통합적 재난관리체계 발전방안 연구

기후변화 대응을 위한 중앙·지방 정부의 역할 중심

2022년 8월

행정안전부

이 일 령

국외훈련개요

1. 훈련국 : 미 국

2. 훈련기관명 : 콜로라도 주립대학교

(CSU: Colorado State University)

3. 훈련분야 : 재난 및 안전관리

4. 훈련기간 : 2020. 12. 20 ~ 2022. 10. 19.

훈련기관 개요

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■ 연 혁

- 1870 년에 개교한 대학으로 150 년이 넘는 전통을 자랑하고 있음. 개교 당시 최초 명칭은 Colorado Agriculture College 로 시작했으며, 이로 인해 학교가 위치한 로키산맥 인근 산 능성에 학교를 상징하는 알파벳 'A'가 새겨져 있음. 현재는 매년 신입생들이 좋은 학점을 기대하는 마음으로 A 페인트 칠을 다시 하는 행사를 개최

- 재학생 규모 35,000 명이 넘으며 교수진만 2,300 여명 정도 되는 공립대학교로서 콜로라도 주내 기술자의 30%, 주내 주민의 23 만명이 넘는 숫자가 이곳에서 학위를 받을 정도로 콜로라도 주내 터줏대감 같은 대학교임. 현재 콜로라도 볼더대학교(CU Boulder) 다음으로 규모가 큰 학교이며, 행정학 분야가 유명한 또 다른 주립대학교인 콜로라도대학교(University of Colorado at Denver, CU Denver) 와는 전혀 다른 학교이니 혼동하지 않도록 주의

- 학교가 위치한 곳은 '포트콜린스(Fort Collins)'라는 도시로 명칭에서 알 수 있듯이 과거 군사기지가 생기면서 도시가 형성된 곳이며, 현재 군 기지 자리는 역사 유적지구로 남아 있음. 콜로라도 주도인 '덴버'에서 북쪽으로 약 100km 지점에 위치한 콜로라도 중북부의 중심도시임. 대학도시로 교육·문화 관련 시설이 많으며, 최근 많은 기업이 들어오면서 인구가 급증함. 쾌적한 환경, 훌륭한 문화시설, 풍부한 일자리 등으로 미국에서 가장 살기 좋은 도시 중 하나로 거론됨

■ 기능 및 조직

- 콜로라도 주립대학교는 “CSU"로 줄여 부르며, 학교 상징은 숫양(Ram)임. 학교나 학생들 모두 ”Go Ram", "We're Ram"처럼 자신들을 Ram 으로 표현하며, 학교 행사나 스포츠 경기 시 해당 마스코트를 자주 볼 수 있음.
- CSU 는 총 8 개 단과대학으로 구성되어 있으며, 약 300 여개의 학위, 자격증 프로그램 등이 존재함. 전염병, 대기 과학, 청정에너지, 환경 과학 및 생물 의학 기술 분야가 유명하며 매년 3 억 달러 이상의 연구비가 투자되고 있음. 수의학, 작업 요법, 저널리즘, 농업 및 건설 관리 분야 등 대형 공립대학교 답게 마이너 한 분야에서의 연구도 활발히 이루어지는 학교임.
- 학교관련 순위를 살펴보면, 등록금 및 학업만족도 등을 고려한 콜로라도 주내 4 년제 대학 1 위, 학교시설 및 학습 환경 등을 고려한 전미 종합평가 A-, 녹색환경을 고려한 지속가능성 대학 No.1 등 각종 랭킹에서도 좋은 성적을 거두고 있음. 자세한 사항은 홈페이지 참고(admissions.colostate.edu/rankings)

■ 소속 학과 소개

- 본인의 경우 CSU 의 자연자원 대학 내 생태과학 및 지속가능성(Ecosystem Science and Sustainability) 분야의 전문과학석사(Professional Science Master) 과정에 재학. 해당 학과는 2019 년까지 “온실가스 관리 및 측정 전문과정”이란 명칭을 사용하다 지금은 “생태과학 및 지속가능성 전문과학 석사과정”으로 명칭이 바뀜.

- 명칭의 변경에서 보듯이 본 과정은 기후변화와 온실가스를 과학적으로 연구, 측정하고 이를 줄이기 위한 방법 들을 탐색하며, 국가 간의 갈등관리, 온실가스 정책 등을 연구

- 졸업학점은 최소 36 학점 이상을 이수해야 하며, 이중 18 학점은 필수, 18 학점은 선택이나 선택과목 중 최소 9 학점 이상은 GIS, 프로그래밍 등 기술실습(Lab) 분야를 이수해야 함. 또한 최소 4 학점 이상의 인턴쉽 과정을 의무적으로 이수해야 졸업할 수 있음.

The study of integrated disaster management development focused on responding to the climate change crisis considering the role of Central and Local Governments

2022. 8.

Colorado State University
Ecosystem Science & Sustainability

AJ Lee

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1. Introduction

When I was a child, most of kids as same age of me could see the TV advertisement of Coca-Cola that was polar bear drinking a coke with a red scarf representing upcoming a big holiday, Christmas. Thus, even now a few decades gone after that, whenever Christmas approaches, I frequently have remembered the white polar bear happily drinking Coke. However, these days kids perceive a polar bear as a representative endangered animal by the climate change getting worse. Also, the Coke company is no longer using this cute character, once as famous as Rudolph at Christmas, in their advertisements, because of changed image. In just a few decades, the image of polar bears has changed dramatically from the cuteness to the pity of the endangered species. In addition, as you can admit, it is becoming a daily life to see the news that the heat wave hitting a new record or severe floods occurring in everywhere of the world. As like that, the climate change has made a lot of changes to the global society for the just short period of time.

And many experts are warning that these unprecedented changes are only the beginning, and that unless dramatic efforts to reduce fossil fuel are made, the risks of the climate change will increase and threaten the very existence of human beings in the future. Therefore, a perception of the climate crisis differs from generation to generation as the polar bear image

mentioned before. While young people are calling for change from the older generation who is believed for them to have ruined the planet and demanding a stronger response to the risks, older generation cannot easily let off their long-held way of life believed as right. This perception gap for climate change is not only in generation difference, but also it appears differently depending on personal wealth status, the level of economic development of country, and religious or traditional customs. So, the issue of climate change is very complex because so many people are affected differently, and it will take a lot of time, sacrifice and pain to solve it. Maybe instead of tackling climate change, adapting to it might be the right expression.

