Wind energy and environment

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Abstract

For mankind to be able to continue life at a high level of comfort and satisfaction, first of all it is necessary to provide a significant amount of energy. Electrical and mechanical energy as well as thermal energy in the form of heat or domestic hot water over 75% is ensured by combustion of fossil fuels, which generates a large amount of gaseous and solid pollutants.

In the last decades, mankind has searched for new sources of primary energy that, transformed into electricity or heat, do not pollute the environment, under the generic name of renewable energy.

Currently, the most used renewable energy source is wind energy, which has grown, mainly due to the financial support policies adopted in most countries in the world.

Making an onshore / offshore wind turbine involves a series of energy-consuming activities, both in wind turbine components manufacturing and building on a given location. Wind turbines also affect the environment, directly and indirectly throughout their life cycle. In addition, the decommissioning of these colossi with growth tendencies has a number of difficulties, especially for offshore winds, generating enormous quantities of waste.

Depending on the type of turbine and its power, the work involves research, design, manufacturing and experimentation.

These activities, as well as the actual realization of wind turbines in the current technology, are energy consuming and produce a series of waste in fuctoning and especially decommissioning.

In this paper, an assessment of the embodied energy and energy produced by a wind turbine at an onshore site is made.

Chapter. 1 Energy consumption to build a new wind turbine

1.1 General aspects

Given that most of the onshore wind turbines of various companies currently have an installed capacity of 1- 3 MW, a wind turbine of 3 MW will be considered in the analysis. For this analysis, average values of turbine and site specific parameters will be considered.

1.2 Design and experimentation

The design of a new wind turbine involves energy-consuming activities, the evaluation of which is in accordance with Table 1.2.1. For the assessment of the energy encompassed at this stage were considered the specificities and activities specific to the development of the new wind turbine as well as generic data related to experimentation in a Onshore location at a distance of 50km from the existing transport routes.

Table 1.2.1 Embodied energy for a 3 MW onshore wind turbine

No	Activities	Unit	Qty	specific energy (kWh/unit)	Embodied energy (kWh)	Total energy (MWh)
1	Research	Hours / month	240	150	36000	36
2	Experimental prototype – human factor	Hours / month	18	150	2700	39
3	Experimental prototype – design of nacell model	tons	76	15000	1140000	1179
4	Experimental prototype – excavation of access road	km	50	12000	600000	1779
5	Access road – concrete pouring	tons	15000	300	4500000	6279
6	Access road – asphalt pouring	tons	200	420	84000	6363
7	Experimental prototype – design of tower	tons	325	15000	4875000	11238
8	Experimental prototype – design of foundation	tons	7260	35	254089	11492
9	Experimental prototype – concrete foundation	tons	5723	350	2002928	13495
10	Iron rebar for concrete foundation	tons	636	11800	7503030	20998
11	Experimental prototype – assembly	Hours / month	5	150	750	20998
12	Experimental prototype – operation for 1 year	Hours / month	12	120	1440	21000
13	Wind turbine prototype production	energy	45% of energy required to build components			9450
14	Energy used to make the prototype	energy	energy required to build and assemble components			30450
15	Percentage of repartition to mass production	10%	energy transferred to mass production			3045

1.3 Onshore turbines

For assessing the energy involved in building an onshore 3 MW turbine power plant, the data from a wind turbine installed in Constanta County Romania is considered. For this assesment, a distance of 50 km between the existing transport routes and the 3 MW onshore turbine has been taken into consideration.

All dimensions of the components of the onshore wind turbine considered in the assessment are from the 3 MW wind turbine installed in Constanta County Romania.Table 1.3.1 shows the energies embodied in the wind turbine stages considered.

Table 1.3.1 The energy embodied in the construction and operation of a 3 MW onshore wind turbine

No	Activities	Unit	Qty	specific energy (kWh/unit)	Embodied energy (kWh)
1	Excavation of access road	km	10	1200	12
2	Access road – concrete pouring	tons	3000	300	912
3	Access road – asphalt pouring	tons	40	420	929
4	Excavation for turbine foundation	tons	7260	35	1183
5	Foundation – concrete pouring	tons	5723	350	3186
6	Iron rebar for concrete foundation	tons	636	11800	10689
7	Turbine tower production	tons	325	15000	15564
8	Turbine tower assembly	Hours / month	5	70	15564
9	Turbine nacelle production	tons	76	15000	16704
10	Turbine nacelle assembly	Hours / month	2	70	16704
11	Total for turbine production and assembly	Energy	Energy required for components production		81448
12	Final assembly	Energy	30% din energia necesară realizării componentelor		24434
13	Operation, overhauls and repairs at 5 years	Hours / month	10	70	24435
14	Total energy used for turbine production and assembly	Energy	energia necesară realizării și montării comp.		130317
15	Total energy used for turbine production and assembly and operation	Energy	energia necesară realizării si expolatării		130317

Chapter. 2 Annual production of electric energy of one wind turbine

2.1 General aspects

The amount of electricity produced by a wind turbine was estimated on the basis of engineering calculations, taking into account the average wind speed at the turbine site.

