Electrical Power and Energy Engineering

transcribed plenary speech of
Mr Anura Wijepala
Chairman, Ceylon Electricity Board; Department of Electrical Engineering, University of Moratuwa, Sri Lanka

The topic I am speaking on today is environmental responsibilities of power and energy professionals. So in this presentation I am sharing with you my 10 years experience in teaching subjects on energy and environment at university of Moratuwa Sri Lanka. Engineering has reached far heights since the industrial revolution some 150 years back. Inventions of electricity, internal combustion engine, digital computer, mobile communication, just we heard a lot just a while ago, the Internet similar many others have build a world beyond the imagination of 10 Arthur C. Clerks put together. Further up marvels of the medical sciences have challenged every conceivable illness except few such as AIDS. Final result of all these has been an outburst of population which in turn has post an spiraling increase in the demand on all resources and specially on energy. Figure 1 shows the world population growth for the last 10,000 years and it is interesting to note that 2,500 years ago when lord Buddha was living and preaching Buddhism world population would had been just under 100 million people. And it is also interesting to note 200 years back the world population has been around 1 billion and during just the last 200 years population has exploded to 7 billion mark. So there is a profoundly a stage turning taking place in human history. Even under moderate growth scenarios UN estimates the population to cross the 10 billion mark by the end of this century.

The enormous pressure exerted by the huge population environment, food supply and energy is unprecedented. And repercussions of climate change are felt all over the world. Meters thick snow falls in north America, flash winds, flash rains, flash floods, in many countries including Sri Lanka, heat waves in Europe, India and other countries are not the same news stories we were used to hear some 30 years back. The 5th assessment report AR5 the climate change was issued by inter-government panel on climate change last year and it conclusively blames green house gases for causing global warming and the climate change. Engineers and scientists working in the energy sector can play a decisive role in controlling GHG emissions and finding alternative ways to keep the energy demand met. In this context though Sri Lanka is a low carbon emitting country in needs to be conscious about the local as well as the global responsibilities for the sake of future children who will remember us as far sited great parents of the twenty first century. Our planet, beautiful to look at from space, earth is the third from the sun in the solar system.

Astronauts are yet to find a similar planet having conducive conditions for life though their explorations have extended millions of kilo meters in to the space. On this globe with an average diameter about 12,700 kms human beings live at the bottom of the atmosphere. It is taken fro granted that atmosphere to be inexhaustibly large having comparable dimensions with the earth. Unfortunately this gut feeling is wrong. Atmosphere is surprisingly thin. Scientists have estimated that 75% of the total mass of the atmosphere is within the first 11 kilometers. First 11 kilometers is the distance is where all whether happens most of air planes take their flights etc. It is looking to this thin atmosphere humans started to emit green house gases since the start of industrial revolution.

If we look at the history as indicated in figure 3 world has been carbon neutral until recent times. We can see the green line until 1850 or little later than that the world has been using almost only bio mass. Bio mass catches carbon dioxide through photo synthesis from the atmosphere and releases the same when burnt. Unfortunately by today when contributing bio mass for energy generation has become less than 10% and oil, coal, gas and all of which are fossil fuels have to be taken over. Contribution of nuclear is also limited due to socio-political and security issues. Contribution from new renewable sources such as wind, solar and small hydro is not significant. Large scale utilization of fossil fuel started only after the invention of steam engine, steam turbine and the internal combustion engine. Automobiles, steam and diesel electric trains as well as production of electricity unleashed the fossil fuels what we call the sleeping ghost from its underground caves.

However not until the last part of the twentieth century the scientists were able to re- late green house gases as the culprit for the warming of the planet.

The green house effect, part of the solar radiation coming on to earth reflected back by the clouds, the earth surface etc. and part is absorbed by earth and as well as the particles of the atmosphere. The earth radiates this heat back in form of infrared radiation most of it generally end up in the space. This is ab- sorbed by molecules such as carbon dioxide, methane, nitrous oxide and they are re-radiated in all directions. Part of that comes back to the earth. This is what you call the green house effect. Thus these gases act as a green house. And more such gases are present in the atmosphere more will be the heat retained, increasingthe temperature of the earth. Starting from the indus- trial revolution some 150 years back, fossil fuels are burnt in bulk. And the carbon dioxide concentrations have steadily increased. We can see in this picture the correlation and relationship between the carbon dioxide concentration in the atmosphere and the rate at which we have been using fossil fuels since 1800. As the figure also shows the carbon dioxide concen- tration which was about 208 parts per million before the 19th century which has increased to 350 million by now. And it is strictly on increase as scientist have estimated as the rate of about 1 ppm every year.

