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SUSTAINABLE DEVELOPMENT OF DISADVANTAGED REGIONS BY RENEWABLE ENERGY SOURCES INTEGRATION

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Abstract. The article addresses the concept of sustainable energy development and the need to promote it, particularly in economically disadvantaged regions, to find optimal long-term solutions to conventional energy production. One of the sustainable development solutions of economically disadvantaged regions is the integration of renewable energy sources (RES) into existing energy systems. The proposed integration solutions were based on the analysis of the energy potential of a region in western Romania, a region economically disadvantaged by the closure of the mining and the thermal power plant (CET) existing in the area. The amount of energy required for installation to cover the electricity consumption of the population in the region was the basis for interpretations on the choice of RES solutions. The integration of RES in the context of sustainable development ensures the following: socio-economic development of the regions, access to energy, energy security, reduction of polluting emissions and reduction of negative health effects. The purpose of this article is to bring to the attention of the local government the importance of the energy potential of the area and the opportunity for the economic recovery of the whole region, while reducing GHG emissions

Key words: sustainable development, renewable energy, disadvantages regional, integration.
JEL code: O18, O44, Q42, Q47, Q57, R11

Introduction

Reducing energy use through efficient use of resources is currently one of the main concerns at the global level. At the same time, increasing greenhouse gas (GHG) emissions requires measures that strike a balance between protecting the environment and ensuring energy security (Vasilescu E., 2017; Zafar S., 2013; Bahnareanu C., 2010; Greenhouse Gases…, 2019). On this line, for the period 2020-2029, the EU has set maximum allowable greenhouse gas emissions for the atmosphere, which means that to ensure environmental protection and energy security - as a basic condition for sustainable development - it will be necessary to use the best available technologies, upgrading and efficient use of different renewable energy sources, gradually replacing depleting conventional resources.

For a sustainable and smart EU development, it is necessary to promote a more resource efficient, greener, more competitive economy based on knowledge and innovation and with major investment in less developed regions of the EU. In general, investments were made in Romania in urban areas, and rural localities with few households and especially disadvantaged regions did not come to the attention of the authorities (Foris D., 2018). For this reason, for Romania, the basic objective of regional development should be to reduce existing regional imbalances, by stimulating balanced development, by recovering delays in the development of disadvantaged areas due to various economic and geographical conditions, and by preventing new imbalances.

The integration of RES can contribute to the economic recovery of disadvantaged regions as a result of the industrial decline in Romania. The use of renewable energy potential through the local adoption of small-scale energy systems close to the place of consumption contributes significantly to the reduction of losses in transport networks as a solution for long-term economic recovery. The

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ways of integrating and optimizing solutions open the way to research for many years to come, as the development and integration of small-scale RESs facilitates access to energy for the underprivileged population. Local economies can be configured so that the energy potential is a means of economic recovery and improvement of the quality of life by reducing GES emissions. Access to energy is a key element when talking about the sustainable development of economically disadvantaged areas because they are vulnerable to rising fossil fuel prices. By developing and integrating small-scale RES, investment is encouraged, which has a direct effect on the living conditions of the population while ensuring the region's energy independence. Until recently economic growth could be quantified by increasing energy consumption and the amount of polluting emissions, the economic recovery is based on renewable energy. The model of the three pillars, Economy-Ecology-Society, provides a schematic classification of the sustainable development objectives (Bruckner T., 2014). The use of RES can contribute to sustainable development following the 3 pillar model as RES is the natural environment and the use of these resources does not reduce the possibilities for use.

As arguments for the use of small to large SREs can be retained: the possibility of increasing energy demand for the final consumer and balancing the energy price even as the primary resource wall grows.