However, despite these gloomy predictions, the hope is that the world is aware of the risk of climate change and is working to address it little by little, albeit slowly. From now, I will look into the cause and current trend of climate change briefly and how the world prepares to it. And then look for what we can get lessons from that, and how to apply that to Korean disaster management system.

2. Theoretical Background

2.1. The cause of Climate Change

As most people already know, the cause of climate change is stem from warming the Earth. And the cause of warming planet is come from “Greenhouse Gases (GHG).” Long story shorts, the energy absorbed and released by the planet must be equal by the law of energy conservation ($E_{absorbed} = E_{emitted}$). But some planets with atmosphere layers cannot emit same energy absorbed to the space because a part of emitted energy is caught by atomic structure of GHG in the atmosphere. Considering only the temperature, ignoring other conditions necessary for growth, such as moisture and soil components, it is naturally necessary to have an appropriate temperature to have an environment where the planet can live. In order to do so, the Earth need to be maintained at a temperature that is neither too cold nor too hot, and the presence of the atmosphere that could hold the planet's radiant heat to an appropriate level. Some experts argue that the reason why the Earth was able to maintain its habitable environment even in the ice age over the past was because greenhouse gases in the atmosphere were able to maintain a certain level of temperature by capturing the Earth's radiant heat. So, greenhouse gas is literally a vital factor to establish an appropriate temperature in the planet where is favorable to habitats. Over the past time, GHG concentrations have changed frequently, warming or cooling the Earth accordingly. Many of the Ice Ages we know well were times when the Earth was cold because the

concentration of these gases was not enough high to catch heat radiation energy. Although the increase and decrease of the global temperature were repeated several times over the Earth history, there was a tendency that the upper and lower limits of the temperature were maintained at a certain level overall. In other words, it can be interpreted that the concentration of GHG in the atmosphere has been continuously circulating for a long time at the boundary of a certain level. This stability is because the three components of nature, that is, the atmosphere, land, and ocean, have been in balance while emitting or absorbing and storing greenhouse gases.

However, since the Industrial Revolution, manmade greenhouse gases have been emitted, and the stability of GHG has begun to break. The Industrial revolution, represented by the steam engine, burned a huge amount of coal, and after that, various fossil fuels such as oil and natural gas also started to be combustion all over the Earth. Although there are many types of greenhouse gases in the atmosphere, but Carbon Dioxide(CO2), it is known as doubling concentrations of the gas make warming mean temperature of the Earth by 3 degrees Celsius. So, the emissions from the fossil fuels we consumed so far have been stocking in the atmosphere for a long time, they have been catching heat radiation more and more by their concentration growing. It appears that this apparent physical causality is causing so-called climate change, global warming, which breaks the cycle of

increasing and decreasing global temperature that has been going on for a long time since the birth of the Earth (Figure1).

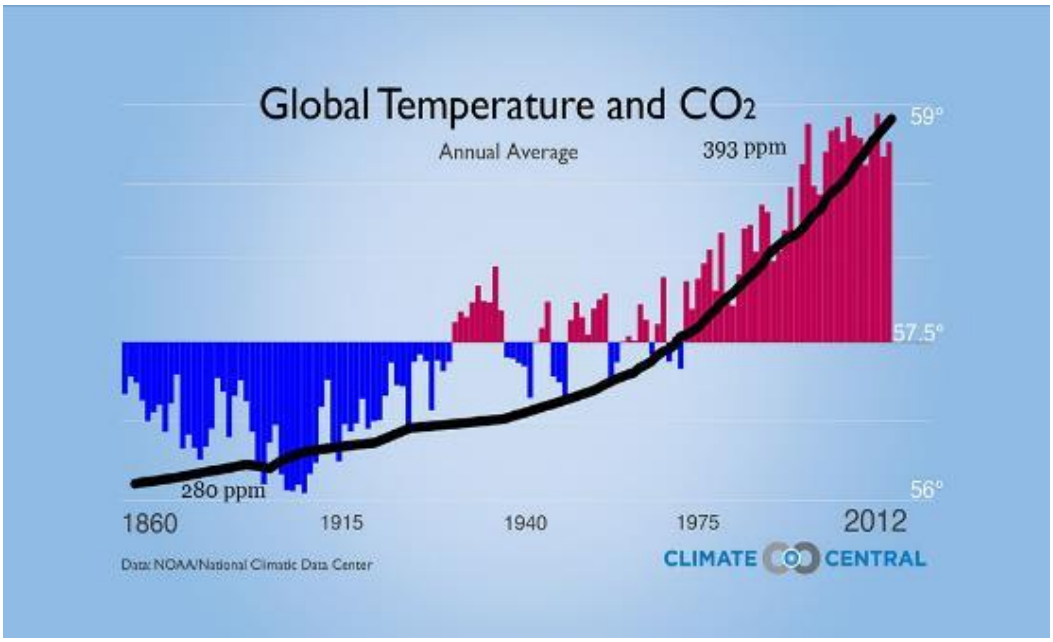


Figure 1. The trend of global temperature and CO2 concentration (source: Climate Central organization report)

According to the study, before the industrial revolution, the amount of CO2 in the atmosphere was very steady for thousands of years at about 280 ppm, while the one is about 405 ppm these days and is increasing. Since the risk of climate change have been raised by scientists, the world has been slowly cooperating until now, recognizing climate change as a common problem rather than a specific issue for some countries.

2.2. The Climate Agreement and Current GHG emissions trend

As you see the figure below, the world has made many climate

agreements so far. Since 1988, 'Intergovernmental Panel on Climate Change (IPCC)' was established, the global has been responding climate crisis through big three agreement, UNFCCC, Kyoto Protocol, and Paris agreement (Figure 2).

