Utilization of renewable energy sources to improve the sustainability of farming

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ENERGY 4 FARMING

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The importance of renewable energy sources

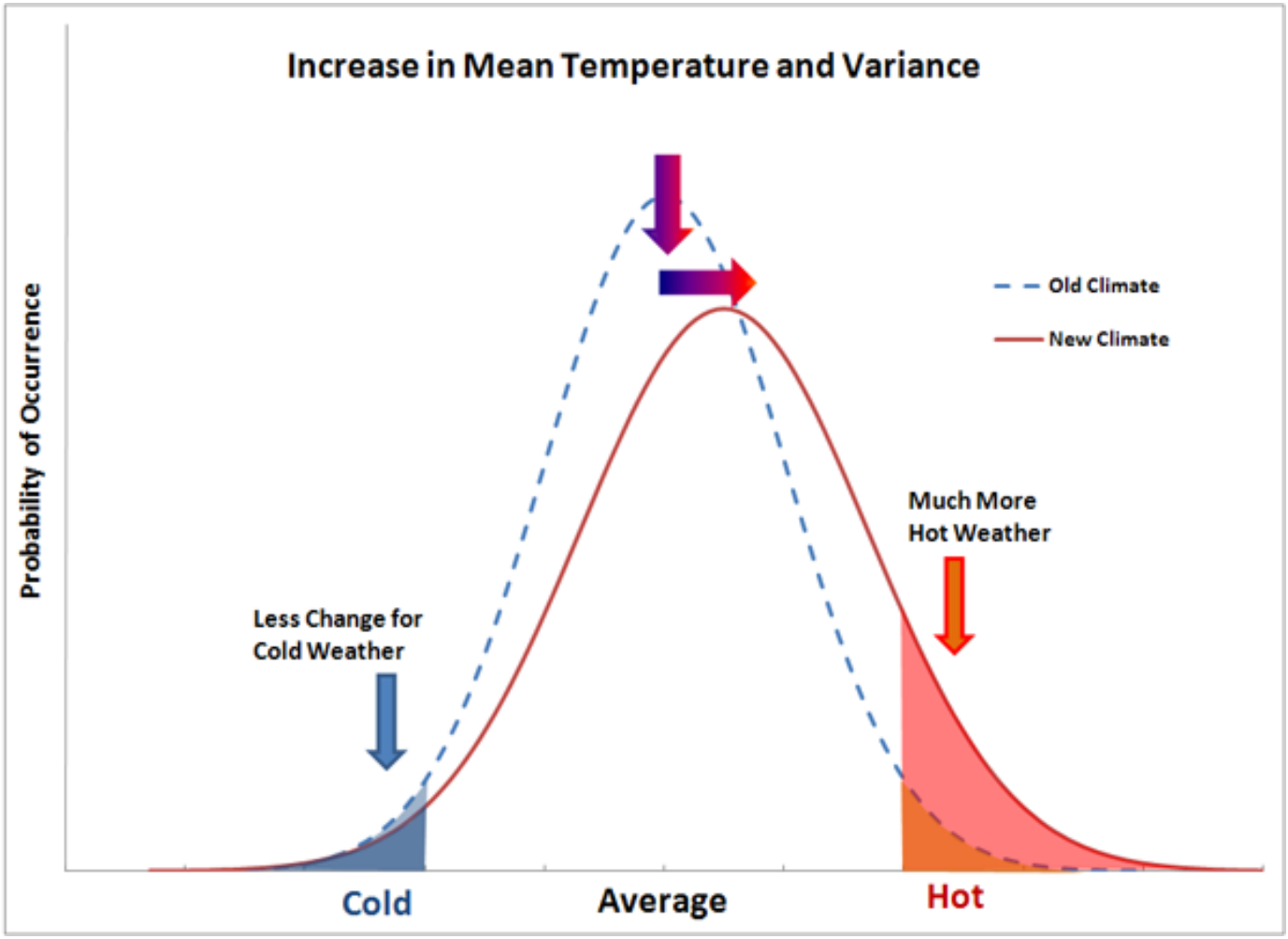
- **Renewable energies** are sources of **clean, inexhaustible and increasingly competitive energy**.
- They differ from fossil fuels principally in their diversity, abundance and potential for use anywhere on the planet, but above all in that **they produce neither greenhouse gases** – which cause climate change – **nor polluting emissions**.
- Growth in clean energies is **unstoppable**, as reflected in statistics produced annually by the International Energy Agency
- Clean energy development is vital for combating **climate change** and limiting its most devastating effects.
- The transition to an energy system based on renewable technologies will have very **positive economic consequences** on the global economy and on development.
- According to the International Renewable Energy Agency (IRENA), doubling the renewable energy share in electricity generation to 57 % worldwide by 2030 will be necessary for meeting the Paris Agreement targets.

