VIC 3220, Australia; david.jones@deakin.edu.au
* Correspondence: zaheerallam@gmail.com

Received: 31 January 2020; Accepted: 25 February 2020; Published: 27 February 2020

check for updates

Abstract: As the Coronavirus (COVID-19) expands its impact from China, expanding its catchment into surrounding regions and other countries, increased national and international measures are being

An Interesting Definition


SmartCitiesCouncil

LIVABILITY
WORKABILITY
SUSTAINABILITY

HOME | OUR PARTNERS | CITY RESOURCES | PREMIUM RESOURCES* | GLOBAL ALLIANCES | JOIN SCC |

Definitions and overviews

The smart city sector is still in the "I know it when I see it" phase, without a universally agreed definition. The Council defines a smart city as one that has digital technology embedded across all city functions; click on any of the articles below for additional perspectives.

The Smart Cities Council is a for-profit, Partner-led association for the advancement of the smart city business sector. It promotes smart cities in general and our Partners in particular.
Allied Telesis • Alstom Grid • Bechtel • Cisco • Cubic Transportation Systems - Enel • GE • IBM • Itron, Inc. • MasterCard • Mercedes-Benz • Microsoft • Ooredoo • Qualcomm • S&C Electric Co. • Schneider Electric

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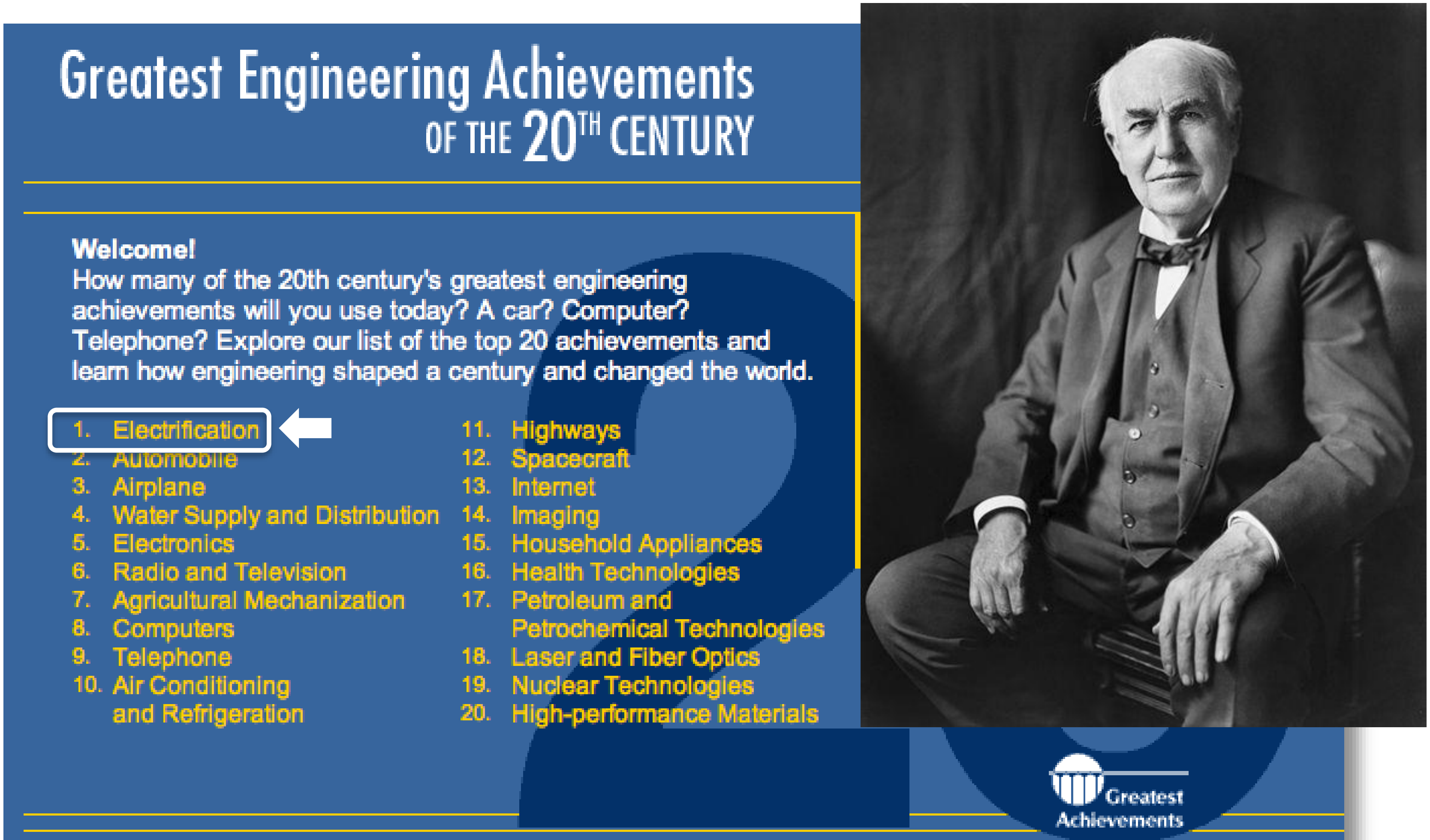
2
Smart Grid





Also the traditional power grid is *smart*



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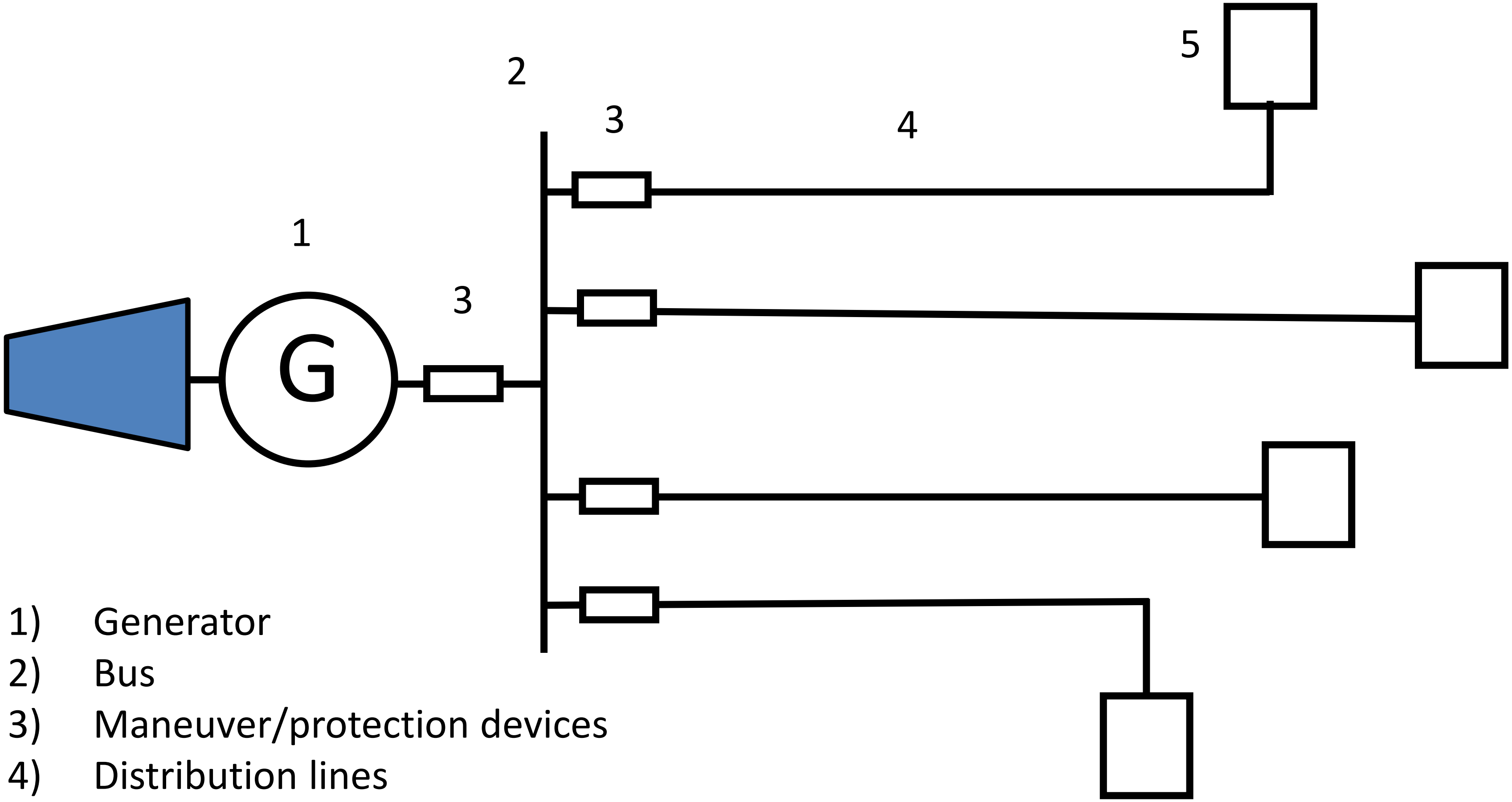
Electrical Power System Evolution

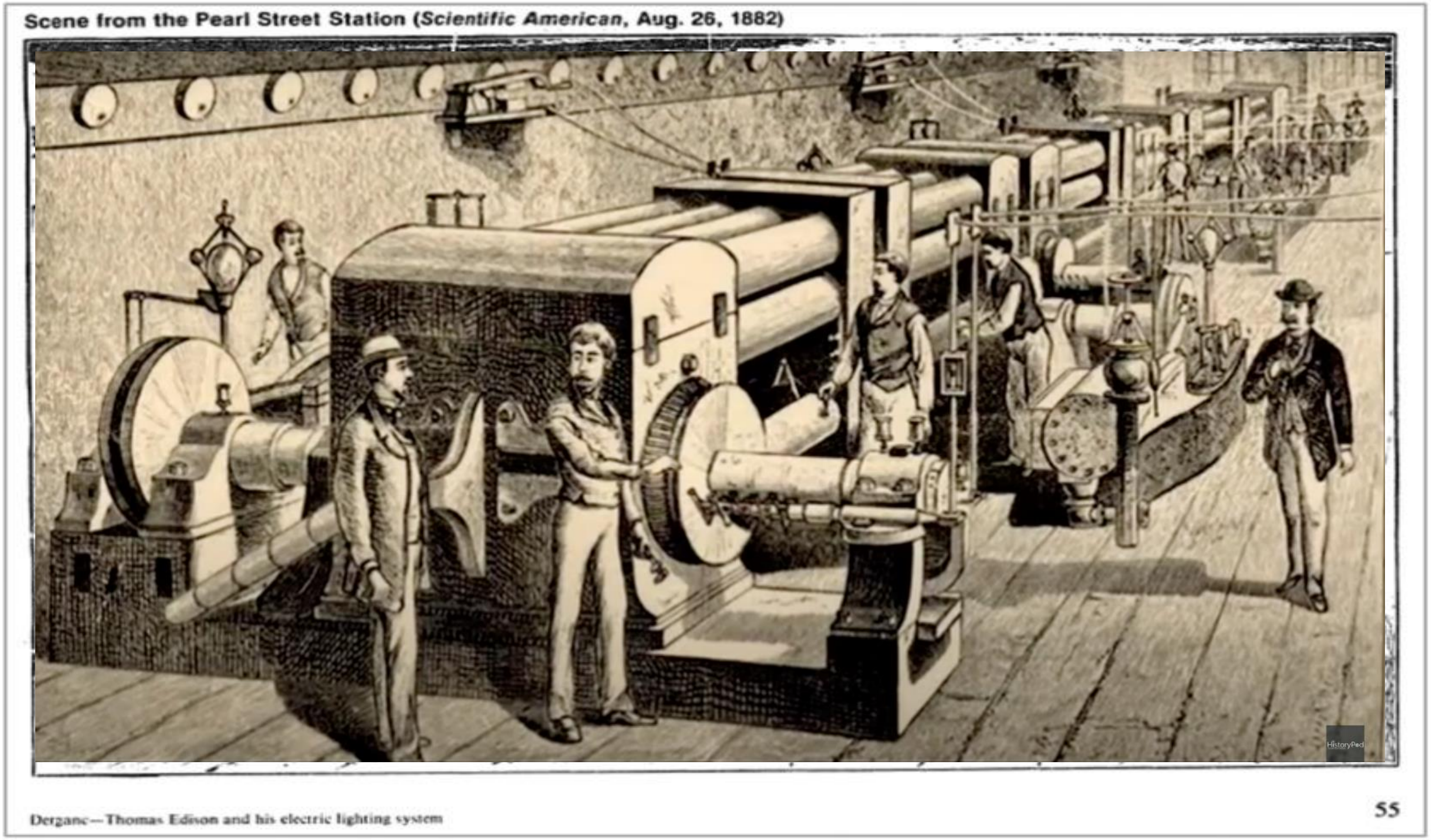
Simple(st) configuration



1) Generator
2) Bus
3) Maneuver/protection devices
4) Distribution lines
5) Loads

Electrical Power System Evolution

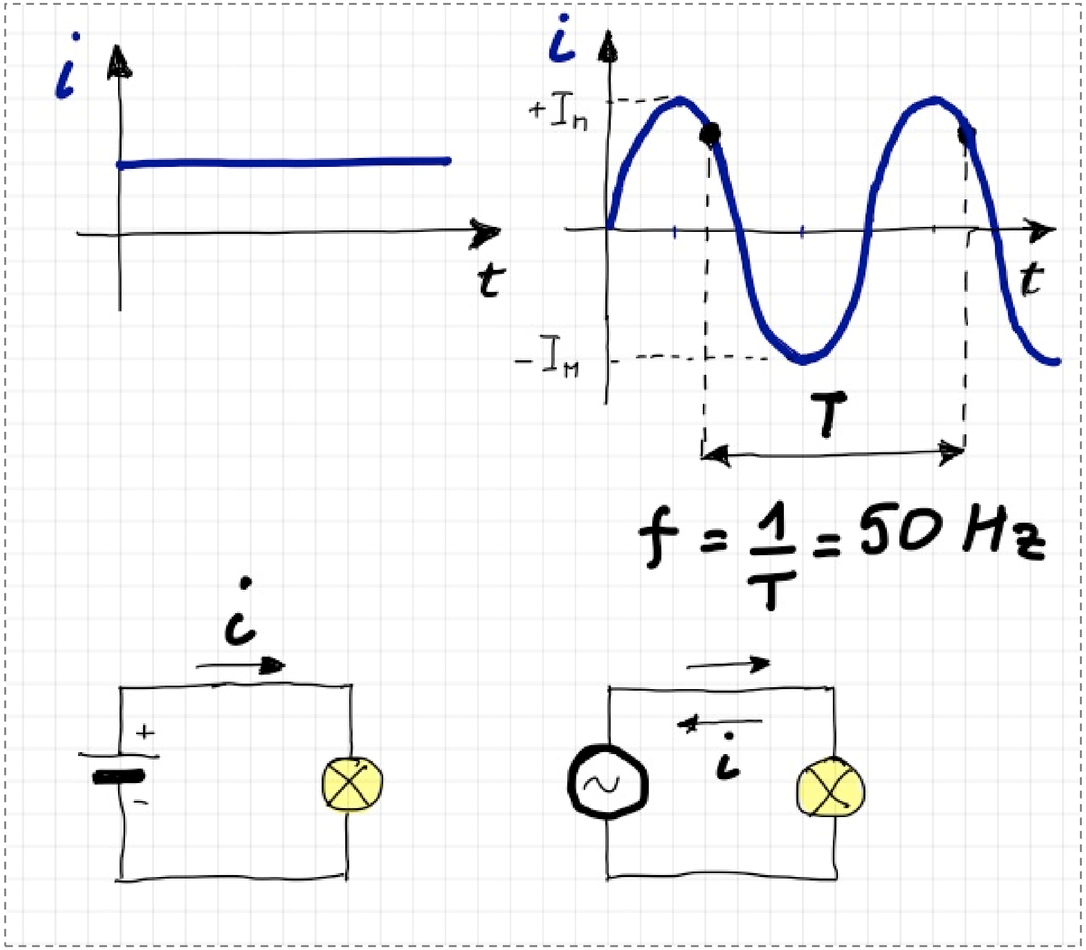
Simple(st) configuration



1982 Pearl street Power station by Thomas Alva Edison

L. de Andrade and T. P. de Leao, "A brief history of direct current in electrical power systems," in *2012 Third IEEE HISTory of ELectro-technology CONference (HISTELCON)*, 2012, pp. 1–6.