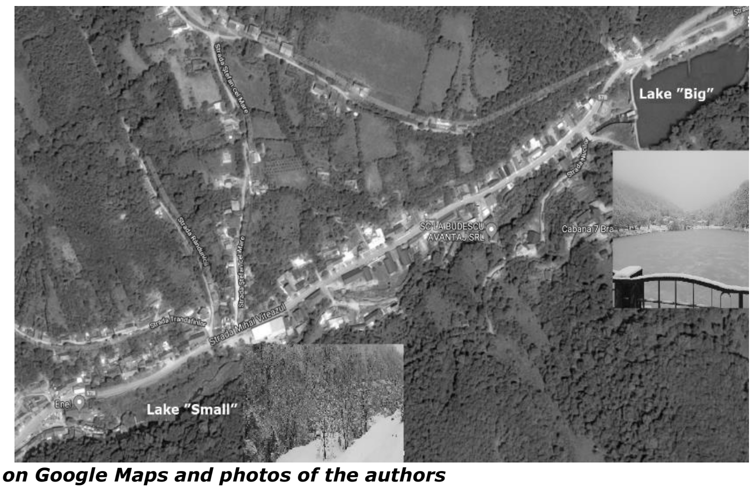
Analysise of the local context by assessing the energy potential of the disadvantaged region

Oravita is a small city in western Romania that is part of a mining region with a tradition of exploiting uranium, coal and gold, currently economically disadvantaged.

This paper presents an assessment of the renewable potential in the area to determine whether renewable energy production can cover the entire electricity consumption of the Oravita population and ensure an economic recovery of the region. The method of selecting new technologies and renewable energies was based on the analysis and synthesis of climatic parameters (solar radiation, wind speed, temperature, etc.).

- **Hydro potential**

Upstream of Oravita, on the Oravita Valley, there are two artificial lakes witch is presented in Fig. 1 (The Storage…, 2019).



Source: image based on Google Maps and photos of the authors

Fig. 1. **Oravita Valley**

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Lake "Big", located at an altitude of 315 m, has a length of 230 m, width of 120 m, area of 1,4 ha a reception area of 9km^2 and a volume of 133300 mc. The dam has a height of 13.4 m, and in the rest the maximum depth is 4 m due to the high degree of clogging.

Lake "Small" located at an altitude of 285 m, about 800 m downstream of the lake, has a length of 145 m, width of 70 m, area of 0,2 ha, reception area of 10 km2 and a volume of 43000 mc. The height of the dam is approx. 9.6 m.

The two artificial lakes were set up between 1700 and 1750 for the purpose of watering the city and the local industry, regulating the transit of the floods, ensuring a flow of service to the gullies, ensuring the water flow of a thermal power station, but also for recreation. At present, the role of the large lake is only to regulate the transit of the floods and recreation. The small lake due to the fact that the dam is in an advanced degradation state with significant infiltration and a 99 % lagging of the ladle is inoperative.

- **Solar potential**

Taking into account the EU targets, Romania set a target power of 260MW by 2020 through the implementation of photovoltaic with an installed power of about 6MW each. The implementation of photovoltaic plants can lead to a reduction in CO_2 emissions of about 1.5 % (Iacobescu F., 2012).

For this reason, a simulation of the solar potential for the interpretation of solar radiation was performed for the analysed region. Radiation is the propagation of particles or waves, a distinction has to be made between short wave solar radiation and long-wave terrestrial. The lower the wave length, the higher the energy transported. Visible light is part of short wave radiation.

The radiation is differentiated into:

- Global radiation (shortwave downwards (KW ↓))
- Direct and diffuse (scattered) radiation
- Reflection of shortwave radiation (shortwave upwards (KW ↑))
- Terrestrial Radiation (longwave upwards (LW ↑))
- Atmospheric counter radiation (longwave downwards (LW ↓) - also called greenhouse effect)

The global radiation simulation for Oravita was conducted - for a week (31.01.2019-07.02.2019) using Meteoblue (Meteoblue…, 2019) which uses data from around 200 measuring stations distributed around the world. Meteoblue models are meteorological services that provide graphical predictions on global radiation and wind speed based on NMM technology (Nonhydrostatic Meso-Scale Modeling). Meteoblue provides the hourly solar radiation prognosis and compares the seasonal distribution of PV system yield for different tilt angles, so PV power generation management can be optimized.

In Fig. 2, the outdoor temperature variation [°C] for the year 2018 and information on solar radiation through comparative graphs are represented for Oravita between 2017, 2018 and the first period of 2019 reported at year dd 1985 (Meteoblue…, 2019), information that is needed to establish solutions for the integration of PV systems into the national energy system. The year 1985 was chosen as the reference year because the lowest average temperature (8.4 °C) was recorded this year (The climate..., 2018). The study is limited to the first week of February because during this period there are low temperatures and high relative humidity.