Climate change in agriculture

- **One of the greatest challenge of our agricultural production in the future**
- Changes the distribution and values of meteorological parameters
- We can find significant time and spatial changes at certain meteorological variables
- Temperature rising
- Changes the length of vegetation periods
- Increasing the heat amount, growing degree days (GDD) or growing degree units (GDUs)
- Drought, dryness length, occurrences, and severity increasing
- Increasing the fluctuation or variability of meteorological parameters
- Increasing the probability of weather damages, weather disasters
- Extreme events will be more frequently in the future
- Changes the phenological phases
- New pests, new plant diseases, plant infections appearance

How can we interpret the future changes of climate?

Statistical explanation of climate change



Source: Adapted from IPCC (2001) (Ref. 39).

Global problems of current food production

- Outsourced agricultural production structure (South America, Asia, Africa)
- High shipping costs
- The food chain from producer to consumer is slow, going through many hands
- Freshness is difficult to ensure
- Exposure to pests and pathogens increases significantly due to monoculture production
- Significant soil degradation can be expected

Local problems of current food production

- Low purchase prices
- Profitability for the producer is low
- The product is expensive for the consumer
- Agricultural machinery relies on fossil energy
- Plant protection costs are high
- The proportion of irrigated areas is low
- Ice nets, shading nets and modern frost protection equipment are used just in few places, few cultivation areas
- Farms are largely vulnerable to extreme weather events
- Current agricultural production is unsustainable !!!!!

Availability of water for the agricultural production

- Water is a critical input for agricultural production and plays an important role in food security.
- Irrigated agriculture represents 20 percent of the total cultivated land and contributes 40 percent of the total food produced worldwide.
- The biggest problem or risk for future agricultural production is the water use.
- The essential question is whether the right amount and right quantity of water is available to agricultural production
- Due to population growth, urbanization, and climate change, competition for water resources is expected to increase, with a particular impact on agriculture.
- Most governments and water users fail to invest adequately in the maintenance of irrigation and drainage systems.
- Increasing the severity of drought due to the unfavourable precipitation distribution causes additional problems for agricultural production.

How much water do we need to produce 1 kg of food

Source: MrGeogWaggPosted on March 30, 2015

Sustainability

This is a process “that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

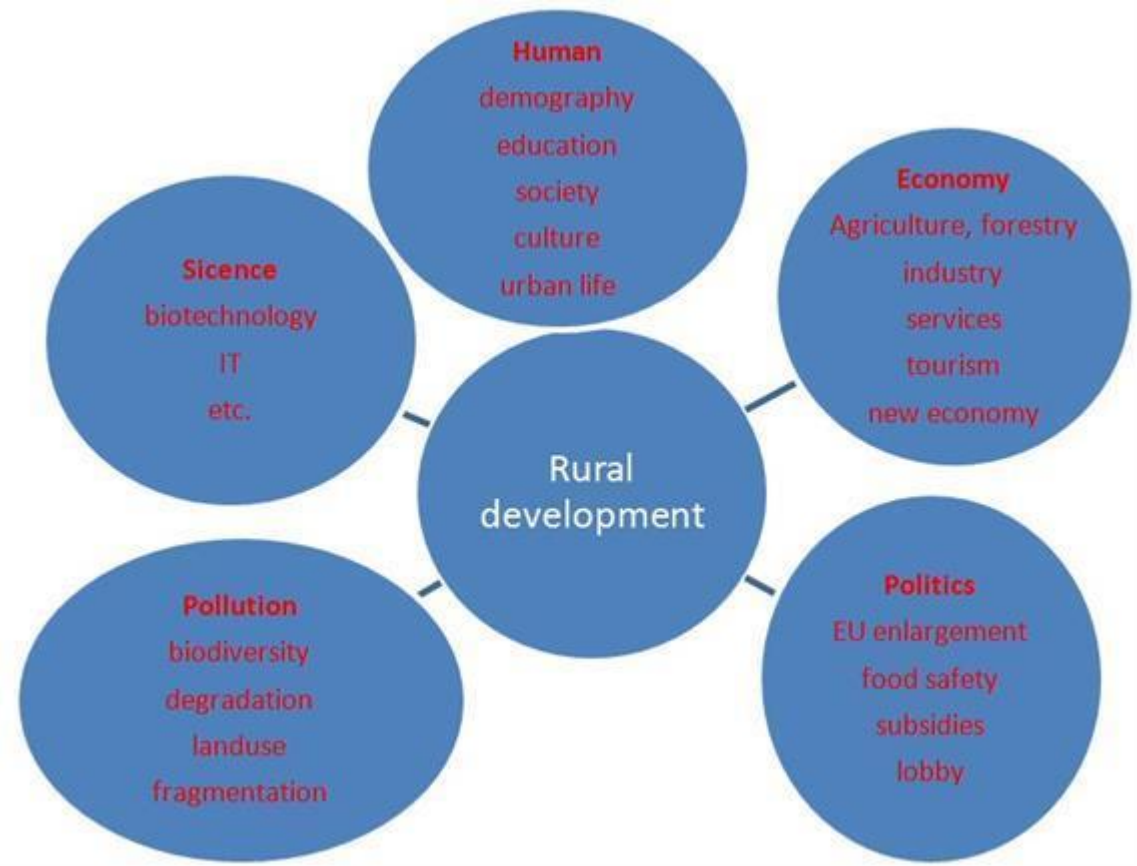
Source: Brundtland Report (1987)