The war of currents



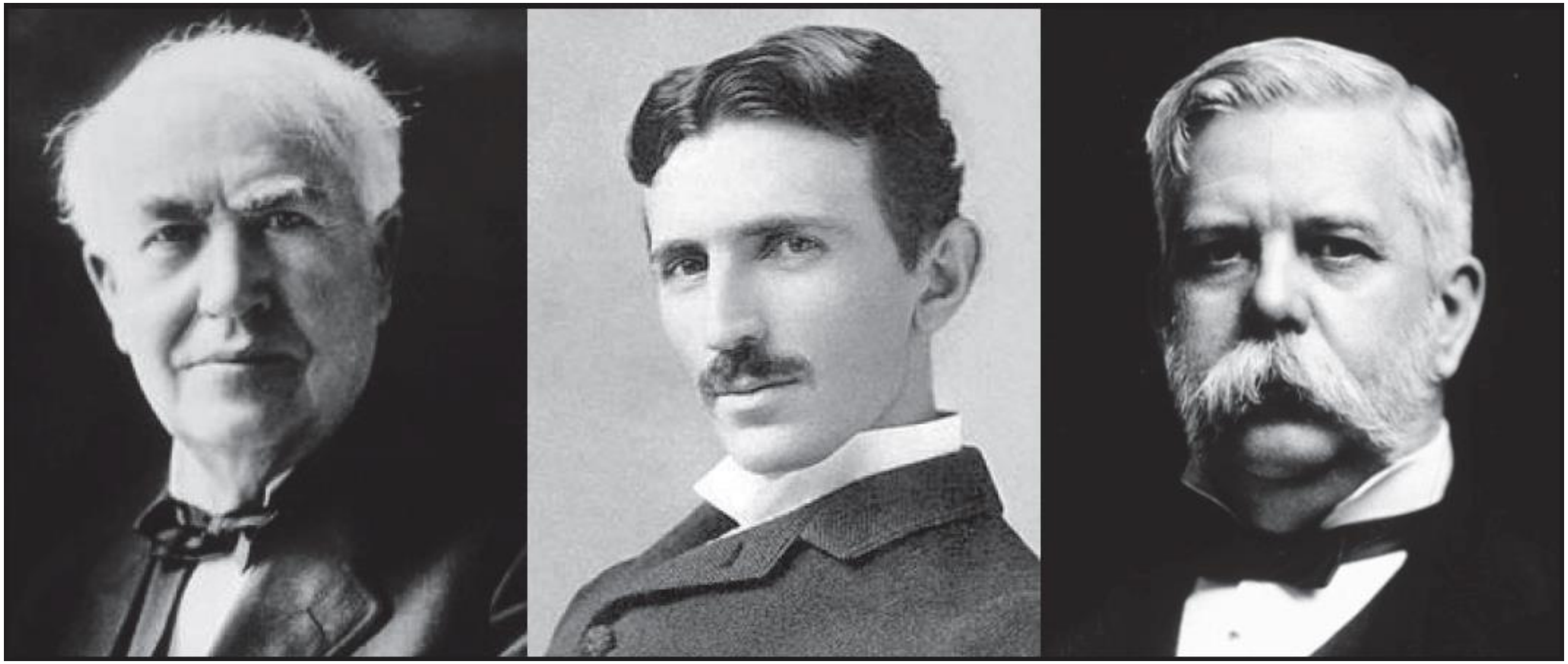
DC Current

Pile, Battery
Dynamo
PV Panel

AC Current

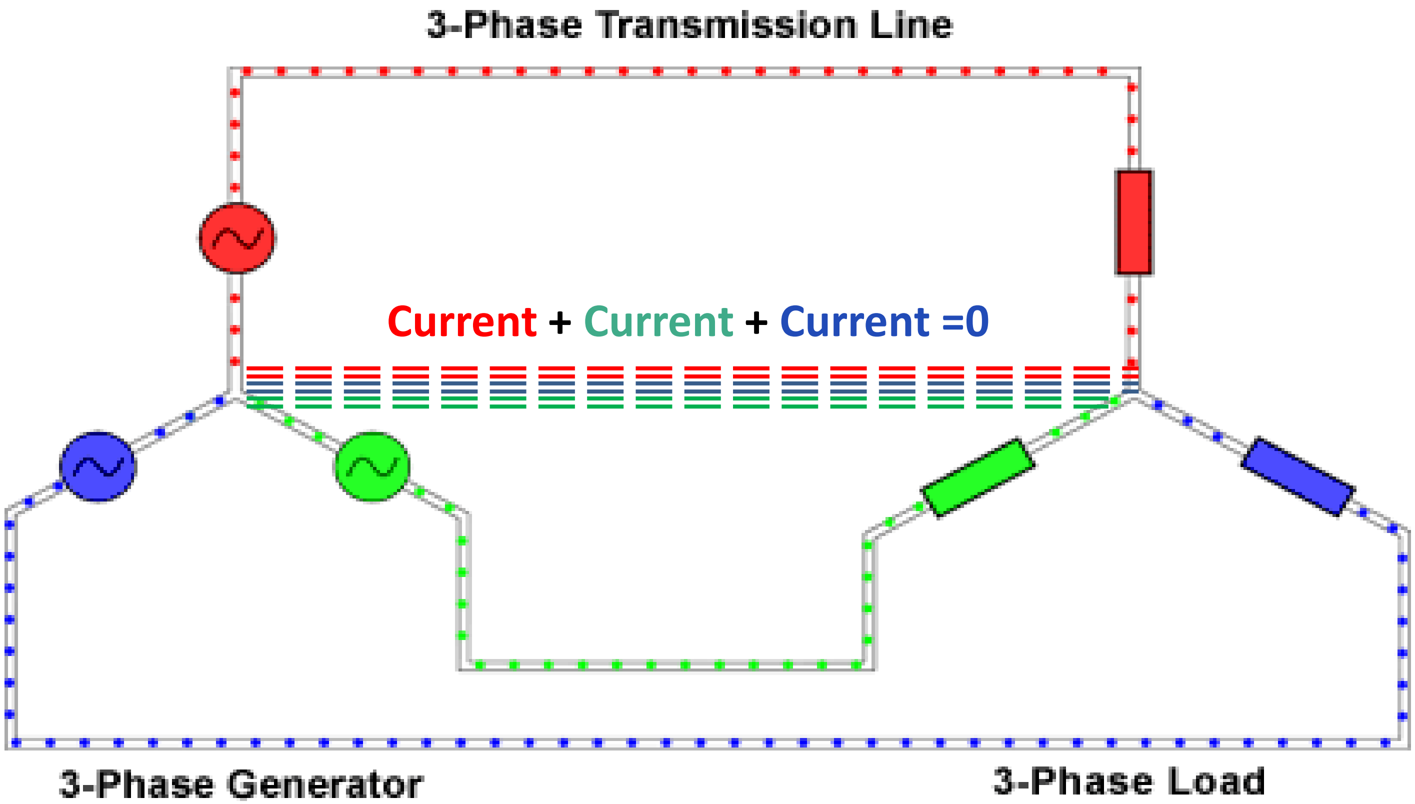
Alternator

The war of currents

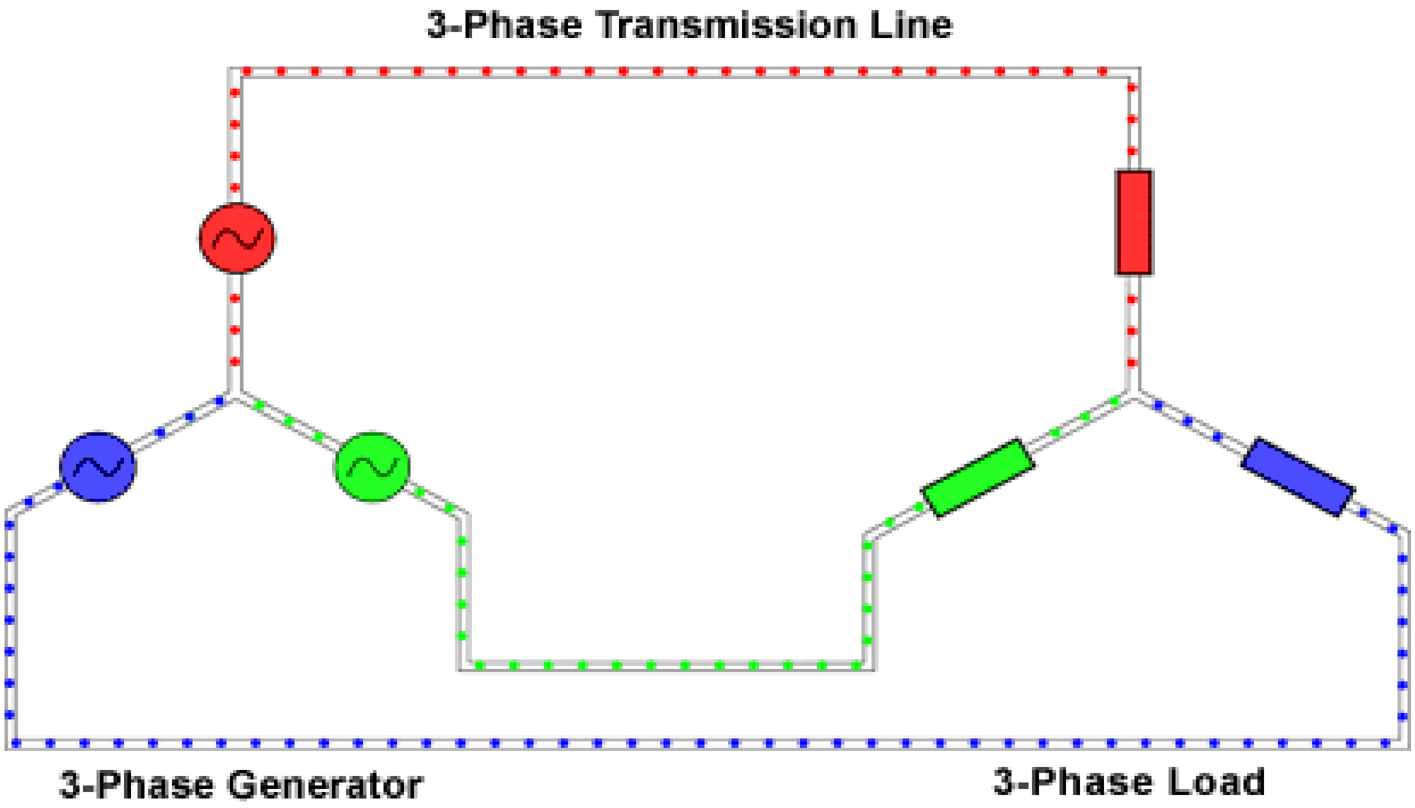


In **1896**, the first AC generation and transmission system was finished in the Niagara Falls using Westinghouse equipment.

Three phase systems

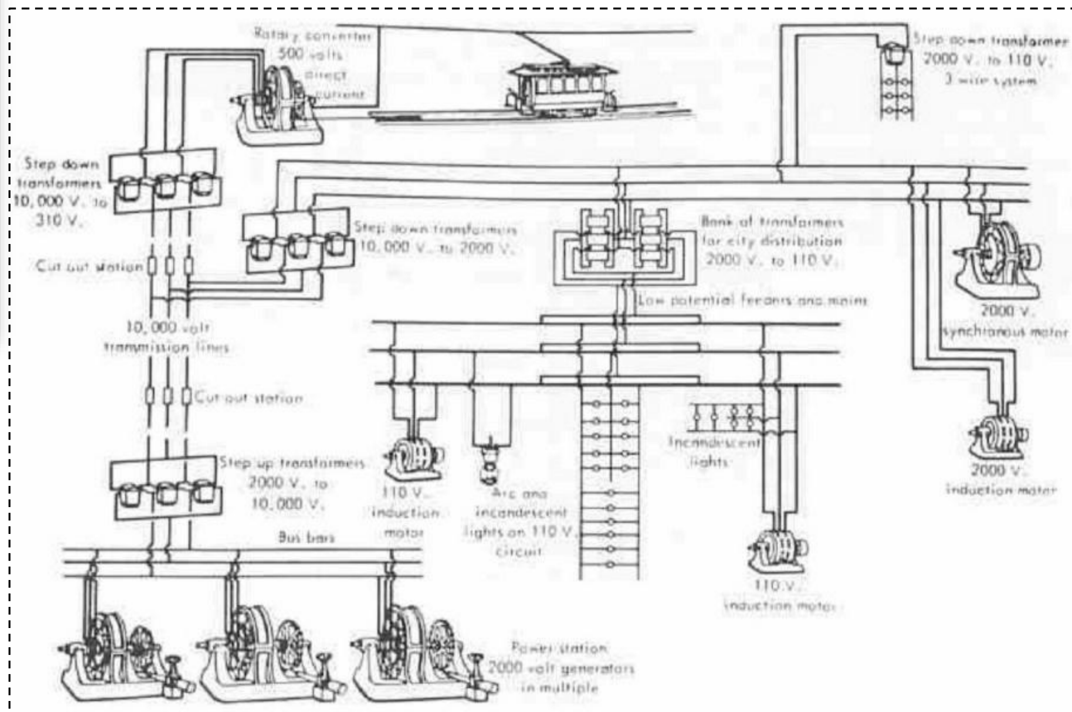


Three phase systems



The war of currents

But the event that marked the success of alternating current was a few years before 1896: **The Frankfurt exhibition in August of 1891**: a **25,000 Volt** three-phase transmission line (42 Hz), starting from the hydroelectric plant built for a cement factory in Lauffen, on the Neckar river and with a distance of **175 km** reached Frankfurt.



Electrical Power System Evolution

AC systems development

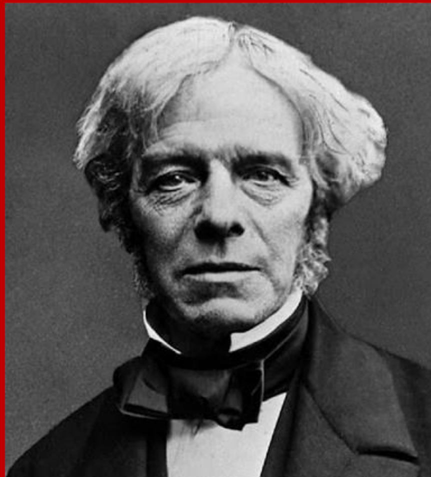
Transformer → different voltage levels for generation, transmission, distribution, and use

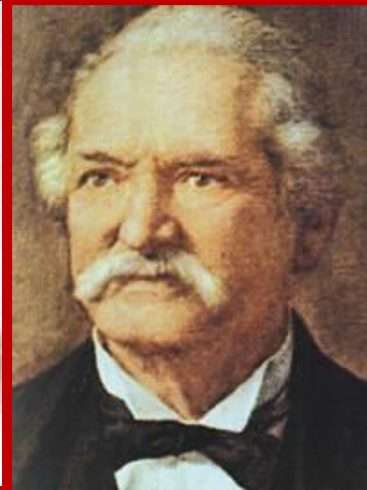
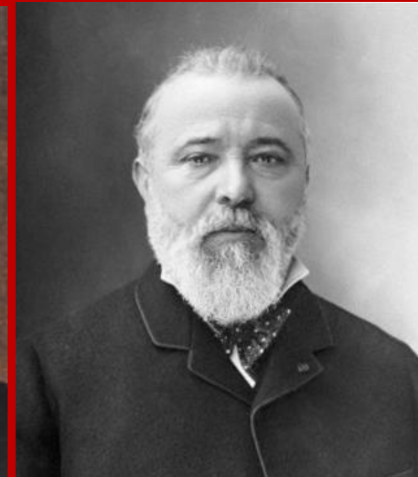
Three-phase networks → smooth, non-pulsating flow of power and also bring an easy way to interrupt current on high-voltage equipment

Induction motor → rugged, cheap, and serves the majority of industrial and residential purposes

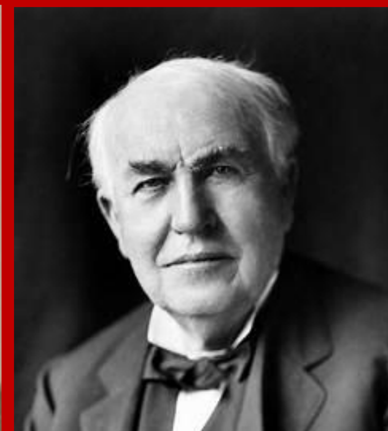
Advent of **steam turbines**, (best at high speeds) → great advantage to AC generators (commutators of DC motors and generators impose limitations on the voltage, size, and especially in speed of these machines)

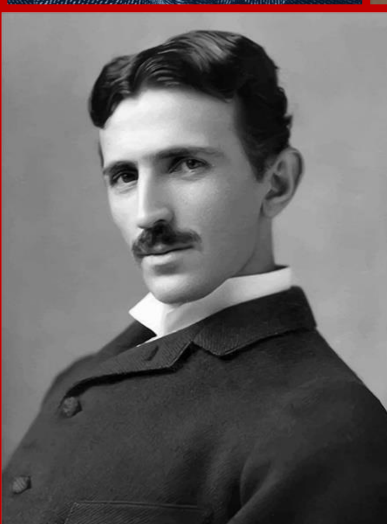
Inventors such as **Galileo Ferraris**, **Nicola Tesla**, **William Stanley**, **Michael von Dolivo-Dobrowolsky**, **Elihu Thomson**, **Lucien Gaulard**, **John Gibbs**, **and others** working in Europe and North America all contributed to AC technology.

