EDucation for DIgitalisation of Energy

Digitalisation and the energy transition in Europe

With the support of the Erasmus+ Programme of the European Union

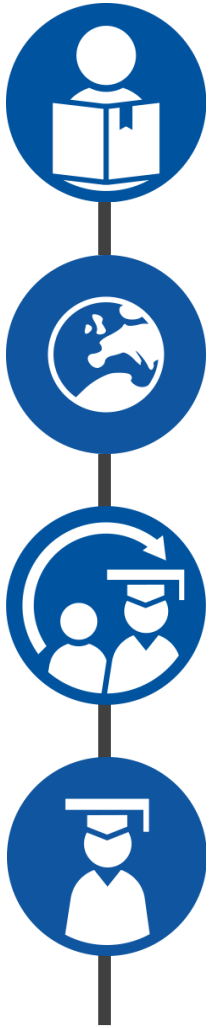
RWTH Aachen University

47,078 students in total

14,150 International students

9,538 First-year students

7,133 Graduates



557 Professors

10,272 Employees (FTE)

€1.108 Billion Financial volume

9,434 Publications

[1]

With the support of the Erasmus+ Programme of the European Union

RWTH Aachen University

1870: Founded as the Königliche Rheinisch-Westfälische Polytechnische Schule zu Aachen (Royal Rhenish-Westphalian Polytechnic School in Aachen).

1872: First lectures are held

1880: The school becomes the Technical University of Aachen [3]

1927: The TH Aachen becomes the Rheinisch-Westfälische Technische Hochschule Aachen (RWTH).

1960s/1970s: RWTH becomes a full university and expands its range of subjects to include the natural sciences and humanities

1990s: RWTH Aachen becomes a university of excellence and expands its international profile

Today: RWTH Aachen is an internationally recognized research university with around 45,000 students [3]

UNIVERSITY RANKING

RWTH is one of the best technical universities

2021 QS Ranking: 18th place worldwide for mechanical engineering

2021 Wirtschaftswoche: 1st place for industrial engineering

2021 Wirtschaftswoche: 2nd place for mechanical and electrical engineering [2]

Over 100 degree programmes:

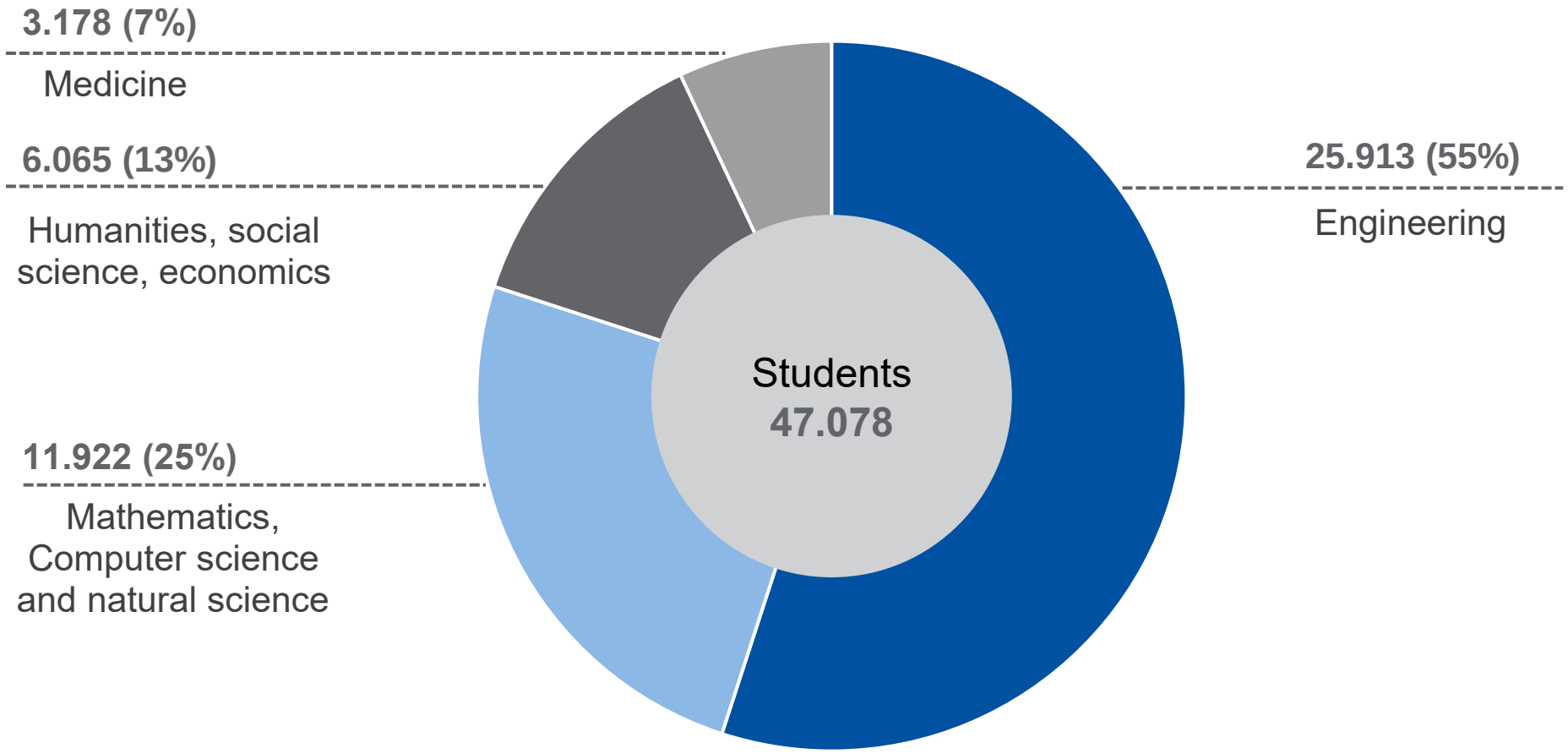
Engineering, Natural Sciences, Earth Sciences, Economics, Humanities and Medical Subjects.

Exchange programs:

Research internships in: China, Japan, India, USA, Canada, Great Britain, Australia, etc.