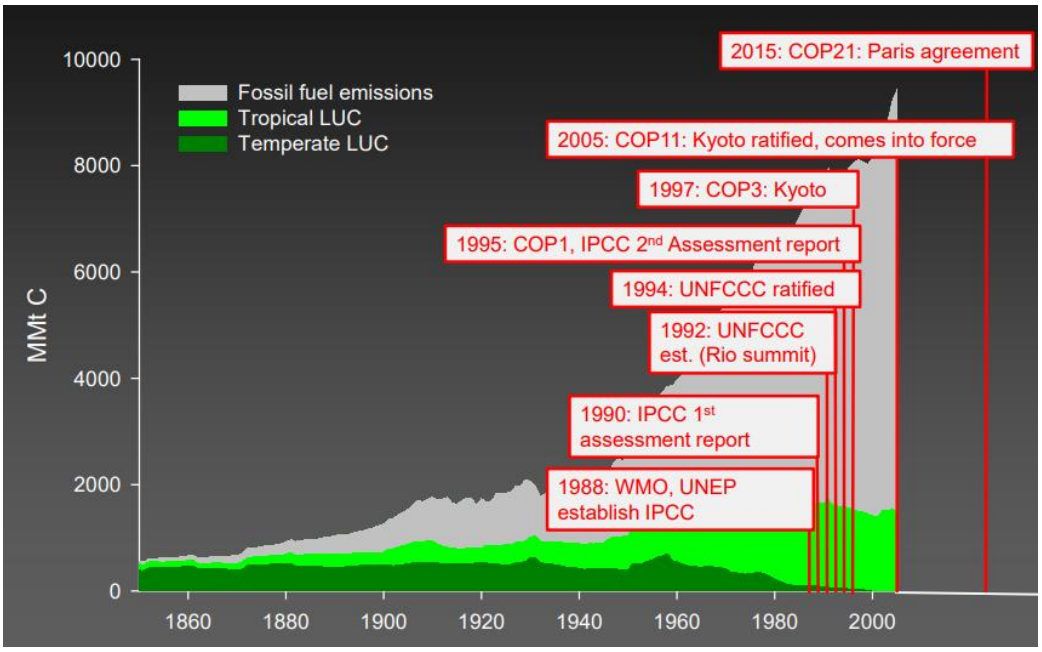


Figure 2. The list of global climate agreement with increasing fossil fuel emissions (source: Dr. Conant presentation for ESS524 in CSU)

First, for the UNFCCC, United Nations Framework Convention on Climate Change, was the first global legal agreement on the control and management of GHG. The agreement differentiated each countries' responsibility to reduce emissions depending on economic status, emissions, historical emissions, and etc. By applying market solutions such as carbon trading to increase the feasibility of implementing the policy of the

convention, countries were obligated to prepare measures to reduce the effect of climate change, and countries with obligation to reduce GHG were asked to provide funds for developing countries. But as it was an international agreement without enforcement and many countries did not feel the urgent need to reduce GHG, as time went on, it remained only a declarative agreement.

In 1997, Kyoto Protocol, UN convention on climate change in Kyoto Japan, was chosen attracting global interests for climate change. The protocol suggested a particular goal that keep to assigned amount of GHG with overall worldwide reduction by at least 5% below 1990 level by 2008-2012. To achieve this goal, Kyoto Protocol also differentiated each country responsibility and charged penalties unless comply obligations. Joint implementation, Clean development mechanism, and Emission trading were allowed among countries to enhance the feasibility of the protocol. But as you have already experienced in 2012, this agreement did not achieve its goal, too. Rather, the rapid economic development of developing countries such as China and India had resulted in a sharp increase in GHG, rather than a reduction goal compared to 1990.

After experiencing several helpless failures of the climate agreement, the Paris Agreement was finally adopted in 2015. It is similar to the Kyoto Protocol that the issue is common but differentiated responsibilities. While it

has many elements of Kyoto, the explicit goal of the agreement is different with the last agreements. Paris agreement set the goal that holds temperature increase well below 2 degrees Celsius by the end of 21st century compared to the period of before industrial revolution and limiting the increase to below 1.5 ℃ is an ambitious goal. It has established NDC, Nationally-Determined Contribution, prior to the agreement so that alleviate repercussion from developing countries such as China, India due to stiff single GHG reduction goal that could curb their economy. NDC allowed each country to set its own reduction target that fit their own circumstances. So, country-specific GHG reduction goals are submitted by nearly every country including China, India, and the U.S. Since then, there have been several dangerous moments that could break this agreement, but the world has been gradually implementing greenhouse gas reductions according to their respective goals. However, due to unexpected external factors such as Covid pandemic and the war in Ukraine, the goals of the Paris Agreement are facing the risk of failure, and there are grim prospects that humanity will probably miss even the last chance to prevent climate crisis. According to the study in 2010, assuming GHG emission rates and carbon sink capacity maintain constant, it would take about 20 years to burn about 100 GtC of budget carbon, which is the amount of carbon that could be burned to keep

rising temperature below 2℃ without global economic damages. Considering that 10 years have already passed since the study showed, it can be seen that there is not much time left when we must achieve radical change in our lives and economic system in order to achieve the goals of the Paris Agreement. Worse, the Ukraine war is exacerbating the energy crisis in Europe that has driven the transition to less-GHG energy systems over the past few years. And as economic sentiment, which has been stifled for years by the pandemic, recovers, consumption of more fossil fuels is increasing around the world. However, even in such a gloomy environment, efforts to reduce greenhouse gas emissions are not diminishing, and voices that more drastic measures should be taken with greater awareness are gaining strength little by little.

3. The Efforts to prevent Climate Change

3.1. Decarbonization options in Energy sector

It is clear that there are no ways to prevent climate change. To express accurately, it should be interpreted counter-measures to mitigate or adapt to climate change. This is because the greenhouse gases already emitted into the atmosphere so far cannot removed for a long time even

millennia. So even if we stop GHG emissions from now, it is hard to prevent warming the Earth in the future, some argue that it will take 200 to 300 years for the global temperature to return the current level. After all we already on the track of unstoppable climate change, and it could be said that we are just trying to slow the global warming by reducing greenhouse gases emissions to prevent human-being extinguish. This is why the goal of the Paris Agreement is set of limitation of increasing temperature not reducing one. Let's take a look at current efforts around the world, including the United States, to mitigate the impacts of the upcoming climate crisis.