- In the interpretation of sustainability, the balance between economic, social, and natural is the main focal point.
- As agriculture is mainly a rural activity it is worth looking at the sustainability reading of rural areas.
- As the ecological functions of the rural areas become more and more important, the following values get into the forefront:

- *biological and landscape diversity,*
- *environmental protection,*
- *native species,*
- *non-industrial agriculture,*
- *landscape characters*

Multidimensional rural development

Rural development is determined by the following factors:



(Source: Patkós Cs. 2013)

Sustainability in agriculture

- To achieve sustainable goals, farmers can follow different strategies, depending on their local circumstances.
- Broadly used techniques can be the cultivation of plants that can serve as natural fertilizers, innovative crop rotation systems or drip irrigation.
- The biologically active and humus rich soil are basic criteria for successful arable land cultivation.
- The modern tillage practices are usually drastic interventions to the life of the soil.

- Using deep ploughing techniques, we mix different habitats in the soil and upset the balance in the soil, resulting in the destruction of soil life because most of the organisms in the soil cannot adapt to rapid change

No-till farming (also known as zero tillage)

- This is an agricultural technique for growing crops without disturbing the soil through tillage.
- No-till farming decreases the amount of soil erosion tillage causes in certain soils, especially in sandy and dry soils on sloping terrain.
- Other possible benefits include an increase in the amount of water that infiltrates into the soil, soil retention of organic matter, and nutrient cycling.
- These methods may increase the amount and variety of life in and on the soil.

https://youtu.be/sJCgXsT0ha4

A guide for farmers about how to reach the proper agricultural and environmental conditions

- **Created by Hungarian National Agricultural Chamber**

1. A minimal soil coverage must be kept after harvesting the Summer and Autumn crop cultures with the use of different secondary crops. Through them the ecological balance can be improved too.
2. Together with the placement of organic fertilizers, a mixing ploughing is needed.
3. In order to minimize the water loss through evaporation it is recommended to compress the soil after tillage.
4. The aim of stubble ploughing is to keep the moisture of the soil, accordingly a shallow ploughing is needed. Its other function is to stimulate the proper heat and biological balance too.
5. It is forbidden to burn stubble, reeds, plant debris, and grasslands, instead it is recommended to keep some of the plant by-products on the cultivated soil and then turn them into the soil.

