TM8

Decentralized energy systems

Social aspects of energy production and use

Piotr Stankiewicz
Andrzej Augusiak
Maciej Galik
Krzysztof Tarkowski

Teachener

Funded by the
Erasmus+ Programme
of the European Union

Introduction

We are facing today a significant shift from classical, central and hierarchical systems of energy production and distribution, based primarily on big size power plants powered by conventional energy sources towards local, decentralised energy systems (DES) based mainly on renewable energy sources and smart grids solutions. Decentralising the energy system is about generating energy close to where it is going to be used.

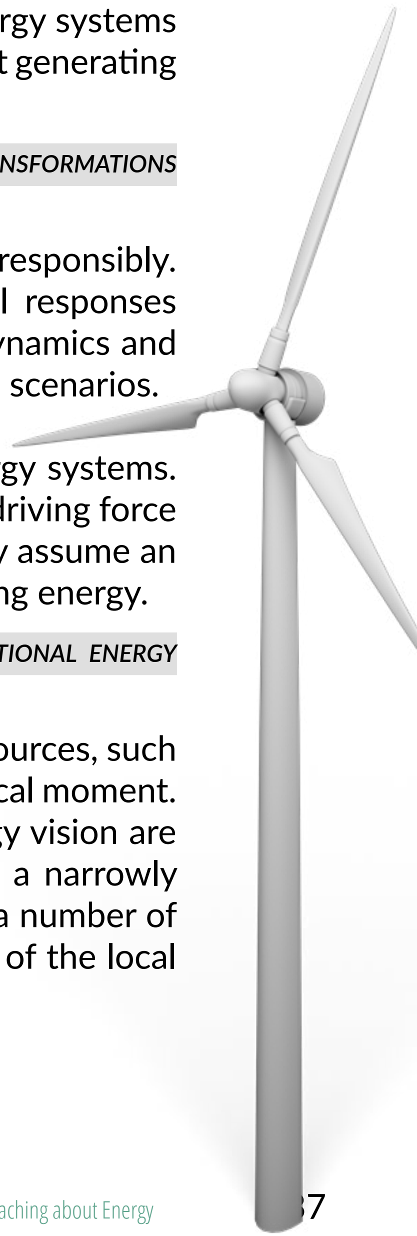
» *The change implies not only the implementation of new energy technologies, but also important social, cultural and political transformations in our societies.*

This shift allows a large number of consumers to become producers and to manage their energy consumption more responsibly. This requires a comprehensive assessment of their sociotechnical co-evolution, how technologies and societal responses evolve together, and how their co-evolution affects current trends. The goal of the course is to analyse drivers, dynamics and consequences of those complex socio-cultural trends. Focus will be put on the strategic analysis of possible futures scenarios.

The main aim of the course is to introduce students to the socio-political aspects of the decentralization of energy systems. The motivation behind these changes is not only due to technological developments or economic issues. The main driving force are wider social and political trends. Many energy supply projects that are being developed and implemented today assume an active role for consumers in energy production, who become 'prosumers', at the same time producing and consuming energy.

» *The shift towards being involved in energy production and deciding for oneself whether it is based on renewable or traditional energy sources is due to the* **growing public awareness of human-induced climate change.**

Therefore, not without significance is the fact that energy generated by households is based on renewable energy sources, such as windmills or photovoltaic cells. The aim of the classes is to make the students aware that we are currently in a critical moment. In the face of anthropogenic climate change, the discussion and decisions related to future scenarios of the energy vision are absolutely crucial. In order to understand the significance of these changes, it is necessary to move away from a narrowly understood technical and economic analysis. The changes towards decentralised energy systems are entangled in a number of social issues. Energy decentralisation is a part of a political decentralisation, with the emphasis on the importance of the local communities and their responsibility for itself.



The teaching module is composed of 3 successive sessions:

1

Session 1: Innovative Technological Solutions in Energy Production and Distribution
consists of a lecture and group work, the subject of which are the selected technical and economic aspects of decentralisation of energy systems.

115 minutes

2

Session 2: Decentralized Energy Systems from SSH perspective
is similar in form but concerns socio-political aspects.

135 minutes

3

Session 3: Scenario analysis: 'Road map' and 'What if?
takes the form of a scenario analysis exercise and summarizes the course.

135 minutes

Session 1:

