Redemption of the lands occupied by the photovoltaic panels in the agricultural circuit

Redarea terenurilor ocupate de panourile fotovoltaice în circuitul agricol

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Abstract. *Nuclear energy is a source of energy that can restore large areas of land in favor of agricultural exploitation. Also, by means of nuclear energy, the required energy for the sanitation and arrangement of unexploitable land surfaces and for feeding irrigation systems can be ensured. The article makes a comparative study between renewable technologies (nuclear, wind and photovoltaic) addressing both classical high-power (LR) and small-scale systems (SMRs) located in electrical energy consumption centres. The study highlights the advantages of nuclear energy in terms of land use, agricultural production, impact on wildlife and finally the possibility of cogeneration.*

Key words: nuclear energy, RES, agricultural surfaces, thermal island

1. Introduction

Nuclear energy is relatively one of the most cost-effective and reliable energies compared to other sources. Apart from the initial cost of construction, the cost of generating electrical energy is cheaper and more sustainable than other forms of energy such as oil, coal and gas. One of the additional benefits of nuclear power is that it involves minimal risk of cost inflation compared to traditional energy sources that fluctuate regularly over periods [1]. Nuclear fission generates much more energy than fossil fuels such as coal, oil or gas. The process produces nearly 8,000 times more energy than regular fossil fuels, resulting in fewer materials used and causing less waste [1].

Nuclear energy is the lowest carbon source of energy with a lower carbon footprint than other sources such as fossil fuels [1, 2].

A typical 1,000 MW nuclear power plant (NPP) has an average need of 34 ha to operate, while for the same installed power wind systems occupy 24 ha and solar systems 92 ha, according to the Nuclear Energy Institute (NEI) [3].

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Although fossil fuels are non-renewable and have high CO_2 emissions, they are still used in the production of glass, cement and pottery, as well as in medicines such as aspirin [1].

Considering these reasons, it is important to conserve fossil fuels by using them as sparingly as possible and finding alternative sources of energy to perform some of the functions that we currently rely upon fossil fuels to perform [1].

2. Comparative study between renewable energy sources (nuclear, wind and photovoltaic)

Analysing the share of electrical energy consumption in Romania (Fig. 1) as a result of efficiency measures, there is a slight decrease in electrical energy consumption in the residential sector, services and industry, as well as a slight increase in agriculture and transport [4].

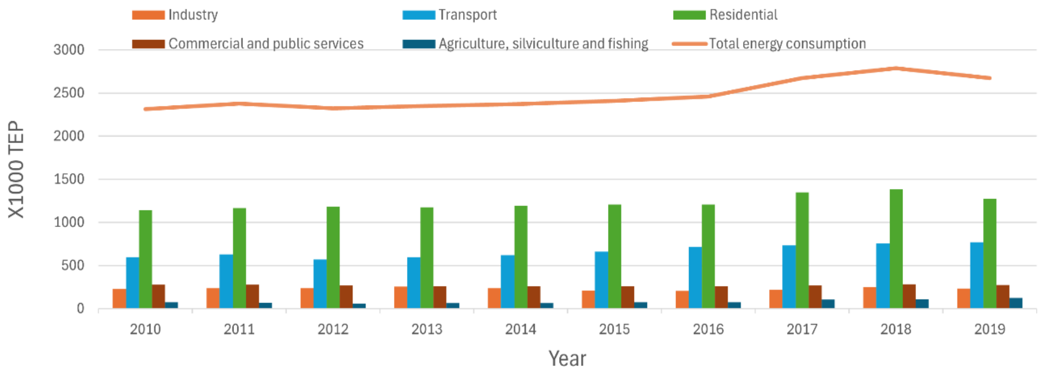


Fig. 1. Share of electrical energy consumption in Romania by sectors of activity [4]

On the other hand, the directive of the European Court of Auditors provides for the installation of 1,000,000 charging stations for electric vehicles by 2025 [5], which will put immense pressure on the Energy System (ES) of the European Union, forcing Member States to rethink their own ES. Analysing the share of energy sources participating in electrical energy production in Romania, 1/3 represents fossil fuels and 2/3 are renewable energy sources (RES) (Fig. 2) [6].