As of 2018, the global greenhouse gas emissions are about 49 billion ton CO2eq as shown in the figure below. And if you break down the emissions by sector, you can see the energy sector accounts for the largest share at around 74 %. Therefore, the largest part of the global GHG reduction efforts is focused on reducing the use of fossil fuels in the energy sector (Figure 3).

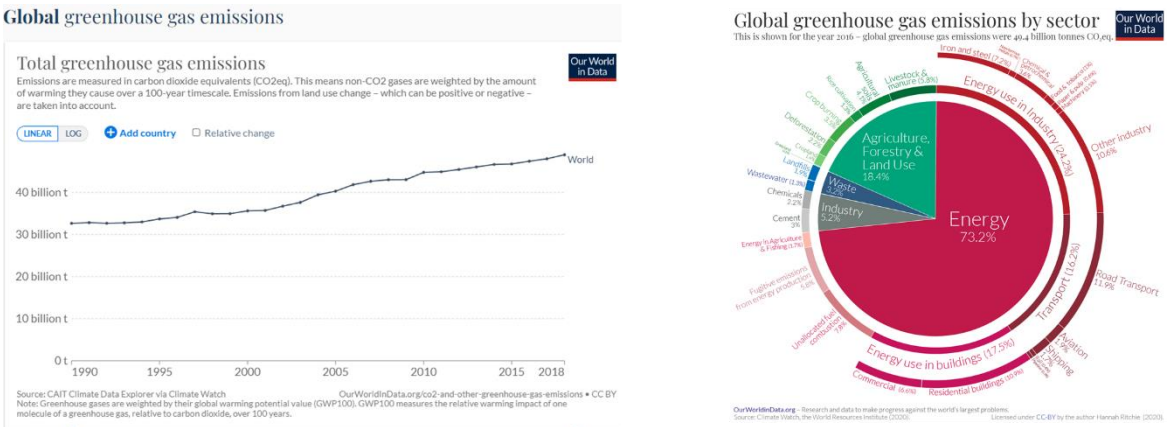


Figure 3. Global greenhouse gas emissions and the broken emissions by sector (source: Our World in Data website)

It seeks to achieve its goals by many ways such as increasing the use of renewable energy like solar and wind power, increasing energy efficiency, and innovation in energy storage technologies, mainly in industry, building, and transportation field which accounted for most usage of the energy. However, these mitigation efforts are by no means easy. Most of the greenhouse gas emissions are carbon dioxide. And most of this CO2 comes from the energy sector of industry and transportation, as mentioned earlier.

There are several reasons why it is difficult to reduce CO2 in the industrial sector. According to McKinsey report (2018), first, 45% of CO2 cannot be reduced by changing the feedstock, only by changing the process. And 35% of the emissions are generated by combustion, and alternative fuels such as carbon-zero electricity of hydrogen mush reach high processing temperature and are accompanied by changes in furnace design. Industrial processes are often highly integrated, so any change to one part of the process will necessarily entail change to the entire process. Also, production facilities are generally long-lived. In the case of regular maintenance, it can be operated for more than 50 years, so changing the process in an existing production facility is expensive to modify or rebuild. And the process change to zero-carbon affects price competitiveness. For most carbon-intensive products such as ammonia, cement, ethylene, and steel, cost is a decisive consideration. there may be few companies are willing to bear the increased

price of commodities by adopting a low-emission process.

Despite the challenges outlined above, companies in the four main areas can bring their CO2 emissions close to zero through a variety of approaches. The most promising are improving energy efficiency, electrification of heat, using hydrogen made from carbon-free electricity as a feedstock or fuel, using biomass as a feedstock or fuel, and applying carbon capture and storage (CCS) or usage(CCU) technologies. In general, the most important factors are low-carbon energy source, especially carbon-free renewable electricity generation and sustainably produced biomass. The availability of captured CO2 storage capacity, along with public and regulatory support for carbon storage, will impact the feasibility of CCS implementation. But the optimal combination of decarbonization options may differ as the most practical or economical option depending on regional factors, so companies should investigate closely these factors and evaluate their options on a site-by-site basis. Let me introduce respective main decarbonization option briefly.

Improving energy efficiency is a cost-effective way to reduce CO2 emissions by around 15-20%. One of the well-known equations in the field of climate change research is the ‘Kaya Identity’. A simple equation that describes future CO2 emissions. In which four factors drive CO2 emissions: Population, GDP, Energy intensity, and GHG intensity.

$$CO_2\ emission = Population \times \frac{GDP}{Population} \times \frac{Energy}{GDP} \times \frac{GHG}{Energy}$$

Figure 4. Kaya Identity Equation

Since population and GDP are unlikely to decrease in the future and human-being cannot adjust intentionally, so these factors can be viewed as continuous increasing constants. After all, only energy intensity and GHG intensity can be controlled by mankind, and energy intensity can be reduced by increasing energy efficiency. Improving energy efficiency would be a good start, but not enough to achieve the greenhouse gas reductions required by the Paris Agreement. And because energy efficiency improvements can have a longer financial payback time than companies accept, so many companies may not pursue these improvements to the extent necessary for a 15-20% emission reduction. Therefore, long-term support from the government to solve the difficulties in businesses sector will be required.

Next, where carbon storage is available, CCS offers the lowest cost decarbonization option. It is also the only technology that can completely reduce process-related CO2 emissions in cement production. But for now, CCS is still expensive. Further innovation will be required to make it cost-competitive with other decarbonization options, such as carbon-free power generation. According to economic analysis, If the wholesale price of zero-

carbon electricity is $50 per megawatt-hour or less, using electricity to produce heat or hydrogen may be more economical than CCS in many situations. For example, at less than $35 per megawatt-hour, it is cheaper to use hydrogen as a fuel in newly built ammonia or steel plants designed around hydrogen than using CCS (Figure 5).

