Name:

Enrolment No:

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

DEHRADUN

End-Semester Examination May 2019

Program/course	**: MA Economics (EE)**	**Semester**	**: IV**
Subject	**: Energy and Climate Change**	**Max. Marks**	**: 100**
Code	**:** OGET 8008	**Duration**	**: 3 Hrs**
No. of page/s	**: 11**		

Section A (attempt all)

Q1. Define the following terms.

i.	Climate Change	**[2]**	**CO1**
ii.	Paris Agreement	**[2]**	**CO1**
iii.	Solar Energy	**[2]**	**CO1**
iv.	Carbon emission	**[2]**	**CO1**
v.	International Climate Change Negotiations	**[2]**	**CO1**
vi.	Wind energy	**[2]**	**CO1**
vii.	Carbon capture and storage	**[2]**	**CO1**
viii.	Electric Vehicle	**[2]**	**CO1**
ix.	INDC	**[2]**	**CO1**
x.	Sustainable Development Goals	**[2]**	**CO1**

	SECTION B **Answer any four questions**		
Q2.	Explain critically energy environmental interaction at regional level.	**[5]**	**CO3, CO4**
Q3.	What is carbon budget? Describe in context of Paris Agreement.	**[5]**	**CO3, CO4**
Q4.	Explain Green House Effect in context of climate change.	**[5]**	**CO3, CO4**
Q5.	What is deep decarbonization? How we can we achieve it?	**[5]**	**CO3, CO4**
Q6.	Why companies having crude oil reserves are not happy about deep decarbonization?	**[5]**	**CO3, CO4**

SECTION C

Answer two questions 2 X 15 = 30

Read the following article and answer the questions given at the end of the article:

The Ministry of New and Renewable Energy (MNRE) has proposed making it mandatory for solar power developers to follow glass recycling procedure for solar photovoltaic (PV) panels under a new framework. The National Green Tribunal (NGT) had on 4 January 2019 directed the MNRE to prepare a policy for the management of Antimony present in solar glass panels. Antimony Containing Solar Panel Glass (ACSPG) is used globally to improve the stability of the solar performance of the glass upon exposure to ultraviolet radiation and sunlight. "Producers may be made responsible for ensuring recycling of end-of-life glass panels as part of their extended responsibility as in the case of e-waste which covers used lead-acid batteries, packaging material, etc,". It also added that the power generators will have to ensure environmentally-sound handling of used solar panel waste.

The ministry has given several recommendations regarding the use of Antimony. The generators might set up facilities for safe dismantling of used solar panels or should tie-up with an authorised dismantling facility. The end-of-life solar panels are required to be collected and stored safely until the option for recycling is available. It should never be disposed or dumped in open landfills as it may release Antimony into the environment.

India has witnessed large solar PV installations in the past five to six years. These panels will turn into waste over the next 15-20 years. As the glass in the PV panels is reusable at the end of its life, improper disposal may result in the loss of this recyclable material. Other countries including Germany have developed PV recycling technology and Antimony containing glass may be recycled without affecting its properties.

The recycling process of a tonne of PV panels is likely to produce 686 kilogram (kg) of clean glass and 14 Kg of contaminated glass. The recycled glass can be used to produce new panels with Antimony containing glass. However, in case recycling facilities are not available, the concept note stated that the industry should look at the option of disposal in secured landfills or their safe storage.

Q7.	Why safe disposal of solar panels is important? Examine critically.	**[15]**	**CO1, CO4**
Q8.	What are the various options of safe disposal of solar panels? Which one is environmentally friendly and why? Describe critically.	**[15]**	**CO3, CO4**

Section D

Answer the question 1 X 30 = 30

Read the following case study and answer questions given at the end of the case study:

Deep Decarbonization: The Three Pillars and National Case Studies
Case Study: US Deep Decarbonization

The energy system has infrastructure inertia; you don't just change things overnight, you have a stock of buildings, of vehicles, of power plants, and they're going to change over an extended period of time. That is all incorporated into this analysis.

Electric reliability: we don't want to come up with a fantasy electricity system that wouldn't actually provide reliable electric power.

So that is a technical constraint in the scenarios. The scenarios you'll see have the same energy services as the long-term government forecasts from the Energy Information Administration.

What that means is, people are basically consuming as much energy or at least getting the same kinds of services out of energy that they're projected to right now.

That is, you're living just as comfortably, you're getting as much transport as you want, you're able to wash your clothes, you're able to heat your house and so forth, in a way that's very similar to what we do today.

And the economy is as productive as what we anticipate under other circumstances.

The question we asked was:

Can you achieve the same kind of economy and daily life that we have now under a deeply decarbonized system?