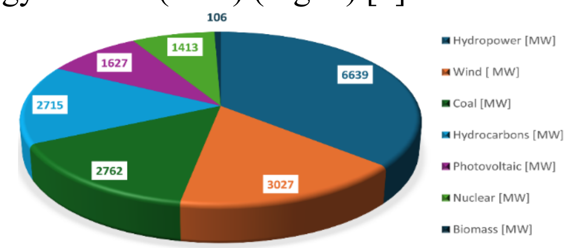
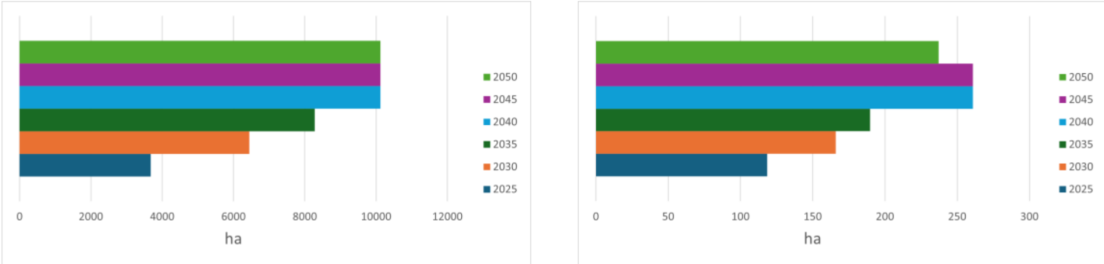


Fig. 2. Electrical energy production in Romania [6]

Romania's proposed targets for reducing greenhouse gas emissions consider three scenarios [7].

The baseline scenario for moving away from fossil fuels by 2050 calls for increasing solar and wind capacity to around 20% of the energy mix, with 27% hydrogen deployment by 2040, with a target of 30% by 2050 [7].

These commitments involve occupying large areas of agricultural land (Fig. 3, 4, 5) [7].



a) b)

Fig. 3. Land areas occupied by RES in the Baseline scenario. a) Solar, b) Wind [7]

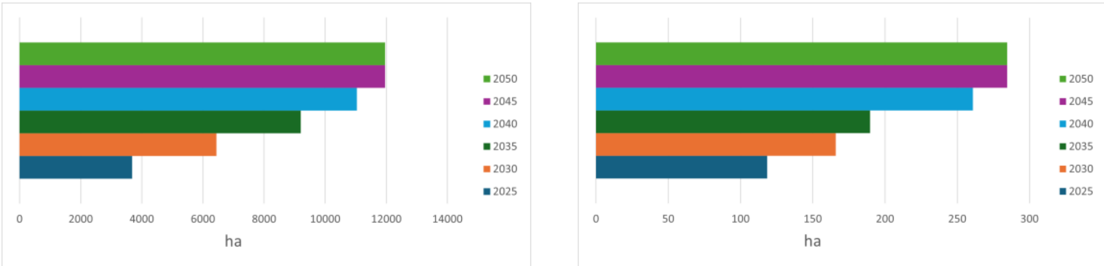


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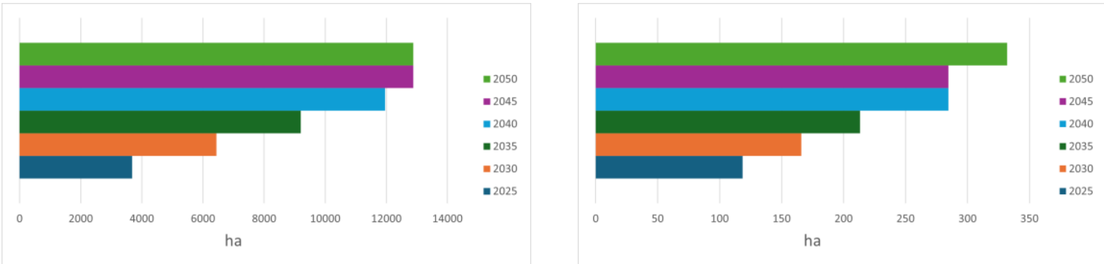
Fig. 4. Land areas occupied by RES in the Medium scenario. a) Solar, b) Wind [7]



a) b)

Fig. 5. Land areas occupied by RES in the RO Neutral scenario
a) Solar, b) Wind [7]

In opposition, the fluctuating nature of solar and wind energy forces us to consider a possible alternative to them (Fig. 6) [8].

According to data recorded since 1 January to 20 March 2024, spring equinox, nuclear energy is found to be a source capable of ensuring the stable operation of the National Energy System (NES) (Fig. 6) [8].