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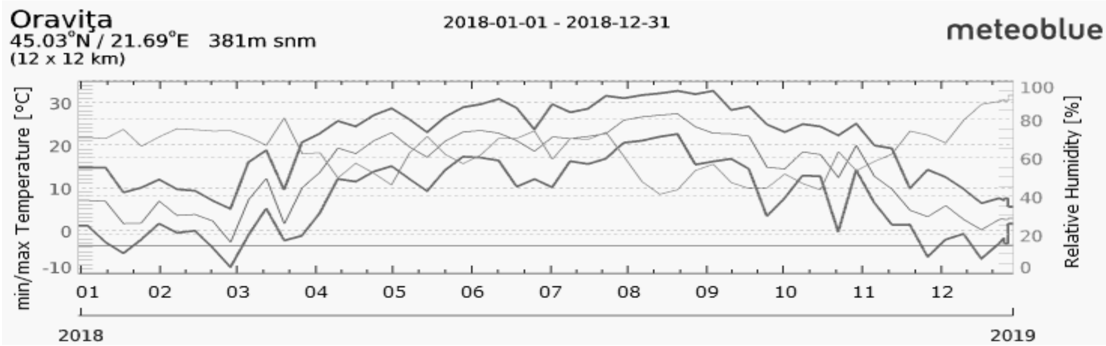
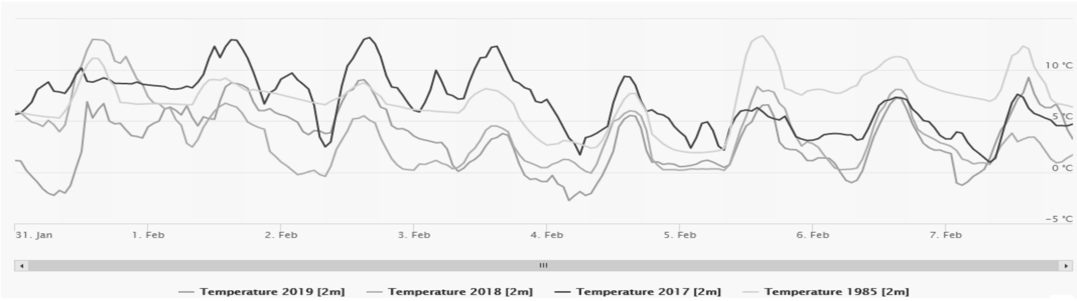


a)



b)

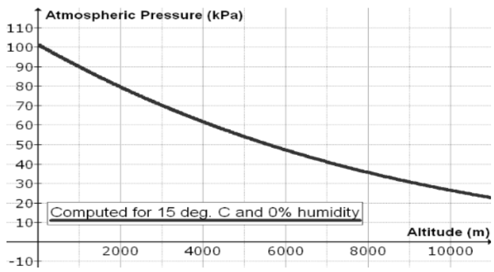
a) The variation of the outdoor temperature in 2018;
b) The comparative variation in outdoor temperature in the first week of February vs. To the year 1985;
Source: simulations of the authors based on Meteoblue weather

Fig. 2. **The variation of outdoor temperature and solar radiation in Oravita**

- **Wind potential**

In order to evaluate the wind potential of Oravita, the wind speed was simulated for the same period because wind energy can compensate for the lack of energy generated by the su- using meteoblue (Meteoblue…, 2019). Thus, with Meteoblue based on seasonal climatic models, the climatic diagrams of Oravita were made. Based on these can be estimated, wind conditions depending on the wind direction, average wind speed, or can be appreciated the risk of freezing the blades of wind farms.

The atmospheric pressure varies with altitude - as the altitude increases - atmospheric pressure decreases. Figure 3 shows the variation of atmospheric pressure with altitude, calculated at 15 ° C and 0 % relative humidity (Portland State..., 2004).



Source: Portland State Aerospace Society, 2004

Fig. 3. **Atmospheric Pressure vs. Altitude**

In order to have a clear picture of the evolution of the wind velocity according to the atmospheric temperature, in Fig. 4 (Meteoblue…, 2019), it was graphically represented the variation of the wind speed and the direction of action.