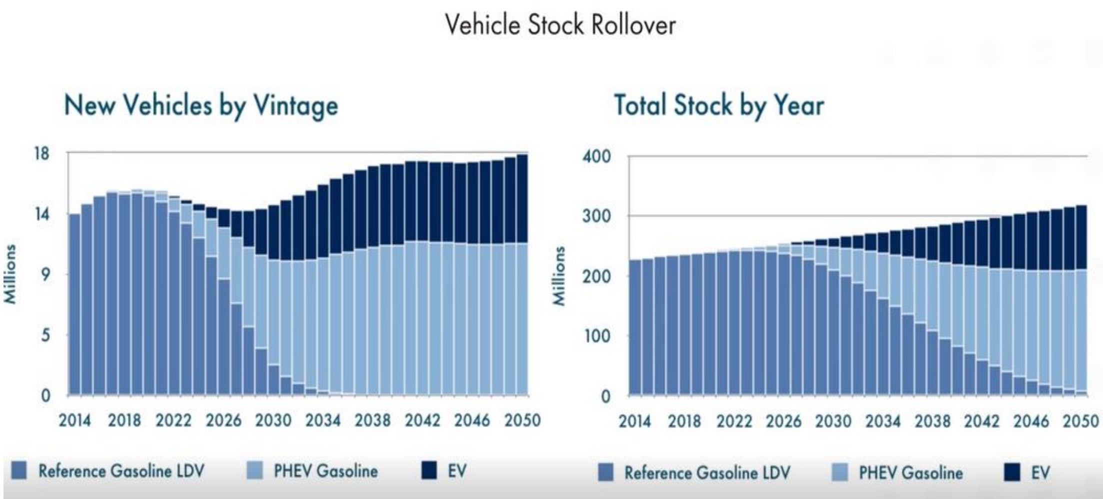
The technology that was used is commercial or near commercial-that's to say it exists today-and doesn't incorporate any technological miracles.

And finally there are reasonable environmental limits on what you can do. You can't use excessive amounts of biomass that will have other damaging effects on ecosystems; similarly, there's great limits on how much hydroelectricity you could use.

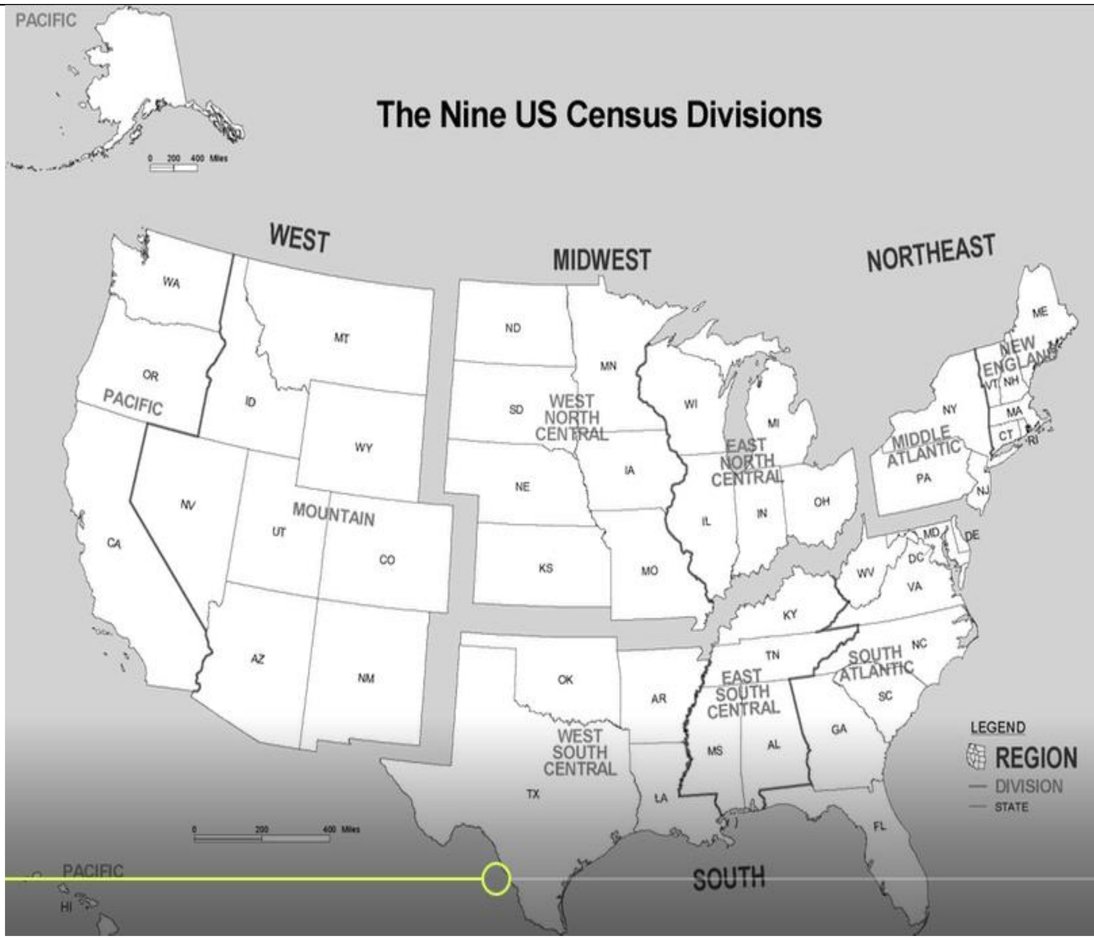
The work was done with something called the Pathways Model, which is an energy system model with user-defined scenarios: it has 80 demand sectors and 20 supply sectors; it has a great deal of detail of all the stocks of energy supply and demand' equipment-there's many different kinds of refrigerators and light bulbs and power plants and vehicles incorporated in this-and each one has its own lifetime that's typical in its own vintage.