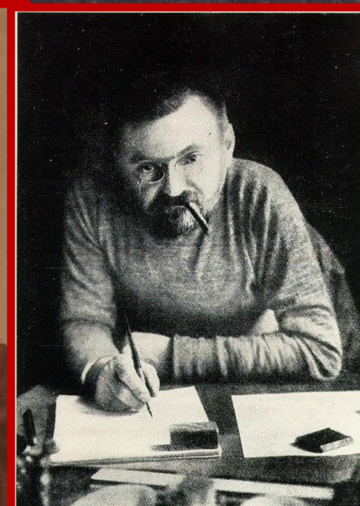




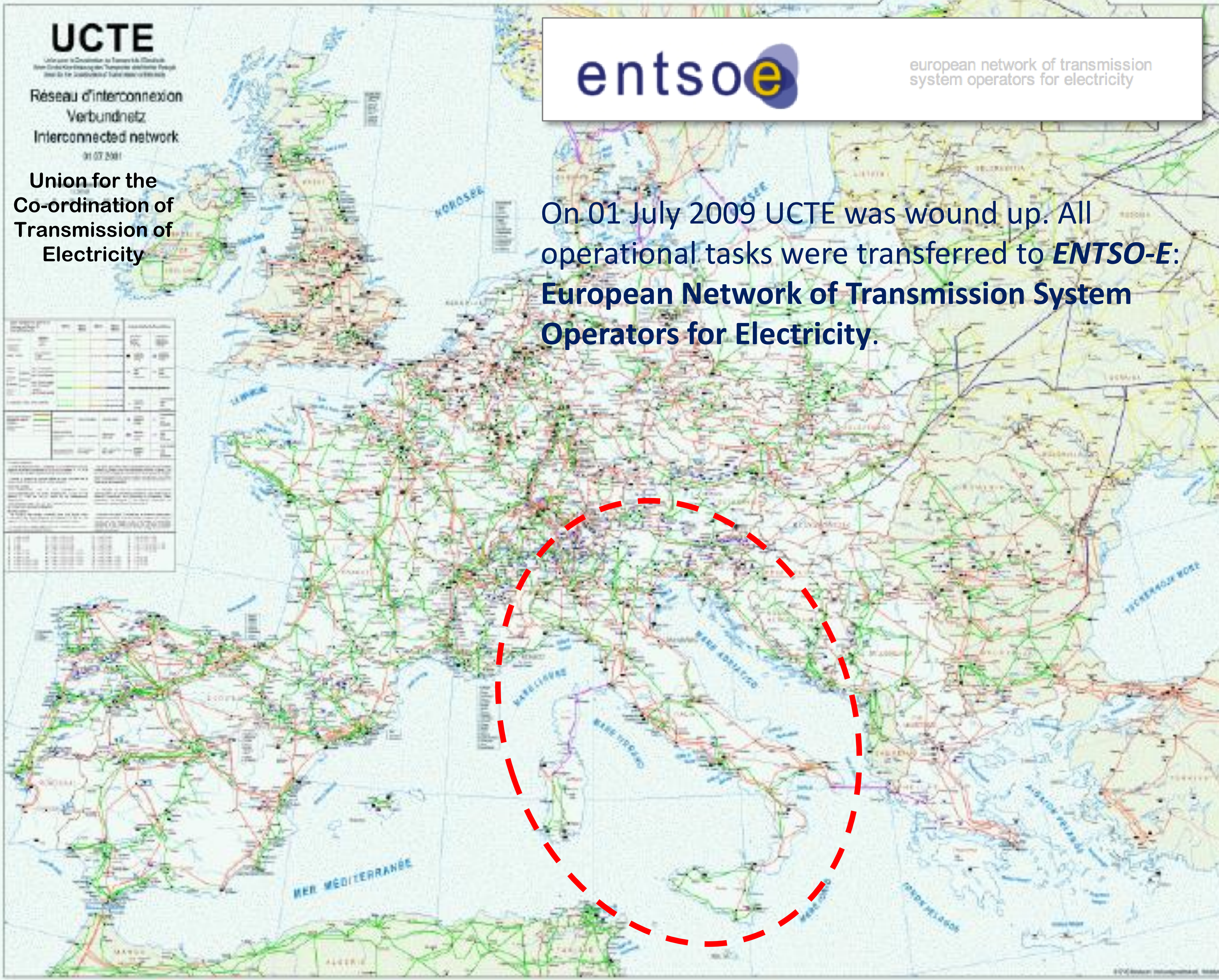





(Faraday, Pixii, Pacinotti, Gramme, Ferraris, Foucault, Jablochkov, Edison, Zipernowski, Blàthi e Déri, Tesla, Blàthy, Dobrowolsk, Steinmez)





Union for the Co-ordination of Transmission of Electricity

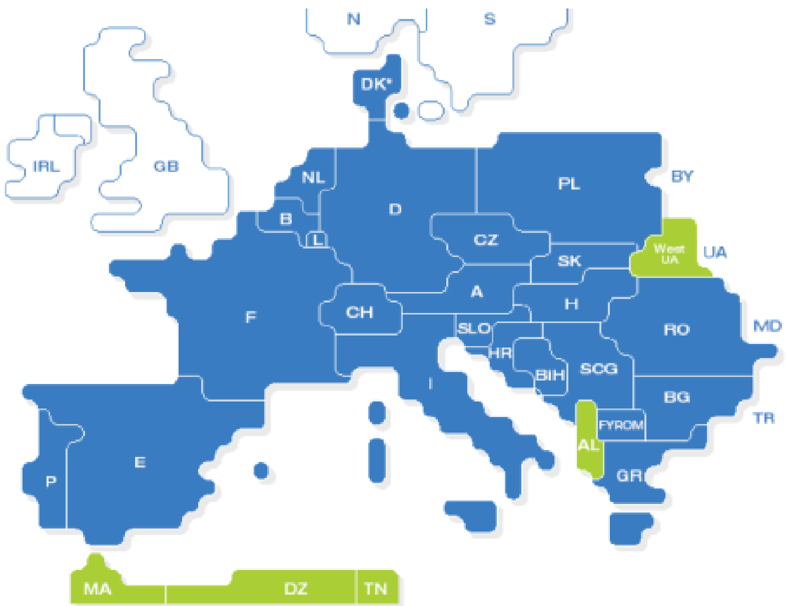
On 01 July 2009 UCTE was wound up. All operational tasks were transferred to ***ENTSO-E***: **European Network of Transmission System Operators for Electricity**.

Frequency control
in an interconnected power system

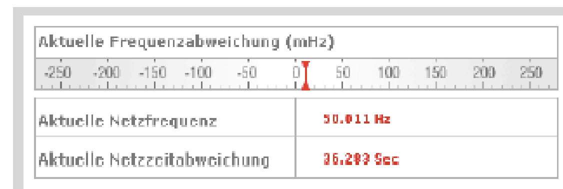
Why is balancing power required?

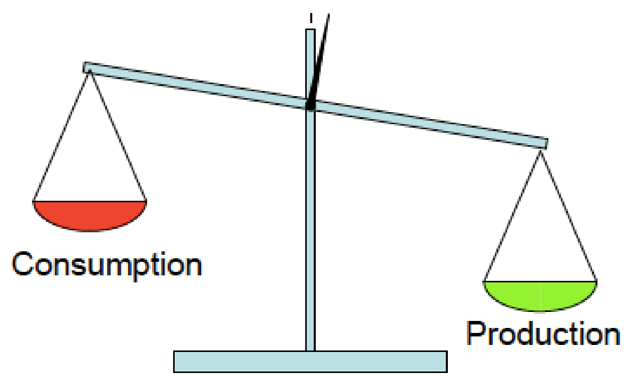
Keeping the frequency constant

At every instant
Σ Power production = Σ Power consumption



Source ENTSO-E-Map: http://www.entsoe.eu





ystems - University Enterprise Training Partnership

Renewable sources

Hydro

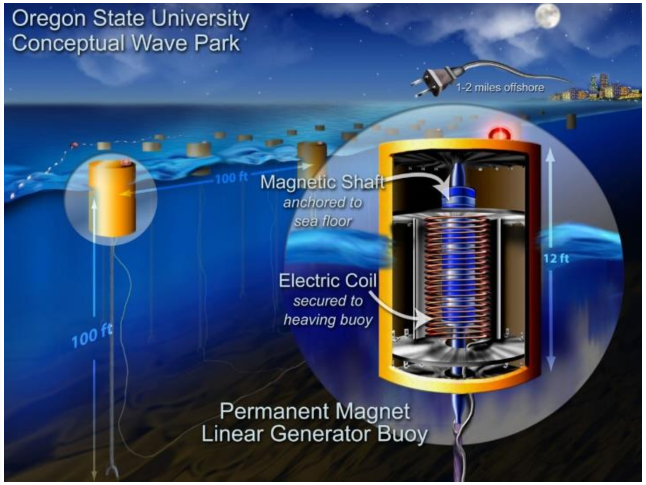
Biomass

Photo Voltaics

Solar Thermal

Geothermal

Wind



Marine

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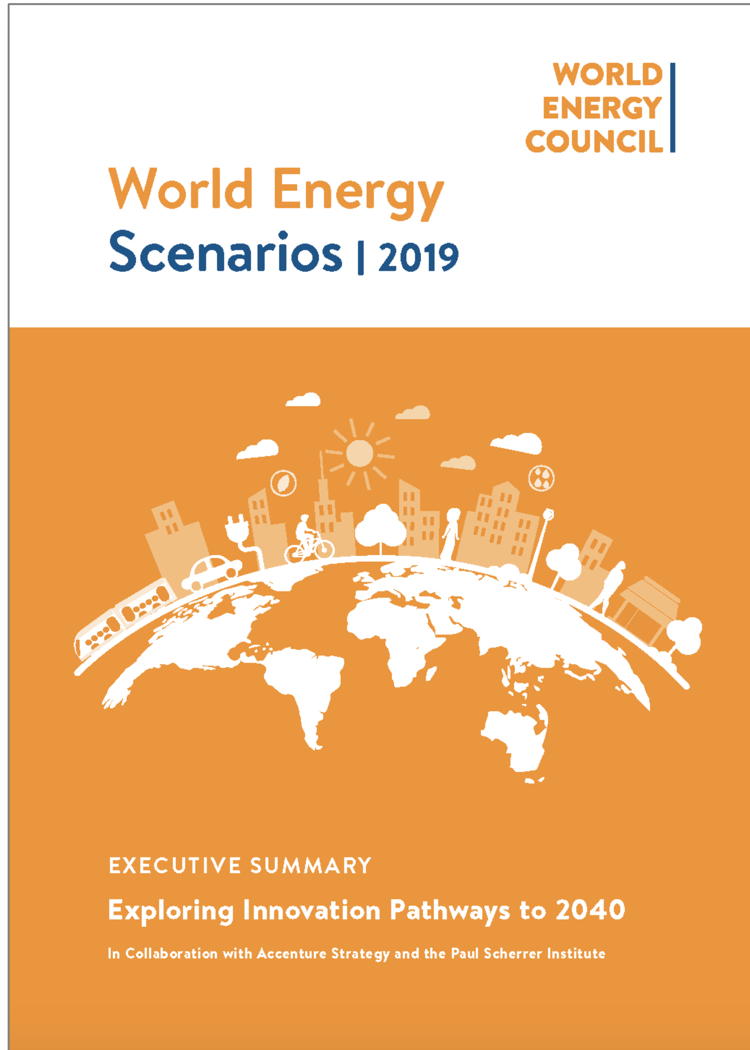
The world energy council reports



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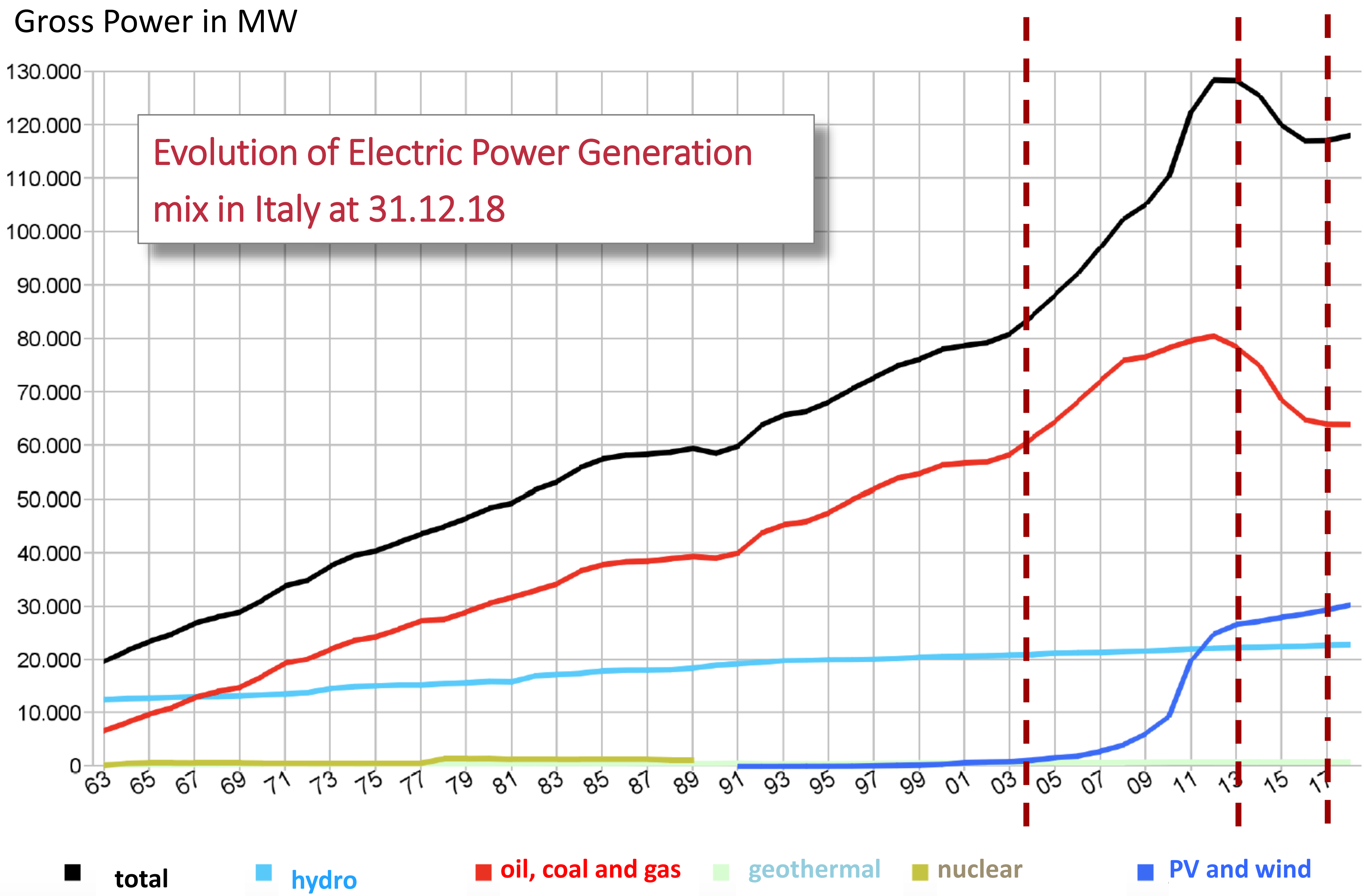
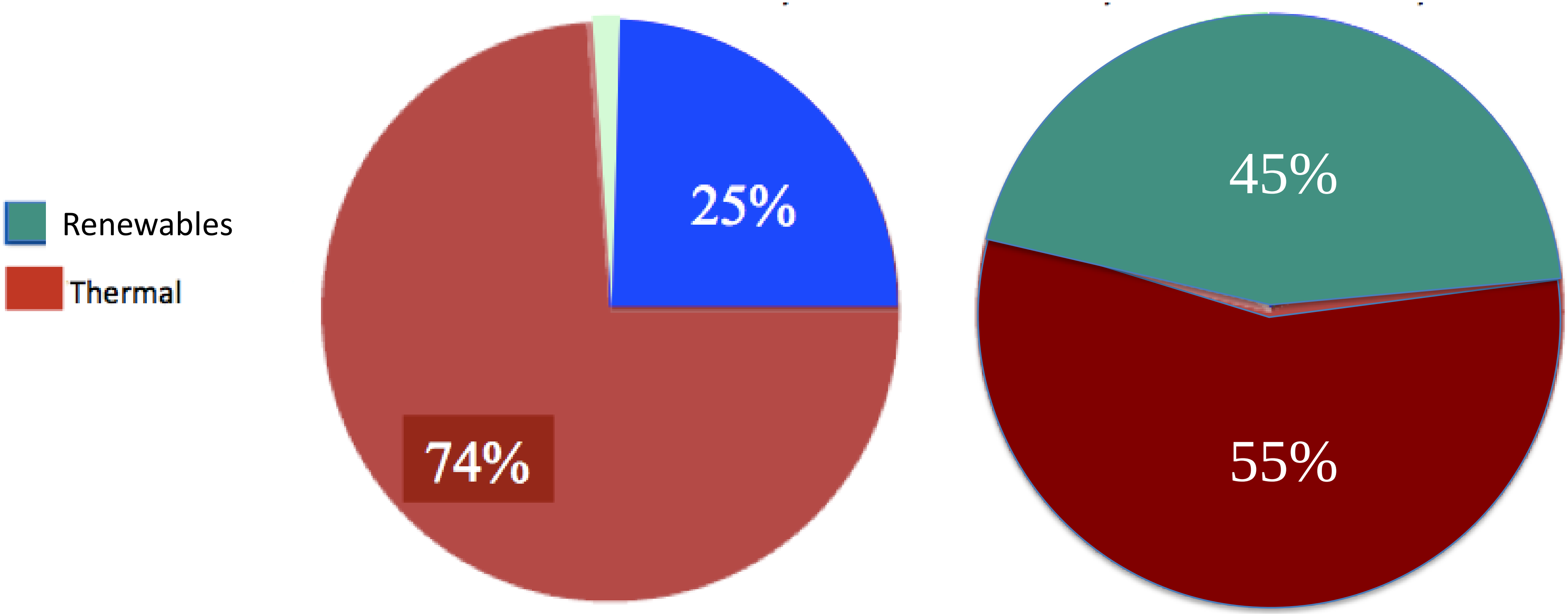
Electric Power Installed in Italy