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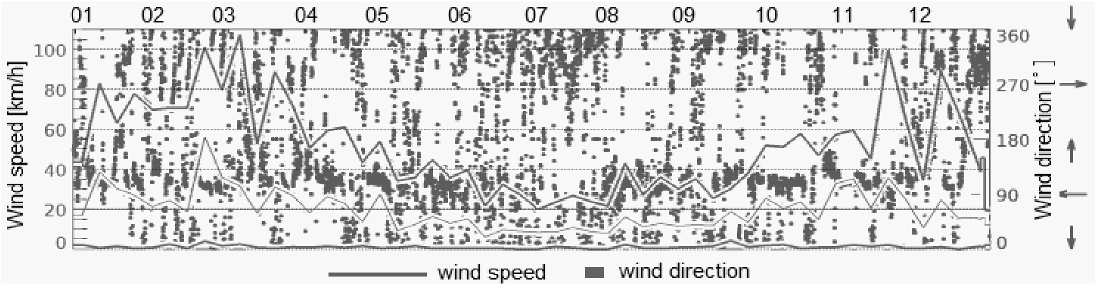

Source: simulations of the authors based on Meteoblue weather

Fig. 4. **The wind speed variation in Oravita during 2018**

From the Fig. 5 analysis , it can be noticed that the greatest variations of the wind speed are recorded during the winter - spring period. This confirms the influence of atmospheric temperature on local winds. Because the normal atmospheric pressure is 1013.25 mb (760mmHg), the simulations were performed at an altitude of 10m and 80m respectively, which were, however supplemented also by bad weather conditions (900 mb) and are rendered in Fig. 5.