Total Transport Sector Inputs						
Transport FEC	EJ	0	0	0	0	0
Transportation final electricity	TWh	0	0	0	0	0
Transport CO2 emissions	MtCO2					
CO2 intensity of transport FEC	tCO2/TJ					
Productive Sector Inputs and Indicators						
Industry Inputs (includes manufacturing, agriculture, mining, construction)						
Industry value added	B 2005$	$0	$0	$0	$0	$0
Industry FEC	EJ	0.00	0.00	0.00	0.00	0.00
Industry final electricity	TWh	0	0	0	0	0
Industry non-electricity FEC	EJ	0.00	0.00	0.00	0.00	0.00
Industry steam	EJ	0.00	0.00	0.00	0.00	0.00
Industry coal	EJ	0.00	0.00	0.00	0.00	0.00
Industry coal w/ccs	EJ	0.00	0.00	0.00	0.00	0.00
Industry pipeline gas	EJ	0.00	0.00	0.00	0.00	0.00
Industry pipeline gas w/ccs	EJ	0.00	0.00	0.00	0.00	0.00
Industry liquid fossil fuels and other	EJ	0.00	0.00	0.00	0.00	0.00
Industry solid biomass	EJ	0.00	0.00	0.00	0.00	0.00
Industry biofuels	EJ	0.00	0.00	0.00	0.00	0.00
Industry non-electricity CO2 emissions	MtCO2	0	0	0	0	0
Industry fugitive and process emissions	MtCO2	0	0	0	0	0
Industry total CO2 emissions	MtCO2	0	0	0	0	0
Industry Indicators						
Share of Industry in GDP	%	0%	0%	0%	0%	0%
Industry energy intensity	TJ/$					
CO2 intensity of Industry FEC	tCO2/TJ					
Non-electricity CO2 emission factor	tCO2/TJ					
Disaggregated inputs and indicators in industrial sub-sectors (IF AVAILABLE)						
Cement production	Mt	0	0	0	0	0
Cement FEC	EJ	0.00	0.00	0.00	0.00	0.00
Cement final electricity	TWh	0	0	0	0	0
Cement non-electricity energy-related emissions	MtCO2	0	0	0	0	0
Cement fugitive and process emissions	MtCO2	0	0	0	0	0
Iron & Steel production	Mt	0	0	0	0	0
Iron & Steel FEC	EJ	0	0	0	0	0
Iron & Steel final electricity	TWh	0	0	0	0	0
Iron & Steel non-electricity energy-related emissions	MtCO2	0	0	0	0	0
Iron & Steel fugitive and process emissions	MtCO2	0	0	0	0	0
Mining production	Mt	0	0	0	0	0
Mining FEC	EJ	0	0	0	0	0
Mining final electricity	TWh	0	0	0	0	0
Mining non-electricity energy-related emissions	MtCO2	0	0	0	0	0
Mining fugitive and process emissions	MtCO2	0	0	0	0	0
Non-Ferrous metals production	Mt	0	0	0	0	0
Non-Ferrous metals FEC	EJ	0	0	0	0	0
Non-Ferrous metals final electricity	TWh	0	0	0	0	0
Non-Ferrous metals non-electricity energy-related emissions	MtCO2	0	0	0	0	0
Non-Ferrous metals fugitive and process emissions	MtCO2	0	0	0	0	0

So if you have a 1995 vehicle right now, it's probably not going to last that much longer in this model, because is coming to the end of its lifetime.



All nine US census divisions are separately modeled, and the electricity system which is in three so- called interconnects or interconnected power systems in the United States are all separately modeled.



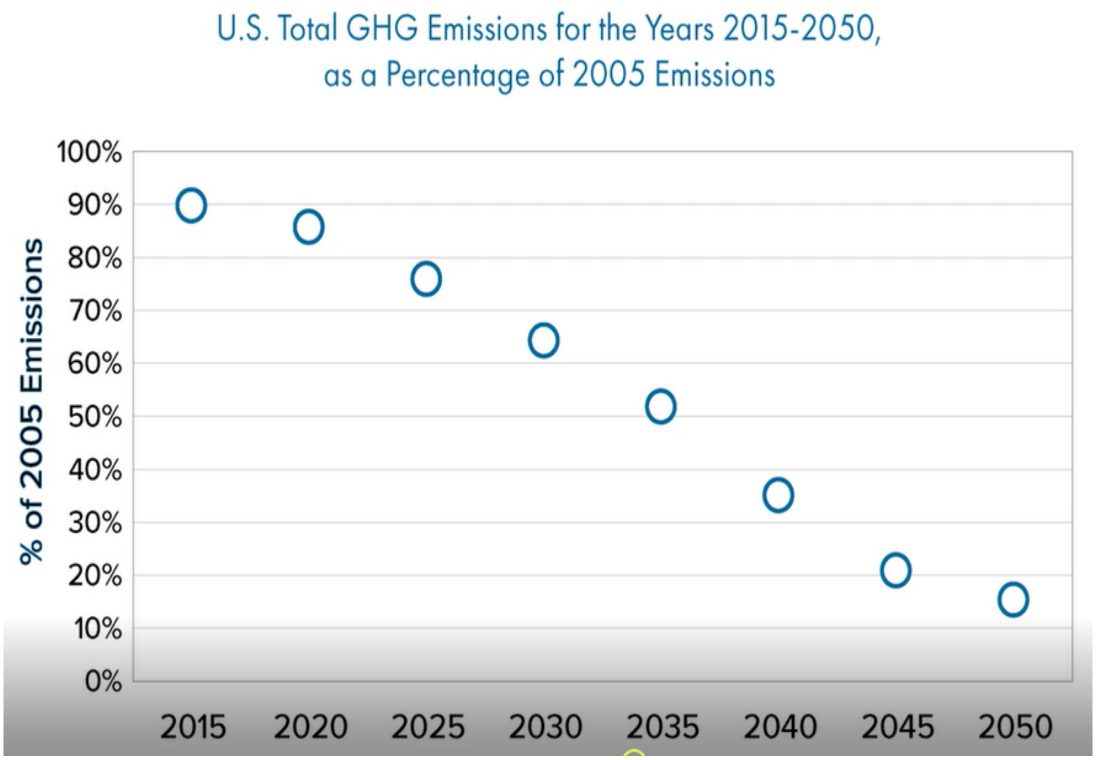
Again, this is by way of saying what we've done is create a representation of the United States and the way that it uses energy that is very believable.