Double degree programs: France, Czech Republic, Spain, Russia, Poland, Brazil, Japan, China [4]

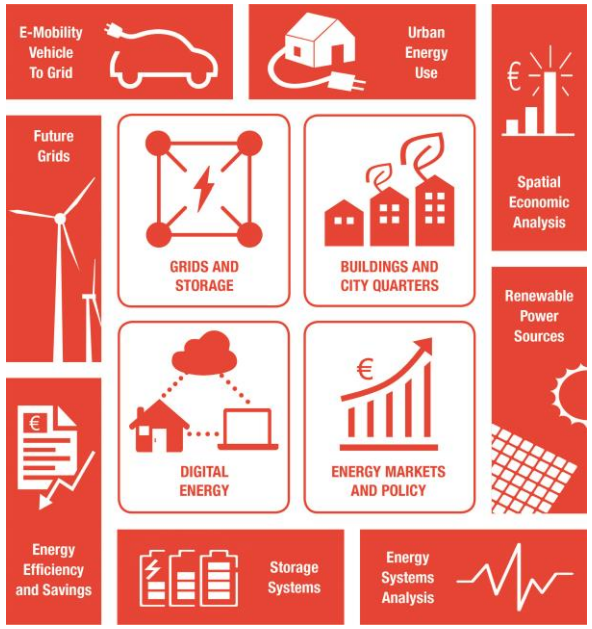
RWTH Aachen University



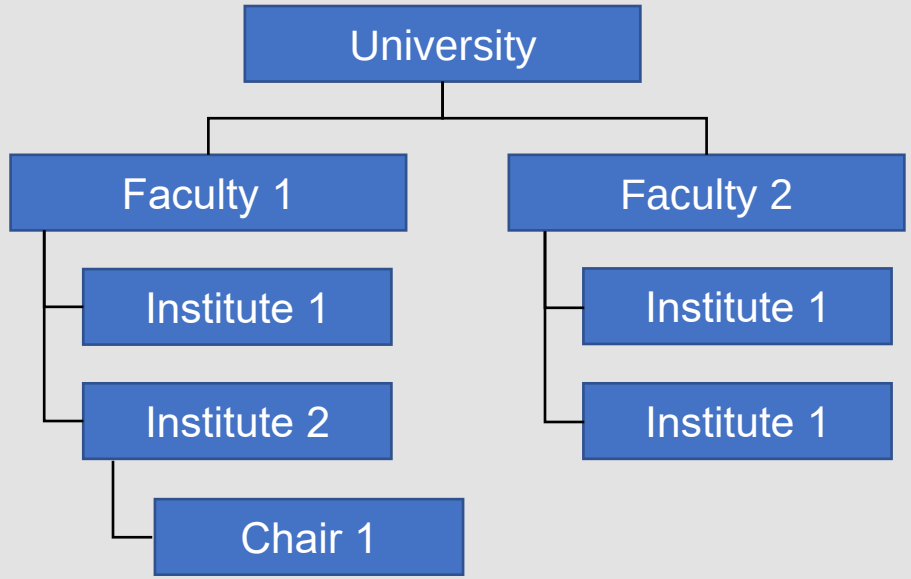
[1]

With the support of the Erasmus+ Programme of the European Union

E.ON Energy Research Center



- June 2006: Largest research cooperation in Europe between a private company (E.ON) and a university (RWTH).
- Research areas: Energy savings, and efficiency and sustainable energy sources.



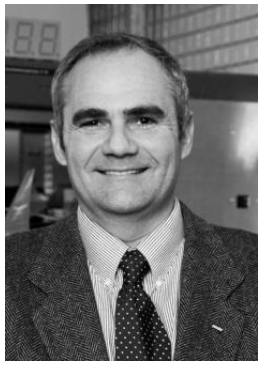
Faculty: larger organizational unit (OU) in the university, includes several institutes/chairs.
Institute: OU specializing in a particular field, may include several chairs
Chair: OU within an institute or faculty, headed by a professor, offers courses and research projects

- Four institutes with 7 professorships in 3 different faculties
  - Department of Electrical Engineering and Information Technology: ACS & PGS
  - Department of Mechanical Engineering: EBC
  - Department of Economics: FCN

With the support of the Erasmus+ Programme of the European Union

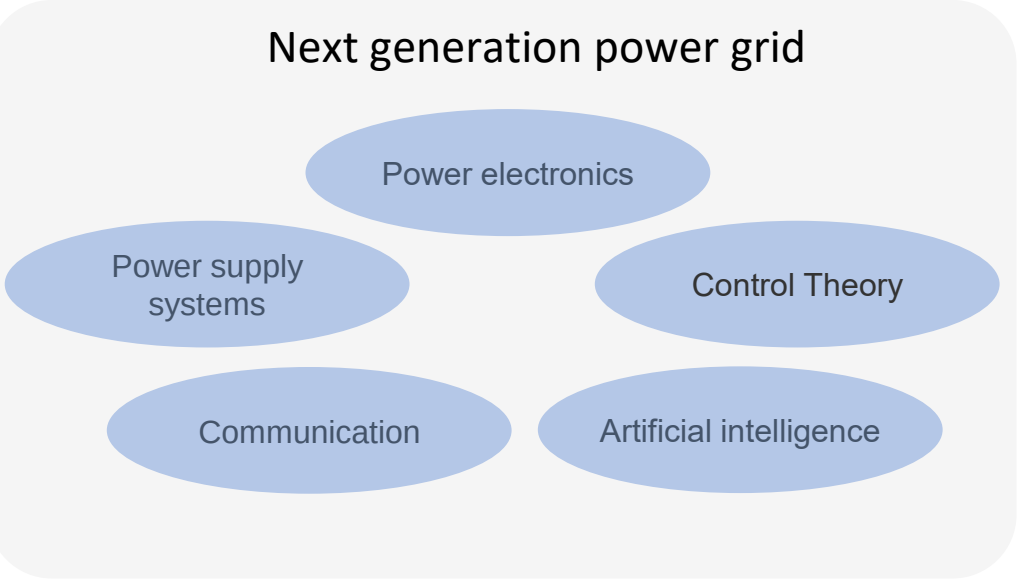
Institute for Automation of Complex Power Systems (ACS)

- Founded in October 2008
- 2 professors: Prof. Monti and Prof. Ponci
- >60 research assistants and post-docs
- numerous student assistants
- Research areas:
  - Next generation energy network
  - Control and automation technology
  - Smart cities
  - Internet of the future