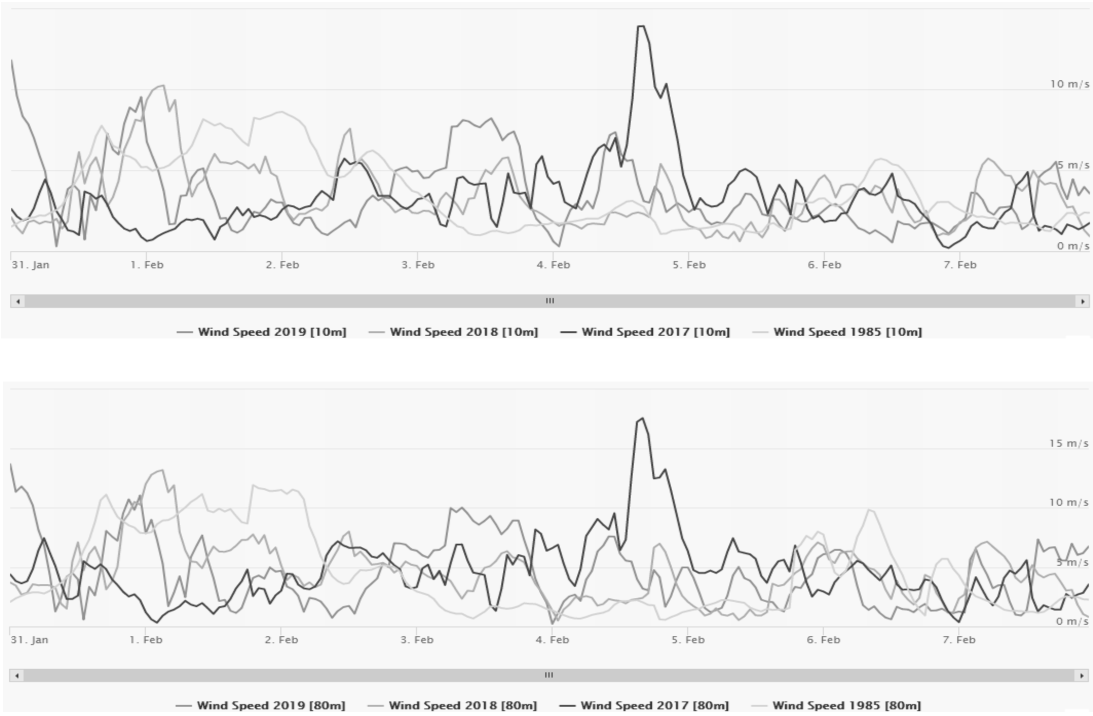

Fig. 5. **The wind speed variation in Oravita at different altitudes**

Solutions to integrate renewable sources: discussion

The predominantly prevalent relief of the analysed region is made up of an alternative of hills and plains, with the town of Oravita being located at the intersection between the land and the hill. The extended areas and the wind and solar potential exemplified in Fig. 3 and Fig. 6 of the region, provide conditions favourable to the development of RES investments. The rich hydrographic network, complemented by the two artificial lakes (Fig. 1), is also worth mentioning. On the other hand, the instability of the renewable energy sources is an essential inconvenient, as illustrated in Fig. 2 and Fig. 5. In times of frost, as in the case of heat, where the demand for energy is very high (heating and air conditioning respectively), the effect of wind / sun is virtually non-existent, which means interconnecting systems with renewable sources in order to achieve a balance in operation, or integration of electrical energy storage systems.

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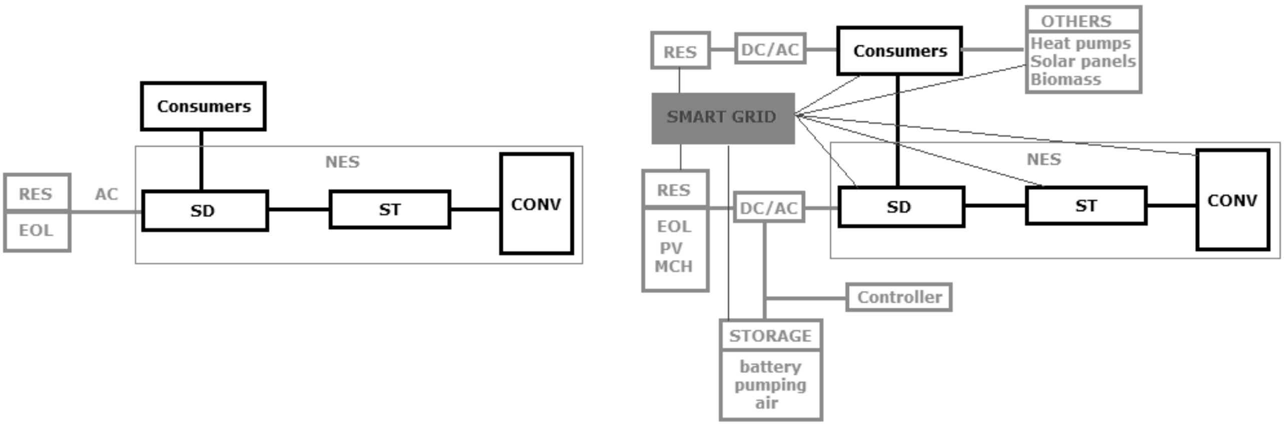
Smart Grid energy grids represent a doubling of the grid by a computer network that connects operators on the electricity market, significantly improving the way the user's power supply process works, while ensuring real-time interaction between operators from the entire production, transport, distribution, supply and use chain.

For the analysed region, given that it has both considerable solar and wind potential, smart grids are not a revolution but a necessity to meet users' needs. There is a wind farm in the region with an installed capacity of 9 MW, but when there is No need to deliver energy to the NPS, there is No energy storage and therefore the park either does not produce energy or produces less capacity. Considering that the electricity cannot be stored directly, it is necessary to convert it into other forms of energy, in Oravita the storage solution can be solved by mechanical storage, namely the storage of energy by pumping water into the two existing lakes, storage in batteries of batteries (at the level of consumers / domestic producers). Considering that there are decommissioned / unused mining galleries in the region, another solution for energy storage could be the use of the potential energy of compressed air injected into the difference between the structure of the classical electric power system (existing in the region) and the structure of the intelligent network proposed for Oravita is illustrated in Fig. 6.



a) b)

a) Existent; b) Proposed

Fig. 6. **Energy system existing vs. proposed**

RES - Renewable energy sources; EOL - Wind energy; PV - Photovoltaic energy, MCH – Microhydro plants; AC - Alternative current; DC - Continuous current; SD - Distribution system; ST - Transportation system; CONV - Conventional energy source; NES - National energy system

In order to assess the economic recovery of the region, the possibility of covering the energy demand from RES for all consumers was analysed. Thus, the consumption of energy for the existing consumers in Oravita (public institutions, local economic agents and domestic consumers) was registered in 2018.