Italian Power Generation Mix

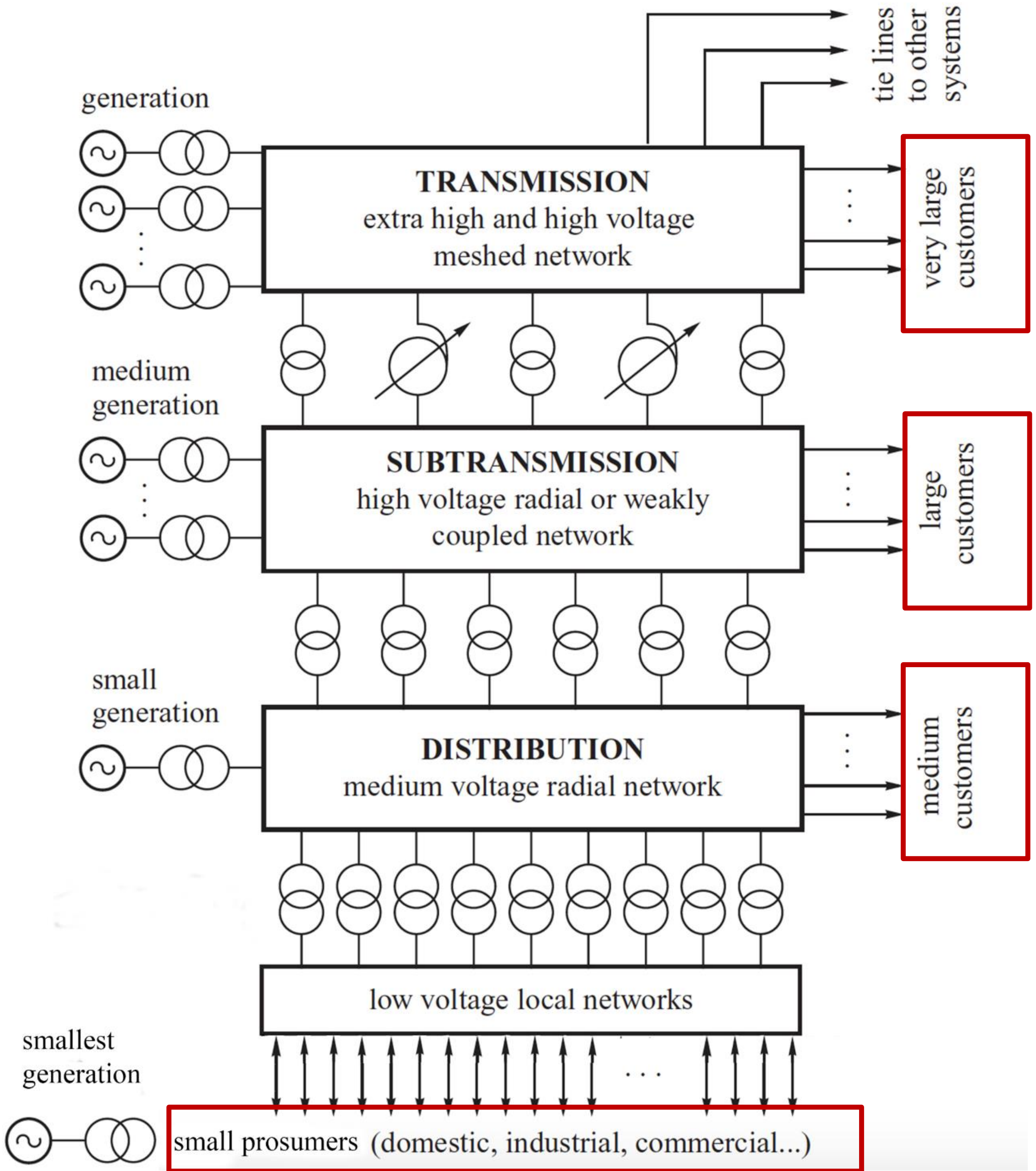
Classification	Plants (k)	Power (GW)	Plants (k)	Power (GW)
Hydroelectric	2	21,1	2,9	22,5
Thermal power	1,9	62,2	3,9	76,9
Wind	0,1	1,1	1,4	8,5
PV	0	0	559,4	18,5
Total	**4**	**84,4**	**567,6**	**126,4**



2004
Start of electricity market

2017
Generation mix further changes

Electric Power System Structure of today



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Smart Grid

From passive to active distribution networks

Transmission

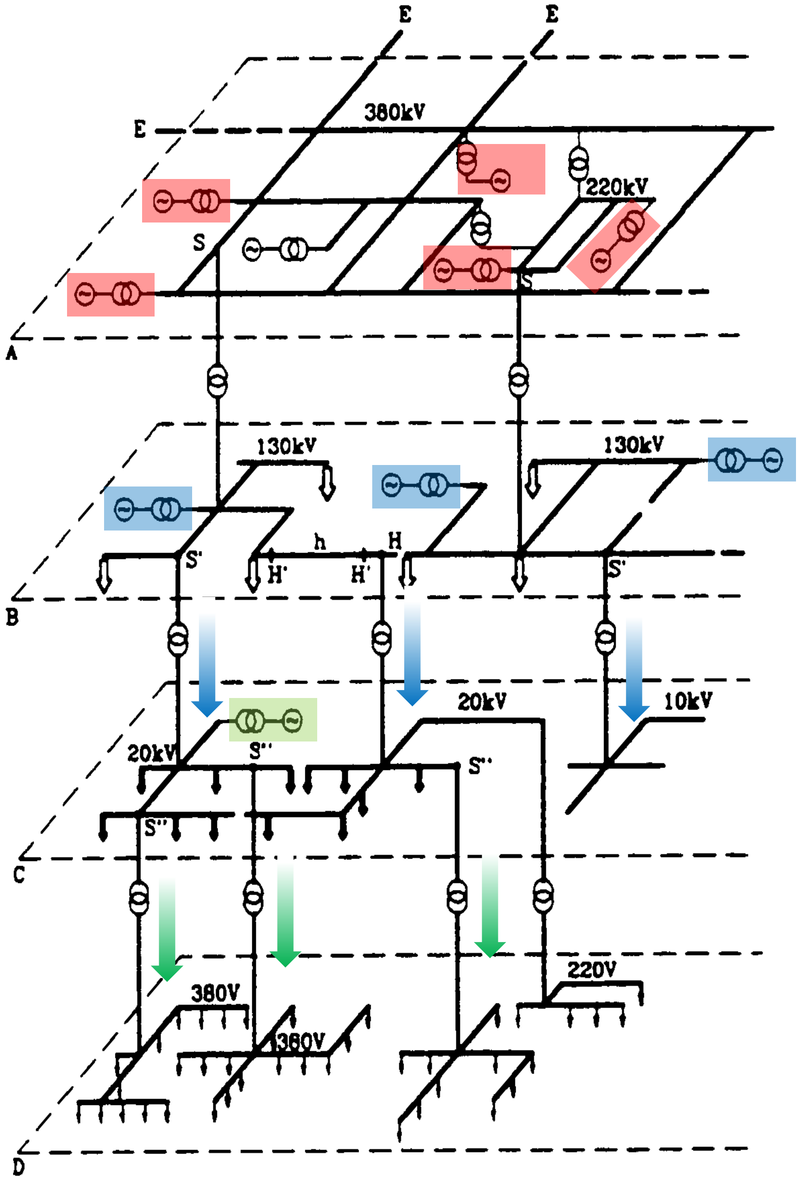
Sub-transmission

Distribution

(medium voltage)

Distribution

(low voltage)



Without **distributed generation**

Unidirectional powerflows

from transmission to distribution networks.

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Smart Grid

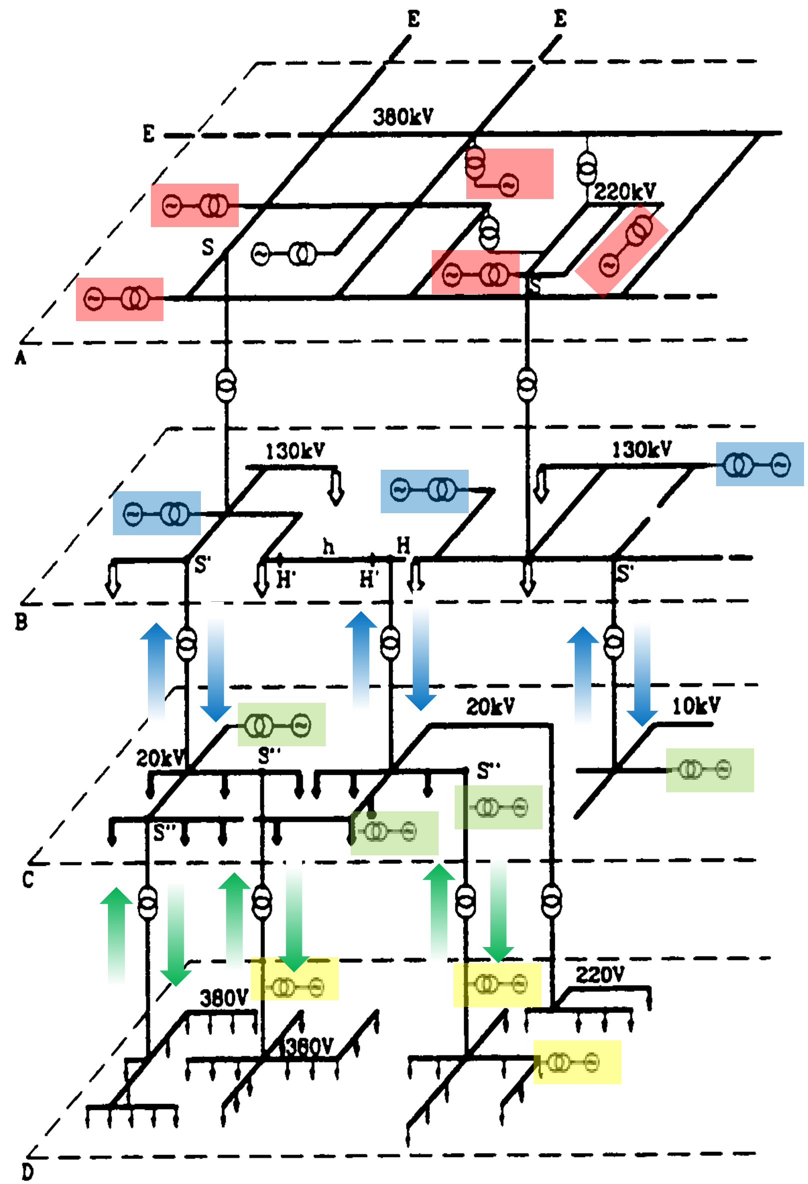
From passive to active distribution networks

Transmission

Sub-transmission

Distribution (medium voltage)

Distribution (low voltage)

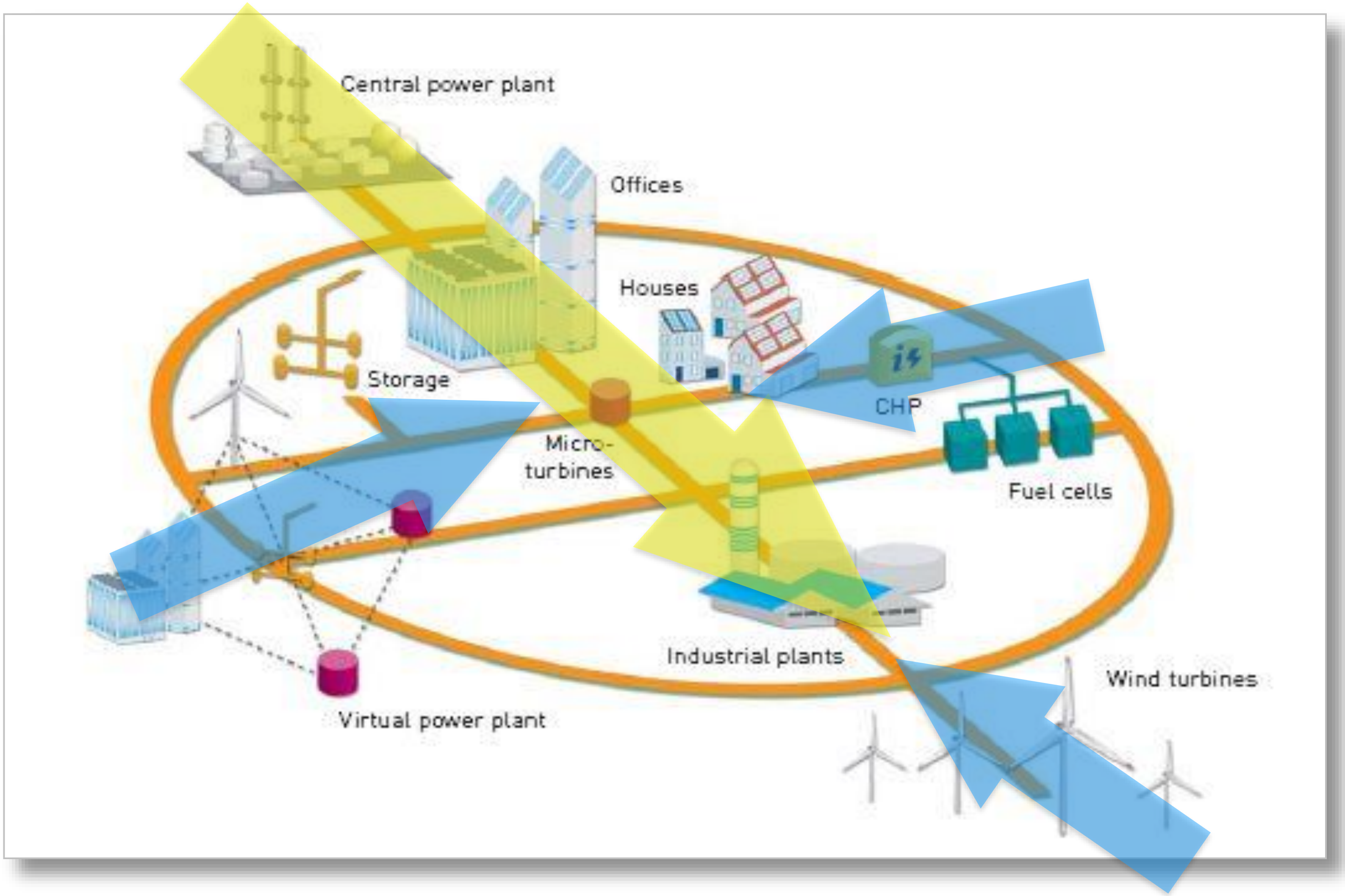


With **distributed generation**

Bidirectional powerflows

between the transmission to distribution infrastructures.

Smart grid – Europe Technology Platform



Smart Grid

Definitions

There are different ones:

European Technology Platform on SmartGrids *“A SmartGrid is an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies.”*

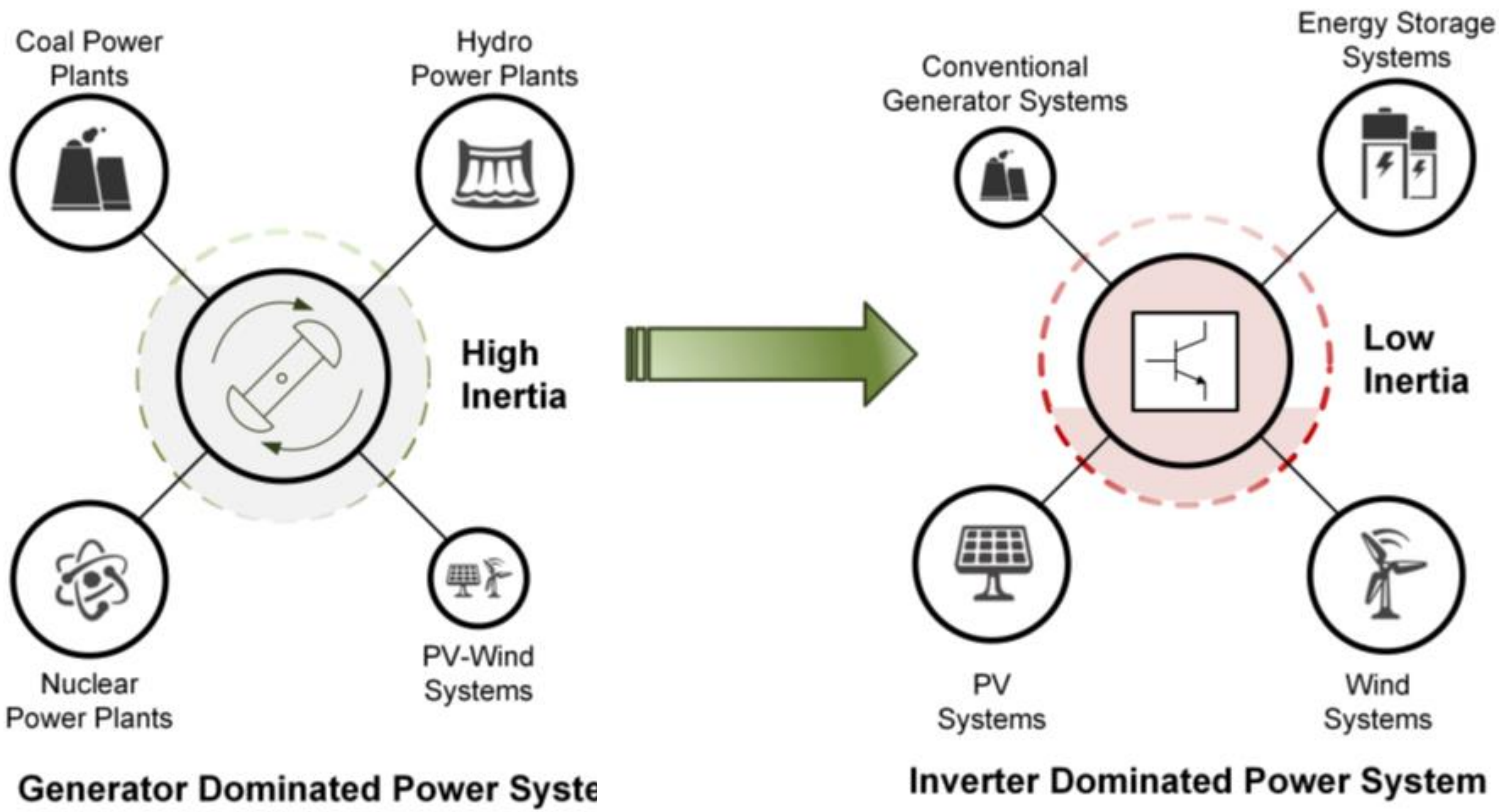
US Department of Energy: *“A smart grid uses digital technology to improve reliability, security, and efficiency (both economic and energy) of the electric system from large generation, through the delivery systems to electricity consumers and a growing number of distributed-generation and storage resources.”*

Department of Energy and Climate Change, UK: *“A smart grid uses sensing, embedded processing and digital communications to enable the electricity grid to be observable (able to be measured and visualized), controllable (able to manipulated and optimized), automated (able to adapt and self-heal), fully integrated (fully interoperable with existing systems and with the capacity to incorporate a diverse set of energy sources).”*