Organic farming

- It is a new way of agricultural production to produce healthier products.
- In traditional agricultural production, plants must be protected from pests and plant diseases, because the consumer market prefers flawless, perfect-looking products.
- However, these may leave undegraded chemicals, which can cause various diseases and permanent damage to health for many years.
- Plant protection based on ecology and biology is the basis for healthier organic farming that produces products free of chemical residues.
- https://youtu.be/Zu0IUHc5qmM

Advantages of organic farming

- Soil building practices such as crop rotations, inter-cropping, symbiotic associations, cover crops, organic fertilizers and minimum tillage are central to organic practices
- Erosive forces is decreased,
- Soil biodiversity is increased,
- Nutrient losses are reduced,
- Helping to maintain and enhance soil productivity.
- Greatly reduce the risk of groundwater pollution
- Organic farming has many advantages as organic fruits are popular with consumers because they contain more nutrients that are important for health,
- Fruits and grapes are richer in flavonoids and other polyphenols such as resveratrol

Advantages of organic farming

- Organic agriculture contributes to mitigating the greenhouse effect and global warming through its ability to sequester carbon in the soil.
- A number of studies revealed that soil organic carbon contents under organic farming are considerably higher.
- The more organic carbon is retained in the soil, the more the mitigation potential of agriculture against climate change is higher.
- The frequent use of under-utilized species (often as rotation crops to build soil fertility) reduces erosion of agro-biodiversity, creating a healthier gene pool - the basis for future adaptation.

Risk of organic farming

- The risk of vulnerability for organically grown crops is significantly higher than for conventional non-organic crops.
- Certain plant diseases can lead to plant death if we cannot protect plants in time with chemicals allowed in organic farming.
- Higher frequency of mechanical weeding affects floral abundance in fields, and may potentially decrease the density and species richness of organisms at higher trophic levels.

Source: Röös et al., (2018)

Sustainable agriculture and energy demand

- For the sustainable agricultural production need clean, inexhaustible and more or less, continuously available energy.
- Renewable energy sources are an excellent response to this demand
- But need to increase the continuous availability of the renewable energy
- Renewable energy produced should be stored for periods when it is not available
- A life cycle assessment provides a systematic means of evaluating renewability.
- Only the clean energy source ensure the high quality yield
- By using renewable energy sources, we can protect soils from pollution
- Utilization of renewable energy sources greatly reduce the risk of surface and groundwater pollution

Energy requirements in agriculture

- are divided into two groups, being direct and indirect.
- Direct energy is required to perform various tasks related to crop production processes such as **land preparation**, **irrigation**, **harvesting**, and **transportation** of agricultural inputs and farm produce
- It is seen that direct energy is directly used on farms and on fields.
- Indirect energy consists of the energy used in the manufacture, **packing** and **transport of fertilizers**, **pesticides, seeds** and **farm machinery**.

Limitations of monoculture cultivation

- The growth in the number of plants in a piece of land and the use of more intensive producing technologies has evoked the growth of demand for irrigation water and the risk of the incidence of plant diseases.
- Consequently, the frequency of the use of insecticides has grown meaning a much bigger cost for agriculture.
- It can be concluded that the agricultural production was not economic and sustainable for a longer term in Europe.
- Because of the continuously growing production costs, profitability in many locations started to decrease to a great extent.
- For economic reasons, it is necessary to switch from extensive monoculture production to sustainable agricultural production

Current problems with the use of conventional fossil fuels

- Fuel has to be transported to the generator's location, which may be quite a distance over some challenging roads and landscape;
- Their noise and fumes can disturb livestock
- Fuel costs add up, and spills can contaminate the land
- Generators require a significant amount of maintenance and, like all mechanical systems, they break down and need replacement parts that are not always available

Advantages of solar energy system

- Generating electricity, heat or biofuels from renewable energy sources has become a high priority in the energy policy strategies at a national level as well as on a global scale.
- Solar energy is one of the renewable energy resources widely used in the agriculture sector for various applications (Gustav et al., 2008).
- No fuel cost, low running costs
- Modular nature
- Long life
- Reliability
- Low maintenance
- Clean energy, avoids greenhouse gas emissions

Photovoltaic power generation

- It is a simple fact that photovoltaic modules produce electricity only when the sun is shining, so some form of energy
- Storage is necessary to operate systems at night.
- One can store the energy as water by pumping it into a tank while the sun is shining and distributing it by gravity when it is needed after dark.
- For electrical applications at night, one will need a battery to store the energy generated during the day.
- Photovoltaic is a well-established, proven technology with a substantial international industry network
- PV systems can be much cheaper than installing power lines and step-down transformers in applications such as electric fencing, area or building lighting, and water pumping either for livestock watering or crop irrigation.