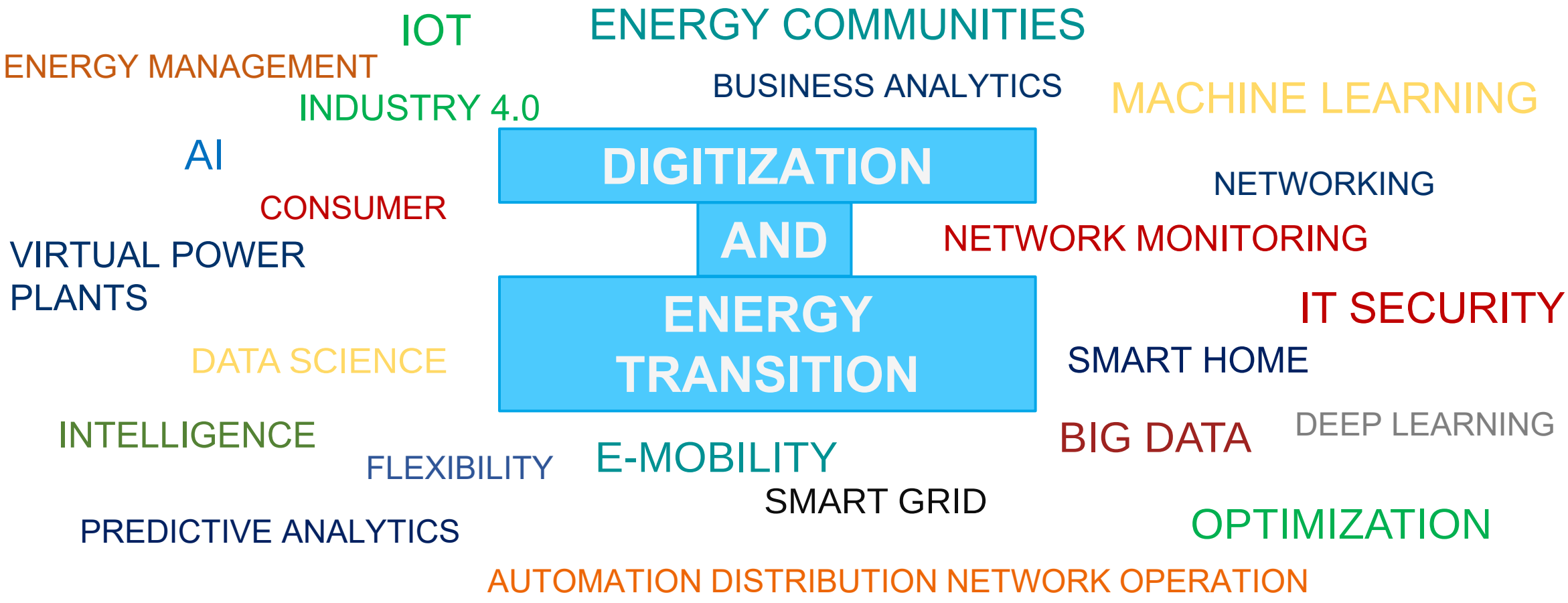
Prof. Monti

Prof. Ponci



With the support of the Erasmus+ Programme of the European Union

Brainstorming



With the support of the Erasmus+ Programme of the European Union

Digitalisation - Risks

What risks can be associated with digitization?

	Jobs can be lost, **humans are replaced by machines**
	**Data misuse** (data can be passed on to third parties without authorization)
	**Industrial espionage**

[8]

With the support of the Erasmus+ Programme of the European Union

Digitalisation - Advantages

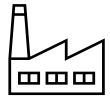
	Efficiency increase
	Improved communication
	Better data processing
	More flexibility
	Higher quality
	New business opportunities

[9]

With the support of the Erasmus+ Programme of the European Union

Energy transition

What are the goals of the energy transition?

	**-95 %*** GHG emissions by 2050
	**- 50 %*** Primary energy consumption & **-25 %*** gross electricity consumption by 2050
	**6 mio. EV** by 2030 & **-40 %**** Final energy consumption by 2050
	**-20 %** Heat demand by 2020 & **-80 %*** Primary energy demand by 2050
	**80 %** Minimum share of renewable energy in gross electricity consumption by 2050

[10]

All percentages with * : Comparative value to the year 1990
All percentages with **: Comparative value to the year 2005

With the support of the Erasmus+ Programme of the European Union

Challenges – Energy industry

AIM

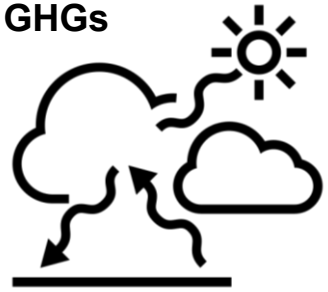
EU 2050

100%

DE 2045

NOW

GHGs



30%

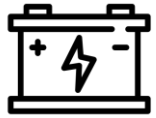
= 219 million T of CO2

of a total of 810 million T of CO2

DE

Challenges

Grid stability



Storage Technologies

Extend power lines

Digitalisation

Affordability

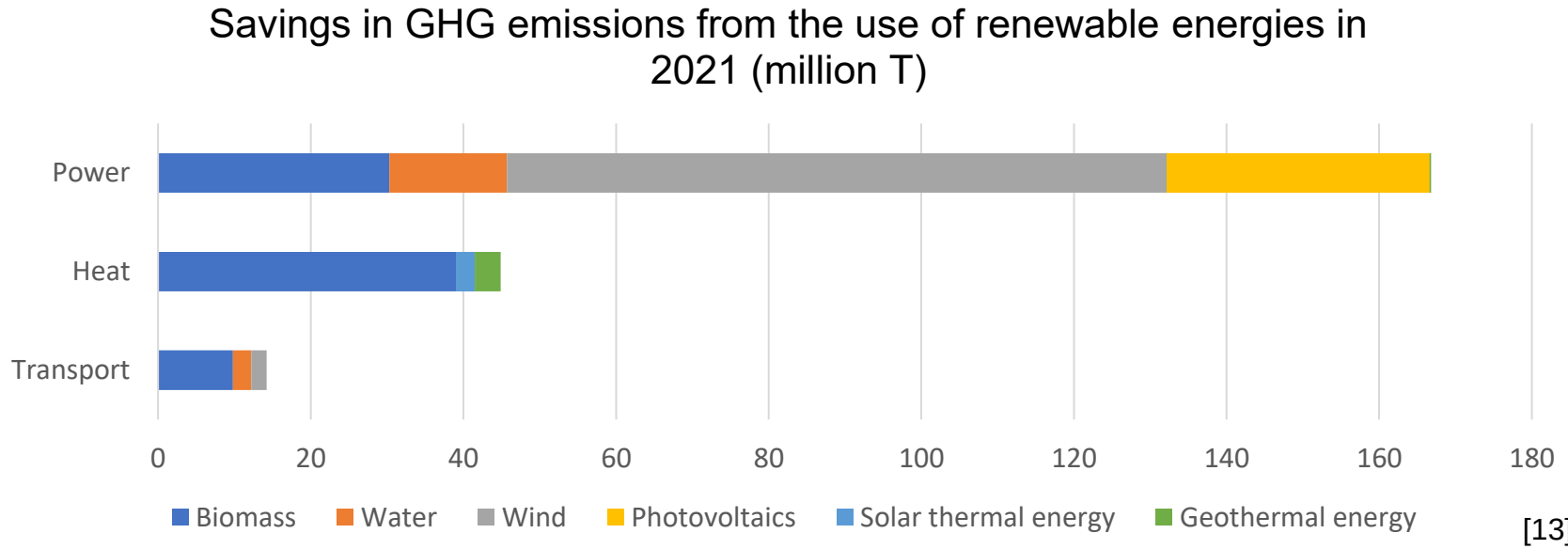
[12]

With the support of the Erasmus+ Programme of the European Union

Energy transition

Why is the energy transition so important?