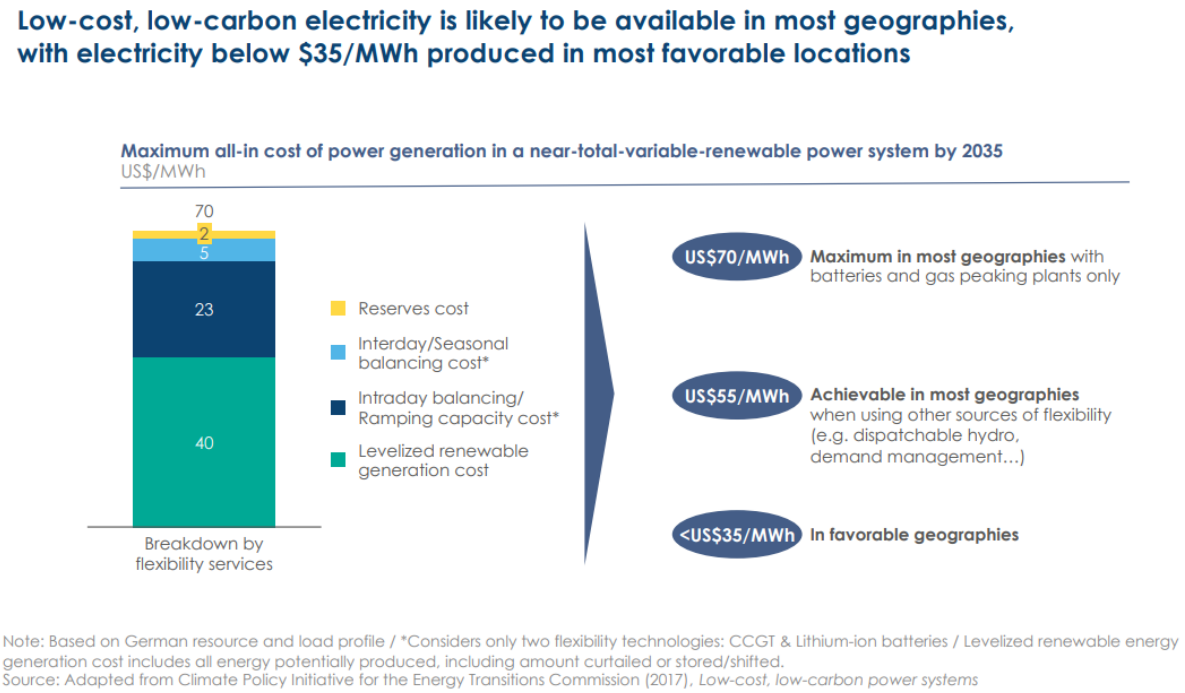


Figure 5. Low-cost, low-carbon power system (source: Adapted from Climate Policy initiative for the Energy Transition Commission, Mission Possible p.16, 2018)

Thus, if the price of electricity produced from zero-carbon renewable sources such as solar and wind falls, a more cost-effective decarbonization options may be available. As the price of electricity produced by renewable energy continues to fall through technological advancement, it is expected

that electricity generation without using fossil fuels will be possible in the not-too-distant future.

Conversion to biomass as a fuel or feedstock can be financially attractive in a cement plant or newly built steel plant because there is already mature technology. Biomass can also replace fossil fuel feedstocks for ethylene and ammonia products. Although this approach is more expensive than using electricity or hydrogen, it can reduce emissions in both areas of production and disposal of end-of-life products. One major challenge, however, is that sustainably produced biomass is abundant in some areas but is scarce worldwide.

Regardless of the decarbonization options introduced so far, except for improving energy efficiency, decarbonization definitely increase electricity demand. For decarbonization, the four key sectors (cement, ammonia, ethylene, steel) must be provided a reliable and low-cost supply of about 25-55 exajoules of carbon-zero electricity per year. This is about 4 to 9 times the amount required if no special efforts are made to reduce CO2. Achieving this increase in carbon-zero electricity supply requires significant and costly transformation of energy systems. Depending on the price of zero-carbon electricity, it will cost between $11 trillion and $21 trillion (0.4-0.8% of global GDP) by 2050 (McKinsey report 2018).

Governments can develop roadmaps for industrial decarbonization at

local and regional levels, creating a clearer outlook for industry and utilities and helping them withstand long payback times. Government can also support decarbonization by coordinating regulations and incentives. For example, changing the financial requirements for utilities and other companies involved in energy generation and distribution could encourage investment in renewable energy generation capacity.

So far, we have identified several efforts to reduce greenhouse gas emissions in the energy sector. But the world is working to reduce GHG emissions everywhere. Various efforts are being made, such as continuously reducing renewable energy costs through technology development, developing technologies to reduce methane generated by livestock, reducing greenhouse gas emissions through conversion of cropland management methods, increasing building energy efficiency, and expanding wooden structures sequestering carbon. In addition, these efforts are being made not only by the government.

3.2. Private Governance respond to Climate Change

These days, private governance is emerging in response to climate change. As the word suggests, private governance refers to a sector of non-government. The world is working hard to achieve the goal of Paris

Agreement as mentioned before. But recently announced GHG emission figure showed a tendency to rise again after a brief decline due to the Covid pandemic. This below-right figure is a picture of the protesters around the "COP 26", Conference Of the Parties. They demand for action right now, not asking for more promises (Figure 6).

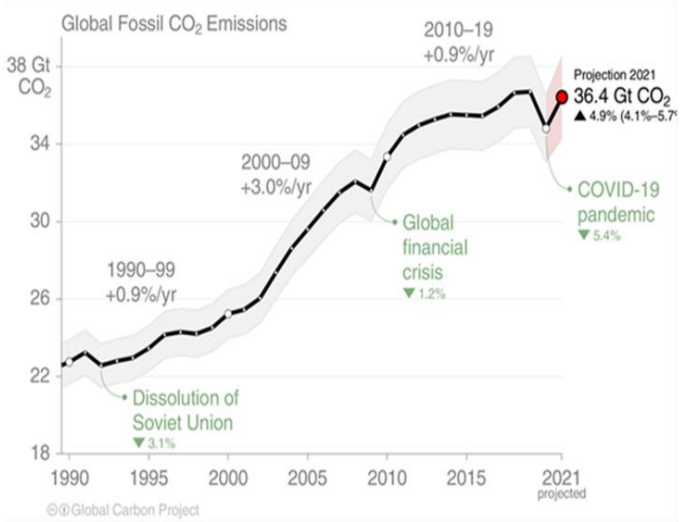


Figure 6. Global GHG emissions (left), and Demonstration around COP26 (right) (source: CDIAC; Le Quéré et al 2018; Global Carbon Budget 2018, Reuter News)

Many people feel that the climate change is a very urgent issue, but each government is not doing enough actions to address it. Although the role of the government is very important in reducing greenhouse gas emissions, there are also many roadblocks. For example, the different position between the US former Trump administration and the current Biden administration on climate change, and China's growing coal power generation due to diplomatic tension with western countries like Australia.