Applications for PV systems on farms, ranches

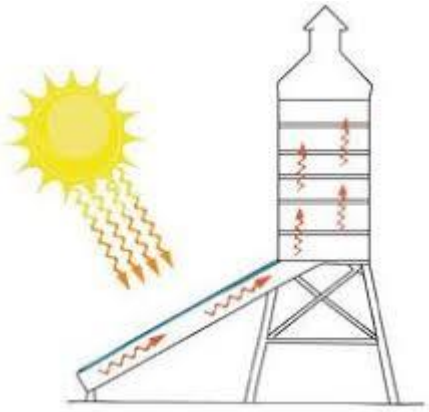
- Power for feed or product grinding
- Electric-powered egg collection and handling equipment
- Product refrigeration
- Livestock feeder and sprayer motors and controls
- Compressors and pumps for fish farming
- Electric fencing to contain livestock
- Battery charging.

Solar thermal applications

- The second most widely used application of solar energy is to produce heat, which has applications for various agricultural processes as follows:

- Drying crops and grains by simply exposing them to the heat of the sun is one of the oldest and most widely used applications of solar energy. But allowing crops to dry naturally in the field exposes them to the elements and contamination as well as birds and insects.

– Modern solar crop driers are still very simple, but also more effective and hygienic. The collector can be as simple as a glazed box with a dark-colored interior to absorb the solar energy that heats air. The heated air in the collector moves, by natural convection or a fan, up through the material to be dried.



Solar thermal applications

– Another use of solar energy for higher agricultural productivity is water heating – particularly in livestock operations. Simple solar water heaters are available to provide low to medium-temperature hot water for this purpose. A commercially available solar water heater can provide water at 60 ◦C in any amount needed.

Wind energy for agricultural applications

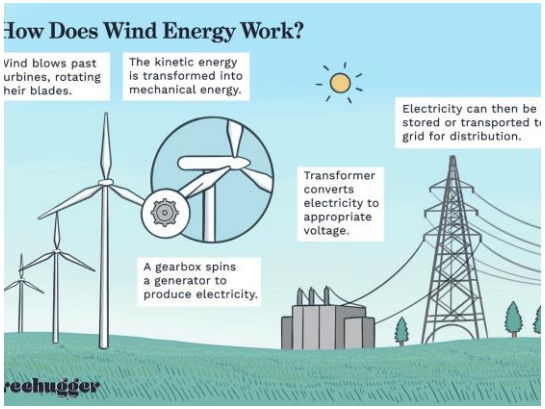
- Small wind systems can provide renewable energy for sustainable agriculture power that can be used directly or stored in batteries.
- These systems are very reliable in areas that get enough consistent wind.
- The systems can be very cost-effective and reliable for many power needs on farms and ranches.

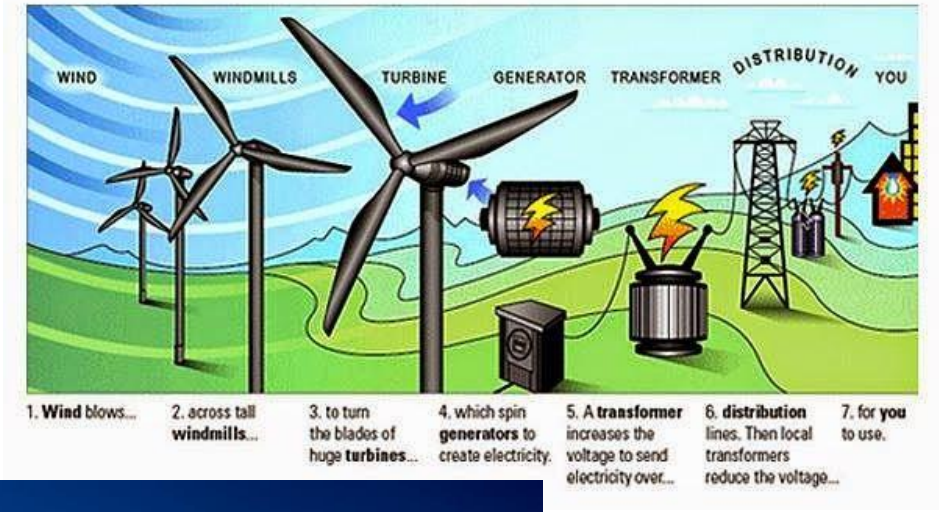
Water pumping using wind turbine

- Wind turbine has significant benefit in the areas where there is a shorter rainy season and hence demand for pumped water.
- After installing wind turbine water pumps in a farm, one can raise higher value crops throughout the year and also supply water to the livestock.
- There is the requirement of appropriate training for the local farmers to use wind turbinebased water pump irrigation.