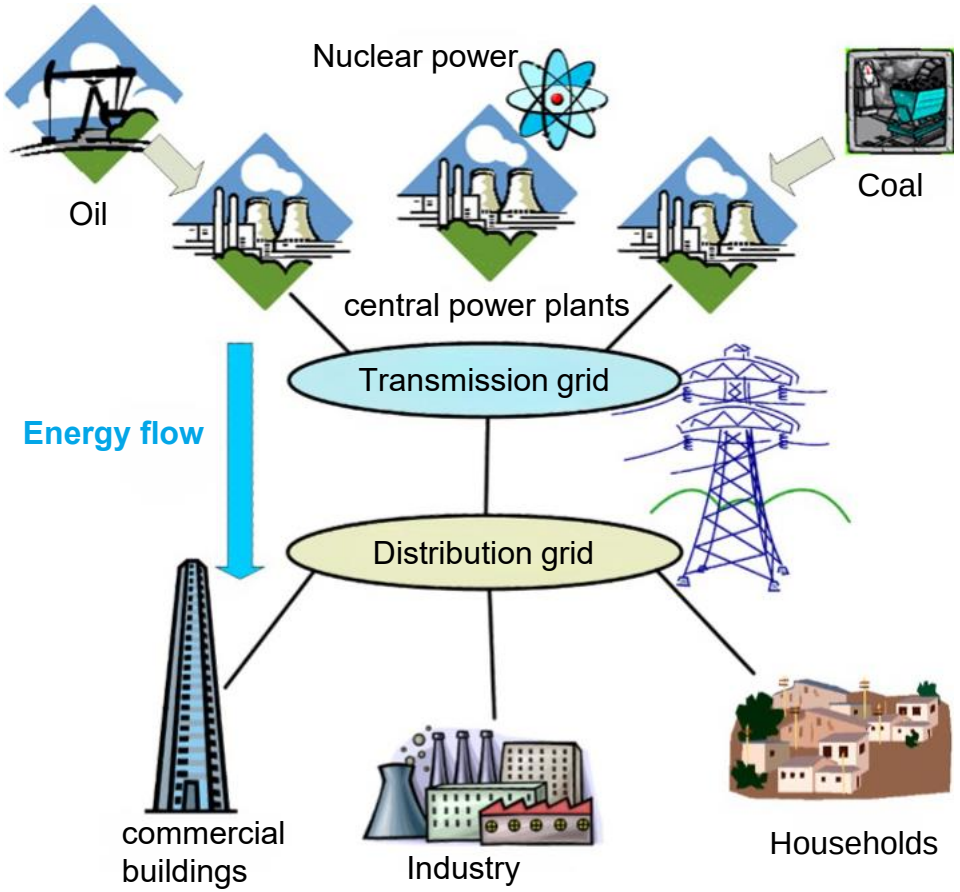
- The climate is protected
  - Less GHG, global warming (climate change) is countered
- No dependence on finite resources such as gas and oil
  - Wind and sun are "infinitely" available



[13]

With the support of the Erasmus+ Programme of the European Union

Today's energy network



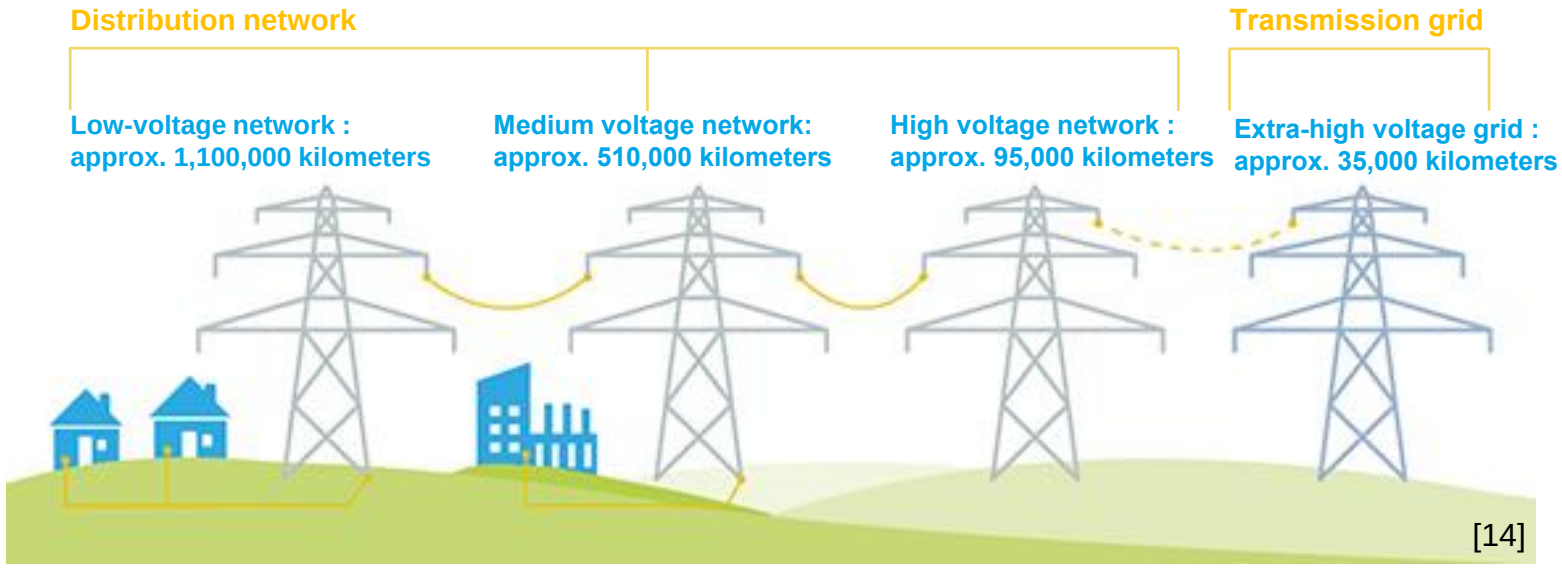
[20]

- System is quasi-static
- Generation is "completely" under control
- Load is statistically predictable
- Load controlled system
- Power flow from transmission to distribution is unidirectional in design
- Distribution is a completely passive system

With the support of the Erasmus+ Programme of the European Union

Today's energy network

The German electricity distribution network is around 1.7 million kilometers long.