Also, even if the government is active in reducing GHG emissions, it will take a long time to enact relevant regulations and obtain the consent of the congress. Given the urgency of climate change, relying on government alone can be a very inefficient solution. Thus, based on this background, the private governance concept has emerged and is becoming increasingly important.

If so, who will be in the private governance? As everyone already knows, it can be said that all parts that are not government bodies belong to the private governance. A typical example would be business, followed by NGOs, industry associations, households and individuals, and communities and religious organizations. And among them, businesses can play a big role. As you know, Amazon has committed to being carbon neutral by 2040, 10 years ahead of the Paris Agreement target. And Google and YouTube have announced they will ban ads from people spreading misinformation about climate change.

Another notable point in the action on climate change is that it recognizes and approach climate change response as an overall social transition movement, not just focusing on reducing greenhouse gas emissions. It is called ‘Just Transition’.

4. Just Transition toward low-carbon society

4.1. What is Just Transition ?

4.1.1. Understanding of Sustainable Development

To understand the concept of Just Transition, from now on, I will introduce a critic summary of the book, 'Planetary just transition? how inclusive and how just?' (Stevis, D., & Felli, R. 2020).

In recent decades, a dual awareness has arisen; although it is important to preserve the natural environment, this must be done alongside a commitment to protect and improve the health and livelihoods of workers and marginalized communities. The idea - later called Just Transition – was first born in the United States in the 1970s. To understand this concept, a rough understanding of sustainable development is first required.

In the past, people thought that humans would be able to dominate nature; in the same vein, from the viewpoint of only focusing on efficient resource management, it was also believed that poverty could be overcome through economic development. However, as the problems of socio-economic poverty and inequity continued to increase alongside environmental problems, the concept of 'sustainable development' was formally introduced in the 'World Conservation Strategy', a 1980s-era

collaborative document between the International Union for Conservation of Nature and Natural Resources, United Nations, and World Wildlife Fund. Since then, sustainable development has become a widely recognized (and used) concept. As a result, it now has many different meanings for different stakeholders, triggering different responses. However, in broad terms, the concept of sustainable development is an attempt to combine growing concerns about a range of environmental issues with socio-economic issues. Thus, this relatively complex concept can be mapped based on two axes: a.) socio-economic well-being and equity concerns, and b.) environmental concerns. Each of these two axes can be further grouped into three categories: Status quo, Reform, and Transformation (Figure 7).

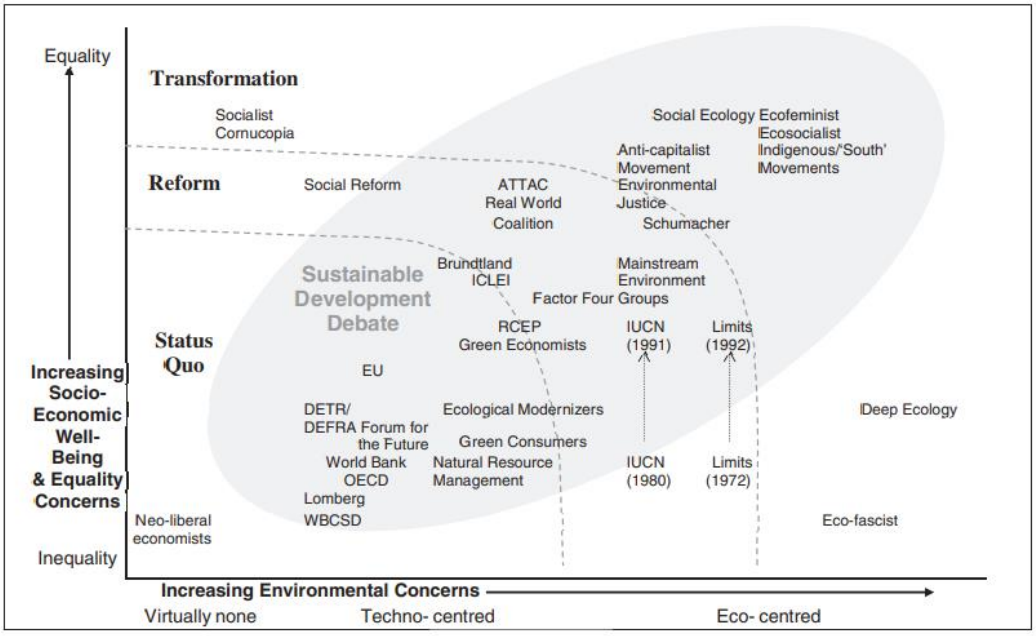


Figure 7. Mapping of views on sustainable development (source: Sustainable Development: Mapping Different Approaches, Bill Hopwood, 2005)

The Status quo argue that adjustment can be made without fundamental changes to society, decision-making tools, or power relations. This is dominant view of government and businesses. This concept claims that business is a driver towards sustainability; increased information, changing value, improved management, and new technologies that operate through markets are all the best means to achieve sustainable development. Overall, most proponents of the status quo are less committed to environmental sustainability. Status quo institutions include the European Union (EU) and World Bank.

On other hand, those with Reform views generally do not seek the root of problems in the nature of the present society, but rather believe that current issues are the cause of imbalances and lack of knowledge and information. These actors focus on technology, good science, market modification and government reform, believing that sustainable development requires government to play a leading role. This group includes a wide variety of people, including some from government and public institutions, but is mostly made up of professionals from academia and mainstream NGOs. They have broad support for dramatic increases in energy efficiency and a shift in energy use from fossil fuels to renewable sources. It is argued that new technologies will not only protect the environment, but also provide broader economic and social benefits to mankind.