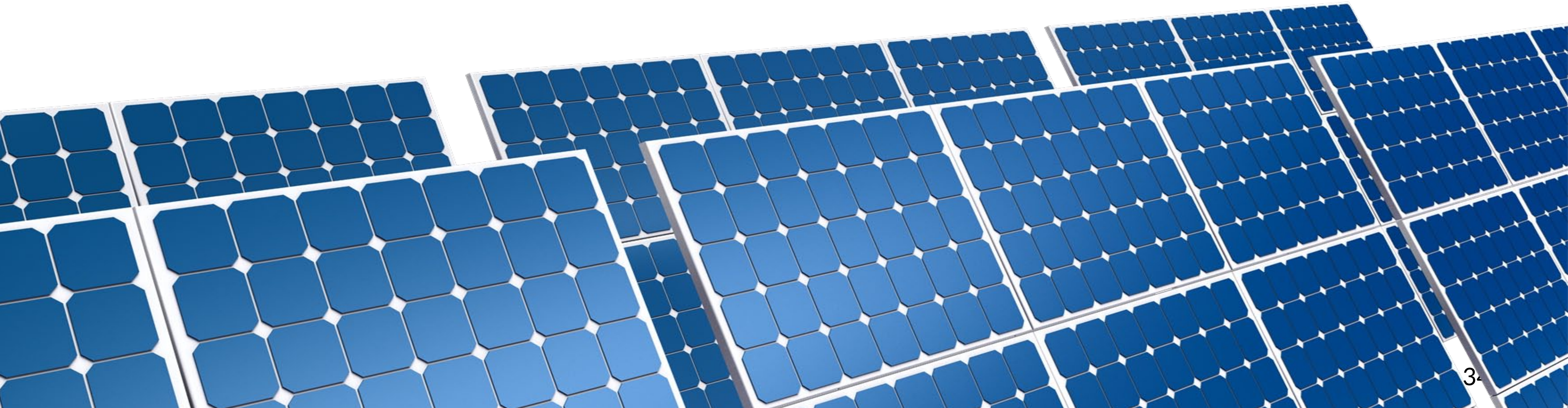
Innovative Technological Solutions in Energy Production and Distribution

a) Session objectives

This session is intended to give students an inside general knowledge of DES technical and economic drivers. After this session, students should have an understanding of main technological options of DES, the shape of future electricity systems and the role of energy customers in DES. Students will gain skills in calculating and evaluating Levelized Cost of Energy (LCOE) and achieve understanding of the factors that influence the adaptation of DES.

b) Session scope

The technical, organizational and legal structures of traditional electricity system have been designed around a limited number of large-scale centralized generation plants connected to a grid that carried (one-way) electricity to customers. With decentralized energy systems that are expected to employ many small-scale distributed units of energy generation, storage, and demand services, electricity grids will notice power flowing in both directions, with more customers producing their own energy and more customers actively shaping their own load profiles. Not only will it reduce energy demand from the central generation, but it will also require revised management of the flow of electricity in real time, use of advanced communication technology, along with proper schemes for assessing costs of distributed generation services.



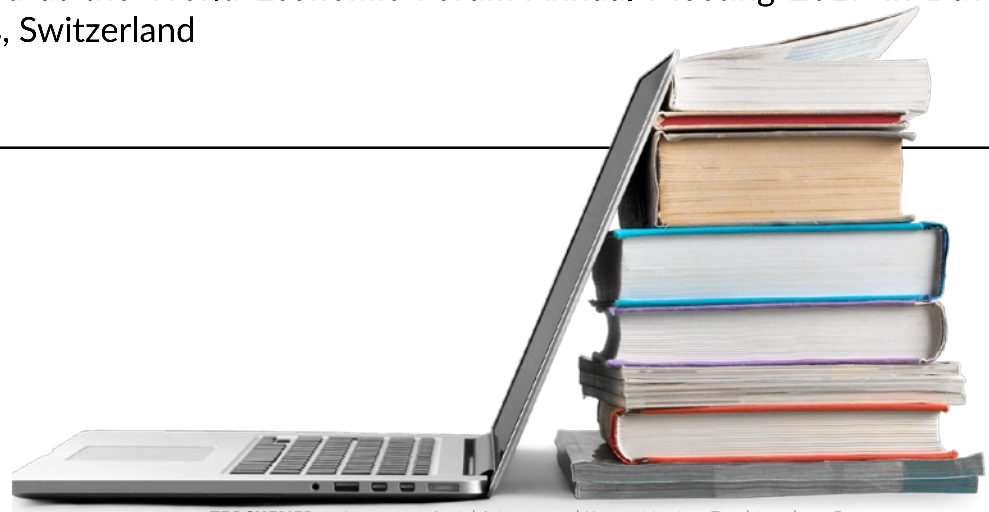
Distributed generation can benefit customers and the system in several valuable ways. For customers, solar can be an attractive and economical option, especially in sunny areas where it generates more electricity. Deployment of solar PV panels has increased dramatically in recent years with global installed capacity reaching 260 GWp (gigawatt-peak) in 2015 and expected to surpass 700 GWp by 2020. This growth has brought down the installed price of residential solar PV from about $7 per watt in 2009 to $3 per watt in 2015 in the US (and less than $3 in parts of Europe, such as Germany). For the system overall and for utilities, distributed generation can supply electricity directly to some percentage of customers, and depending on the status of the grid infrastructure, allows deferral of capital investments to maintain and upgrade grids and related services when these are less economical. In some cases, distributed generation may be the most affordable and expedient way to support load growth, particularly where it would be too expensive or time consuming or difficult to add new infrastructure – see pre-reading materials (WEF 2017).