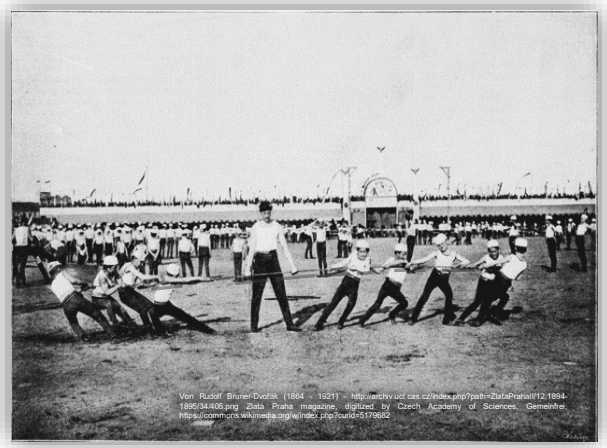
Voltage level	Voltage
Extra-high Voltage	220kV, 380kV
High Voltage	meist 110kV
Medium voltage	10kV – 30kV
Low voltage	230V – 400V

With the support of the Erasmus+ Programme of the European Union

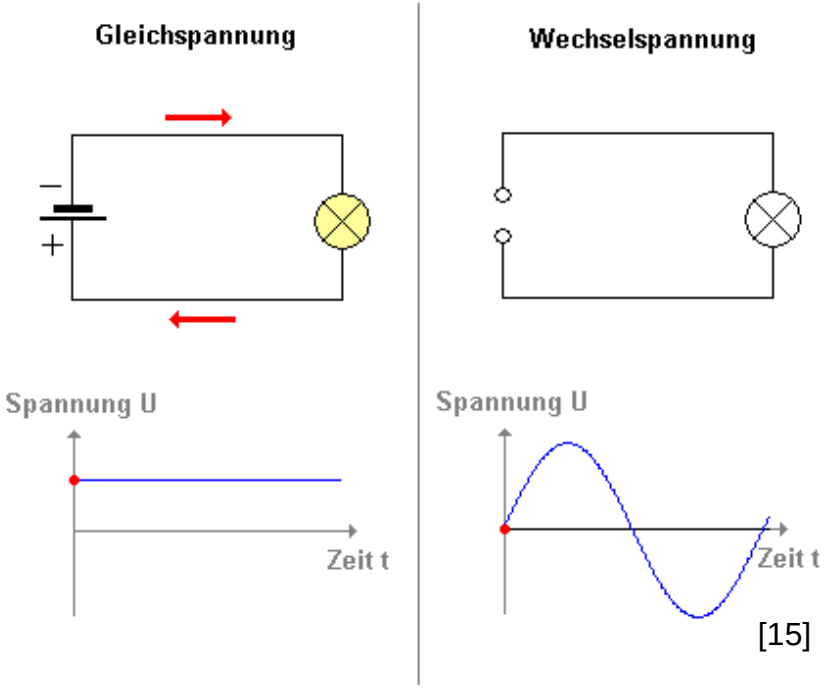
AC and DC network

Direct current(DC)

Similar to tug of war



Uncomplicated. Simple.
Many can join in on both sides.
The height does not matter.



[15]

Alternating current(AC)

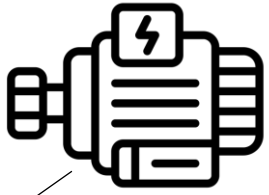
Similar to jumping rope

Conscious synchronization required.
Only two can turn, few can jump.
Different height is a problem.

With the support of the Erasmus+ Programme of the European Union

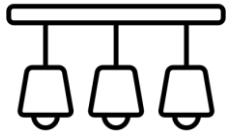
Application of AC/DC

Household appliances

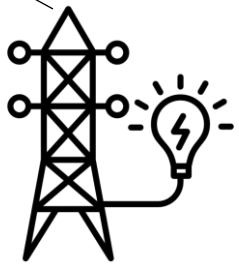


Electric motors in industrial plants

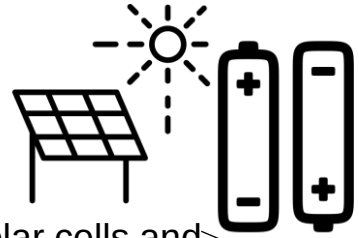
AC applications



Lighting

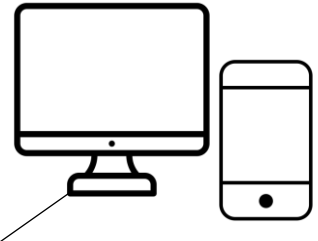


Power transmission over long distance



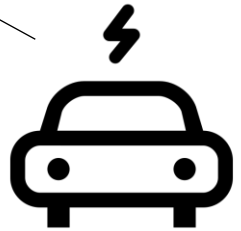
Solar cells and batteries for renewable energy

DC applications



Electronic devices such as computers, smartphones, tablets, etc.