Electric Power Research Institute, USA → IntelliGrid^{SM} initiative which is creating the technical foundation for a Smart Grid. They have a vision of: *“Power system made up of numerous automated transmission and distribution systems, all operating in a coordinated, efficient and reliable manner.”, “A power system that handles emergency conditions with ‘self-healing’ actions and is responsive to energy-market and utility business-enterprise needs.” and “A power system that serves millions of customers and has an intelligent communications infrastructure enabling the timely, secure and adaptable information flow needed to provide reliable and economic power to the evolving digital economy.”*

EURELECTRIC: *“A smart grid is an electricity network that can intelligently integrate the behaviour and actions of all users connected to it - generators, consumers and those that do both - in order to efficiently ensure sustainable, economic and secure electricity supply. As such, a smart grid, involving a combination of software and hardware allowing more efficient power routing and enabling consumers to manage their demand, is an important part of the solution for the future”.*

Towards a low-inertia power system



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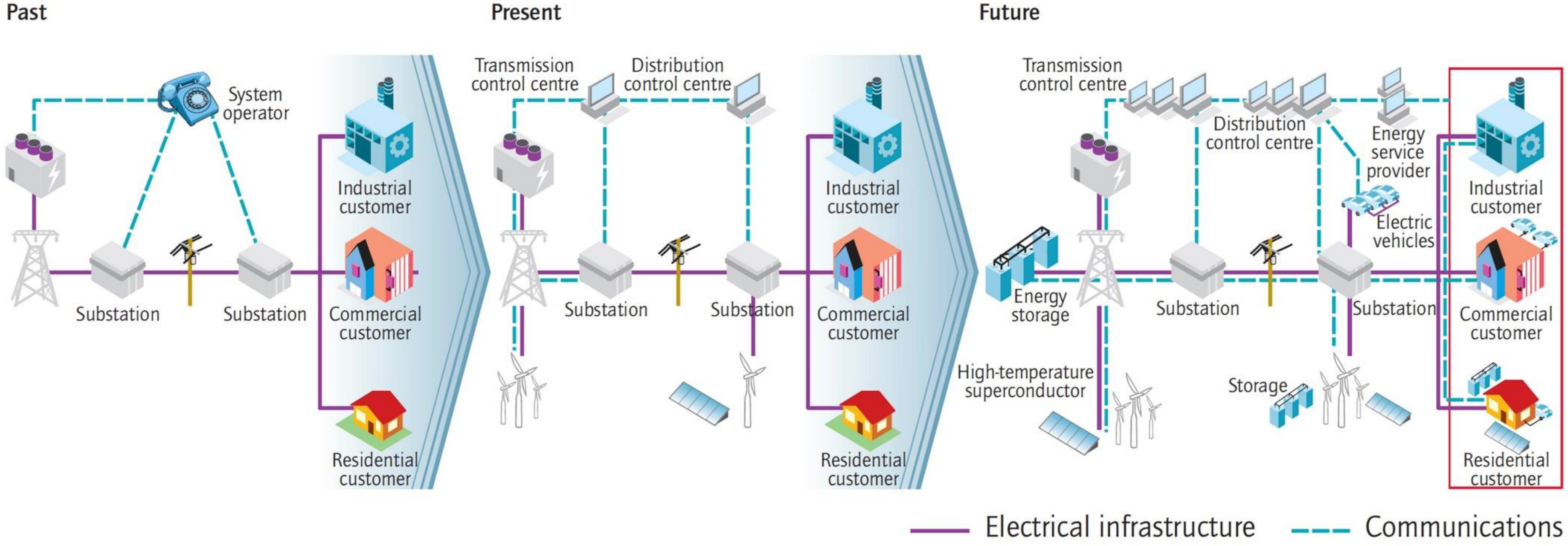
The Role of ICT



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

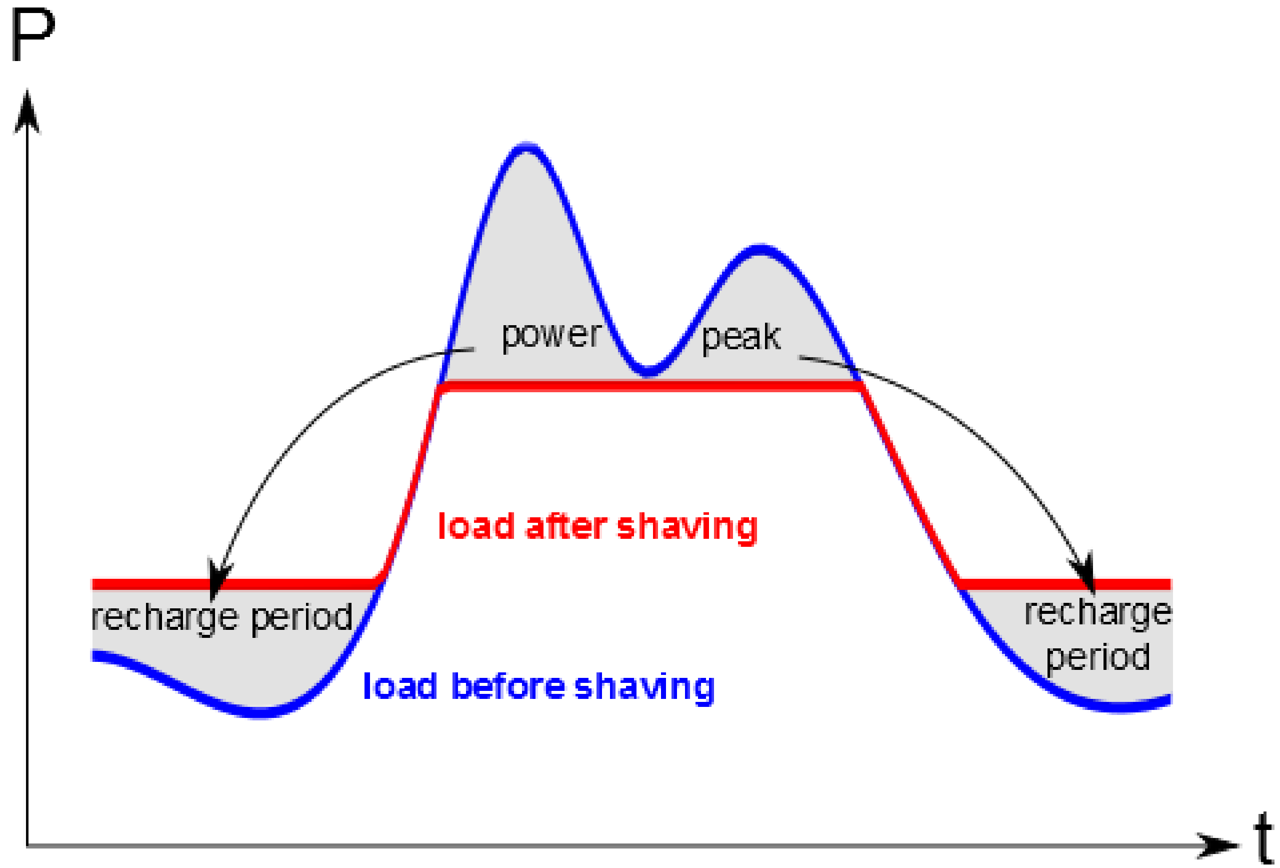
Market liberalization

- From consumers to **prosumers**

Power-flow inversion

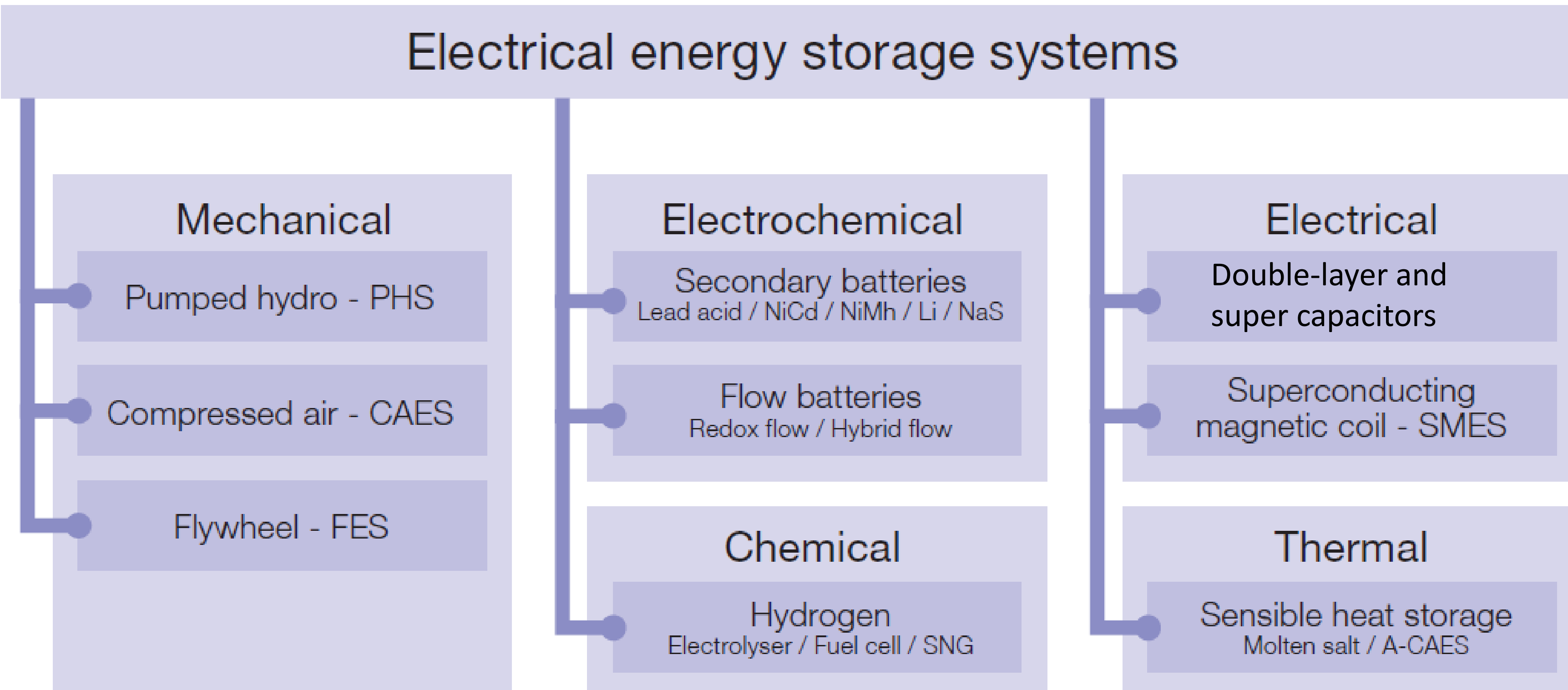
- **Transit limits**
- **Voltage profile variation** on the lines
- Abnormal behaviour of **protections**

3
Storage

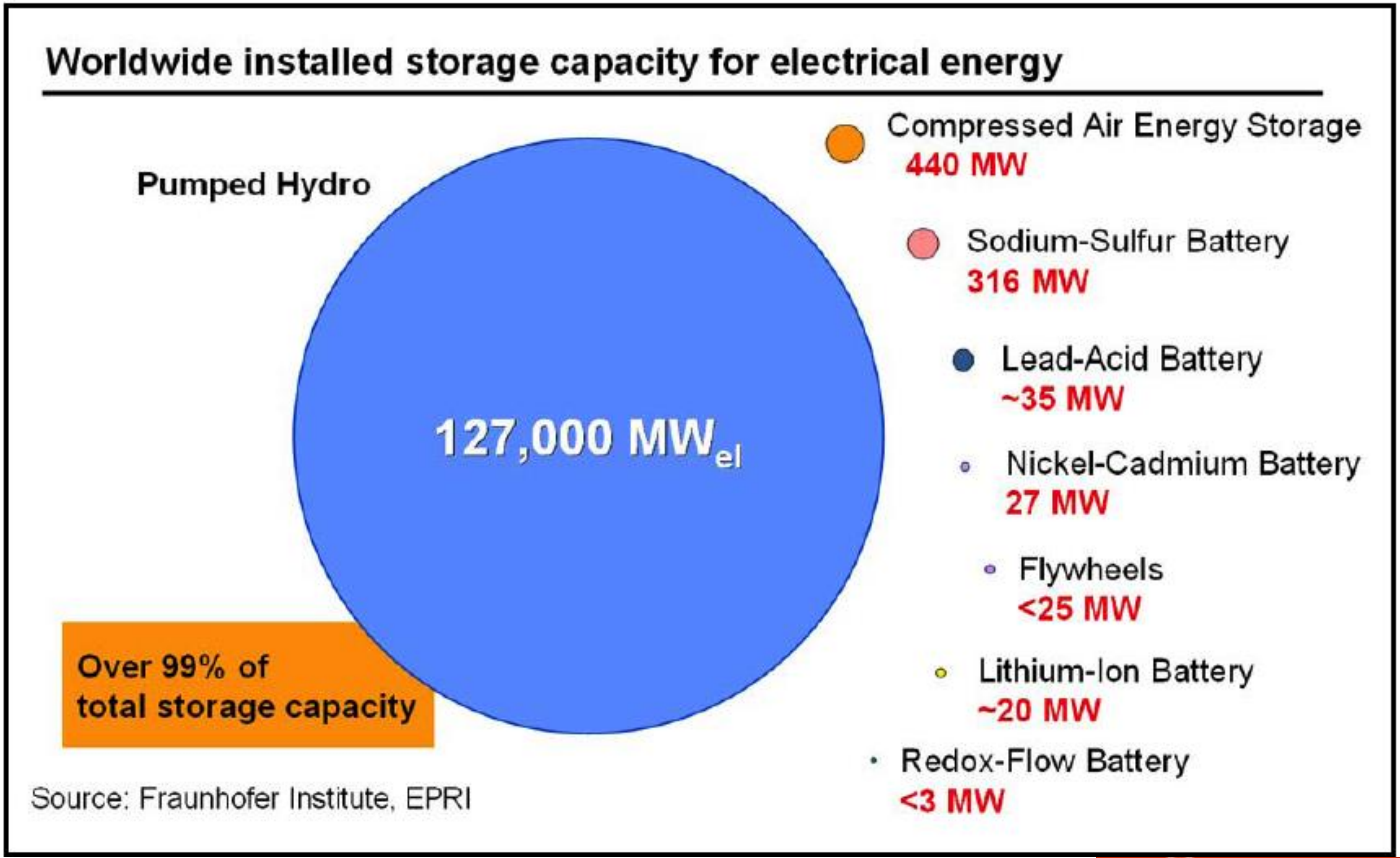


From PEAK SHAVING CONTROL METHOD FOR ENERGY STORAGE
Georgios Karmiris and Tomas Tengnér
ABB AB, Corporate Research Center, Västerås, Sweden

Main storage technolgies for grid and smart grid applications



The role of storage (end of last century)



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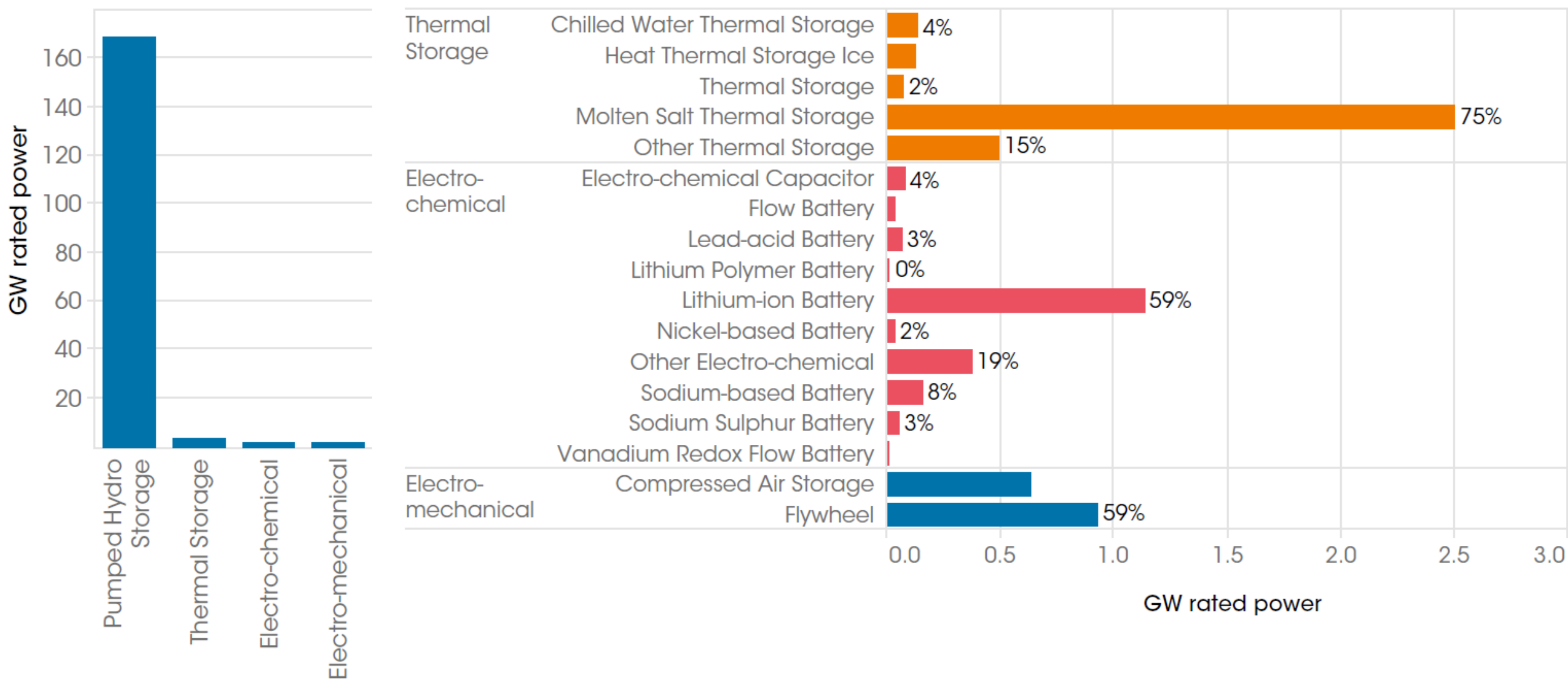
The role of storage (nowadays)