At this moment, there are 2 functional nuclear reactors at Cernavodă (Fig. 7). By building 1 to 4 new nuclear reactors (Fig. 8, 9, 10, 11) in the system, Romania could substitute the production of electrical energy from wind (W), photovoltaic (P), coal (C) and hydrocarbons (H) together. This would lead to the unlocking of large areas of arable land [8].

Consequently, Romania should accelerate the construction works of new nuclear reactors at Cernavodă, following the example of Sweden [9, 10, 11, 12].

Another strong point of opting for the construction of additional nuclear reactors in Romania would be the fact that raw materials are no longer used for the storage of photovoltaic energy, as a result there is no more electrotechnical waste. On the other hand, ways of neutralizing radioactive waste must be considered [8].

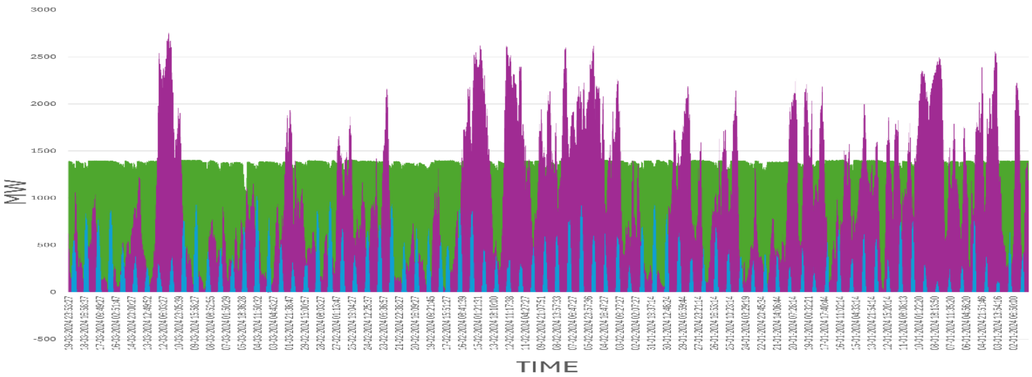


Fig. 6. RES (N, W, P) [8]

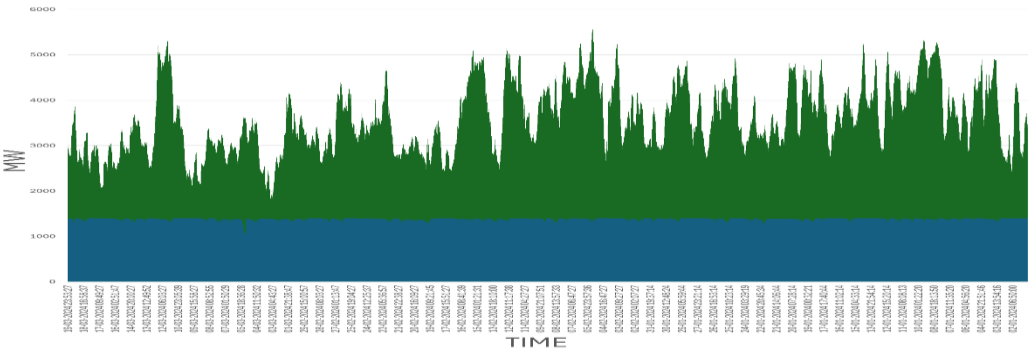


Fig. 7. Nuclear energy (2 reactors) compared to W, P, C and H together [8]

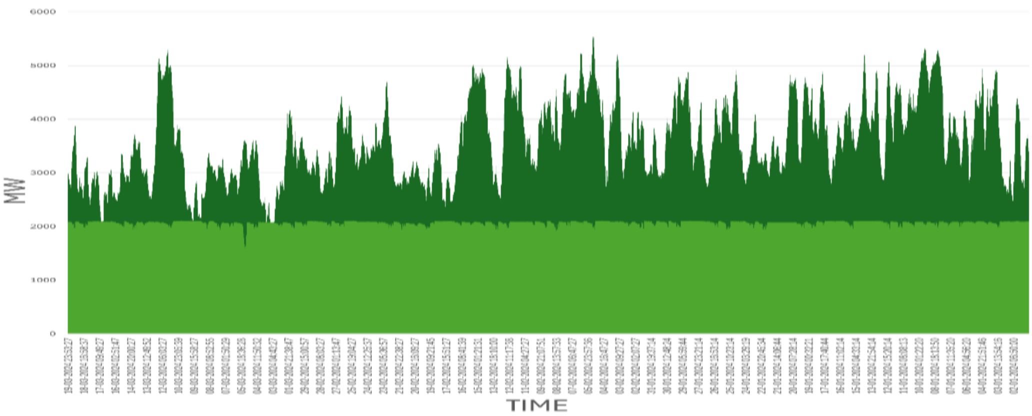


Fig. 8. Nuclear energy (3 reactors) compared to W, P, C and H together [8]