Incentive programmes to encourage distributed generation in the form of rooftop solar photovoltaic technologies have been extremely effective in many cases, and customers have embraced them in many countries. New technologies, such as rooftop solar tiles and building integrated PV (BIPV), are now becoming available, broadening the future potential of distributed generation (WEF 2017).
Energy storage adds flexibility to the system, allowing those electrons to be stored and discharged later when they are needed – for example in evening hours or during times of peak demand. Thus, storage offers a way to flatten out the peaks and valleys of supply and prevent disruptive economics. Today, utility-scale storage (in front of the meter) accounts for the majority of installed storage capacity, providing numerous system functions, and is also proving an effective way to complement peaking plants. Storage is becoming cheaper as a result of advances in battery technologies and is achieving higher capacities that will allow for larger scale deployment. Projections estimate that demand for energy storage, excluding pumped hydro, will increase from 400 MWh globally in 2015 to nearly 50 GWh in 2025. Lithium ion batteries will make up most of the market, and those are likely to become more economical as vast quantities are developed and deployed for use in electric vehicles, a market where the demand for these batteries could reach 293 GWh by 2025 (WEF 2017).

This session introduces and explains main technical and organizational factors that drive the change from centralized to decentralized energy systems (DES). Initial presentation discusses emerging DES options and factors that make the change necessary and feasible. A list of technical and economic pros and cons of DES is given and discussed with students. Then, more stress is put on the economic drivers demonstrating the present competition between centralized and decentralized technologies. Students calculate the Levelized Cost of Energy (LCOE) of several DES technologies and compare it with actual prices of electricity (produced mainly in centralized energy systems). Finally, discussion on the analysis results and parameters will make students aware of DES adoption perspectives.

c) Pre-reading

No.	Author and title	Description
1.	Wolfe, Philip. The implications of an increasingly decentralised energy system. “Energy Policy” 2008, Vol. 36, Issue 12. DOI: 10.1016/j.enpol.2008.09.021	The paper discusses the concept and available technologies of decentralized energy systems that means the production and distribution of energy within the boundaries of, or located nearby and directly connected to, a building, community or development.
2.	Bruckner, Thomas et al. 2014. Energy Systems. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter7.pdf	The energy systems chapter addresses issues related to the mitigation of greenhouse gas emissions (GHG) from the energy supply sector. The energy supply sector, as defined in this report, comprises all energy extraction, conversion, storage, transmission, and distribution processes that deliver final energy to the end-use sectors (industry, transport, and building, as well as agriculture and forestry).
3.	World Economic Forum. 2017. The Future of Electricity. New Technologies Transforming the Grid Edge. http://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf	The report presents a view of the evolving electricity landscape, as it was discussed at the World Economic Forum Annual Meeting 2017 in Davos-Klosters, Switzerland



d) Session activities

Activity 1: Introductory lecture

Methods	Lecture
Keynotes	It is important to avoid any other comments besides technical ones.
Materials	**TTM8-ST1-RM1-Innovative Technological Solutions**
Required accessories	Computer + projector
Time allocation	30 min
Learning outcomes	Understanding of technical and economic foundations of DES

The idea of this lecture is to give the students a **general perspective and knowledge of what Decentralized Energy Systems (DES) are, what are** their key components and how do they turn out in comparison to classic centralized systems. General definitions are given and discussed. The concept of **energy system transition** is given and future modelling is presented. The student is presented with benefits of DES and different options of economic justification. DES options are given with a general explanation of the presented examples. The factor of Distributed Energy Resources (DER) is presented and examples of current and future implementations are given. The student is familiarized with future projections and forecasting based on technological and economic factors. **The growth of energy consumption** is accented with such technologies as electric vehicles and home appliances to stress energy efficiency. The growing importance of demand response is highlighted with a profound stress on technology development. **Digitalization** of the entire grid is discussed as being one of the most important aspects of progress and development in DES. Finally, the role of the energy customer is elucidated as being more and more influential on future decentralized energy system development.

Activity 2:
Case study analysis

Methods	Lecture, workshop
Keynotes	Use the instruction handout to help the students.
Materials	**TM8-ST1-RM2-Case study method of analysis** **TM8-ST1-RM3-Case study presentation with analysis** **TM8-ST1-RM4-Case analysis instruction handout**
Required accessories	computer + projector, calculators, computer laboratory (optional)
Time allocation	45 min
Learning outcomes	Evaluation of DES in practice.

The main goal of this activity is the student familiarization with the evaluation process of DES selection. A short, introductory presentation is given to make the students aware of the cost calculation procedure and to familiarize them with procedure and method of calculations. The procedure for calculating the cost of electricity is described in detail with a profound stress on common assumptions. Next, the students are presented with the case studies that they will evaluate/calculate. The students are divided into two groups and are asked to calculate the given cases. After completion, the students are asked to present the results, compare the two groups calculation results and draw conclusions. As feedback, significant parameters are listed.

Activity 3:
Consequence discussion

Methods	Guided discussion
Keynotes	Inform students that the results obtained at the activity 2 are approximate (many other technical/economic effects may need to be taken into account, e.g. taxes). Help directing discussion on social/political outcomes of DES introduction.
Materials	**None**
Required accessories	None
Time allocation	30 min
Learning outcomes	Identification of SSH aspects of DES.