Figure ES8: Global operational electricity storage power capacity by technology, mid-2017



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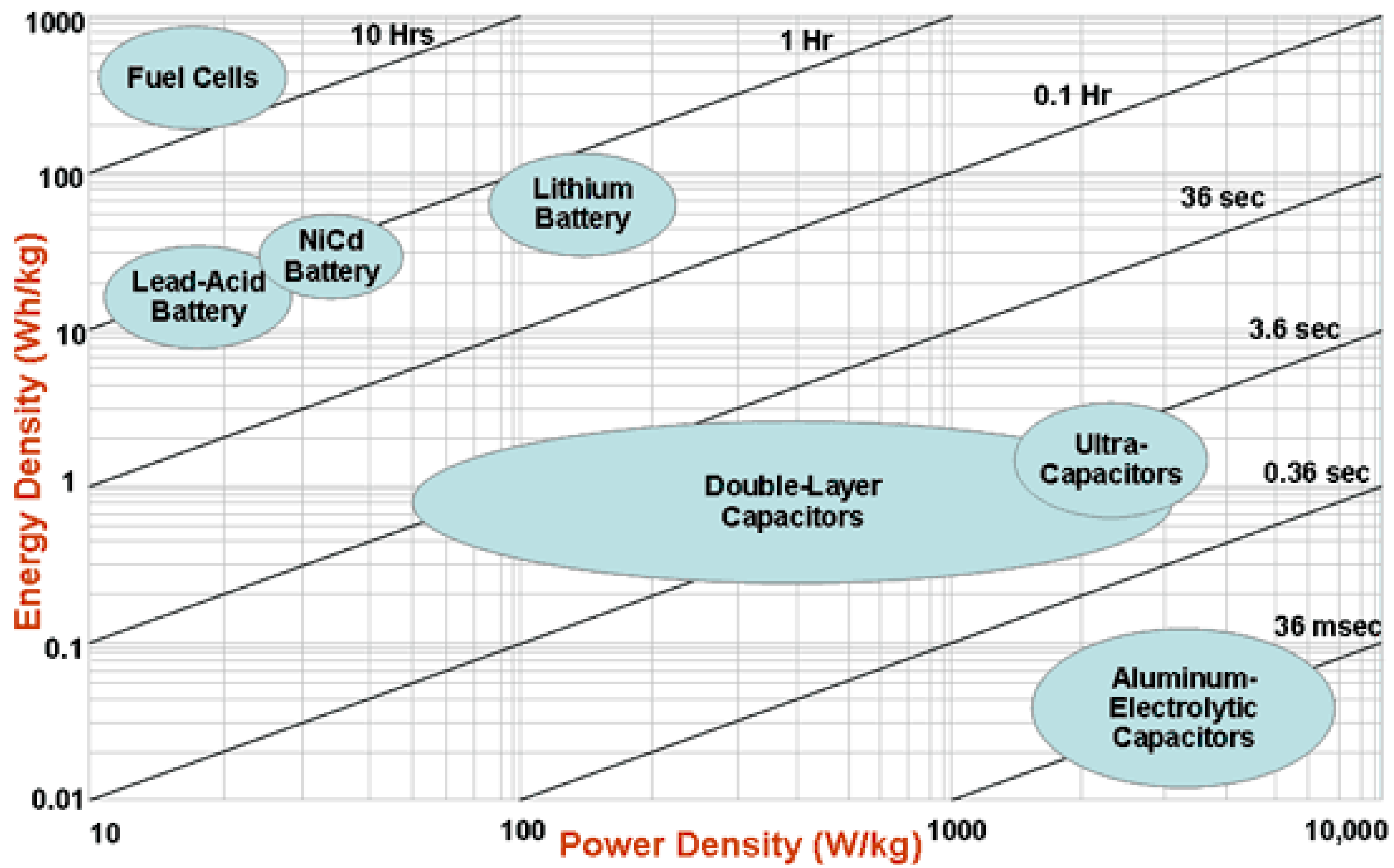
Ragone plot for various storage technologies



Source US Defence Logistics Agency

Lithium ions batteries

Parameters of the main types of Li-ions batteries

	NCA	NMC	LMO	LFP	LTO
Tensione nominale [V]	3,7	3,7	3,7	3,3	2,2
Tipo di catodo	$LiNiCoAlO_2$	$LiNiCoMnO_2$	$LiMn_2O_4$	$LiFePO_4$	$LiMn_2O_4$
Tipo di anodo	C	C	C	C	Li_4Ti5O1_2
Potenza [W/kg]	Alta	Buona	Media	Media	Media/Bassa
Energia [Wh/kg]	Alta	Alta	Buona	Media	Bassa
Vita cicli	Buona	Buona	Media	Media	Alta
Vita calendario	Buona	Buona	Bassa	Bassa per T>30 °C	Buona
Livello di sviluppo	Matura	Crescita/Matura	Matura	Crescita	Crescita
Sicurezza catodo	Bassa	Bassa	Media	Buona	Media
Sicurezza cella	Scadente	Bassa	Bassa	Media	Buona

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Comparison among different storage systems for the most important applications

APPLICATION	Hydro	CAES	Na/S	Na/NiCl	Li/Ion	Ni/Cd	Ni/MH	Pb/Acid	Redox	Flywheel	SC
Time-shift	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (yellow)	◆ (yellow)	◆ (yellow)	◆ (green)	◆ (green)	◆ (red)	◆ (red)
Renewable integration	◆ (green)	◆ (yellow)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (yellow)	◆ (red)
Network investment deferral	◆ (green)	◆ (yellow)	◆ (green)	◆ (green)	◆ (green)	◆ (yellow)	◆ (yellow)	◆ (yellow)	◆ (green)	◆ (red)	◆ (red)
Primary regulation	◆ (green)	◆ (yellow)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (yellow)	◆ (red)
Secundary regulation	◆ (green)	◆ (yellow)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (red)	◆ (red)
Tertiary regulation	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (yellow)	◆ (yellow)	◆ (green)	◆ (green)	◆ (red)	◆ (red)
Power system start-up	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (yellow)	◆ (red)	◆ (red)
Voltage support	◆ (yellow)	◆ (yellow)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (green)	◆ (yellow)	◆ (green)	◆ (green)
Power quality*	◆ (red)	◆ (red)	◆ (yellow) ▷	◆ (red)	◆ (yellow) ▷	◆ (yellow) ▷	◆ (red)	◆ (yellow) ▷	◆ (yellow) ▷	◆ (green)	◆ (green)

LEGEND					
◆ (green)	System suitable for application	◆ (yellow)	System less suitable than others	◆ (red)	System not suitable for the application

* Long interruptions are here disregarded

http://www.iec.ch/whitepaper/energystorage/

4

Energy Communities

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The 'Clean Energy Package'

In **2019** the EU completed a comprehensive update of its energy policy framework to facilitate the transition away from fossil fuels towards cleaner energy and to deliver on the EU's Paris Agreement commitments for reducing greenhouse gas emissions.
The agreement on this new energy rulebook – called the **Clean energy for all Europeans package** - marked a significant step towards the implementation of the energy union strategy, published in 2015.

Member States should put in place appropriate measures such as **national network codes** and **market rules**, and incentivize distribution system operators through network tariffs which do not create obstacles to flexibility or to the improvement of energy efficiency in the grid.

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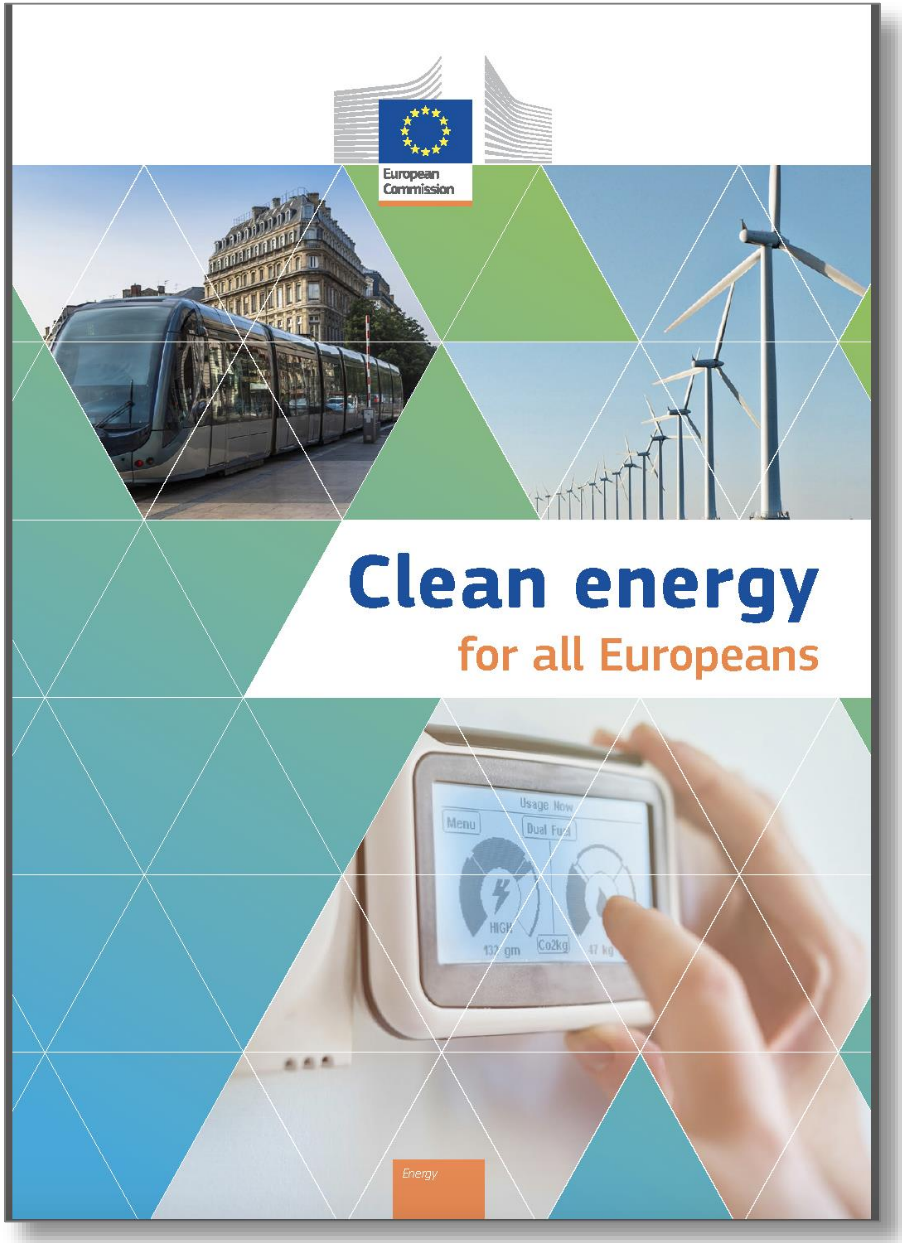
The 'CEP'


European
Commission
Clean energy
for all Europeans
Usage Now
Menu
Dual Fuel
Energy

The ‘Clean Energy Package’

In 2018 and 2019, the European Union approved the legislative package "**Clean Energy for all Europeans**" (**CEP** - **Clean Energy Package**), made up of **eight Directives** that regulated energy issues, including: energy performance in buildings, energy efficiency, renewable energy, electricity market.

Member States should put in place appropriate measures such as **national network codes** and **market rules**, to allow the energy transition and give citizens a leading role in the energy sector, and incentivize distribution system operators through network tariffs which do not create obstacles to flexibility or to the improvement of energy efficiency in the grid.

The directives should be transposed by national laws on the respective subjects. The deadline for transposition of directives by EU member states and, consequently, for drafting national legislation, is June 2021

The EU directive on the promotion of the use of energy from renewable sources

L 328/82 EN Official Journal of the European Union 21.12.2018

DIRECTIVES

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

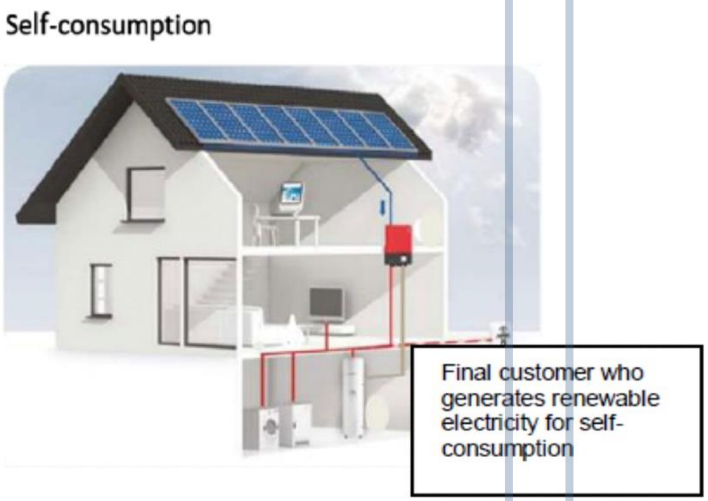
of 11 December 2018

on the promotion of the use of energy from renewable sources

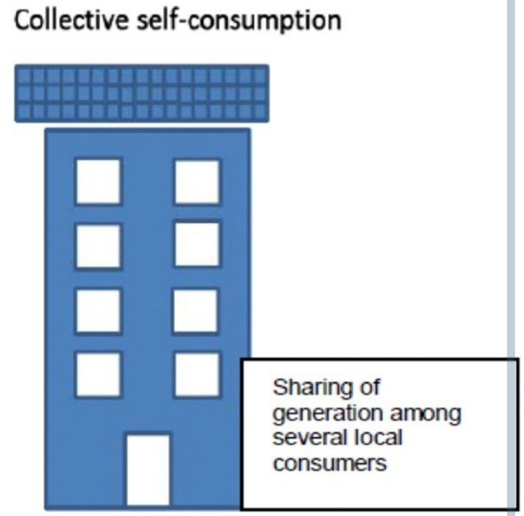
(recast)

(Text with EEA relevance)

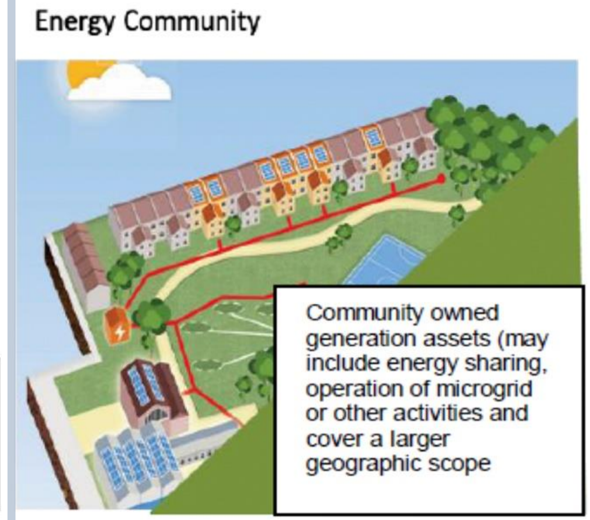
Self-Consumption and Energy Communities



Self-consumption



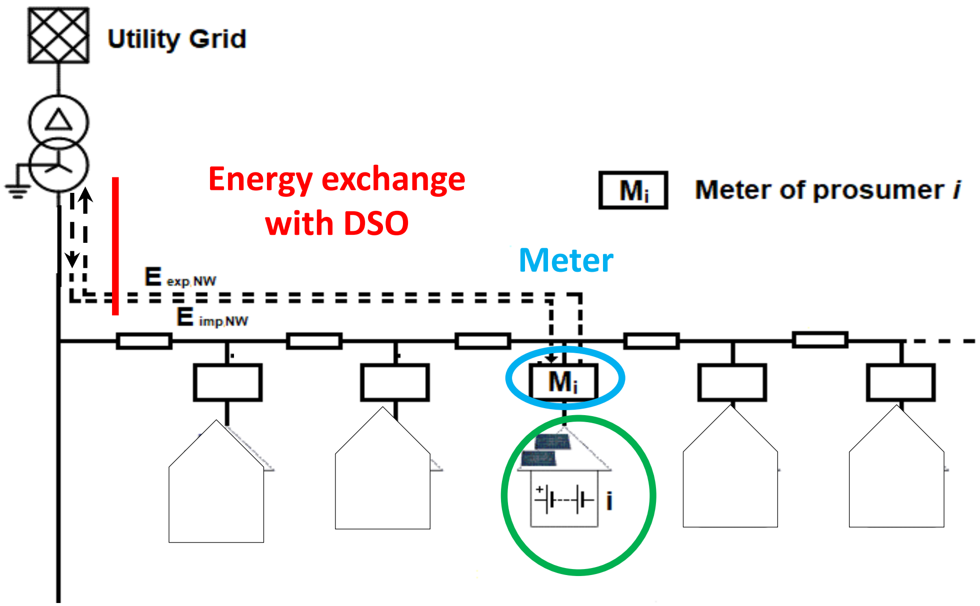
Collective Self Consumption



Energy Community

(Adapted from CEER Report - Regulatory Aspects of Self-Consumption and Energy Communities, 2019)