We also used another model called GCAM from Pacific Northwest National Lab to model non-energy and non-CO2 emissions.

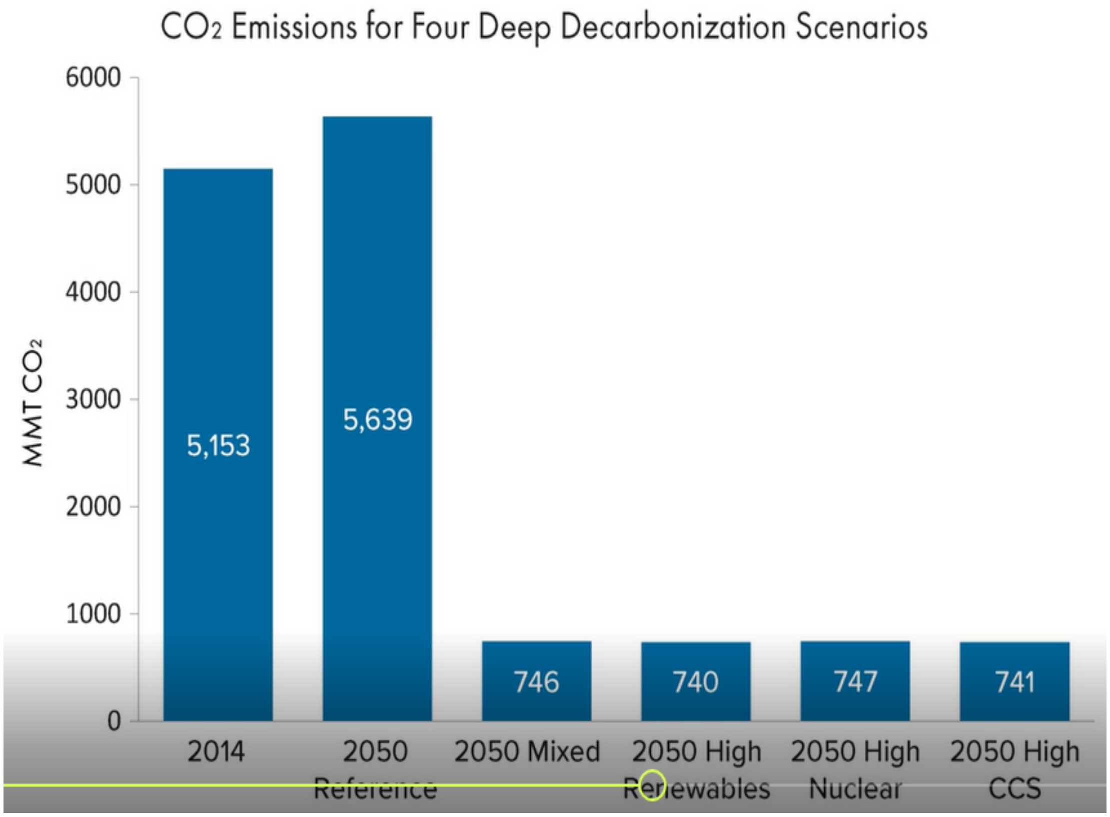
So we have a very credible hybrid modeling approach done by National Labs and energy experts to be able to model all the different kinds of greenhouse gas emissions from the United States and answer our question.

So here's some high-level results.

The first one is that an 80% reduction in greenhouse gases by 2050 in the United States is an achievable result.



The second is that there are multiple feasible technology pathways. So you see on this slide what our current emissions are in the US; what our forecast emissions from the EIA are for the year 2050; and then the four very low levels of emissions are all different scenarios that reach per-capita energy emissions of 1.7 tons per person in 2050.



We built four scenarios, all of which reach the emissions goal that we have for the year 2050, reducing recent US per capita CO2 emissions by a factor of 10 below the present while still providing all the energy services that our economy and our productivity require.