Activity 3 is a guided summary discussion of activity 2 from which arguments are drawn. The aim is to make the students come to two important conclusions: 1) that energy price from DES units can be competitive with energy price from centralizes large power plants; 2) that energy price is strongly dependent on the size of the generation unit – therefore, deciding on the DES option would more beneficial if more people would be involved, which may lead to new organizational/legal forms of energy generation. This in turn points out to social/political effects that arise from energy generation in DES.

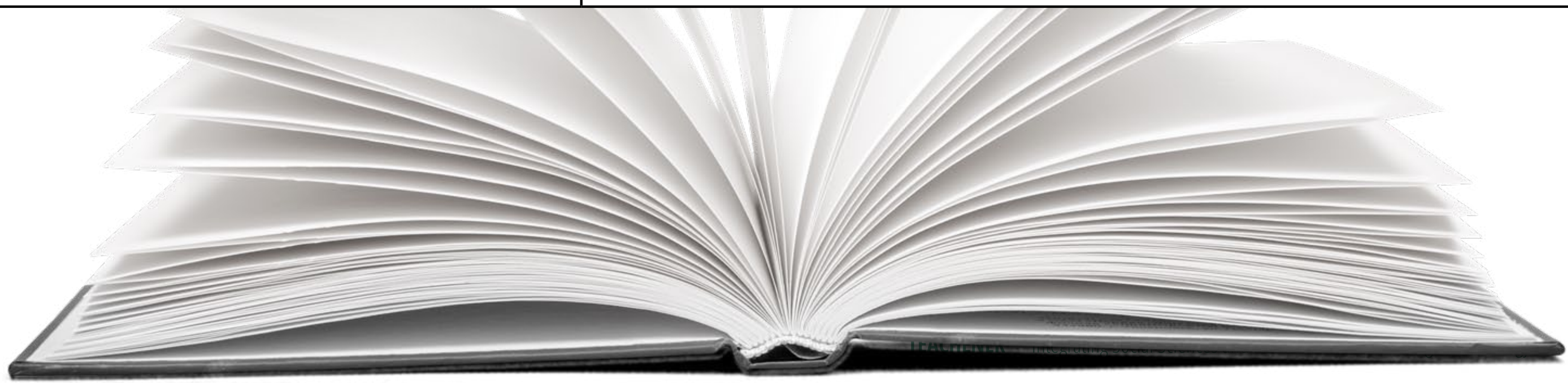
Activity 4:
Assignment for self-study

Methods	In-between session work, webquest
Keynotes	Ask the students to keep to the allotted time.
Materials	**None**
Required accessories	Presentation program
Time allocation	10 min
Learning outcomes	Identification and evaluation of a chosen DES case.

The aim of this activity is for the students to investigate by themselves an existing DES example. It is a general facilitation exercise which is the ground for session 2. The students are asked to prepare a short presentation (up to 5 min) based on a selected DES case and technology.

e) Additional resources

No.	Author and title	Description
1.	Elfvengren, Kalle et al. The Future of Decentralized Energy Systems: Insights from a Delphi Study. "International Journal of Energy Technology and Policy" 2014, Vol. 10, Issue 3-4. DOI: 10.1504/IJETP.2014.066883	The paper evaluates how decentralized energy technologies will develop in Finland in the next five to ten years. By gathering data and insights, the paper also offers general views on future decentralized energy applications and market opportunities.
2.	National Academies of Sciences, Engineering, and Medicine. 2016. The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies. Washington, DC: The National Academies Press. DOI: 10.17226/21712	The report considers innovations that may improve the performance and lower the cost of currently available and help develop new advanced energy technologies.
3.	European Commission. 2012. Energy Roadmap 2050. Luxembourg: Publications Office of the European Union. DOI: 10.2833/10759	The UE brochure that comprises the text of the European Commission's communication 'Energy roadmap 2050' (COM(2011) 885 of 15 Dec 2011 The report debates how to put in place the policies, milestones and instruments to deliver European long-term goals: energy security, sustainability and competitiveness.



Session 2:
Decentralized Energy Systems from Social Sciences and Humanities (SSH) perspective

a) Session objectives

The aim of the session is for students to understand the socio-political aspects of decentralization of energy systems. The key dilemmas related to the decentralization are presented from the SSH perspective. Students are familiarized with different possible scenarios for decentralization of energy systems.

b) Session scope

From an economic and technological point of view, the change towards DES aims to reduce the costs of transmission and production of the energy itself. Although these factors are important, especially as global energy consumption is growing, they are not decisive. There are many social, cultural and political aspects which seem to play a key role in changing the way we think about energy. As it was presented in Session 1, most modern DES are based on renewable energy sources, e.g. biomass, biogas, geothermal power, small hydro, solar power or wind power. It is often the case that the current use of renewable energy sources is incompatible with, economic rationality'. The factor that determines that people want to use renewable energy sources is the growing awareness of human influence on the destabilization of the global climate. It is also related to the fact that people want to have more influence on energy management, which translates into social and political support for DES.