The figure 6 depicts the average global temperature increase during the last 150 years which shows def- inite tendency for the continued increase. And this figure shows the rate of release of carbon dioxide to the atmosphere since the industrial revolution due to anthropogenic activities. The various activities we do that are the various activities we do for power gen- eration etc. by the human beings. In 1950 the car- bon dioxide rate has been 5 billion tons a year. And just in 60 years in 2010 the rate has increased by 7 folds. To 35 billion tons a year. Remember by now we are releasing over 35 billion tons of carbon diox- ide into the atmosphere every year. The impact due to climate change are quite fatigue. Warming of at- mosphere heat waves melt of glaciers, sea level rise etc. extreme whether ocean acidification are a major impact of climate change. Warming is obvious. We have never heard of heat waves when we were young. Heat waves in India and some parts of the Europe in summer have becoming a norm. 2003 European heat wave was a worst causing the death for several 10s of 1000s. It extreme precipitation is already in expe- rience. The precipitation rates are often higher than the discharge rates of drainage systems. Causing flash floods in many parts of the worlds including Sri Lanka.

Melting glaciers cause two problems. The one is the obvious sea level rise. Second is the reduction of what we call Albedo. The so called reflection of in- coming solar radiation back to space by its white sur- face. When sun light falls on water most of the heat will be absorbed. Kyoto protocol. I think we all have heard about the Kyoto protocol. The Kyoto protocol is an agreement under the industrialized countries they would reduce their collective emission of green house gases on average by about 5% compared to 1990 emis- sions of those countries. The agreement was signed in 1997 and came into full force after ratification is 2005. Although United States signed the agreement I think we all know that the US is the biggest polluter in the world being a heavy energy consuming coun- try. And the signed agreement they refused to ratify it. And later withdrew from the Kyoto protocol. The re- ductions were to come to effect in the period 2008 to 2012 but by 2012 even countries like Japan, Canada and Russia withdrew from the protocol stating they cannot afford committed reduction of green house gas emission. The post analysis indicates that major draw back of the Kyoto protocol was that it had no compul- sory targets for the developing countries. Which sub- sequently became the major green house gas emitters due to high economic development rates and massive population of the two countries.

The year 2012 under the Kyoto protocol the reduction target would have been achieved, dawn and dust and so did the commitments of Kyoto protocol. The pend- ing argument, the arguments of the two parties the developed countries and the developing countries are having at the moment. So developed countries, the industrialist countries, argue that the countries should be allowed to emit green house gases according to the present pattern and reduction should come there on. While developing countries specially China and India with over 1 billion people each argue that it should be based on per capita emissions. That is on the ar- gument on every body has the same right to emit to the atmosphere. How ever different countries and re- gions have set their own targets on renewable pene- tration. For example EU has the first target of 20% of the electricity renewable by 2020 and the second target of 50% by 2050. Sri Lanka has similar

targets 10% of electricity by 2015 and 20% by 2020. And re- member all these are voluntary targets. We don't have a binding agreement or protocol among the countries yet. And UN Chairmen Ban Kee Moon was hopeful that such an agreement is possible by 2015 but it is yet to be seen whether it will be materialized.

Energy sector conversion efficiencies. Although there have been mild improvement in energy conversion ef- ficiencies ground breaking efficiency increases have not been made during the last several decades. Aver- age efficiency of electricity generation remains around 40% and automobile fuel efficiency lies in the range of 10-15 kilometers per liter while vehicle engine effi- ciencies are 15-20%. Burning of coal in power plants emit an average of 0.95 kilograms. That is almost one kilogram for every kilo watt hour it generates. Simi- larly other fuels also emits varying amount as shown in the table. Similarly carbon dioxide emissions when fuel is burnt in automobiles and other equipment are shown in Table 2. That is when we burn one liter of petrol in our car we emit almost 2.3 kilograms of car- bon in to the atmosphere. Look at how many liters of petrol you need a day and multiply it by 2.3 and remember that, that amount we force to emit every day.

New Renewable Energy and Nuclear. Solar, wind small hydro, bio mass, and the few similar other sources are categorized as NRE sources, New Re- newable Energy sources and scientists have second thoughts in including large hydro into this group. This exception is due to the involvement of the reservoir. Usually large hydro plants have a reservoir which has many environmental impacts and the latest findings indicate these reservoirs are sources of methane which is a green house gas due to perishing of submerged vegetation. Nuclear is expected to play a vital role but with half a century of experience still the contribution from nuclear is under 3%. Chernobil and Fukushima accidents have made such public opinions many nu- clear countries have taken decisions to entirely stop nuclear programs and even to decommission existing plants. Germany is also in the same route. They are also either decommissioning or getting away from nu- clear. Solar energy, the most commonly available en- ergy source in the world has seen vast sight during the last 10 years. Photo voltaic panel prices have slumped down and concentrated solar power what we call CSP plants are getting popular in many countries. The biggest hurdle to overcome in PV is the unacceptably low efficiency of energy conversion.