Tab. 1 shows the values for energy consumption and the possible values recorded from RES (solar, wind and hydro) integrated in a network with mechanical storage (batteries, pumping, compressed air).

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Table 1

Energetic situation existing vs. proposed about RSE

No	**Situation**	**Installed power RSE [MW]**				**Storage [MW]**	**Consumption [MW]**	
		Wind energy	Solar energy		Hydro energy		**Total consumption**	**Public consumption**
			Domestic	Farm				
1.	Existing	9	-	-	-	NO	2.42	0.39
2.	Proposed	24,5	8,89	2	0,5	YES		

Source: author's calculations based on monitoring and simulation

Even if in the existing situation, the power installed in RES represents 372 % of the power consumed by the city, we appreciate that the energy potential can lead to the economic recovery and the improvement of the living conditions of the population.

In 2010, the technical documentation for the expansion of the existing wind farm with 12.5MW was developed, which demonstrates, in addition, the existence of the wind potential in the area (Garbacea A., 2011).

The wind potential can also be exploited by building a wind farm of 12MW on the hill between Oravita and Ciclova. The park can be connected to the LEA 110kV high-voltage power line Oravita-Crivina. In this area, in 2012, the wind speed was monitored by installing monitoring devices on an anemometric pole at a height of 60m. Following the recording of the measured values a wind constant in SE direction was established. Therefore, the wind potential of the area can be redeemed by producing 24.5MW of electricity (12.5MW demonstrated through technical documentation in 2010 and 12MW analysed in the proposed article). Analysing the situation of the existing land in the vicinity of the electric power lines, Oravita has communal land with a surface of more than 5ha suiTable for the construction of a photovoltaic park with an installed power of 2MW that can be connected to the medium voltage line LEA 20kV Oravita 1.

Therefore, the energy that can be produced by exploiting photovoltaic and wind farms is 26.5MW.

Since the city of Oravita is not connected to the natural gas distribution system (SD), space heating is predominantly local (with firewood), which is a major discomfort for the inhabitants of the ''Zona Garii'' where there are 105 blocks of flats with 2100 apartments. The proposed solution to improve living standards involves the rebuilding of district heating systems fueled by RES, redesigning and rehabilitation of district heating systems using liquid fuels As most of the housing blocks have a circular terraced roof, the installation and orientation of the solar panels is affordable. Approximately 0.8MWp can be installed on approximately 23000mp, which at 1500kWh / m^2 / year of radiation can produce approximately 0.97MWh / year the equivalent of 0.083Tep reducing CO_2 emissions by 969kg/an.

Also on the roofs of the 2698 individual buildings that can be rehabilitated through the "Green House" program 2019 (National Environmental..., 2019) can theoretically install 8.09MWp. In fact, for a correct assessment of the applicability of the "Green House 2019" program in Oravita, it is necessary to carry out a study on the orientation, the surface and the structure of the roofs.

The analysis of the region's renewable potential shows that the proposed options are possible and viable for the economic recovery of the region.

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Conclusions, proposals, recommendations

1) Large scale RES use contributes to reducing GHG.
2) The general inconvenience of the instability of renewable sources can be eliminated by interconnecting RES systems and storage systems.
3) SmartGrid networks ensure the correct and reasonable integration of RES by integrating the generation, distribution and transmission network. In addition, it can improve the demand management function to achieve the ability to interact effectively with consumers.
4) Efficiency and upgrading of electricity grids to respond to increased demand for energy and changes in energy sources leads to improved economic benefits and is a solution for the economic recovery of disadvantaged regions.
5) In the near future, Electrical Energy Storage (ESS) technologies can facilitate other non-electrical energy uses such as transport and heat generation.
6) As per Renewable Energy Percentages must will continue to grow, smart grid technologies in combination with adequate storage technology, policy support and regulation will essentially be to create network infrastructure to sustain a sustainable future.
7) Energy storage technologies have the ability to add flexibility, control and demonstrate the generation of back-up to the power grid. This is the critical link between supply chains and demand. It is a key element in increasing the role of generating renewable energy in the electricity grid.

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