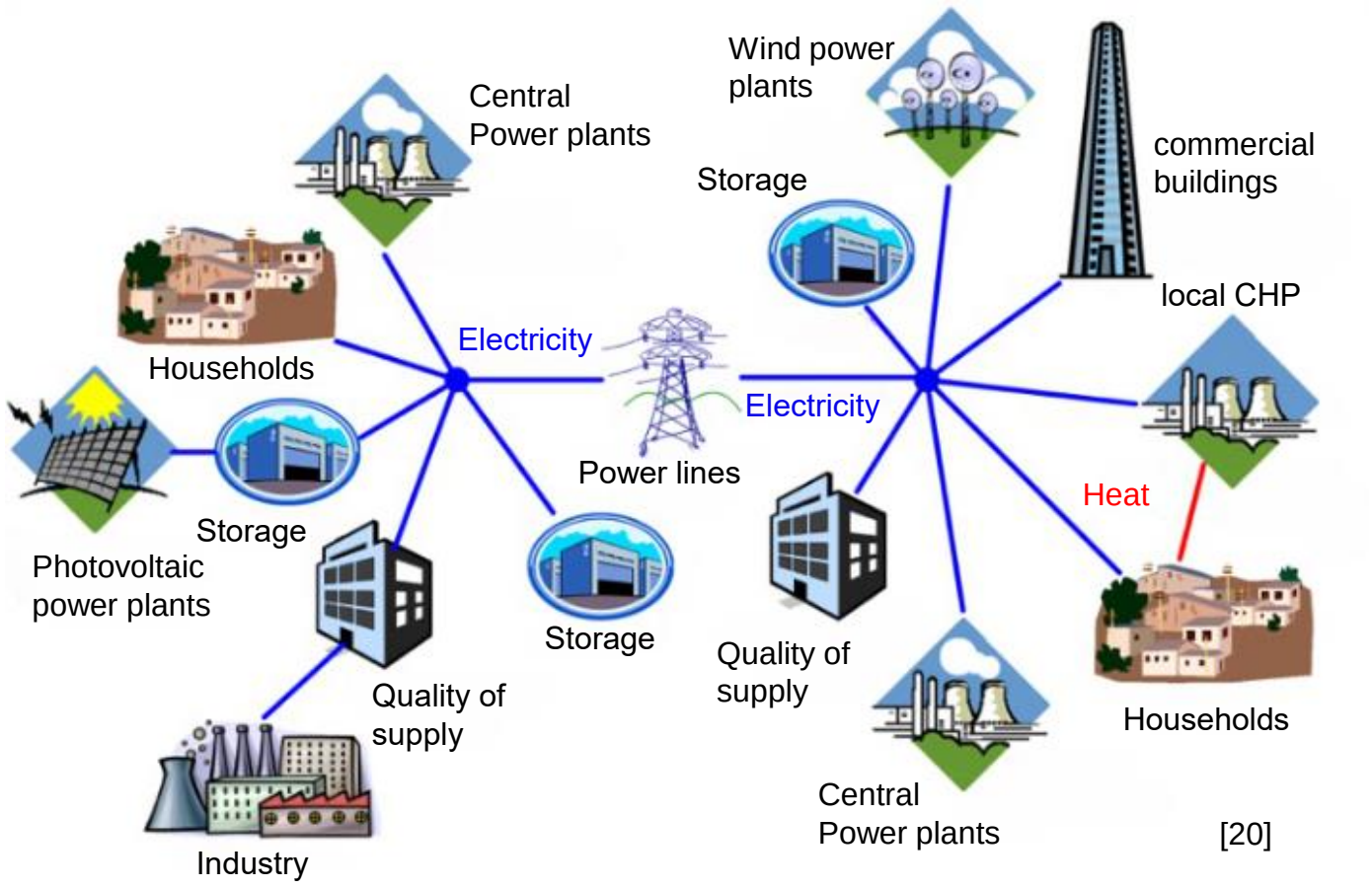
DC motors in industrial plants



Electric vehicles

With the support of the Erasmus+ Programme of the European Union

"Future" energy network



[20]

- More distributed generation
- Renewable energy sources are not fully predictable (uncertainty) and cannot be controlled
- Generation-controlled system
- Power is also injected at the distribution level (bottom-up power flow)
- The system is characterized by higher dynamics and low physical inertia (coupling of different grids)

With the support of the Erasmus+ Programme of the European Union

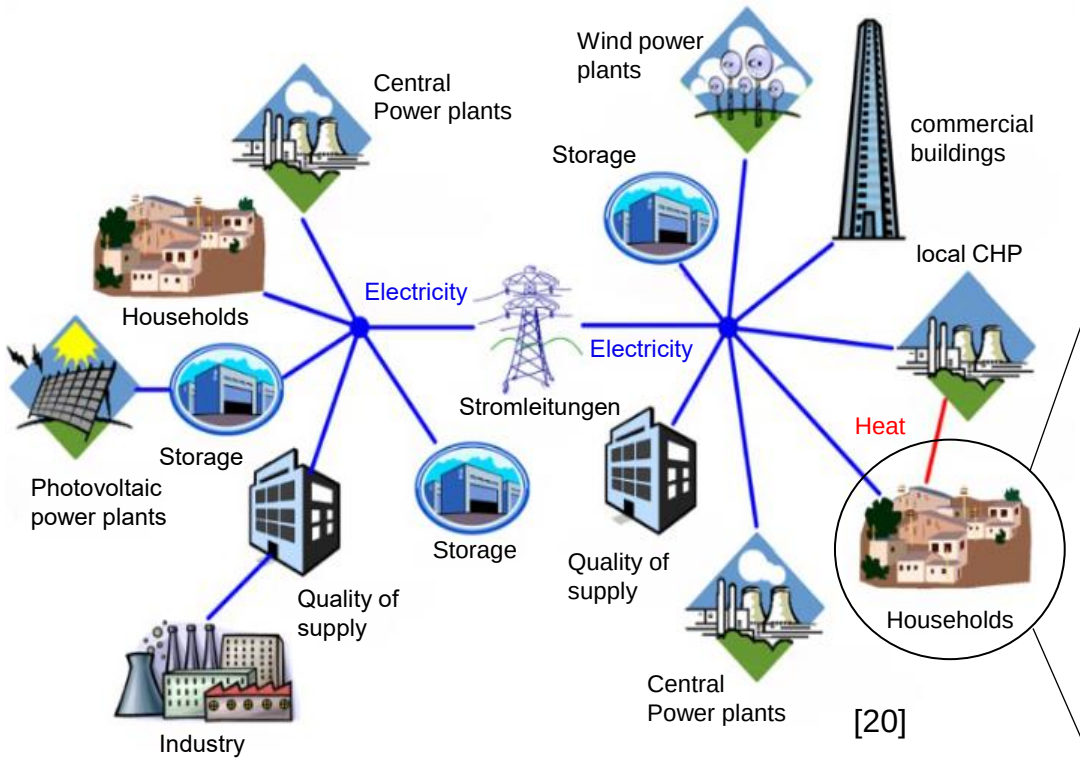
"Future" energy network - Challenges

Challenges
1. Large number of smaller renewable energy plants
2. Adaptation of market structures and development of new flexibility options
3. Coordination of large number of actors
4. Integration of a large number of heterogeneous systems
5. Cyber attacks
6. Social acceptance
7. Roles and functions of government institutions, economic actors, civil society organizations, scientific institutions