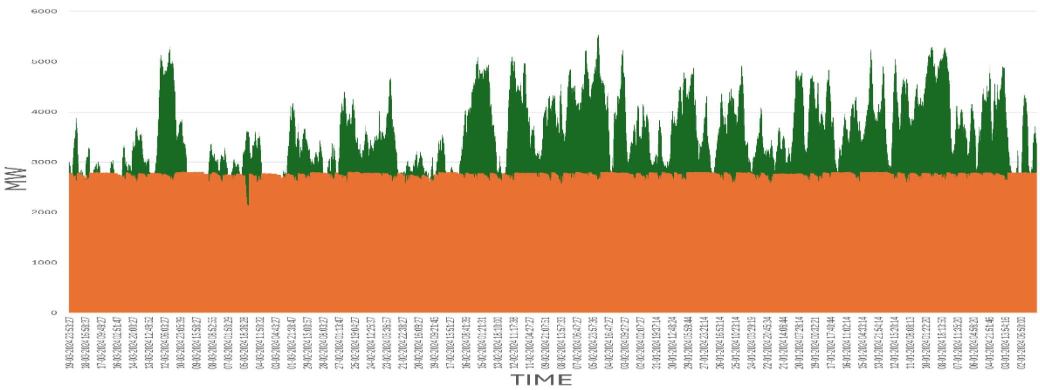


Fig. 9. Nuclear energy (4 reactors) compared to W, P, C and H together [8]

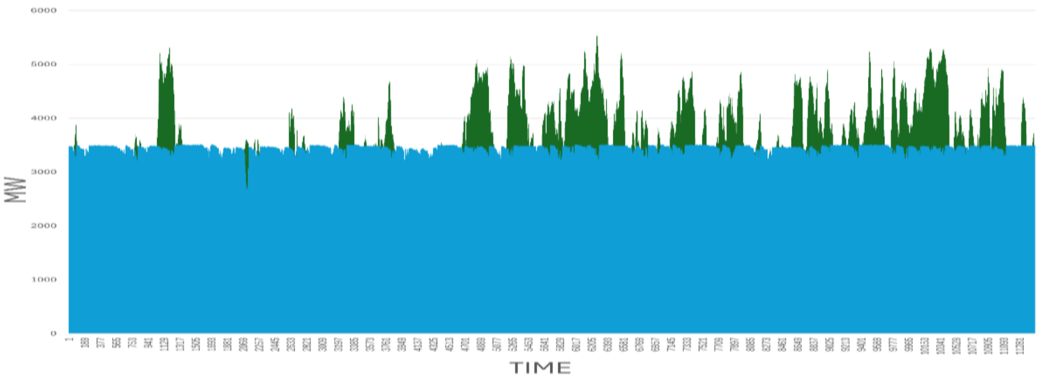


Fig. 10. Nuclear energy (5 reactors) compared to W, P, C and H together [8]

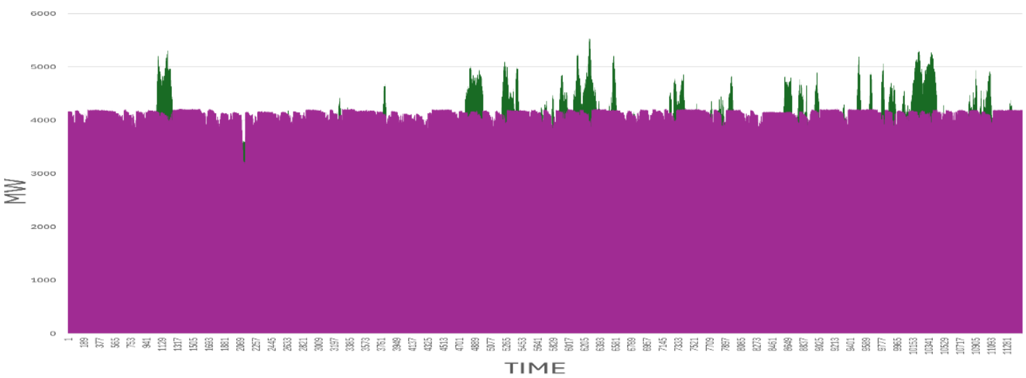


Fig. 11. Nuclear energy (6 reactors) compared to W, P, C and H together [8]