DES are not just technological speculation, futurology or distant plans - there are many initiatives and projects already in operation. Decentralisation of energy systems occurs in two socio-political settings: one is the climate change debate and the second the Global North and South divide. The former results in trends aimed at mitigating the human impact on the climate through reducing the CO2 emissions. This is also an important cultural trend promoting more eco-friendly styles of consumption. The latter setting deals with inequalities with energy access between developed countries of the Global North and less developed countries of the Global South. This debate is conducted mainly around the concept of energy poverty.
At the end of the session 1, students have been asked to investigate examples of DES. They present the results of the self-study assignments at the beginning of this session in form of short presentations, indicating the most important features of the DES projects. The teacher will then give the students a lecture with an overview of social aspects of DES: current socio-political trends contributing to decentralisation of energy systems, contexts of application, worries and hopes related to DES development. The presentation will be completed with a detailed presentation of an example of the German village of Feldheim.

c) Pre-reading

No.	Author and title	Description
1.	German Village Becomes Model for Renewable Energy Code: TM8-ST2-AM1	News containing information about Feldheim.
2.	Kang, Lin. Energy Self-Sufficient Ecovillage Code: TM8-ST2-AM2	Thesis, in which Chapter Four focuses on the example of Feldheim.
3.	Distributed Energy Systems. Flexible and Efficient Power for the New Energy Era Code: TM8-ST2-AM3	Scientific project on DES describing four cases.

d) Session activities

Activity 1:
Risk identification exercise

During this activity students present examples of DES projects they have self-studied. The follow-up discussion should be focused on SSH aspects. Attempts can be made to classify the projects in terms of, for example, autonomous bottom-up initiatives, government/ EU initiatives, motivations of participants, sources of funding, the share of renewable energy sources, etc. The classification depends to a large extent on the DES examples presented by the students. The examples and their classifications are intended to show different alternative scenarios for the development of the DES. It may also be discussed which scenarios seem the most promising from various SSH perspectives.

Methods	Presentation
Keynotes	The teacher should focus exclusively on the political and social aspects of the DES. It should also draw attention to the fact that many technical aspects can be taken into account from the socio-political side, e.g. sharing local power plants, sharing the revenues from sold surplus energy, bottom-up financing of specific technological solutions, etc.
Materials	**None**
Required accessories	Computer+projector
Time allocation	30 min
Learning outcomes	Students will have opportunity to confront the examples they have found of contemporary attempts to decentralize energy systems, as well as how they perceive what SSH aspects are.

Activity 2:
Decentralized energy systems – social aspects

Methods	Presentation
Keynotes	The teacher should focus exclusively on the political and social aspects of the DES. It should also draw attention to the fact that many technical aspects can be taken into account from the socio-political side, e.g. sharing local power plants, sharing the revenues from sold surplus energy, bottom-up financing of specific technological solutions, etc.
Materials	**TM8-ST2-RM1-DES**
Required accessories	Computer+projector
Time allocation	55 min
Learning outcomes	Students will be acquainted with the most important examples of contemporary solutions for DES and the most important threads in the discussions about them.

This activity tends to present social, political and cultural aspects related to development of DES, focusing on the climate change debate and the Global South and North divide. Students are introduced with concepts, notions, trends and phenomena either influencing or resulting from development of DES.

In case of global climate change debate following issues play an important role:
- Policy trends such as transitions to low carbon emission technologies ('Energy transitions').
- Departure from conventional energy sources.
- Popularity of eco-friendly ways of life in Western European culture.
- Development of electro-mobility industry.
- Growing sector of renewable energy sources (RES), coupled with EU Energy Goals supporting the development of RES.
- Energy prosumption as a growing trend in the energy market.
- Green economy.

As an illustration how the climate change debate translates into energy trends may serve the **Energy Union Strategy** and the **2050 Energy Roadmap**. Decentralization of energy systems is one of the instruments to achieve the goals and decrease CO2 emission caused by conventional energy production systems.

An important role in DES plays the concept of 'energy community', i.e. a community which is independently meeting (partially or totally) its own energy requirements – i.e. heating, cooling, electricity or all three – through decentralized generation. Excess energy, where available, is sold back to the grid. The 'energy community' concept resulted from a social movement promoting the use of renewable energy sources (RES) on a local scale and in world economy as a part of a new, more eco-friendly way of life. It is also recognised by EU law.

There are numerous examples of local energy communities based on production and consumption of energy from 'own' energy sources (energy prosumption). They are often technologically innovative and make use of smart metering technology, as well as blockchain and artificial intelligence in energy contracting. Sometimes they take the form of fully autonomous and self-sufficient 'ecovillages'. Examples of such initiatives can be found in Additional Resources section of this session. In the presentation, the case of Brooklyn Microgrid has been selected for the lesson.

Development of DES takes place within a broader paradigm called '**energy transition**', which describes the reorientation in energy policy occurring due to global climate change and meaning shift towards decentralized renewable energy systems.

From a socio-cultural point of view, the trend towards decentralization and local production, distribution and consumption of energy can be seen as part of the '**energy democracy**' approach, which emphasizes the role of citizens in taking decisions on energy development strategies in their communities, governing the energy systems autonomously and participating as prosumers in local energy market.
The other perspective of DES development, Global North vs Global South, deals primarily with the problem of '**energy poverty**' in less developed countries. It refers to the situation of large numbers of people having very limited access to energy (mainly electricity), and thus very low consumption of energy, using dirty and polluting fuels to meet their needs and spending a lot of time collecting them.