Transformationalists argue that current issues are rooted in the fundamental features of today's society and the way humans interact with the environment. These actors argue that drastic changes in society and/or changes in human relationships with the environment are necessary to avoid increasing crises and possible collapse in the future. They believe that social and political action is needed for sustainable development, which generally includes those outside the centers of power, such as indigenous groups, the poor and working class, and women. Furthermore, this group believes that a massive redistribution of wealth and power is necessary for truly sustainable development. Eco-socialist and Eco-Fascist movements are commonly considered transformationalists, although academic concepts such as Deep Ecology also fall under this banner.

Given the need for fundamental change, the deep link between human life and the environment, and the common link in power structures that exploit both people and the planet, we can argue that transformation is essential. However, we do not believe that transformative way is the only rational direction. Reform now is better than nothing, and transformation may not be immediately feasible. Some argue that movement toward reform or transformation is the baseline for the concept of Just Transition.

4.1.2. Understanding of Just Transition

JT (Just Transition) is an American labor movement that was started by Tony Mazzocchi, a trade union activist of the Oil, Chemical and Atomic Workers' Union (OCAW) in the 1970s. The goal of the movement was to preserve the natural environment while protecting the health and livelihoods of workers. Since then, Just Transition has developed and spread to other regions and support groups, from environmental justice organizations to the international trade union movement, all the way to international organizations and to the private sector. Ultimately, the JT concept has seen inclusion into the full text of the Paris Agreement and the 2009 COP documentation, demonstrating increasing planetary scope and international support.

JT proposes that justice and equity should form an integral part of the transition to a low-carbon world. While most people agree that equity and justice should be included in policy debates and decisions on low-carbon development, the various stakeholders involved in the debate often have distinct views range from simple claims of job creation in the green economy to radical critiques of capitalism to rejection of market solutions. To meet these diverse needs, we can use a.) scale to address the geographic and temporal inclusivity of JT, and b.) scope to address social and ecological

inclusivity.

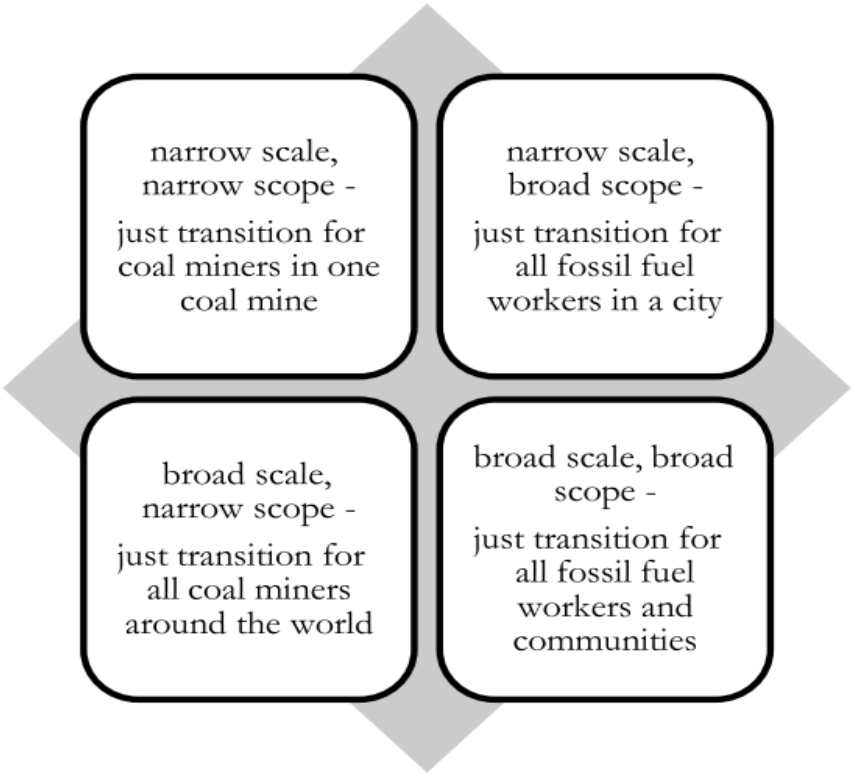


Figure 8. Configurations of scale and scope: Degrees of inclusion (source: Planetary just transition? How inclusive and how just? Dimitris Stevis, Romain Felli, 2020)

Scale indicates the spatial and temporal reach of a particular proposal or policy. Spatiality is not purely physical or legal artifact, but a product of debate and politics. The temporal scale of policy is also the product of politics and debates, influenced by various people, places, and geographical boundaries. Many analysts have argued that space and time are products of a common social process that forms the boundary between humans and nature.

Scope is another dimension of JT. When assuming that everyone will

ultimately benefit from justified transition initiatives (such as a low-carbon future), scope considers which actors or supporters should be directly supported (in some form of resource allocation); this can range from benefiting only a single interest group, all the way up to large organizations focusing on holistic societal benefits. The authors of JT emphasize the need for a holistic approach to planetary issues. For example, transformation in the energy sector needs to cover all major fossil fuel sources such as natural gas and tar sands, not just the source that are the most convenient to address such as coal. In addition, material extraction and labor practices within the renewables sector must also be examined as the authors assert that there is no evidence that conditions are more ethical socially and ecologically compared to the fossil fuel industry. By taking a broad scale and scope, international institutions can initiate transformational change.

Certain regional JT can inevitably become more democratic and ecological compared to the planet. However, JT, which may appear liberating at one configuration of scale and scope, can nonetheless be exclusionary and unfair when placed in an entire historical context; for example, a national carbon policy may only offload responsibility onto other members of the global community. In light of this, the more comprehensive Planetary Just Transition (PJT) was introduced. The views of the PJT may differ not only in terms of breadth or inclusiveness, but also in terms of the depth of their

claims of justice. The authors examine the latter, focusing on how to strike a balance between justice between humans and between humans and nature.