Most commercial panels with right prices have effi- ciencies in the range of 10 -12%. this is where the scientists have to step in and come out with inno- vative techniques to improve their efficiencies. CSP technology provides heat storage and their by the op- eration of the power plant can be extended to night hours as well. The draw back of PV power plants is that they operate for a limited number of hours dur- ing the day. And the storage technologies are very ex- pensive. Thus engineers and scientists are called up on to develop onto develop the battery technologies and also economical battery technologies for efficient and economical energy storage. Development in wind power sector has also been significant. It has the draw back of being seasonal as well as intermittent. In the off seasons the grid operator has to have the alterna- tive sources to meet the demand. And intermittent grid operator has to have alternate sources to meet demand. And intermittent calls for ready hot reserve power which is expensive. Pump storage power plants provide the solution against intermittency but it also makes an additional cost. Biomass being a carbon neu- tral source has great potential in aiding combating the climate issue. Concept of plant energy plantations are taking off now and sustainability of such plantations are being tested. Bio fuel such as palm oil and ethanol are also substitutes for fossil fuels. Tidal energy, wave energy, Ocean terminal energy etc. are not in leading commercial operation due to either to resource limita- tions or to technological limitations. Again scientists and engineers have to make new innovations as how to convert these sources to electricity, economically.

The solutions. To arrest the climate change issue there is one and only one option. That is to reduce car- bon dioxide emissions. Of course this is easily said than done. IPCC has estimated that if global aver- age temperature increases to be limited to within 2° by the end of the century, the total cumulative carbon dioxide emissions since 1870 has to kept under 2,900 Giga tons. As shown in the figure from1870 remember hundred and 50 years ago To 2011 world has already emitted 1,900 Giga tons of carbon dioxide. For the balance period of 89 years from now to end of the cen- tury, the available quarter is only thousand Giga tons of carbon dioxide. And as we saw in the previous fig- ure, our

consumption rate is our emission rate is about 35 Giga tons per year. Which means we can go ahead with only in 30 years we will finish this 1,000 Giga ton quota. And therefore we will never be able to at least limit the temperature increase to 2° by the end of the century. So does drastic changes are required in the way people live. The way electricity is generated. The way transportation is being done and so on.

If global average warming is to be limited to 2° it should be remembered that world is suffering from the present problems only the just 1° average temper- ature rise. Sri Lanka can be proud that the country has reached 3,000 dollar per capita GDP while still having low per capita emission of 0.6 tons of carbon dioxide. Thus in the world as well as in the region Sri Lanka is a low carbon emitting country. There- fore Sri Lanka can justify that it has a natural right to emit more. For the economic development a coun- try needs cheap energy. And there are no options but to go for cheap power generation technologies such as coal power generation. Sri Lanka can also look at the problem in broader terms. Industrialized coun- tries when they were emitting carbon dioxide for that cheap power the world was unaware of the climate change problem or its course, the greenhouse effect. It was not until the late 1980s that IPCC came out to the first assessment report which is indicating that it is most likely that GHGs are causing the climate change. But the argument that everybody has the same right to emit, people living in the warm countries can be fairer in thinking that those who are living in colder countries such as Scandinavia need more energy for mere survival. And probably they deserve a better car- bon quarter quota. But one thing is clear. Whoever emits the problems are common to all. Whether the polluter, or not every country will have to take their share of consequences. Low emitting country can be unlucky and we have to face the harder environmental calamities.

Carbon footprint. From the day one is born, starting the energy needed to produce the very napkin that it is covered , until his coffin is burnt, one day one keeps on emitting carbon dioxide in numerous ways from the cradle to the coffin. When anything new is used, be it a cloth, pen, shoe ,paper, car , simply anything, some kilowatt hours, some energy is used for that pur- pose. So therefore we can count how much carbon dioxide is emitted from the day one is born until he is dead . That is carbon footprint one leaves in the world. And the smaller the carbon footprint the lower is the effect that he makes for the environment and global issues. Therefore it is the duty of all to make sure that we as individuals and corporates or the or- ganizations and then finally as a country we all keep our carbon footprint as small as possible.

Thank you very much ladies and gentlemen.