PART TWO – LECTURE AND NOTE-TAKING – WIND – ANSWER KEY – 13 pts

(1 PT.for each question)

13. How did the lecturer define energy? **The amount of work a physical system can produce.**

14. How much of world's electricity is generated by non-renewable resources? **(about) 80 % / 79 %**

15. Apart from pumping water and transport, for what **two** other purposes was the wind used in history?

    Irrigation / grind grain / drain lakes & marshes

16. Who brought the idea of windmills to the Western world? **Crusaders & merchants**

17. Why did the windmills lose their importance in America?

    Government policies favoring fossil fuel power plants

18. Why did wind power generators lose their popularity in the 1960s?

    Decline in fossil fuel prices

19. What positive impact did the oil embargoes of the 1970s have on wind turbine technology?

    Technology developed rapidly / old ideas were refined / new ways of converting wind energy / interest in wind energy increased

20. What type of energy is converted to electricity by wind turbines? **kinetic**

21. What is the main function of the gearbox? **Increase the speed of the rotors**

22. What is the main function of the yaw drive? **Turn the turbine against the direction of the wind**

23. What were the **TWO** main obstacles to wind energy mentioned in the lecture?

    a. **Wind is a variable resource / amount of energy depends on the speed of the wind**

    b. **Wind is capital intensive / wind requires high initial investment**

24. How does the speaker feel about the future potential of using the wind to generate electricity?

    Likely to be one of the most promising power sources of the future / the cost of wind energy won't be as expensive.

LISTENING TWO – WIND ENERGY - TAPESCRIPT

Good morning everyone. If you remember last week's lecture, we talked about nuclear power as an alternative energy source to fossil fuels. Today, we'll continue to talk about alternative energy sources and our topic will be wind energy.You may remember from last week's lecture that we went over the definition of what we mean by energy. Let's see how much you remember. How did we define energy last week? Anyone remembers?

St. 1: erm, the power that makes something work?

Good, thank you. Anything else?

St. 2: the output of a system that makes things work?

OK. Good points, thanks. Well, according to physicists, energy is the amount of work that a physical system can produce; and, if we follow on from that, I mean if energy means the amount of work that a system can produce, again as you may all know from what physicists say, it can neither be created nor consumed or destroyed. But, we also know that energy can be transported though power lines and it can be stored. And, no matter how energy is created, transported or stored, at the end of the chain of transformations, energy is lost into the water or the air, before being irradiated outside of our atmosphere.

However, like I said before, in order to make proper use of energy, it will have to be converted and energy may be converted or transferred to different forms: which brings us to the topic of this lecture: the wind energy. But, perhaps before we look at wind energy as an alternative energy form to fossil fuels, and before we look at how wind turbines generate electricity, we should look at some interesting figures related to world electricity generation – and especially look at the current status of how electricity is generated.

Now, here are some interesting figures related to world electricity production: the hard truth is 63% of electricity in the world is produced through the burning of fossil fuels such as wood, coal, oil, natural gas, which are non-renewable forms of energy sources. 16 % of world electricity is produced by nuclear power and about 20% of world's electricity is produced through renewable resources such as the wind, solar energy, geothermal and wave energy. A final striking truth about world energy resources: please remember that the source of nuclear energy is uranium, which, although not as easily exhaustible as gas or oil, is still a non-renewable energy source. So if we add up fossil fuels and uranium, almost 80% of world's electricity seems to be produced by using non-renewable sources.

Now, I suppose that clearly shows the need to exploit alternative, renewable energy sources, such as the wind. And we'll move onto how wind energy works in a minute but first of all, a bit of history: As I take you quickly through the history of using wind energy, I would like to emphasize the main functions that the wind served in history. The wind is, actually, one of our earliest energy resources; it is not a modern-day energy source, at all. Wind has been harnessed throughout history for different purposes, first to power boats and this was the first function that the wind served: transportation – it provided the strength with which people could sail on water and go places. The second function of the wind was its use in the windmills to grind grain, which I will mention in more detail later on. After using the wind in the windmills to grind grain, it was later used to pump water and that would be the third main function of the wind. The fourth one would be the use of the wind for irrigation, and this function, using windmills to irrigate the land was put to use especially in the US. Finally, wind energy was used to drain lakes and marshes but more info on that later.

And let's now move onto the history of wind energy in more detail. An interesting point here is about the initial use of the wind in windmills. The very first windmills were used at the beginning of the Islamic civilization in the 7th Century. These first windmills were used for pumping water and grinding grain Also, we know that the Ancient Chinese used windmills for exactly the same purposes. By the 11th century, people in the Middle East were using windmills extensively for food production.

So far, that is the situation in the Eastern world, so to speak. You see, water windmills were unknown in Europe for quite some time and they were introduced to Europe around 1300 A.D by the returning merchants and crusaders. So, the Western world discovered the windmill much later than the Eastern when it was brought over by the crusaders and merchants. Then, the Dutch brought a totally new use of the windmill, other than using them for food production. And this was the fifth function the wind which I mentioned a little while ago: draining lakes and marshes. What I mean is, the Dutch took the Eastern windmill and refined it and adapted it for draining lakes and marshes in the Rhine River Delta.