And these four scenarios are all quite different:

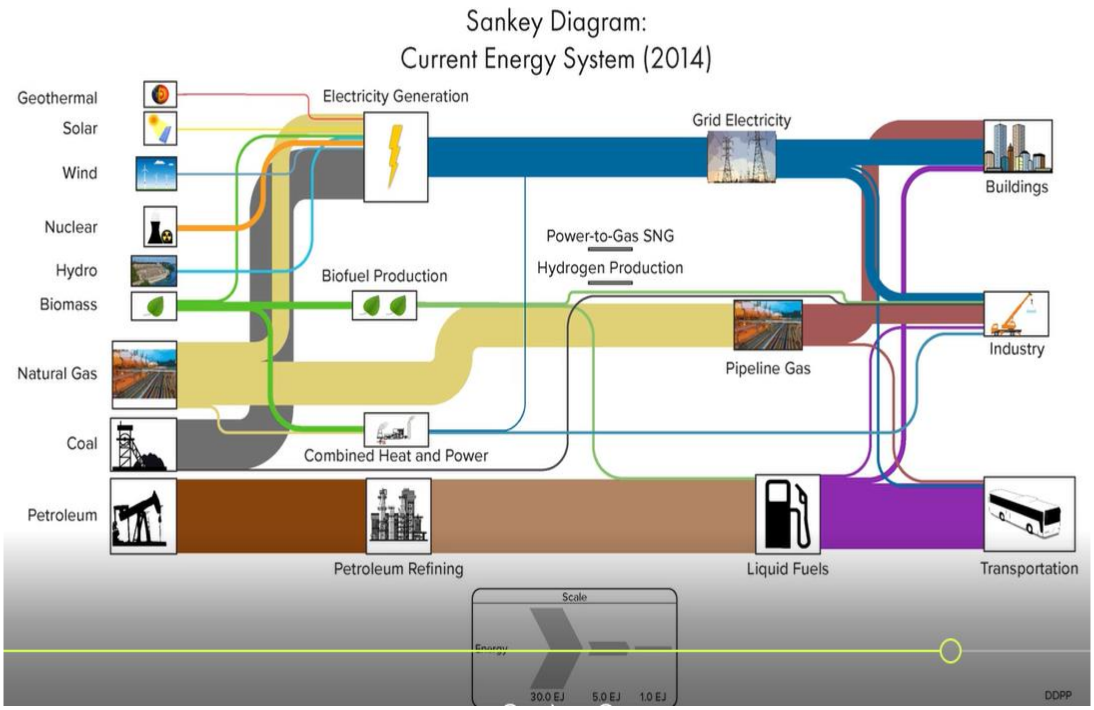
we refer to them as:

- the High Renewables Case,
- the High Nuclear Case,
- the High Carbon Capture and Storage Case, and
- the Mixed Case.

Those names refer to the kind of electricity system involved, but in fact, they're even more variable than that, because these cases also explore different kinds of transportation systems, different measures in industry, different kinds of building measures, and so forth.

But for a shorthand we refer to what's the dominant part of their electricity mixes. The point is, all four of these are able to achieve deep emissions reductions without hardships, and consistent with realistic constraints about grid reliability and infrastructure inertia.

Our current energy system-this is something called a Sankey diagram-is represented here. What it shows on the left-hand side is for 2014, primary energy is on the left. So you can see that that's dominated by very small amounts of renewable energy, like geothermal, and solar, and wind, and very large amounts of fossil fuels, like natural gas, coal, and petroleum.



As you move from left to right in this diagram the primary energy undergoes transformation to become the kind of energy that we actually use when we plug something into the wall, or we put it into our vehicles, or whatever.

What I want you to notice is on the right-hand side we've created three sort of mega end-use sectors-buildings, industry, and transportation-that's basically where energy goes for final consumption, and in the middle you can see the kinds of transformations.

Pay special attention to the blue line on top, which is electricity generation. So you can see different kinds of fuels going in and grid electricity coming out.

Let's look at a deeply decarbonized energy system in 2050. This is one of our four scenarios called the Mixed Case.

So one thing that you'll note is on the left- hand side where we have primary energy the renewable energies are much larger- those lines are much thicker-than they were in the current case, and the fossil fuel lines are much smaller to the point where coal-which is really incompatible with a deeply decarbonized system-is basically non-existent, and the other fossil fuels-petroleum and natural gas- are greatly reduced; meanwhile that blue line that represents grid electricity is greatly expanded, and this gives you a hint as to how we go about achieving a deeply decarbonized energy system while still providing whatever the economy and our daily lives need.

Q10.	What would it take for the U.S. to achieve an 80% greenhouse gas emission reduction below the 1990 level by the year 2050; is it technically feasible; what would it cost; what physical changes are required; and what are the policy implications for the U.S.?	**[30]**	**CO1, CO3, CO4**

Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

DEHRADUN

End-Semester Examination 2019

Program/course	**: MA Economics (EE)**	**Semester**	**: II**
Subject	**: Energy and Climate Change**	**Max. Marks**	**: 100**
Code	: OGET 8008	**Duration**	**: 3 Hrs**
No. of page/s	**: 11**		

Section A (attempt all)

Q1. Write short notes on the following terms.

i.	COP 22	**[4]**	**CO1**
ii.	GHG Emission	**[4]**	**CO1**
iii.	Solar Irradiation	**[4]**	**CO1**
iv.	Renewable Energy Policy of India	**[4]**	**CO1**
v.	Energy from Hydrogen	**[4]**	**CO1**
	SECTION B **Answer any four questions**		
Q2.	Explain critically energy environmental interaction at global level.	**[5]**	**CO3, CO4**
Q3.	Critically examine carbon budget in context of Paris Agreement.	**[5]**	**CO3, CO4**
Q4.	What are Green House gasses? Examine their role in rising global warming.	**[5]**	**CO3, CO4**
Q5.	Is it possible to decarbonize Indian economy? Justify your answer.	**[5]**	**CO3, CO4**
Q6.	Why companies having crude oil reserves are not happy about deep decarbonization?	**[5]**	**CO3, CO4**
	SECTION C **Answer two questions** 2 X 15 = 30		