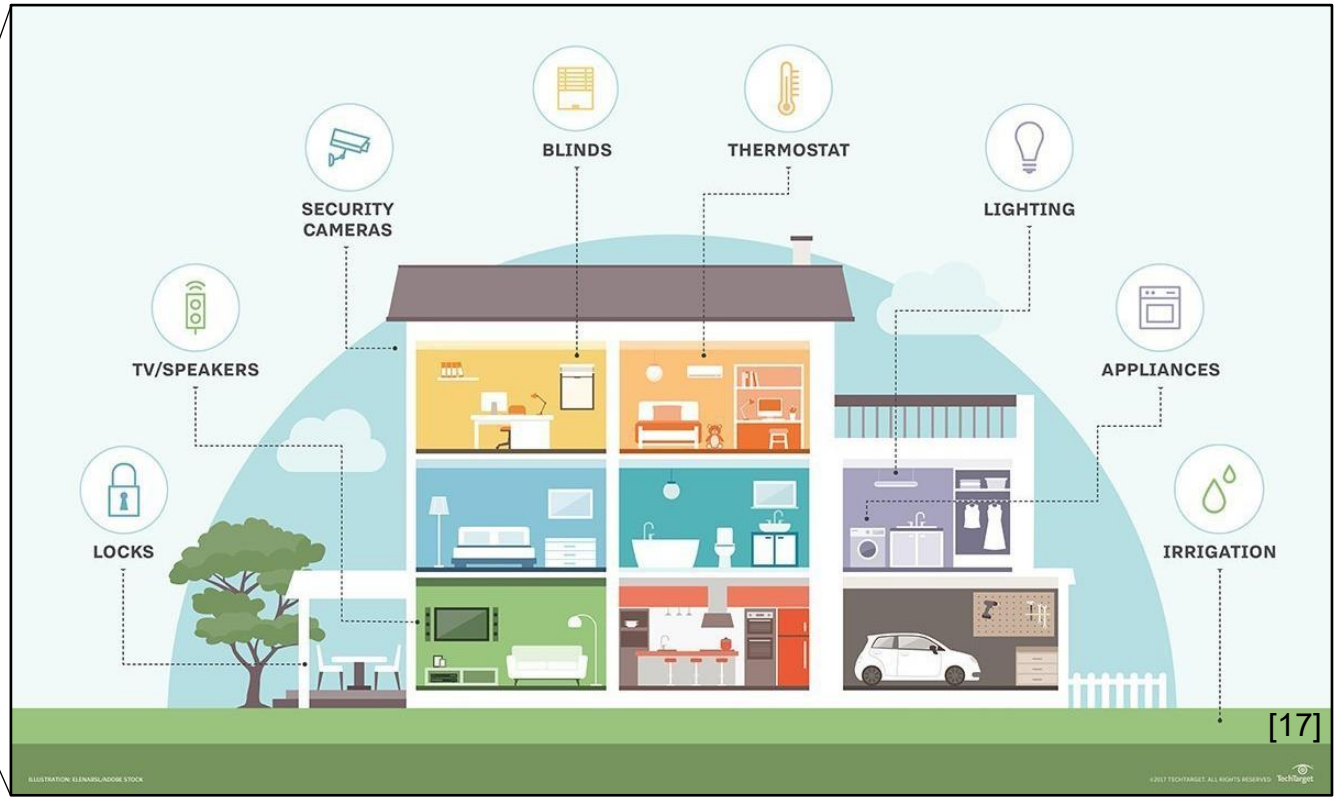
[22]

With the support of the Erasmus+ Programme of the European Union

Smart Home



[20]

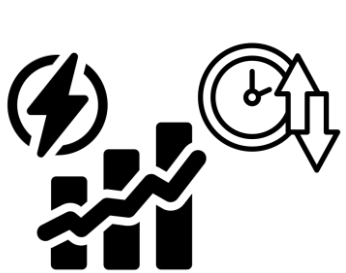


[17]

With the support of the Erasmus+ Programme of the European Union

Smart Home – Smart Meter

[18]



Power consumption in real time

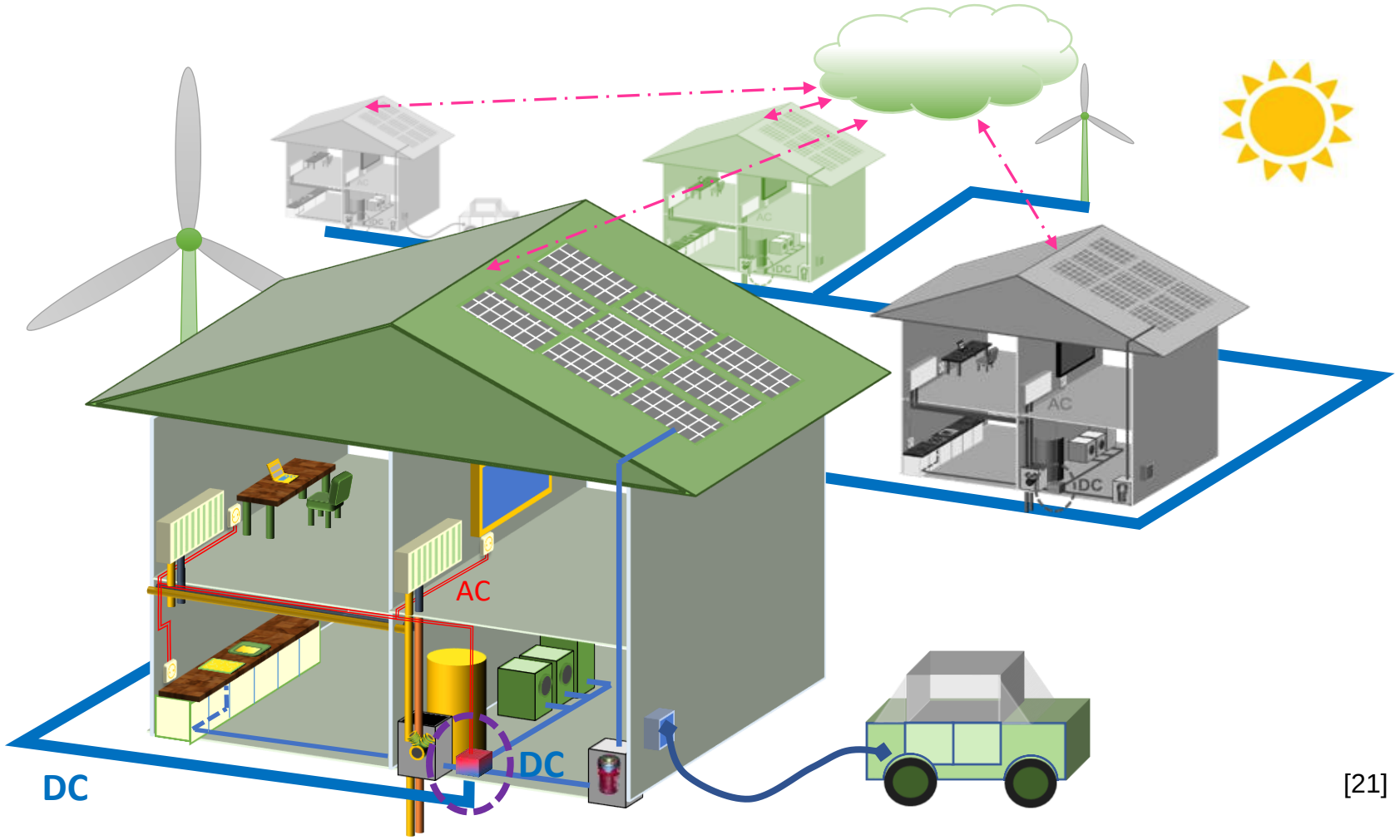
Energy supply company

Consumption analysis and management

Smart meters are an important part of the energy transition and can help **reduce electricity consumption** and **facilitate the integration of renewable energies** into the power grid.