According to the estimates of International Energy Agency, 1.2 billion people in the world do not have sufficient access to electricity. Most of them live in Sub-Saharan regions of Africa and India. However, the problem affects not only less developed countries, but also poor communities in Global North. According to IEA, energy demand in developing nations is likely to increase by 65% between 2010 and 2040. Decentralized energy systems (mini-grids) can be a solution for 70% of those living without energy access.

Example of Feldheim

Feldheim is a 100% energy self-sufficient "Ecovillage" in Brandenburg. Energy for households and local companies comes from windmills, photovoltaic cells and a biogas power plant (a product of methane fermentation of organic compounds e.g. sugar waste, municipal waste, animal waste, slurry, waste from the agri-food industry, biomass). The first wind turbines were built in Feldheim in 1995, and in small steps for almost twenty years, with strong financial support from the state, the inhabitants have gained green energy autonomy. However, it didn't come without troubles – the community had to negotiate the terms with the energy company, concerning the possibility to sell the surplus of produced energy to the central grid (see TM8-ST2-AM1).

The aim of the presentation is to present an example of DES-related phenomena, which are energy self-sufficient communities. Besides, the goal is to familiarize the students with real conditions in which the establishment of DES takes place.
The example enables to stress out possible scenarios for the impact of socio-political aspects on the implementation and development of specific technologies and solutions. It serves s a summary of the lecture and prepares students for the next activity.

Activity 3:
Socio-political scenarios of energy systems change – discussion

Methods	Presentation
Keynotes	The teacher should focus exclusively on the political and social aspects of the DESs. It should also draw attention to the fact that many technical aspects can be taken into account from the socio-political side, e.g. sharing local power plants, sharing the revenues from sold surplus energy, bottom-up financing of specific technological solutions, etc.
Materials	**None**
Required accessories	Computer+projector
Time allocation	40 min
Learning outcomes	Recognize that decentralization of energy systems has far-reaching socio-political consequences. As well as drawing attention to the fact that the trend towards decentralization is not only the result of technological possibilities, but also mainly of cultural factors.

Students should propose several possible scenarios for the development of decentralised energy systems (e.g. conversion of conventional power plants, focus on the idea of being a prosumer, importance of the role of renewable energy sources). Students should discuss future forecasts and evaluate them in a socio-political perspective. The discussion should end with a summary done by the teacher, who comments on the conclusions drawn by the students.

Activity 4:
Introduction to scenario analysis

Methods	Discussion
Keynotes	The teacher should focus exclusively on the political and social aspects of the DESs. It should also draw attention to the fact that many technical aspects can be taken into account from the socio-political side, e.g. sharing local power plants, sharing the revenues from sold surplus energy, bottom-up financing of specific technological solutions, etc.
Materials	**None**
Required accessories	None
Time allocation	10 min
Learning outcomes	Students are familiar with the principles of scenario analysis techniques. Readiness to prepare two kinds of scenario analysis regarding decentralised energy systems.

In this activity students are only presented with rules of the activity which will open the next session, to help them prepare for it. They are divided into two groups and asked to prepare themselves for doing a scenario analysis during the next session.

They should adopt roles of experts team members from a **consultancy company hired by the European Commission** in order to prepare a scenario analysis on the future of DES. One group as the experts team prepares a 'Road map' analysis, the second one a 'What if?' one.

In the 'Road map' exercise the expert team has been asked by the EC to present a plan to transform the European energy system from its current state to a 100% decentralised one in ten years from now. They should describe the way leading to introduction of decentralised energy system in Europe instead of existing centralized systems. They have to indicate processes and key factors which would enable a total resignation of centralised energy systems on EU-level in ten years. In order to do so, students should identify existing (and expected) barriers and opportunities, advantageous and (dis)advantageous conditions for DES development. They should identify chances and obstacles on economic, political, social, cultural and technological level. In other words, they have to show what should happen in the EU to enable the decision of abandoning centralised energy systems in Europe in ten years.