Self consumption



Prosumer

- PV
- Storage
- Loads

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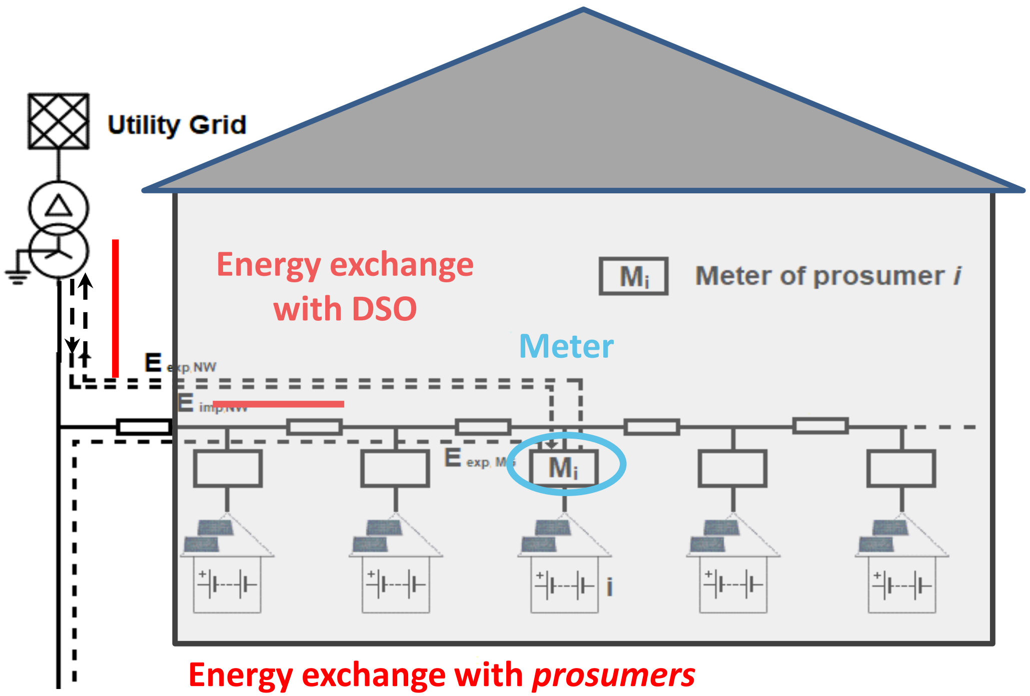
Collective Self consumption

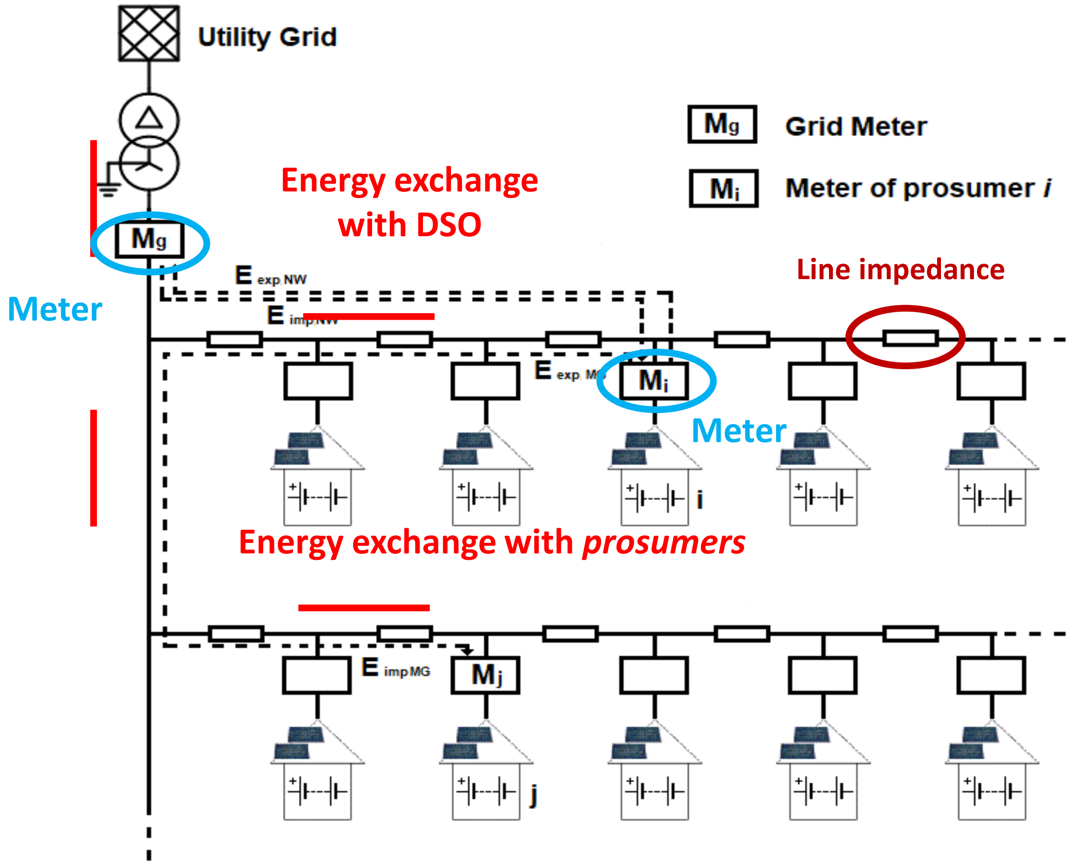


Energy exchange with *prosumers*

Prosumers

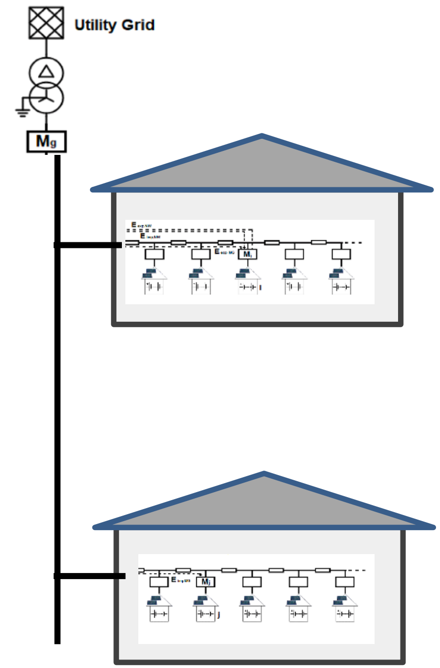
- PV
- Storage
- Loads

Energy Community



Prosumers
- PV
- Storage
- Loads

Prosumers
- PV
- Storage
- Loads



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The Geco Project

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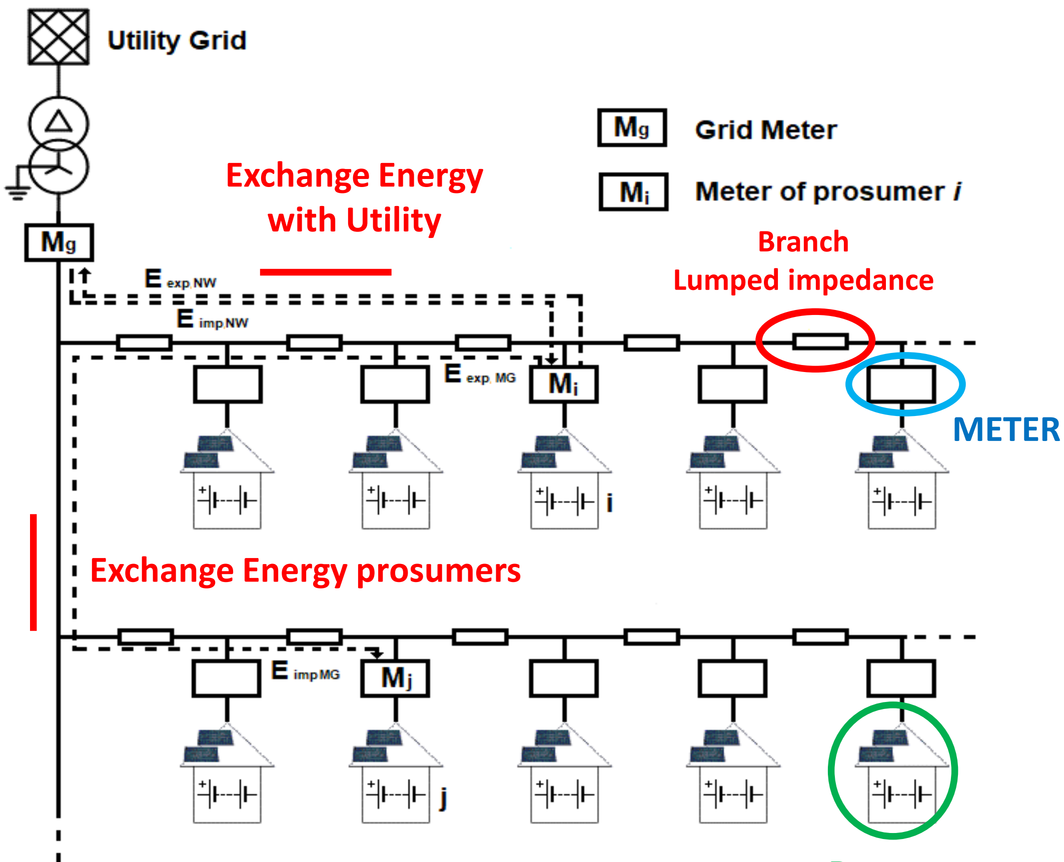
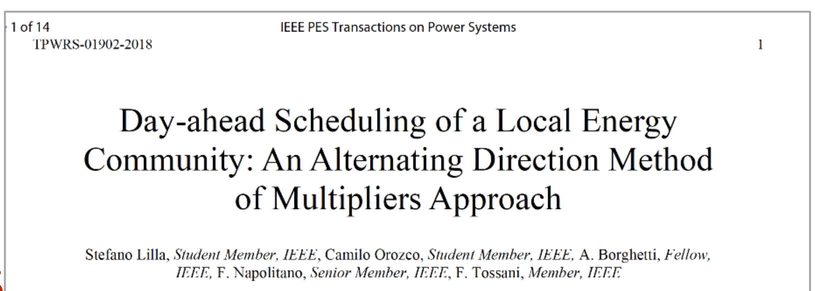
2019 – WP4 Distributed management of electricity load and generation for prosumers enablement



- A LEC is a set of residential or small industrial sites, each connected to the **same distribution network** and acting as a **prosumer**.
- The **cooperation** minimizes the power exchanges with the utility grid and reduces the **energy procurement costs**.
- The day-ahead scheduling optimizes the operation of the **battery energy storage (BES)** units, in agreement with the **electricity billing procedure**.


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*

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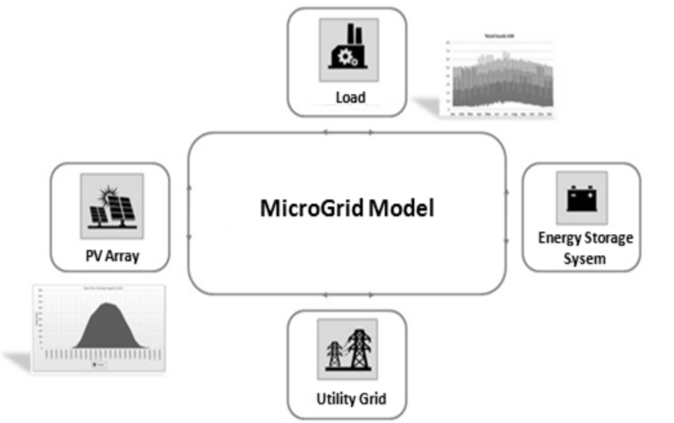
2019 – WP4 Distributed management of electricity load and generation for prosumers enablement



Parametri – Base Case

P_r^{PV}	fotovoltaico
$P_{\max}^{Load}$	carico
$E_{\max}^{b}, P_r^{b}$	storage

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

Power Balance Constraint

AIMMS®

Minimizzazione della funzione obiettivo

$$OF = \sum_{t \in T} \left(p_t^{imp} P_t^{imp} - p_t^{exp} P_t^{exp} \right) \Delta t$$

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Day-ahead scheduling of a LEC

ENERGY PROCUREMENT COST IN € (NEGATIVE VALUES INDICATE REVENUES) FOR EACH PROSUMER IN FEEDER 1 WITH BES UNITS

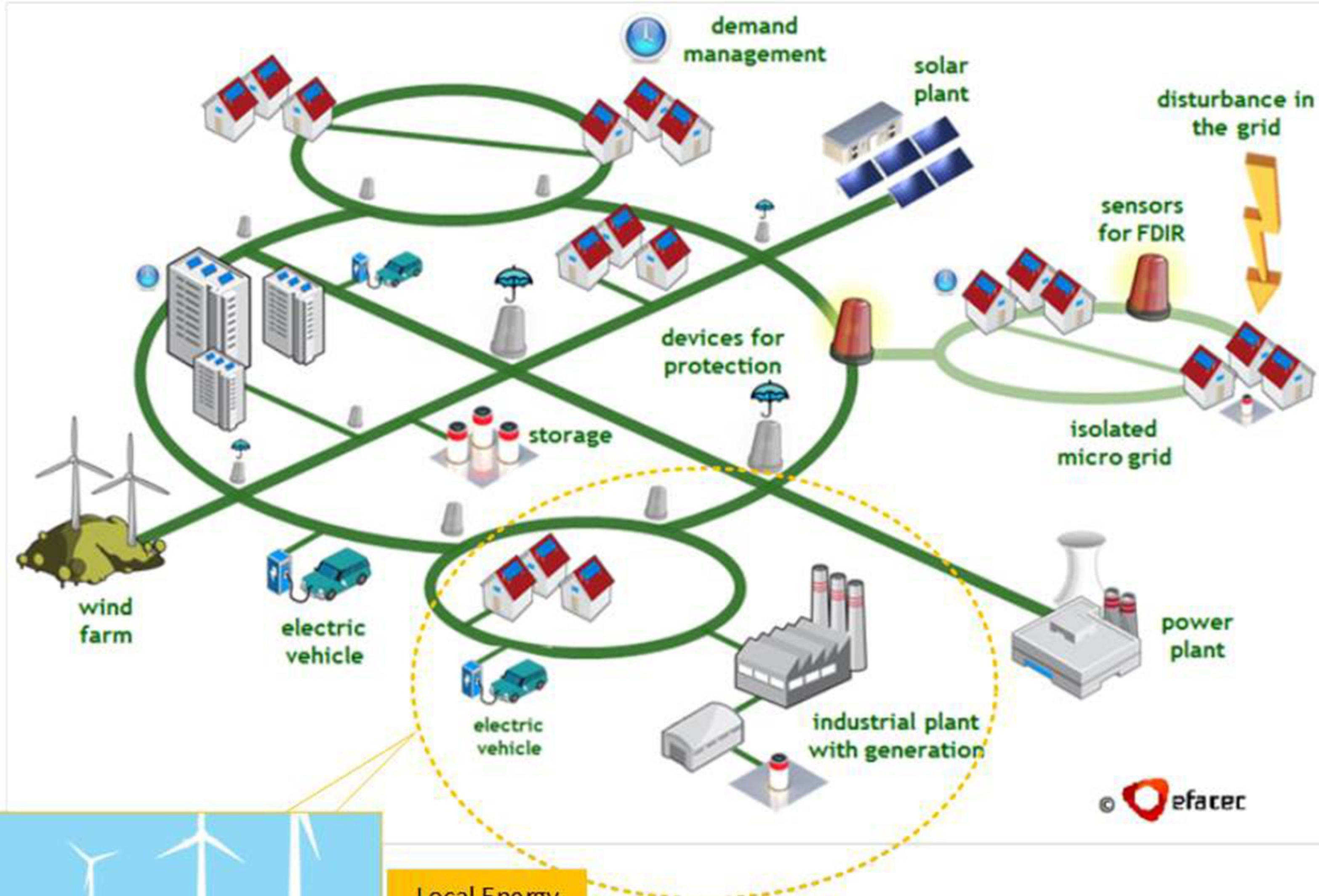
prosumer	1	2	3	4	5
with internal exchanges	5.29	0.09	0.94	-1.00	-0.68
without internal exchanges	5.43	0.27	1.09	-0.84	-0.49

ENERGY PROCUREMENT COST IN € (NEGATIVE VALUES INDICATE REVENUES) FOR EACH PROSUMER IN FEEDER 2 WITH BES UNITS

prosumer	6	7	8	9	10
with internal exchanges	-0.21	14.76	1.61	-0.48	-2.34
without internal exchanges	-0.15	16.28	1.69	-0.30	-1.70