	Read the following article and answer the questions given at the end of the article: The Ministry of New and Renewable Energy (MNRE) has proposed making it mandatory for solar power developers to follow glass recycling procedure for solar photovoltaic (PV) panels under a new framework. The National Green Tribunal (NGT) had on 4 January 2019 directed the MNRE to prepare a policy for the management of Antimony present in solar glass panels. Antimony Containing Solar Panel Glass (ACSPG) is used globally to improve the stability of the solar performance of the glass upon exposure to ultraviolet radiation and sunlight. "Producers may be made responsible for ensuring recycling of end-of-life glass panels as part of their extended responsibility as in the case of e-waste which covers used lead-acid batteries, packaging material, etc,". It also added that the power generators will have to ensure environmentally-sound handling of used solar panel waste. The ministry has given several recommendations regarding the use of Antimony. The generators might set up facilities for safe dismantling of used solar panels or should tie-up with an authorised dismantling facility. The end-of-life solar panels are required to be collected and stored safely until the option for recycling is available. It should never be disposed or dumped in open landfills as it may release Antimony into the environment. India has witnessed large solar PV installations in the past five to six years. These panels will turn into waste over the next 15-20 years. As the glass in the PV panels is reusable at the end of its life, improper disposal may result in the loss of this recyclable material. Other countries including Germany have developed PV recycling technology and Antimony containing glass may be recycled without affecting its properties. The recycling process of a tonne of PV panels is likely to produce 686 kilogram (kg) of clean glass and 14 Kg of contaminated glass. The recycled glass can be used to produce new panels with Antimony containing glass. However, in case recycling facilities are not available, the concept note stated that the industry should look at the option of disposal in secured landfills or their safe storage.		
Q7.	Examine environmental impact of disposal of solar panels.	**[15]**	**CO1, CO4**
Q8.	Discuss various options of safe disposal of solar panels? Which one is environmentally friendly and why? Analyze critically.	**[15]**	**CO3, CO4**
	Section D **Answer the question** 1 X 30 = 30		

Read the following case study and answer questions given at the end of the case study:

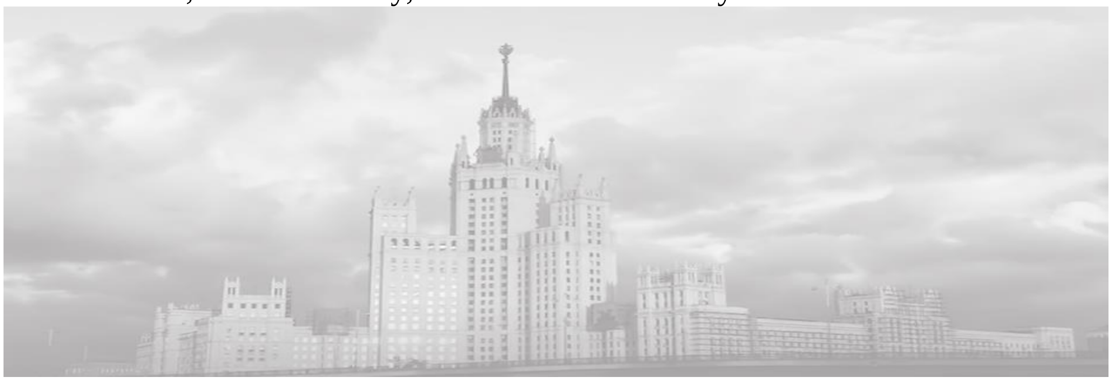
Deep Decarbonization: The Three Pillars and National Case Studies
Case Study: Russia Deep Decarbonization

Everybody knows that Russia is a huge country. By territory, Russia plays very important role in global ecological systems; of course, it plays significant role in climate change issues.

One of the focuses of research for the last twenty years already is low-carbon development for Russia. It is a very challenging issue, of course. Russia has huge reserves of fossil fuels-oil, gas, coal, shale gas and oil, and other resources-but, on the other hand, Russia has also carbon-free sources of energy and many other technologies and resources available for climate-friendly development in this century.

Russia got a very important and serious task through Deep Decarbonization Project:
Can we see, can we model Russian economy being climate-friendly, targeting to well-below 2 C degrees goal that we now have in the Paris Climate Agreement?

It is, of course, challenging. Russia needs a lot of CO_2 and other greenhouse gases from energy sector, from transport, industries, waste and landfill, and forestry. The climate science is not a top-priority for Russian people, for Russian government, for Russian business, it is evident. As well as many environmental challenges are not on top of priorities, but over time, perception of the issue is changing. So we should say that after ratification of Kyoto protocol, by now, more and more people feel changes and impetus on themselves, on the economy, environment where they live.