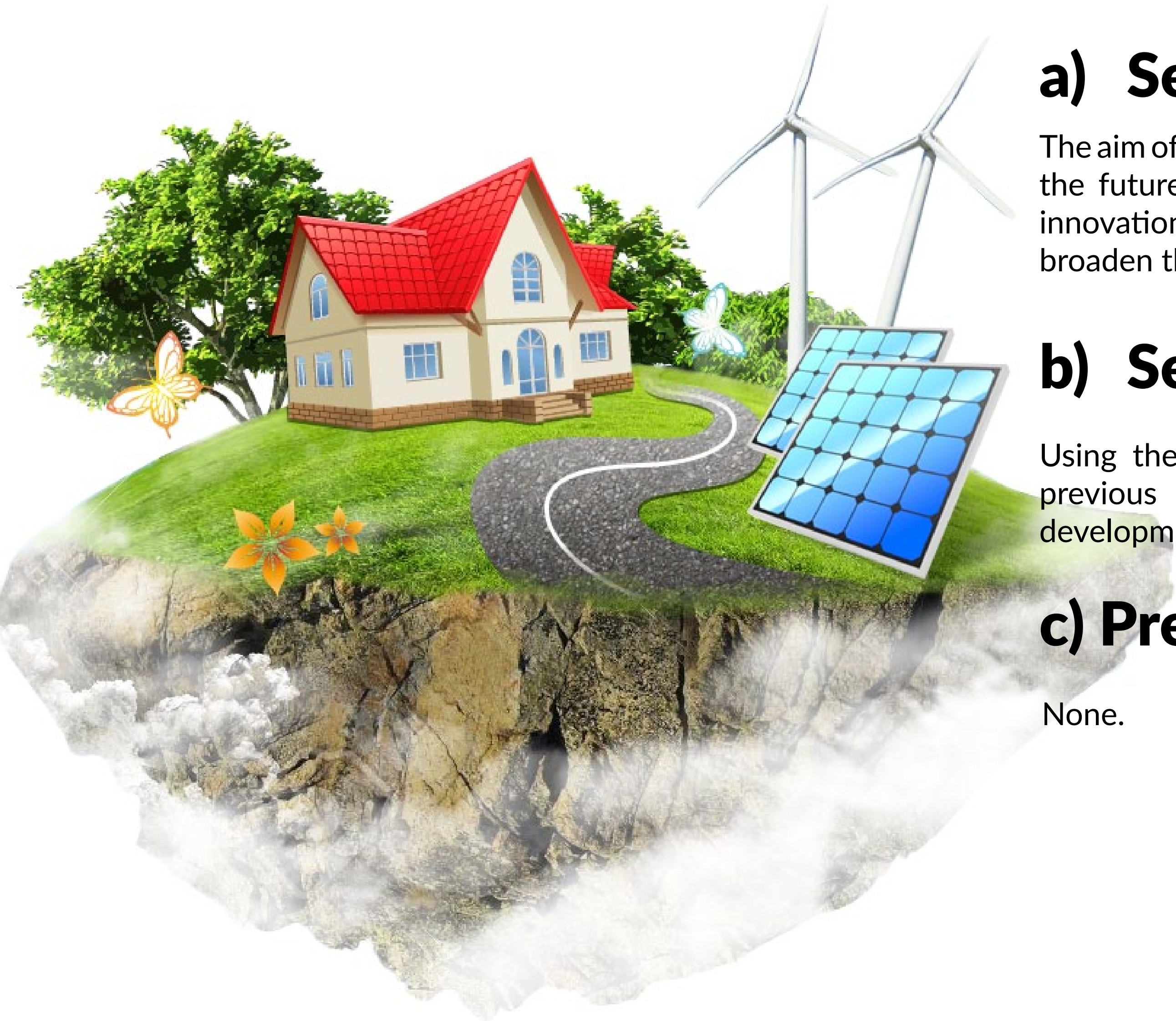
The 'What if?' analysis starts from the point where the 'Road map' ends. In this exercise the other expert team has been asked by EC to identify possible consequences of introduction DES in the EU and resignation of centralised systems. Students have to think about technical, economic, political and social consequences of DES development for the European countries.

At the end students are asked to divide the work within the teams between their members and get ready for preparations for the discussion between session 2 and session 3.

e) Additional resources

No.	Author and title	Description
1.	This Is What Energy Democracy Looks Like https://www.youtube.com/watch?v=A2c9vsJeGFM	Introductory video on energy democracy.
2.	The energy transition to energy democracy https://www.youtube.com/watch?v=ZTmeNmWEupg	Video showing how to move towards energy democracy.
3.	Renewable Energy Technologies in Denmark https://www.youtube.com/watch?v=d4eiTbPV47g	Video showing exemplary technological solutions of renewable energy in Denmark.
4.	Ten Years of Community Energy https://www.youtube.com/watch?v=5QtvyrQHJQE	Scottish experiences with energy communities.
5.	Local Energy Systems https://www.eon.se/en_US/samhaelle---utveckling/local-energy-systems.html	Swedish experience of developing energy self-sufficient village of Simris.

Session 3: Scenario analysis: ‘Road map’ and ‘What if?



a) Session objectives

The aim of the session is to develop among students ability to analyze the future consequences of the implementation of technological innovations. Through the scenario analysis method, students are to broaden their "social imagination".

b) Session scope

Using the two analytical methods presented at the end of the previous session, students analyse possible scenarios of DES development and its consequences.

c) Pre-reading

None.

d) Class activities

Activity 1:
‘Road map’ and ‘What if?’ analysis

Methods	Group work/workshop
Keynotes	The teacher should be prepared to possibly help and guide the students.
Materials	**TM8-ST3-RM1-Innovative Technological Solutions** **TM8-ST3-RM2-Case prognosis**
Required accessories	Flipchart, markers
Time allocation	100 min
Learning outcomes	Competence to understand factors influencing development of DES as well as its consequences.

A brief reminder of the main rules of the ‘Road map’ and ‘What if?’ methods is given at the beginning. Students, divided into expert teams, prepare the analysis using knowledge and materials collected before the session. For the group work 60 minutes should be reserved. After that, a presentation of group work and subsequent discussion after each presentation comes (2x20 minutes).