With the support of the Erasmus+ Programme of the European Union

A Future DC Neighborhood as an IoT System

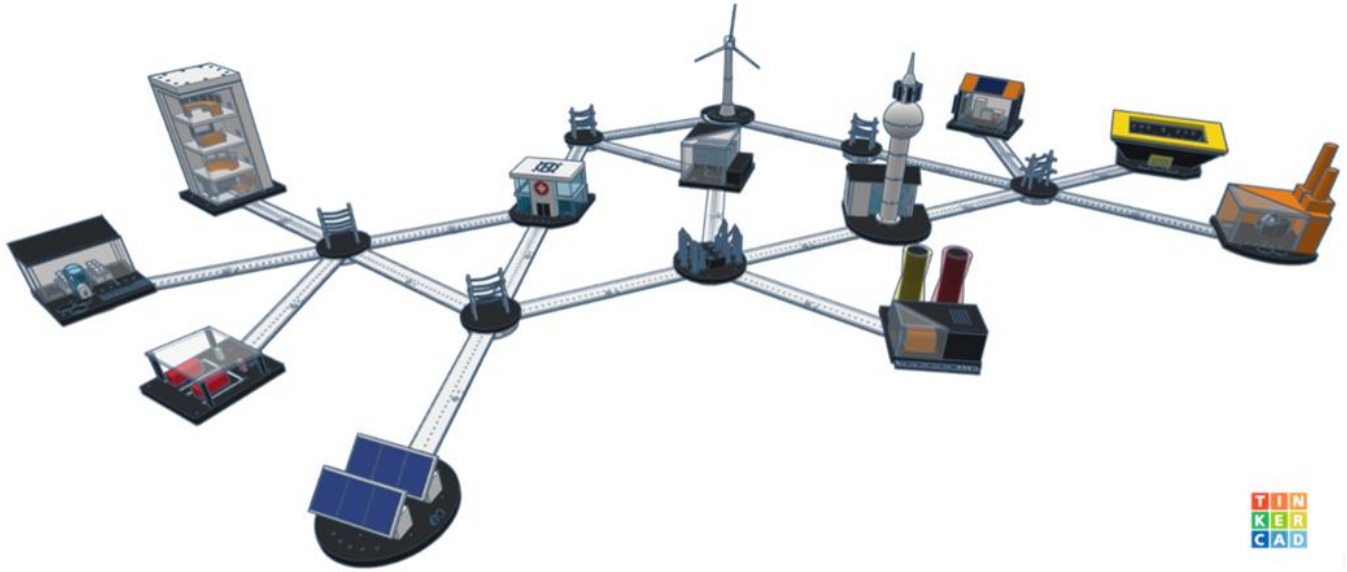


[21]

With the support of the Erasmus+ Programme of the European Union

LEGOS

- **L**ite **E**mulator of **G**rid **O**peration**s** (LEGOS) developed by RWTH, a multi-layered learning platform for demonstrating use cases of smart energy services.
- LEGOS consists of nodes that can connect up to 6 branches and one unit (generator, consumer, storage, etc.). Each branch enables measurement and control of the energy flow between two units, with LED strips visualising the magnitude and direction of the current flow.
- Units can be remotely controlled through haptic interaction or as IoT devices.



With the support of the Erasmus+ Programme of the European Union

EDDIE Project

What is EDDIE?

- **ED**ucation for **DI**gitalisation of **E**nergy
- A four-year EU collaborative project funded by Erasmus+.
- An innovative strategic approach to education in the European energy sector as an industry-driven movement where skills are derived from real-world application needs.
- The challenge is to develop a long-term plan for the digitization of the European energy sector that enables the current and future demand for these skills to be matched with the supply of improved vocational training systems and beyond.

[19]

With the support of the Erasmus+ Programme of the European Union

EDDIE Project

Project goals:

Development of an innovative blueprint strategy for the digitalization of the energy value chain

Establishment of a European Alliance for Sector-Specific Skills

Introduction of improved/new qualifications into national vocational training systems and beyond

Promote cooperation and mobility between European training centers, universities and companies.

Improve the attractiveness of the energy sector as a career choice.

With the support of the Erasmus+ Programme of the European Union

Sources

[1] https://www.rwth-aachen.de/cms/root/Die-RWTH/Profil/~enw/Daten-Fakten/
[2] https://www.topuniversities.com/universities/rwth-aachen-university
[3] https://www.archiv.rwth-aachen.de/web/rea/Seite/geschichte_18.htm
[4] https://www.rwth-aachen.de/cms/root/studium/Im-Studium/Internationales/Exchange-Incomings/~bqtt/Austauschprogramme
[5] https://www2.deloitte.com/content/dam/Deloitte/de/Documents/Mittelstand/Digitalisierung-im-Mittelstand.pdf
[6] https://www.welt.de/wirtschaft/article140401411/Maschinen-koennten-18-Millionen-Arbeitnehmer-verdraengen.html
[7] https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/fachbroschuere_konsum_4.0_barrierefrei_190322.pdf
[8] https://doi.org/10.1007/978-3-658-24637-2_3
[9] https://drs.consulting/digitalisierung-vorteile/
[10] https://www.umweltbundesamt.de/daten/klima/europaeische-energie-klimaziele
[11] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en
[12] https://westmbh.de/wp-content/uploads/2022/04/Green-Deal-Broschuere_20220316.pdf
[13] https://www.umweltbundesamt.de/service/newsletter/archiv/agee-stat-aktuell-nr-32022
[14] https://www.bmwi-energiewende.de/EWD/Redaktion/Newsletter/2015/3/Bilder/infografikverteilernetz.jpg;jsessionid=C12243FD93638DA22C87C2CFE5540D82?blob=poster&v=3
[15] https://www.schule-bw.de/faecher-und-schularten/mathematisch-naturwissenschaftliche-faecher/physik/unterrichtsmaterialien/e_lehre_1/elektrizitaetsuebertragung/wechselspannung.htm
[16] https://www.fischerfutureheat.de/gleichstrom-wechselstrom-mischstrom/
[17] https://www.computerweekly.com/de/definition/Smart-Home
[18] https://s3.amazonaws.com/ae-lane-report/wp-content/uploads/2018/08/ThinkstockPhotos-477245622-1240x1229.jpg
[19] https://ses.jrc.ec.europa.eu/eirie/en/eddie-project
[20] Vorlesung Prof. Monti: Automation in the power supply system
[21] Vorlesung Prof. Monti: The Digital Energy Revolution
[22] https://www.bmwk.de/Redaktion/DE/Publikationen/Sinteg/executive-summary-uberblick-uber-die-zentralen-ergebnisse-von-funf-jahren-sinteg.pdf?__blob=publicationFile&v=10

With the support of the Erasmus+ Programme of the European Union