Then the windmill continued to be used around Europe and to serve multi purposes. In the late 19th century, the settlers, the pioneering Europeans who settled in the new found America, took this technology to the New World. In America, they began using windmills to pump water for farms and for ranches, that is, they used the windmills for irrigation purposes. And finally, it was in America that the wind was used later to generate electricity for homes and industry. Over 8 million mechanical windmills have been installed in the U.S. since the 1860's and some of these units have been in operation for more than a hundred years. And, these windmills were a very important part of American farm life. Back in the 1920's and 1930's, farm families used wind generators for all sorts of purposes: to power lights, radios, and kitchen appliances. So, wind energy was becoming very popular. But, then, in the 1930s, most windmills lost their importance and became obsolete. The modest wind industry was literally driven out of business and the main reason why windmills became less popular was government policies favoring fossil fuel power plants. So, you see, Industrialization, first in Europe and later in America, led to a gradual decline in the use of windmills. The steam engine replaced European water-pumping windmills.

The popularity of using the energy in the wind has always fluctuated with the price of fossil fuels. In other words, the relationship between the use of fossil fuels and the wind has been a “rocky” one, so to speak. Let me give you a few examples: when fuel prices fell after World War II, interest in wind turbines diminished and the fossil fuels became popular. Again, in the early 1960s, wind energy lost its popularity one more time. The reason for this was again fossil fuel prices. There was a huge decline in the fossil-fuel prices this, unfortunately, made wind energy uncompetitive with steam-powered generating plants using fossil fuels.

On the other hand, when the price of oil skyrocketed in the 1970s, so did worldwide interest in wind turbine generators. All over the world, there began a renewed interest in the power of wind to generate electricity. So, the oil shortage of the 1970’s had an unexpected positive impact on the development of wind turbine technology. And what I mean by this positive impact is how, after the oil embargoes of the 1970s, wind turbine technology developed rapidly. The technology that followed the embargoes refined old ideas and introduced new ways of converting wind energy into useful power. Many of these approaches have been demonstrated in "wind farms" or wind power plants both in the United States and Europe.

Let’s now have a quick look at how wind turbines work. Please look at figure 1 as you take notes here. Remember what I said before: in order to make proper use of energy, it will have to be converted and the type of energy that is converted in the case of wind energy is kinetic energy. So, how do wind turbines make electricity? Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind like a regular fan does, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

On your note-taking sheet, you see the 7 main components of a wind turbine:

Number 1 is what we call the “hub”, and number 2 are the rotor blades. The hub (1) and the rotor blades (2) together are called the rotor. The rotor blades capture the wind and transfer its power to the rotor hub. Just to give you an idea of how big these rotor blades can be, on a modern 1000 kW wind turbine, each rotor blade measures about 27 meters in length and is designed much like a wing of an airplane.

The hub is connected to the gear box, which is number 4 in the picture. The function of the gearbox is to increase the speed of the rotors. The rotation speed of the rotor is increased by the gearbox from about 30 to 60 revolutions per minute (rpm) to about 1200 to 1500 rpm.

I have skipped number 3 on purpose and I am coming back to it now. Number 3 is the rotor shaft which connects the gear box to a generator and the generator is shown with number 5. When the gear box is connected to the generator and the shafts are turned with the power of the wind, this produces electricity.

Number 6 is what we call the nacelle: Now, the nacelle is a very important part of the wind turbine. The nacelle contains the key components of the wind turbine, including the gearbox, the rotor shaft, the generator, the brake system and the yaw drive. Now, I just said that the nacelle includes the yaw drive: that’s Y-A-W. The yaw drive is also a very important component because it is used to turn the wind turbine against the direction of the wind, I mean facing into the wind as the wind direction changes. And we know that the direction of the wind does change, right?

The nacelle, as you can see in the picture, is located at the top of the tower, which is number 7 – tower is the piece on which the wind turbine is mounted. And number 8 is very obviously the outlet to the power lines which transfer the generated electricity to where it is needed.

OK, that was the technical background. Now, before I finish the lecture, I’d like to look at the reasons why wind energy is still not as widespread at it should be, given all its benefits. So, yes, the wind is a completely renewable fuel source, as opposed to non-renewable fossil fuels; Plus, it is really environmental friendly – it does not deplete the ozone layer or cause global warming. Why, then, is it not more widespread?

To begin with, wind energy is a variable resource: when I say it is a variable source, I mean we get electricity only when the wind blows. Although modern wind turbines regulate power well and can work with lower speeds of wind, the amount of power they can produce still varies throughout the day, depending on the speed of the wind

Another disadvantage is wind energy is also capital intensive. Capital intensive means the technology for wind energy generation requires a high initial investment and this is much higher that an initial investment one would have to make on a fossil-fuel power generator. In order to give you an idea, let’s compare it with nuclear power and natural gas. Wind power is almost twice as expensive as setting up a nuclear power plant. And the cost of producing one megawatt of electricity is about four times more expensive than regular natural gas powered plants. However, before I conclude, a few last but important points about how we should be perceiving the future of wind energy. Today’s wind power technology is developing very rapidly and soon the cost of building a wind power generator will not be more expensive than a fossil-fuel powered one. Modern wind turbines can safely and efficiently turn wind into useable energy. Wind turbines and wind mills have been a natural part of the northern European landscape for more than 800 years, and an important part of American rural life for more than a century. With all its benefits, the wind is likely to be one of the most promising power sources of the future. Thank you.