While the first expert team present the results of the ‘Road map’ analysis, the second group takes the role of **EU Commissioners.** It should be announced to the students at the beginning of the session and each students should choose a role of a specific EU commissioner from the list given by the teacher. The list encompasses the real posts in the EC, such as Commissioner of Agriculture, Budget/Finances, Climate

Action, Communication Networks, Competition/Jobs, Education, Consumers/Health, Employment/Social Aspects. After the presentation of the first expert team, each member of EC will have to ask a question from his or her area of expertise.

Similarly, when the second expert team present the results of 'What if?' analysis, the first group of students takes the role of **European Parliament Members.** They represent different countries. Students form groups of 2-4 for one country. After the presentation, each group asks questions to the experts team, focusing on consequences of the presented scenario for their country.

Activity 2: Summary discussion

Methods	Discussion
Keynotes	The results of the previous analysis should be distinguished as one resulting from the other. The concept of many factors and barriers should be stressed.
Materials	**None**
Required accessories	None
Time allocation	35 min
Learning outcomes	Verification of future analysis methods understanding.

The aim of this activity is to facilitate the knowledge gained in this module. Profound stress must be put on the idea that the outcomes of future prognosis are dependent on the factors taken into account in the analysis.

e) Additional resources

None.

Assessment methods and final assignment

Session 3 includes the final assignment in which the students are asked to conduct the ‘Roadmap’ analysis and the ‘What if?’ analysis. Criteria to be taken into account:

- Proper identification of barriers (cause, effect, solution)
- Proper identification of non-technical barriers
- Forecast based on non-technical factors (economic, social, political, etc.)

The proper evaluation and marks awarded for the assignment and module are subject to applicable rules of the institution hosting the module.

Glossary

Grid	refers to the electric grid: a network of power generators, transmission lines, substations, transformers and other devices delivering electricity from power plants to our homes or businesses.
IoT	stands for “Internet of Things”. It is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
CES	stand for “Centralized Energy System” which refers to the centralized generation of energy (electricity) in large generating plants and its and transmission/distribution over long distances to energy consumers.
DES	stands for “Decentralized Energy Resources” which refer to a variety of small interconnected energy units.
LCOE	stands for “Levelized Cost of Energy”. It is a ratio of annual power plant costs to the annual electricity production, in $/kWh or in EUR/kWh

NEDC	stands for "New European Driving Cycle". It is a predefined driving cycle designed to assess the emission levels of car engines and fuel economy in passenger cars.
CHP	stands for "Combined Heat and Power". It is simultaneous generation of both: electric energy and heat in the same production process, sometimes also called "cogeneration".
Stirling engine	is a heat engine (patented in the early 19th century) that operates by thermodynamic cycle with no internal fuel combustion (energy is acquired from external sources of heat, such as concentrated solar energy, geothermal energy, waste heat and bioenergy).
EV	stands for "electric vehicle". It is a vehicle that uses one or more electric motors or traction motors for propulsion.
IEA	stands for "International Energy Agency". It is an intergovernmental organization established in 1974, gathering 30 members from the Organization for Economic Co-operation and Development (OECD) countries, providing energy analysis, statistics and publications, including annual IEA World Energy Outlook.
DESS	stands for "Distributed Energy Storage System".
RES	stands for "Renewable Energy Sources"
O&M	stands for "Operation and Maintenance". It refers to servicing of technical systems and equipment.
CF	stands for "Capacity Factor". It is a ratio of actual annual electricity production to the maximum possible annual electricity production.
Nominal capacity	refers to declared full-load sustained power production of a power plant, sometimes also called "nameplate capacity".
Total installed costs	refers to total investment costs of the project and usually includes costs of civil works, grid connection, land, planning, wind turbine, etc.
CRF	stands for "Capital Recovery Factor". It is a ratio used to converts a present value (of total installed costs, for instance) into a stream of equal annual payments over a specified time.
Small-scale power plant	refers to a power plant with nominal capacity less than 1 MW.
SSH	stands for "Social Sciences and Humanities"
Global North/ South	Global North includes, among others, North America, Europe and Asia, and refers to developed, rich and politically stable countries. Global South refers to, among others, Africa, South America and the Middle East, which are generally developing countries, poor and politically unstable.
Prosumer	is a person who not only consumes a product e.g. energy, but also takes part in its production.

Prosumption	is a process of combined energy consumption and production. For instance, having a solar panel on the roof of one's house allows to use the energy in the household and sell the excessive energy to the energy company.
Ecovillage	is a traditional or intentional community with the goal of becoming more socially, culturally, economically, and ecologically sustainable and energy self-sufficient.
Energy democracy	is a political, economic, social and cultural concept that merges the technological energy transition with a strengthening of democracy and public participation. It's main premise is that people should be m ore involved into decision making on energy issues.
Green economy	is defined as an economy that aims at reducing environmental risks and ecological scarcities, and that aims for sustainable development without degrading the environment.
Energy transition	is generally defined as a long-term structural change in energy systems toward more environmentally friendly.