Electricity generation from wind turbine

- The demand for electricity is growing with the increase in population, especially in rural areas which are not connected to the electrical grid.
- Therefore, provision of electricity to the remote rural communities can be made cheaply at the start from a wind power system as compared with other options





Installation of small, high-efficiency wind turbines in rural areas farms

- The cost of installing one wind turbine is close to that of putting up electrical poles, overhead power lines and other equipment necessary to connect to the electrical grid.
- The advantage is that the farm owner owns the generating equipment and is freed from paying monthly electrical bills!

Environmental impact of wind energy farming

- Wind energy farming is an environmentally-friendly option, with the following features:

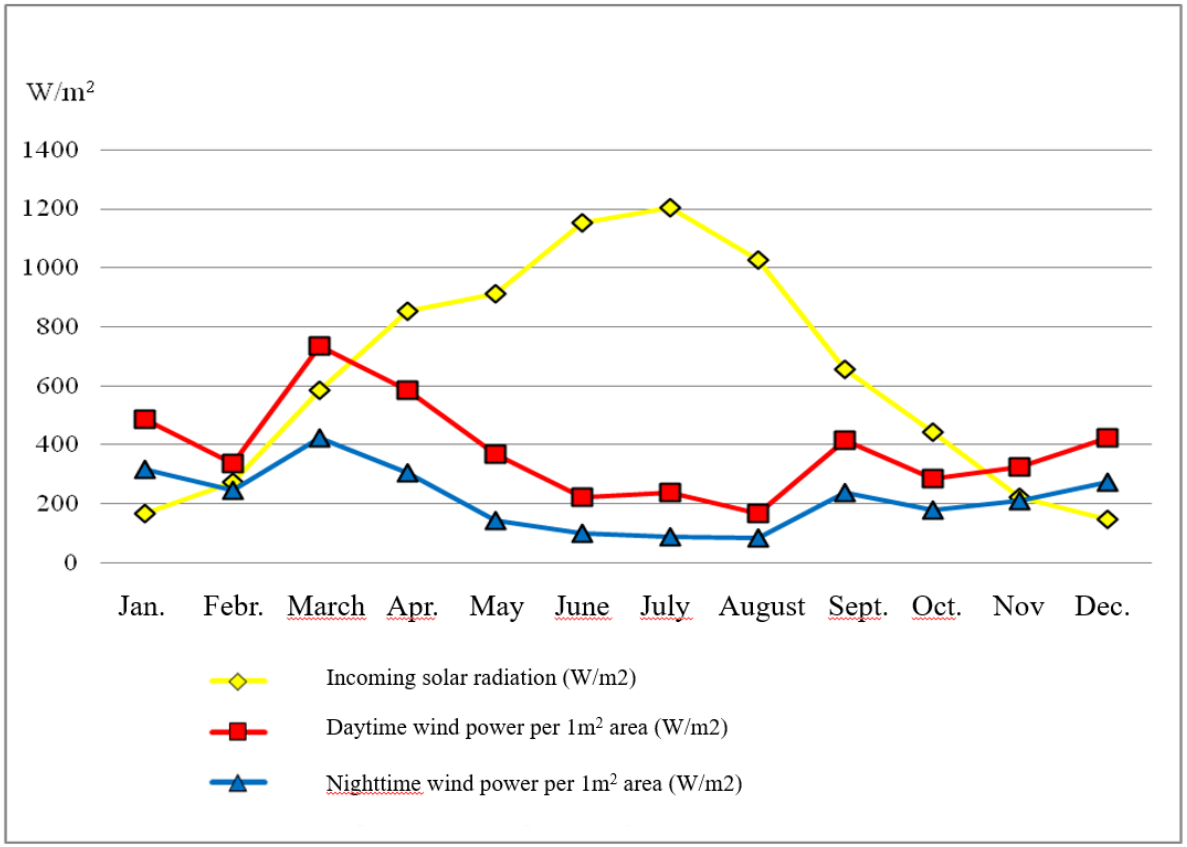
- It is pollution-free: reduces air and noise pollution;
- It does not require fuel for operation;
- It does not produce toxic or radioactive waste;
- It does not create greenhouse gases
- Reduces concentrations of CO_2, SO_2, NO_X, thereby reducing
- acid rain;
- When large arrays of wind turbines are installed on farmland, only about 2% of the land area is required for the wind turbines. The rest is available for farming, livestock, and other uses;
- Concerns about the use of wind energy due to noise pollution and the "visual pollution" of the landscape and the death of birds

Economic feasibility of wind energy farms

- For landowners and farmers, the installation of wind turbines provides additional income and increases the value of arable land.
- Operational and maintenance cost is low.
- Zero input fuel cost.
- It is domestic, reducing the need for importation of fossil fuels. This helps in reducing gas emission from transportation of fuels.