2.2 Onshore turbines

The power generation for 3 MW onshore onshore turbine power installed in Constanta County, Romania for one year is 7500 MWh / year

Cap. 3 Consumption versus energy production of a wind turbine

3.1 General aspects

In order to evaluate representatively the efficiency of electricity production, the analysis considers the difference between the spent energy embodied in the wind turbine and the delivered electricity production (excluding domestic services).

3.2 Onshore turbines

If the 3 MW wind turbine installed in Constanta, Romania, will operate for 25 years without capital repairs, with minimum operating costs, the annual energy produced by it is of (7500 MWh), which returns to a total energy output of 25 years of 187500 MWh

The energy involved for the construction and operation of the wind turbine onshore for 25 years of operation is 1368o7 MWh. If the energy consumption for turbine decommissioning is taken into account, the energy involved is 147911MWh.

For the wind turbines installed in the Dobrogea region, the recovery period of the energy involved in the turbine is 18.24 years. If the energy spent on the decommissioning of the turbine is considered, the recovery period of the energy involved in the turbine is 19.72 years.

For the decommissioning of wind turbines onshore, the following top-down activities are required:

a. removing the blades by means of a heavy crane;

b. dismounting the nacelle;

c. dismantling the nacelle tower sections; the resulting materials are transported for processing and recovery of recyclable materials.

d. decommissioning of the reinforced concrete foundation

For the decommissioning of the concrete foundation, several steps are required for the foundation to be brought to the stage of reusable materials. The necessary activities for decommissioning the foundation are:

d1. performing a truncated excavation around the foundation with a lower radius at least 2 m longer than the foundation radius and an angle of 45 degrees;

d2.the realization of an access corridor from one side with a 5 degree inclination and a width of about 8 m for the access of the machines and the decommissioning machines;

d3. breaking the foundation by dynamics into large pieces;

d4. crushing of reinforced concrete blocks in re-used materials for concrete production;

d5. transportation of materials resulting from crushing the foundation;

d6. filling the resulting dump with the ground and recovering the soil from the surface.

Table 3.1 shows the energies required for decommissioning of the metal part of the onshore wind turbine.

Table 3.1 Embodied energy in required for decommissioning of the metal part of the 3 MW onshore wind turbine

No	**Activities**	**Unit**	**Qty**	**specific energy (kWh/unit)**	**specific energy (kWh/unit)**	**Total energy (MW)**
1	Turbine blade disassembly	Tons	12	1500	18000	18
2	Turbine nacelle disassembly	Tons	64	1500	96000	114
3	Transportation of recyclable materials to processing unit	Tons	76	150	11400	125
4	Tower disassembly	Tons	460	1500	690000	815
5	Transportation of tower to processing unit	tons	460	150	69000	884

Table 3.2 presents the energies required for the decommissioning of the reinforced concrete part of the onshore wind turbine.

Table 3.2 The energy embodied in decommissioning 3 MW of onshore wind turbine concrete

No	Activities	Unit	Qty	specific energy (kWh/unit)	Embodied energy (kWh)	Total energy (MWh)
1	Excavation around turbine foundation	tone	10754	120	1290442	1290
2	Build access around foundation	tone	1461	120	175325	1466
3	Breaking of foundation	tone	5723	30	171680	1637
7	Crushing of foundation blocks	tone	5723	120	686718	2324
8	Recycling of iron rebar integrated in concrete	tone	636	5900	3751515	6076
9	Transport of broken-up foundation blocks	tone	7630	150	1144530	7220
10	Restoring the land to the original state	tone	20000	150	3000000	10220

Chapter.4 Environmental damage caused by wind turbines

The current wind farm exploitation solution is a series of activities and waste that affect the environment as follows.

1. Creation of own access roads to each wind turbine from the national roads leading to the removal of a few hectares from the economic and vegetal circuit;

2. The construction of a wind turbine involves the destruction of soil quality over an area of about 2000 square meters.

3. Very high tangential velocities of blade peaks generate vibrations and high frequency noise that affect turbine neighbors

4. The decommissioning of wind turbines generates a large number of thousands of tons of concrete and metal waste

Chapter. 5 Conclusions

The present paper aims at highlighting the positive and negative aspects related to the realization, exploitation and decommissioning of a medium power onshore wind turbine.

In order to assess the effective efficiency of a wind turbine, the difference between 25-year lifetime energy and wind energy in an onshore wind turbine was considered as a criterion.

In the evaluation, it was considered that 10% of the energy spent for conception, research (including experimentation on a prototype) was added to the energy embedded in the realization of the turbine considered. The energy consumed for the decommissioning of the onshore turbine has also been added to the energy embedded in a turbine.

From the analyzes made and presented in the paper, it results that the wind turbines, as they are currently being realized, have little efficiency compared to the wind potential in the area. Taking into account the efficiency of the current wind turbine type, it is proposed to develop a new generation of wind turbines that do not have parts of external motion and whose efficiency is not influenced by the direction of the air currents.

To increase the efficiency of the wind turbine, it is proposed that they use both the direct action effect of the air and suction currents generated by the leakage of air streams on aerodynamic surfaces.

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