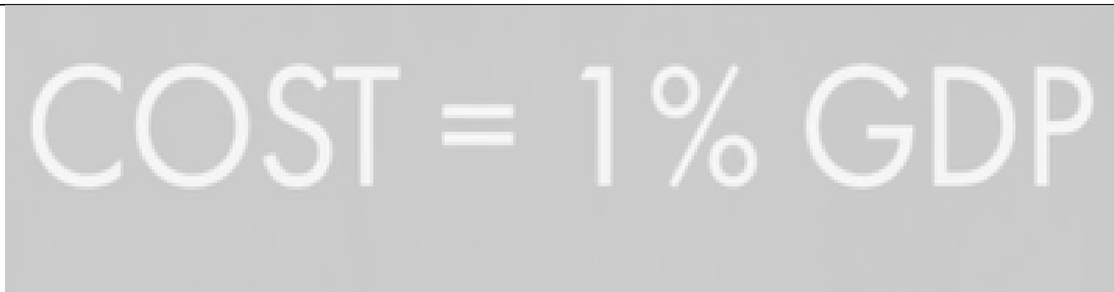
As we remember, according to last surveys, about 80% of Russians understand and consider climate change as a threat. It has different impacts in different regions of Russian provinces, but they consider this as an important challenge. Does it affect decision-making? We are not sure; sometimes, yes.
So if you have flooding in the Russian far-east, and moreover, and thousands of people lost their houses, this is a problem. If you have heatwave in Moscow and the central-European Russia, and thousands of people dying, it is a problem. It is sharp perception of what is going on. Same about forest fires. Same about droughts and loss of crop.

So, we have to find the ways how we can change Russian economy so that we would reduce emissions almost to zero by mid-century. So, what we did was we modeled a few scenarios, looking at different technological options to reduce emissions in Russia. We actually found a few pathways that we can do this significant reduction of carbon emissions.

Specifically, our target was about 87% emission reduction by 2050, mostly of CO_2 emissions, but we also focused on other sectors. We have modeled solutions, model pathways, and now we see how difficult it is to integrate this scientific research results into our agenda for policy-makers.

What we can propose, of course, is that we definitely need to include in the current decision-making technological options and risks and opportunities related to use of different energy sources, for instance. We considered different approaches, and we found that plenty of resources and technologies are available for using green energy rather than fossil fuels, including solar PV, wind, huge tidal power plants that could be installed in the far-east of Russia, in the northwest of Russia; it is related to bio-energy resources, to geothermal, so we did an analysis of investment costs and current costs, and we found that, actually, following the pathway of deep decarbonization for Russia is not really costly.

We decided to compare this result with other countries involved in this decarbonization project, and surprisingly, we found out that other countries have similar results. And overall picture for 16 largest emitting countries in the world, including US, China, India, Russia, Japan, Canada and others, the cost for decarbonization is approximately 1% of GDP for these countries.



So we found out that we do have interesting elements of this long-term story by 2050, cost-reduction for many technologies- especially, renewable energy sources-appearance of new technologies that we might expect, say by 2030, cheaper technologies for carbon capture and storage, options so we see this way of reducing costs.

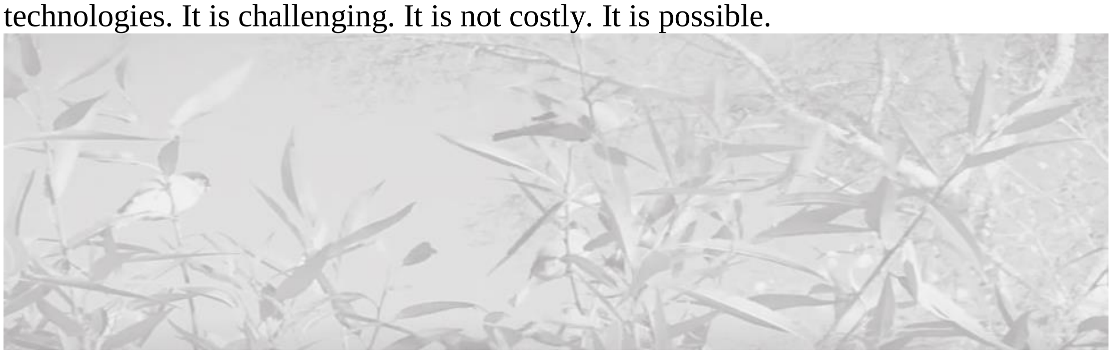
Another part of the story is that we may include in decision-making green options now so that when we substitute outdated technologies in time by new carbon-free technologies, it saves a lot of money for us. So, we concluded that it is fairly reasonable to invest and start policy-making related to low-carbon development in the country. But, we also found out that we have at least two additional strong options for emission reduction. One relates to basic materials. Maybe not many people know that approximately 28% of global emissions are linked with basic materials production and use. So this includes cement, metals, rubber, plastics, and others and we do have in Russia technologies relating to significantly reduce carbon footprint of basic materials.

Another interesting point is forests. Russia is rich of forests, we have huge part of global forests, and this forest is boreal. The boreal forest plays different role than tropical forest, actually, so our forest breathes in carbon dioxide, and keep it-store it-for many decades. So we need to care about this source of sequestration of carbon from atmosphere. And here we have challenges. Russian forest is getting older. We face impetus of climate change so that forest fires appear more often at higher scale, so we need to take measures to keep capacity of Russian forests to absorb carbon.

So this is another challenge we faced in our research. So it's not easy to say, okay, Russia will absorb a lot of carbon because of forest so we don't do anything about emission reduction. So this is the wrong position. We need to do both; reduce emissions, and keep and enhance sequestration. It is challenging. At least by mid-century, it is a task for us.