Analysing the variable character of RES, photovoltaic and wind (Fig. 6), the land areas occupied in Romania (Table 1) can assess the negative impact that these constructions have on the environment [6].

Table 1

Installed power and occupied area of RES [6]

Production type	Installed power	Occupied area
	[MW]	[ha]
Nuclear	1413	47.62
Wind	3027	71.73
Solar	1627	1496.84

It is known that during migration birds do not notice the rotational movement of the blades, producing a real carnage, and supporting photovoltaic panels requires special constructions [13].

Another aspect that should not be neglected is the thermal island effect due both to the high temperature under photovoltaic panels and to the fact that solar radiation is largely reflected from their surface (Fig. 12) [13].

Fig. 12. Resistance structures of photovoltaic panels [13]

Ensuring energy needs and achieving the targets assumed by the strategy can be achieved using nuclear energy.

The principle of electrical energy generation (Fig. 13) in NPPs is like that in thermal power plants (TPPs). The large amount of electrical energy and heat produced by NPPs, no greenhouse gas emissions, low footprint and low operating cost, recommend these systems in the energy mix [12].

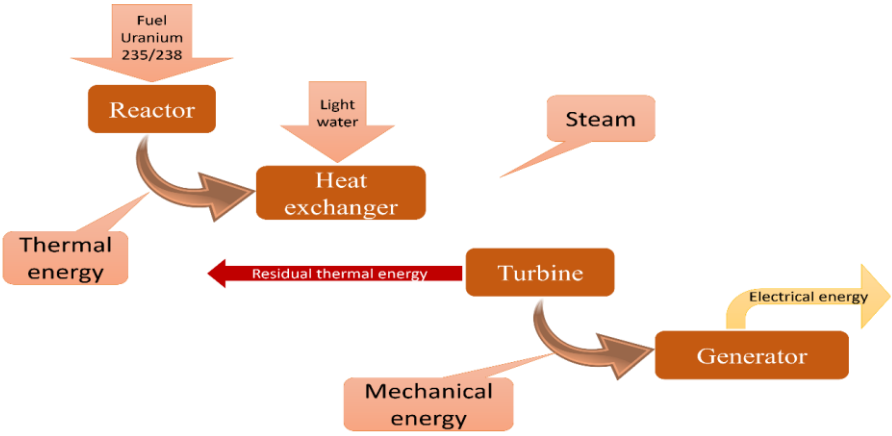


Fig. 13. Block diagram of a NPP [12]

There are 32 countries in the world that have NPPs and 4 of these: France, Slovakia, Ukraine and Belgium use nuclear energy as the primary source for electrical energy production [14]. The installed power in Romania is very small in comparison to other states, representing 0.59% (Table 2) of the installed power in the world [6].

Table 2

Technical characteristics of Cernavoda NPP Units 1 & 2 [15]

Reactor	Technology	Electrical power [MWe]	Thermal power [MWt]
Cernavoda-1	CANDU-6	706.5	2071
Cernavoda-2	CANDU-6	706.5	2071

Even though there have been a few major accidents (Fukushima, Japan in 2011, Chernobyl, Ukraine in 1986, and Three Mile Island, USA in 1979), nuclear technology is increasingly mature. Despite the known advantages, NPPs has the disadvantage of disposable radioactive waste and the imposition of safety and vulnerability restrictions to terrorist attacks. By analysing the targets in the strategy and the estimated production per hectare for different agricultural crops, the quantity not realized due to land occupation by dispatchable photovoltaic and wind systems was calculated (Fig. 14, 15, 16, 17, 18, 19) [7].