Hybrid systems: solar and wind

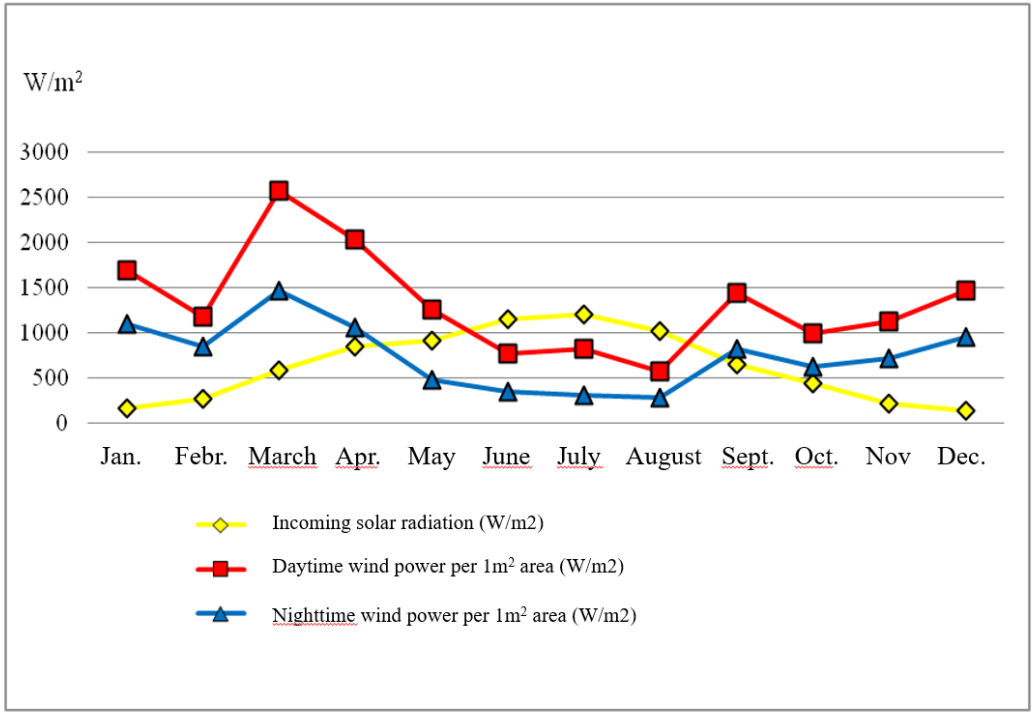
- Looking at the annual dynamics of conventional or climate-based wind speed data and solar data, we can conclude that there is an abundance of solar energy in winter and a shortage of solar energy in winter.
- The energy of the wind speed shows a summer minimum and a winter spring maximum



Annual distribution of 10m altitude wind power and solar radiation per unit area in Szolnok between 2011-2020

Hybrid systems: solar and wind

- As the wind speed increases exponentially with an altitude of 80m above the surface, the wind energy potential is significantly higher.
- At the height of wind energy production, 80 m above the surface, the amount of wind energy exceeds the amount of solar energy (per unit area) during the period from autumn to spring .



Annual distribution of 80m altitude wind power and solar radiation per unit area in Szolnok between 2011-2020