Also, we found very interesting inter-regional issue, for instance, in Asian part of Russia and neighboring countries, including Korea, China, Japan, Mongolia, we can see opportunities for cooperation in using huge potential for green energy. So these sources of energy would account for about a few hundred gigawatts of installed capacity potentially, including solar, wind, tidal, bio-energy, hydro, so this could play important role for decarbonization of neighboring countries as well, including China, which is a big challenge for all of us, for all globe.

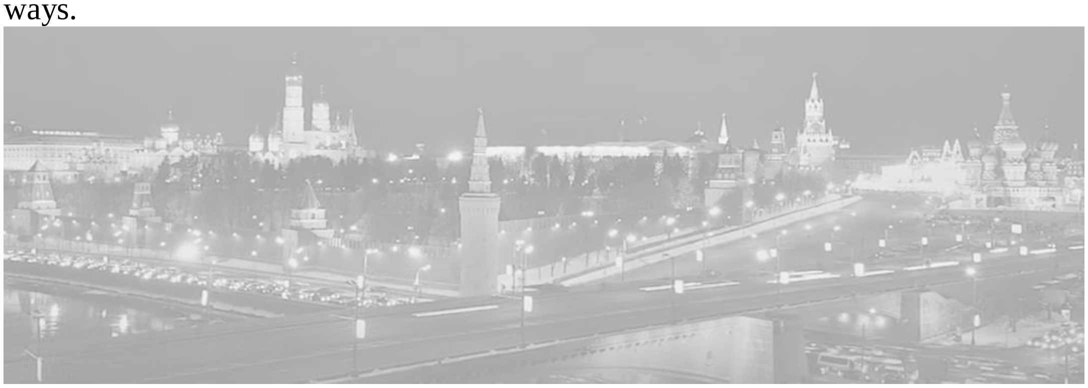
When we discuss what can we do in practice, we definitely should see the whole picture. The picture today for Russia is not just improving slightly energy efficiency or including more percents of renewables; it is a bigger challenge. It is a task to reach net-zero emissions. In this task, the whole story becomes absolutely different. So we have to do plenty of things nowadays to integrate in strategic planning, in business plans of corporations this switch towards huge scale implementations of carbon-free technologies. It is challenging. It is not costly. It is possible.



All projects that we have on energy-efficiency, on renewable energy improves quality of environment, air quality, reduces health risks, improves sustainability of the regional development, so this is multi-task, multi-dimensional story, not just carbon story.

Russia will take the lead in this, because we have huge opportunities for renewable energy and technology options aiming at reduction of carbon emissions dramatically, over 80-90%. But it is not easy. For Russia, it's important to see that Russia is not alone. That Russia is doing as much as the others; as US is doing, as China is trying to do. And of course, cooperation will play important role. Cooperation not in fossil fuels, cooperation in low carbon technologies or in zero-carbon technologies in transport, in energy systems, in many areas where we see emissions.

There are some priority issues, of course, for Russia. Improving of infrastructure, improving of communal heating, energy systems, rearrangement of energy systems in favor of low-carbon technologies, but this is possible to do. And what we see from experience of other countries, when you have strategy for national scale, you will see option for sub-national schemes, some that show efforts. And this is very impressive experience that we can already see in Canada, for instance-in case of Alberta adopting decarbonization strategies on province level-we may see similar things in China, specifically regarding province-based initial trading schemes. We should cooperate, we see and we find ways to do it, and I'm pretty sure it is for all of us to find appropriate ways.



Paris Agreement plays important role, but not only Agreement is important for it, so we need to find bilateral, multi-lateral mechanisms to do so. We may see them in BRICS agenda, we may see them in other cooperative platforms, and among countries, but Russia may be important player in this field and support the others, in terms of inventions, technologies, resources.

Now, we see reality, and reality is sometimes different. It is different in many countries, not only Russia. When lobbyists from fossil fuels play more important role than lobbyists of renewable energy, for instance. So this administrative, this economic financial incentives, are to be resolved; these issues are very important of course. So, Russian policy-makers and businesses should see three processes in order to make decisions faster and stronger. First, the decarbonization is really important and is practical for other big plans, including China, US, India, Brazil, Europe.

So this is a concept, but not scientific concept. This is a practical thing for development; planning cooperation from others. Second, extremely important. We should see divestment from fossil fuels and we already see some process-not everybody believes that this is real-but the scale of it already reached over three trillion US dollars in value of assets divested from fossil fuels.

It is very important for Russian stakeholders, for Russian stockholders, for Russian businesses to feel that okay, so if you do nothing, you are at risk. That investors will face a problem financing the projects. So this is, urgent, very important educator for Russian businesses and policy-makers to switch faster.

The third important element would be carbon pricing. So if you don't see carbon pricing in broader than dimension like it is high, the price for carbon, and it is everywhere, at least in the markets that Russian companies operate in.

If we see this-say, if the price is $15 dollars a ton, or 30 Euro a ton, as in France-this would change the rules of the game. Change economics of projects and regional development. So if we see these three processes moving on, enhancing, over time, it would definitely change the understanding and efforts in Russia.

			
Q10.	Why is decarbonization challenging for Russia? Can we model Russian economy being climate-friendly, targeting to well-below 2^0C goal that we have in the Paris Climate Agreement? Examine critically.	**[30]**	**CO1, CO3, CO4**