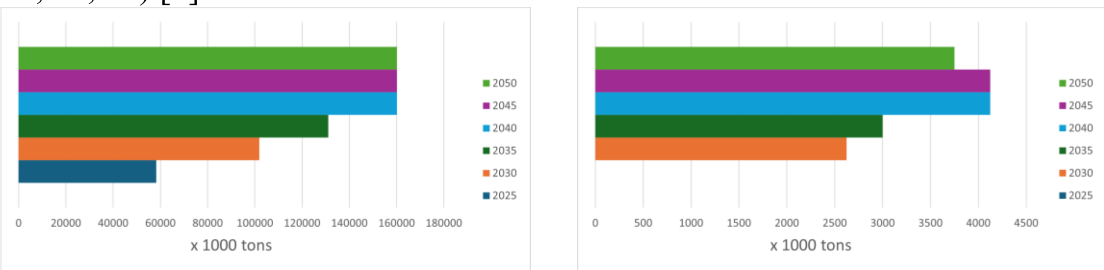


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Fig. 14. Quantities of agricultural products (potatoes) not realized as a result of land occupation by RES systems in the Baseline scenario. a) Solar, b) Wind [7]

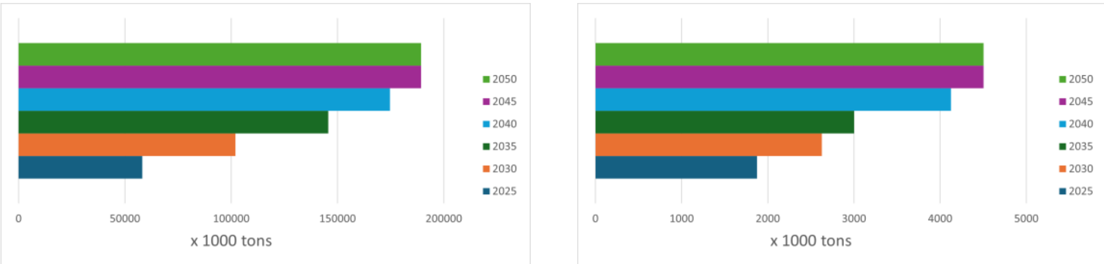

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Fig. 15. Quantities of agricultural products (potatoes) not realized as a result of land occupation by RES systems in the Medium scenario. a) Solar, b) Wind [7]

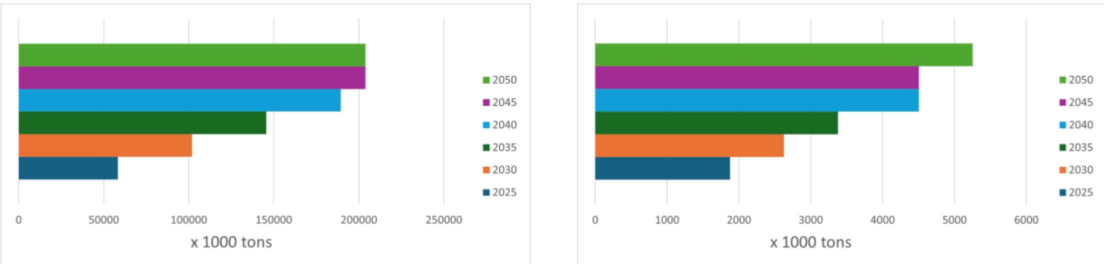

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Fig. 16. Quantities of agricultural products (potatoes) not realized as a result of land occupation by RES systems in the RO Neutral scenario. a) Solar, b) Wind [7]

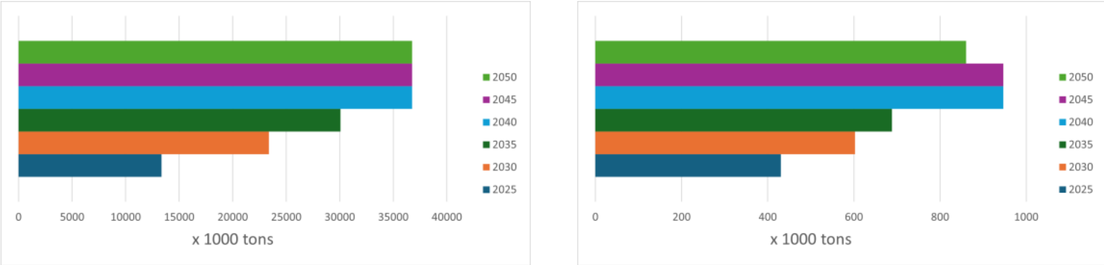

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Fig. 17. Quantities of agricultural products (cereals) not realized as a result of land occupation by RES systems in the Baseline scenario. a) Solar, b) Wind [7]