Other specific renowable energy sources

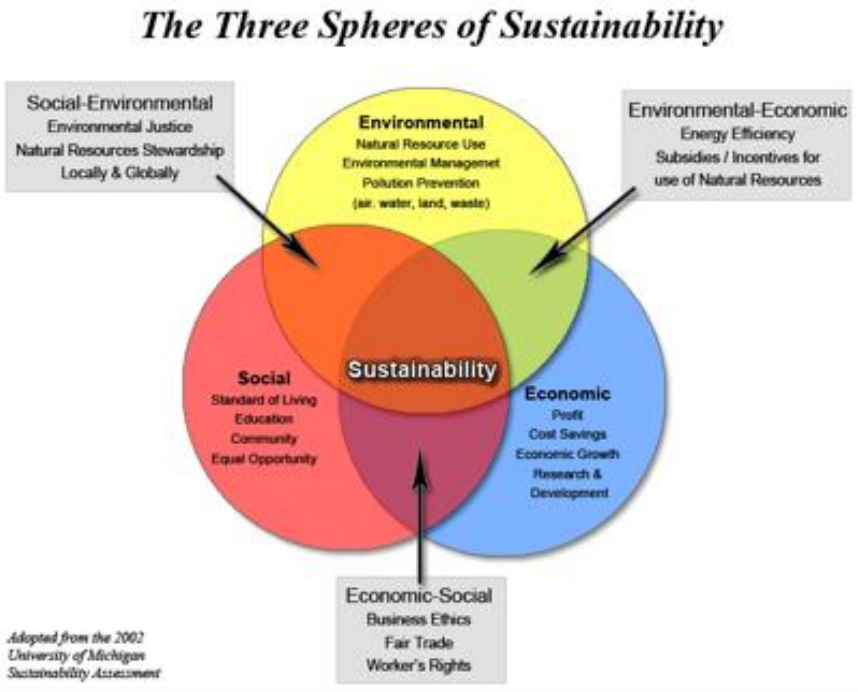
- There are specific renewable resources related to geographical location and geological conditions
- Use of these renewable energy sources may be advantageous in some countries, while in other countries they are not or only very scarce.
- Such renewable energy sources include

- geothermal energy,
- tidal energy,
- wave energy,
- biomass and
- biogas energy.

- Due to the shortness of time, I do not want to talk about these now.

How to teach sustainability? Some useful methods

- **Debate**
- Before the debate: register students' pre-debate opinion (an electronic voting system, results are announced later in the program)
- Each debater gives a 7-minute opening speech
- The moderator opens the floor for questions from the audience and inter-panel challenges
- The debaters have one final opportunity to sway audience opinion through their 2-minute closing arguments
- The audience votes again whether they are for, against, or undecided on the proposition.



Useful methods: Student Analysis of Data

- Students may learn more about a given environmental problem by wrestling with empirical data for themselves, rather than receiving pre-digested analyses from lectures or secondary sources.
- Improve skills on data collection, processing, analysis, visualization, and interpretation
- Ask good questions that can be answered through data analysis
- Let students grapple with the data to answer that question – provide students with an authentic dataset (https://datanuggets.org/tag/agriculture/, https://www.noaa.gov/education/resource-collections/data/classroom-ready, https://www.nationalgeographic.org/education/resource-library/?q=data&page=1&per_page=25&content_type_category=Activity&content_type_category=Lesson)

Useful methods: Interdisciplinarity

- A critical and thorough understanding of issues related to environmental sustainability necessarily involves contributions from a wide variety of disciplines throughout the natural sciences, social sciences, and humanities.
- This may be daunting for students and educators alike since it often requires us to think outside of our intellectual expertise.
- Doing interdisciplinarity well can be a challenge, but it becomes easier with a more effective use of resources on one's campus community and beyond, such as **team teaching with a colleague from a different discipline, organizing guest lecturers** from across campus, or **bringing in guest speakers from the local community**.
- Mostly, however, it requires a courage to step out of one's comfort zone and explore topics that will enrich the learning experience for our students and that will stimulate us to think in new ways as educators.

Useful methods: Ecological footprint estimation

- Task 1: Assess the ecological footprint of your settlement! Make a drawing of it! Think about it and discuss with your peers how big this footprint might have been 30 years ago!
- a) The concept of an ecological footprint: A value that shows human society how much land and water it needs to sustain itself and absorb the waste it produces.
- What do we measure?
  - nutrition
  - housing conditions
  - transport
  - picking
- b) How to conduct the survey?
- Share the following link with your friends from different ages and in different parts of the town, ask them to fill it out and then share their results with you. https://www.footprintcalculator.org/home/en
- c) Summarize the results, plot them on a graph, or place them on the map of the settlement! Pay attention! You can deduce the footprint of 30 years earlier from the answers of the older age group!

Useful methods: project work – community engagement

- Community engagement is incorporated into a course or series of courses by way of a project that has both learning and community action goals
- The project is designed via collaboration between faculty and community partners
- Give students experiential opportunities to learn in real world contexts and develop skills of community engagement
- Give community partners opportunities to address significant needs
- Greater satisfaction with college
- Improved graduation rates

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Thank you for your attention!