Con accumulo

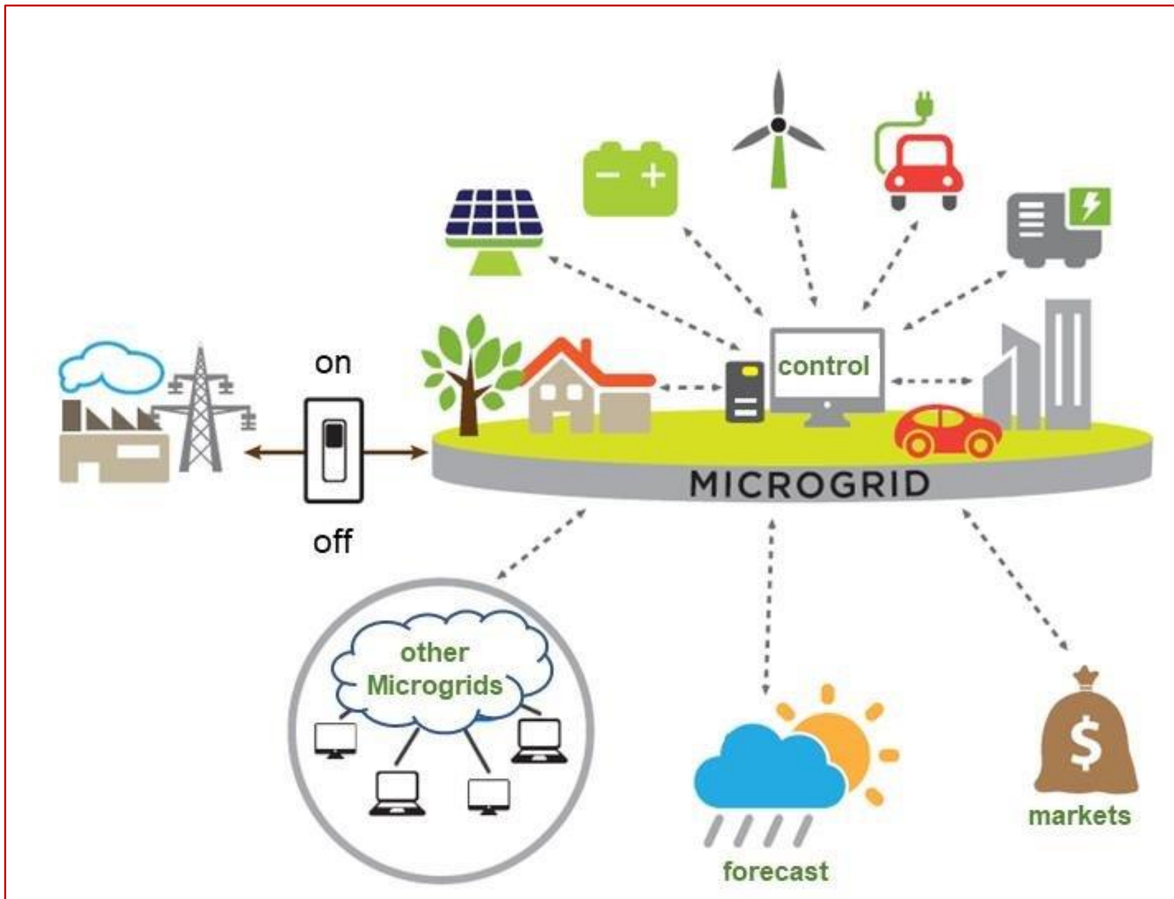
Smart Grids and Energy Communities



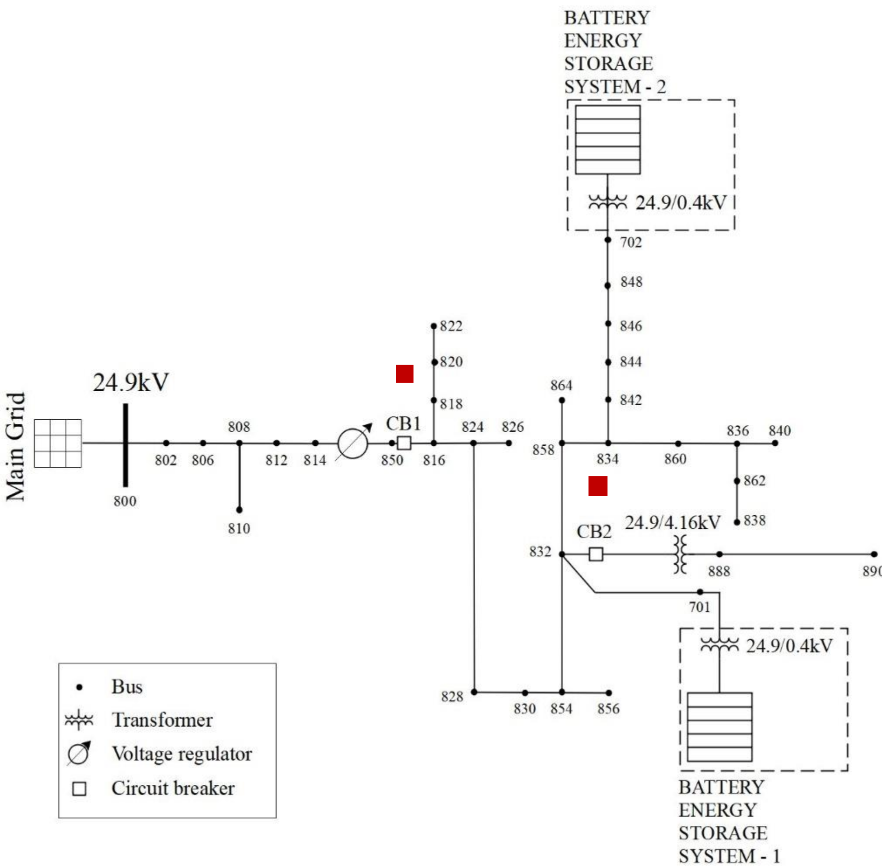
Local Energy Communities

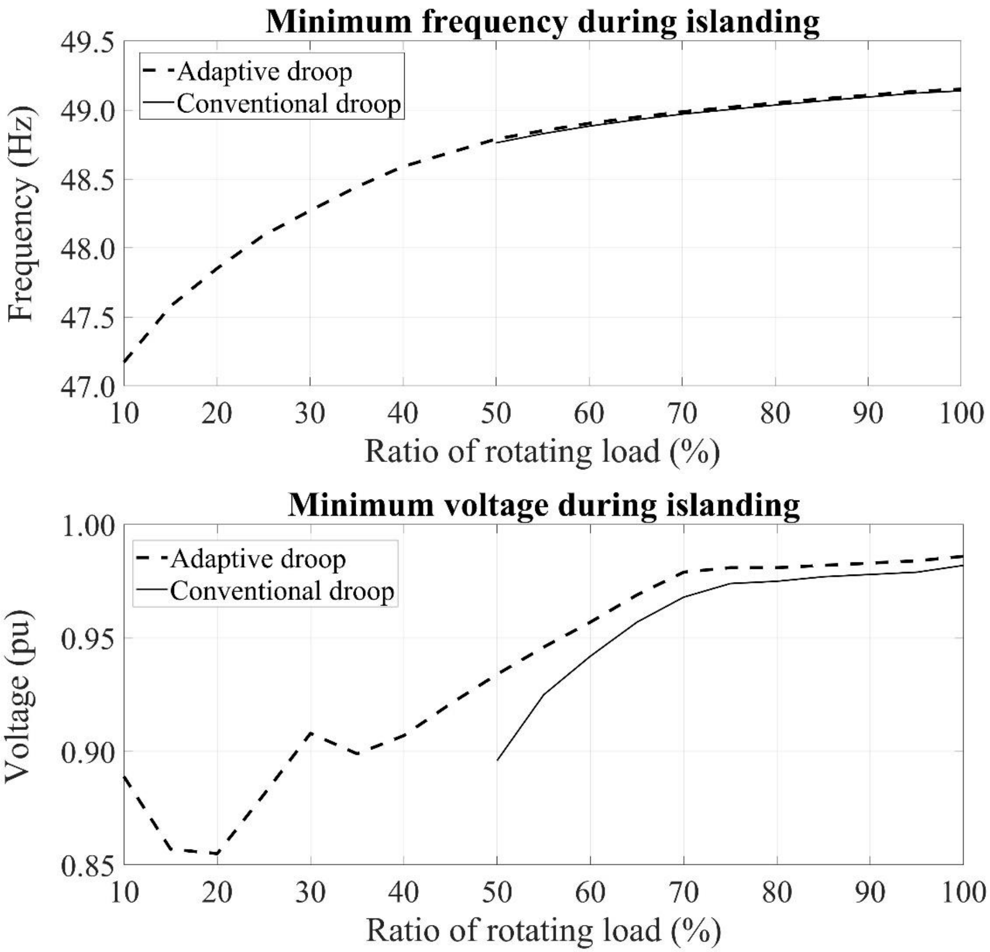
Microgrid

MG: System that interconnects electrical loads and distributed generation sources and that has the ability to operate both in connection with the national electrical system and autonomously (in the so-called **island mode**).



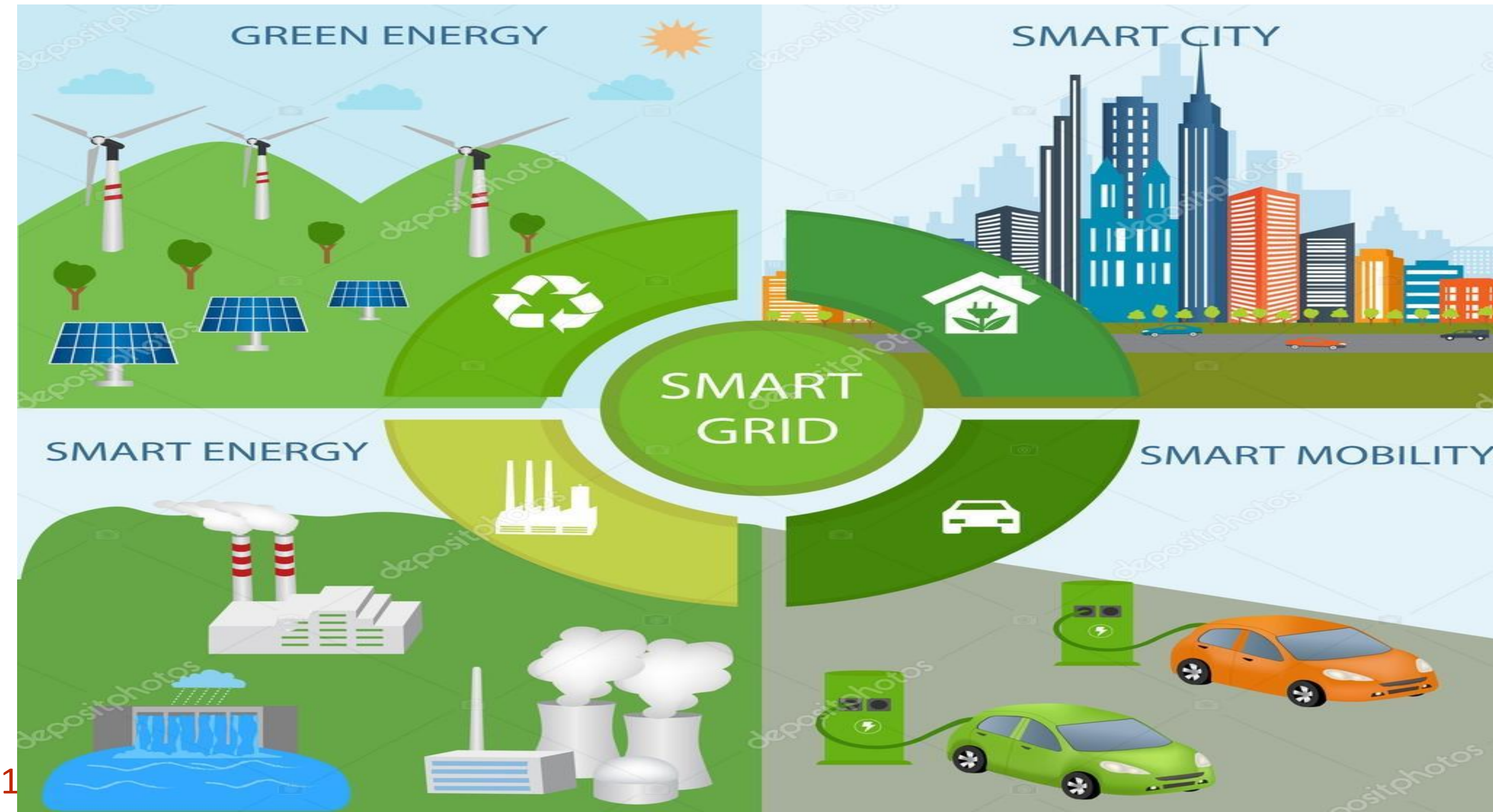
Islanding Transition of a Microgrid with Energy Storage Systems

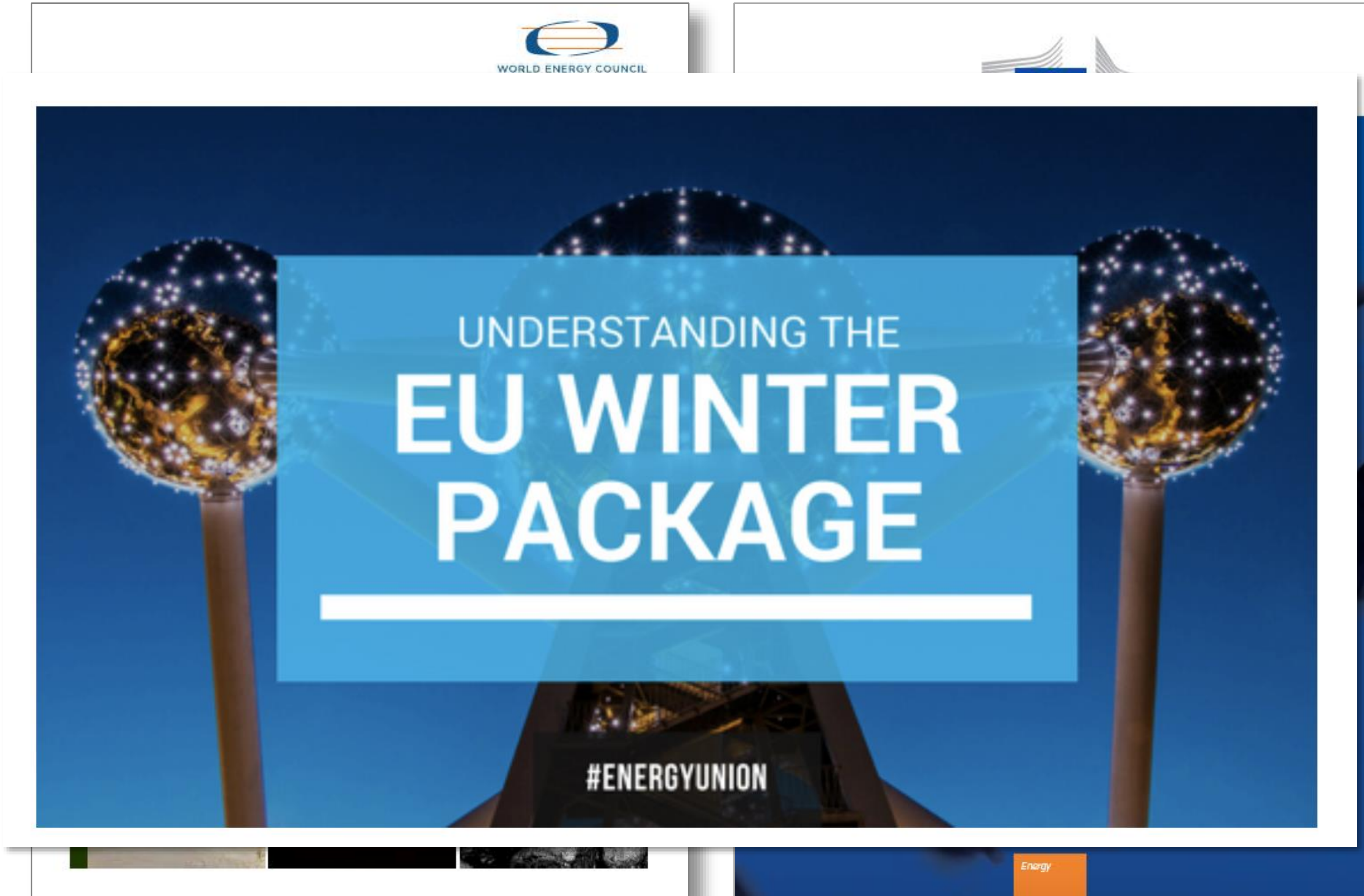




Adapted from J. D. Rios Penaloza, J. A. Adu, A. Borghetti, F. Napolitano, F. Tossani, and C. A. Nucci, "A Power Control Scheme for the Islanding Transition of a Microgrid with Battery Energy Storage Systems" in 19th EEEIC Environment and Electrical Engineering International Conference, 2019.

5
Concluding Remarks





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6

For further reading

The need of multidisciplinary approaches and engineering tools for the development and implementation of the smart city paradigm. Andrisano, O.; Bartolini, I.; Bellavista, P.; Boeri, A.; Bononi, L.; Borghetti, A.; Brath, A.; Corazza, G., E.; Corradi, A.; de Miranda, S.; Fava, F.; Foschini, L.; Leoni, G.; Longo, D.; Milano, M.; Napolitano, F.; Nucci, C., A.; Pasolini, G.; Patella, M.; Salmon Cinotti, T.; Tarchi, D.; Ubertini, F.; and Vigo, D. Proceedings of the IEEE, 106(4): 738-760. 4 2018.

Electric power engineering education: cultivating the talent in the United Kingdom and italy to build the low-carbon economy of the future. Chicco, G.; Crossley, P.; and Nucci, C., A. IEEE Power and Energy Magazine, 16: 53-63. 2018.

Mixed integer programming model for the operation of an experimental low-voltage network. Lilla, S.; Borghetti, A.; Napolitano, F.; Tossani, F.; Pavanello, D.; Gabioud, D.; Maret, Y.; and Nucci, C., A. In 2017 IEEE Manchester PowerTech, pages 1\textendash6, 6 2017. IEEE

Comparison between multistage stochastic optimization programming and Monte Carlo simulations for the operation of local energy systems. C. Orozco, A. Borghetti, S. Lilla, G. Pulazza, and F. Tossani in IEEE International Conference on Environment and Electrical Engineering (EEEIC), 2018.

Robust optimization for virtual power plants. De Filippo, A.; Lombardi, M.; Milano, M.; and Borghetti, A. In Advances in Artificial Intelligence AI*IA 2017 , Lecture Notes in Computer Science, vol 10640., pages 17-30, 11 2017. Springer, Cham

An ADMM Approach for day-ahead scheduling of a local energy community. C. Orozco, A. Borghetti, S. Lilla, F. Napolitano, F. Tossani, IEEE PowerTech Conference, Milan, Italy, 2019.

Virtual Inertia in a Microgrid with Renewable Generation and a Battery Energy Storage System in Islanding Transition, J.A. Adu, Juan D. Rios Penaloza, F. Napolitano, F. Tossani, Proc SynenergyMed, Cagliari, Italy, May, 2019.

Day-ahead Scheduling of a Local Energy Community: An Alternating Direction Method of Multipliers Approach, S. Lilla, C. Orozco, A. Borghetti, F. Napolitano, F. Tossani, accepted for publication on IEEE Trans on PWRS, 2019.

Electric Power Systems Research Group at University of Bologna

https://site.unibo.it/lisep/en

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