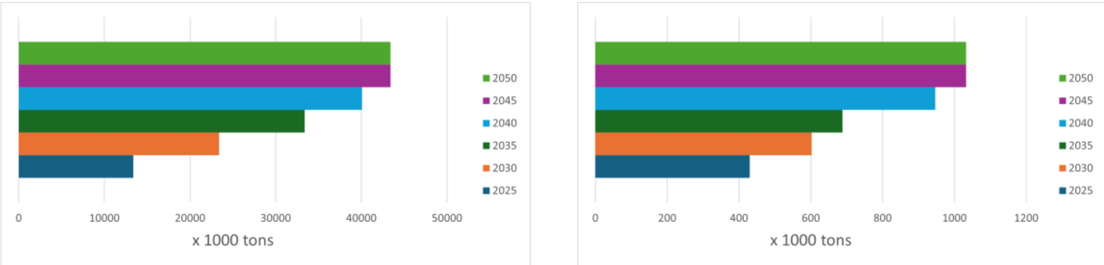

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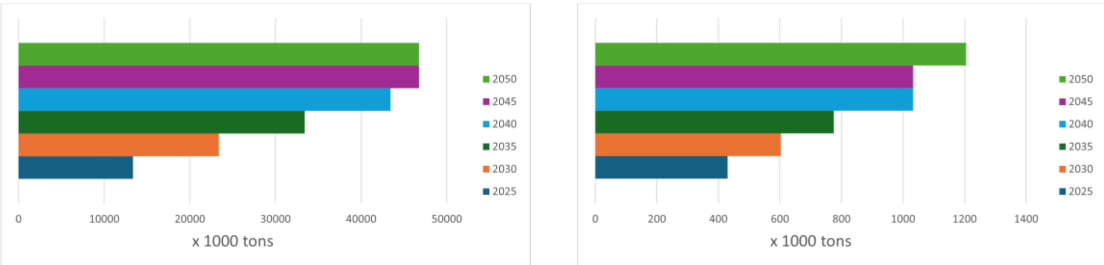
Fig. 18. Quantities of agricultural products (cereals) not realized as a result of land occupation by RES systems in the Medium scenario. a) Solar, b) Wind [7]



a) b)

Fig. 19. Quantities of agricultural products (cereals) not realized as a result of land occupation by RES systems in the RO Neutral scenario. a) Solar, b) Wind [7]

An emerging energy technology is small modular nuclear reactors (SMRs) suitable for areas with limited capacities and dispersed populations.

Small and medium-sized reactors, as defined by the International Atomic Energy Agency (IAEA), have installed capacities of up to 300 MWe compared to classical NPPs which have installed capacities bigger than 700 MWe [16].

SMRs differ from NPPs both by size and modularity in terms of design, installation and low fuel requirements. SMRs require less frequent refuelling, every 3 to 7 years, in comparison to between 1 and 2 years for NPPs. Some SMRs are designed to operate for up to 30 years without refuelling [16].

Furthermore, the storage of radioactive waste, the possibility of underground installation and finally the way of recovering waste thermal energy (cogeneration) represent the advantages of SMRs as opposed to conventional NPPs [16].

SMRs can be said to be a solution to eradicating energy poverty [13], as the technology is known and used in transport, medical, district heating and desalination [16]. SMRs can be appreciated as a solution for developing economies [13].

3. Conclusions

The growing need for electrical energy, but especially the achievement of the targets assumed by European countries, is not possible without the development of stable sources capable of generating large amounts of energy.

The "unloading" of transmission networks and the decentralization of electrical energy generation sources without increasing CO_2 emissions, the provision of thermal energy from reactor cooling water (technological residue) recommends SMRs as an alternative source to fossil fuels.

Even if the benefits obtained are firm, the need to ensure an emergency planning zone (EPZ) determines the implementation of specific preparation procedures and implicitly leads to increased production costs.

Although operational safety is enhanced by underground installation of this equipment in areas with low population density, public opinion is still sceptical about these systems.

This comparative study between RES (N, W, F) presents a possible solution in the future for increasing electrical energy production capacities to a low degree of land occupancy and with low CO_2 emissions, proposes even the notion of "prosumer" of electrical energy and heat.

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