A distinction was made between inegalitarian and egalitarian views. An inegalitarian and anthropocentric view has the potential to produce global environmental injustice, while an egalitarian anthropocentric view instead has the potential to produce traditional global environmental justice in terms of environmental damage and distribution of benefits. An inegalitarian view that privileges nature, whether it is deep ecology, biocentrism, or conservationism, will produce planetary ecological injustice; it has been argued that is the case with worldwide national parks. On the other hand, egalitarian and eco-centric views will produce planetary ecological justice. Overall, situations must address specific controversies and power relations rather than simply rest on a technological fusion of depth and breadth; otherwise, a planetary justice transition would not appear fully formed.

Our challenge, therefore, is to differentiate between a Just Transition that seeks opportunities for more social and ecological justice, and a Just Transition which seeks to identify and manage existing political economies and crises. The PJT calls for solving planetary problems of all complexity by promoting policies that address inequality both at the local and global levels. As such, the study of both planetary due diligence and planetary justice must

be attentive to social relationships that transcend boundaries. Therefore, it will be necessary to study how social forces—especially trade unions and egalitarian social movements—can foster global solidarity strategies around a political agenda that promotes inclusiveness and justice between humans and nature. In our view, the Planetary Just Transition policy requires the inclusion of everyone affected/connected, including nature, not just those most responsible. As a result, there will be the empowerment of the weak and a demand for the weakening of the strong.

Although the concept of Just Transition was unfamiliar at first for me, I was quickly convinced that it was needed to solve a problem entangled with many stakeholders and massive scale, such as climate change. Based on the point of the author's claim, it needs that does not simply consider technological solutions to respond climate change, but begins to consider communities, especially those who are marginalized at the center of power, to move forward for truly sustainable development. These kinds of policies, considering socio-ecological relationships, will be a steppingstone for Planetary Just Transition for a low-carbon world. Today, climate change is a top priority in many countries, and it is self-evident that various measures to solve this problem are causing many social changes and conflicts. Traditional approaches to planetary problems may no longer be effective as they may not address the breadth of inequities long embedded in society, such as

racism, sexism, and the gap between the rich and the poor. As suggested by the author, it is necessary to actively consider the approach of a just transition that pursues more inclusive and more transformational power relationships on a global level.

4.2. Real case of Just Transition responds to Climate Change

While Korea has recently been paying attention to reducing greenhouse gas emissions by using technologies such as electric vehicles and renewable energy generation, the world is seeking to respond to climate change in consideration of the socio-economic movement called Just Transition introduced above, beyond simply responding to climate crisis using technology advancement.

4.2.1. JT of South Africa

Although the South Africa government is working to reduce its carbon footprint, it currently has one of the world's most carbon-intensive economies (Currently, they plan to open 40 new coal mines in addition to 1,600 existing coal mines). The Congress of South African Trade Unions has worked with environmental groups since 2010 to educate people about the negative impacts of climate change and need for more sustainable energy

policies (Cock 2018). Despite these efforts to unite labor and environmental movements, tensions persist over potential job losses and the closure of coal mines and coal-fired power plants. Trade Unions agree that climate change is a threat, but demand that the energy transition does not require a lot of jobs and that developing an environmentally friendly economy and enabling workers to transition to equal and decent green jobs should be a dual focus.

However, some environmental groups oppose these measures and call for faster conversion and closure of coal mines. The National Union of Mineworkers of South Africa (NUMSA) argued against privatized renewables, not against renewables. They were concerned about the point that some environmental groups are insensitive to the risks of a rapid, market-led shift, especially in the context of the high unemployment rate South Africa is facing (Cock 2018) and the growing trend of rising electricity prices that the working class cannot afford. And The One Million Climate Jobs Campaign, an alliance of labor, social movements, and popular organizations in South Africa, calls for a much more radical approach, including a public sector-led shift away from market liberal development paths. This shift includes shifting public investment from fossil fuel projects to climate jobs that can both combat climate change and create jobs. Following the proposed path will strengthen the role of local governments in promoting energy equity and access and create decent jobs. It could also play a role in supporting a

democratic transition from a bottom-up, built-in fossil fuel capitalism. It remains to be seen whether the currently complicated transition movement can truly achieve a truly Just Transition and shift to cleaner energies will take place.

4.2.2. JT of Canada

As a politically positioned oil-dependent economy as an international climate leader, Canada exemplifies the many tensions in the clean energy transition. Government-led efforts to phase out coal while supporting affected workers and communities provide a concrete example of a relatively narrow scope of reform. Fossil fuel production accounts for about 8% of Canada's GDP and 15% of Canadian goods exports (Hughes 2018; Government of Canada 2018a). And more than 200,000 people, about 1% of the total workforce, work directly in the oil, gas and coal sector, and hundreds of thousands work in jobs that are indirectly linked to these industries (Mertins-Kirkwood 2018:16). In communities and regions where fossil fuels are produced, the proportion of jobs and economic activity related to oil, gas, and coal is much higher. In Canada, the extraction, processing, and transportation of fossil fuel is Canada's largest single greenhouse gas emitter and a major contributor to climate change

worldwide. Consumption of fossil fuels, primarily for transportation and power generation, is likewise very emission intensive. To reduce emissions in line with international and national targets, Canadian federal and local governments have begun taking regulatory action to reduce emissions of coal, oil, and gas (Flanagan et al. 2017). Most importantly, in 2015, the federal government announced a nationwide phase-out of coal-fired power generation by 2030. Coal phase-out is expected to prevent 100 megatons of greenhouse gas emissions over the next few decades, which is essential for Canada to meet its 2030 Paris Agreement goal of reducing greenhouse gas emissions by 30% from 2005 levels (Government of Canada 2018b). However, while the policy is a positive step in mitigating climate change, the phase-out of coal is already negatively impacting coal mines and dozens of communities dependent on coal-fired power plants.

While Canada's trade unions and social and environmental activists have been advocating for a just transition to a cleaner economy for decades, the nationwide cessation of coal has created new demands for a just transition for affected workers and communities. For example, in Alberta, representative coal mine city, The Alberta Labor Confederation was a particularly strong voice for the local coal workers, and the Canadian Labor Council (CLC), Unifor, and United Steelworkers organized nationally on the matter. Partly because of this advocacy and partly because of the political

power of the Canadian oil region, governments across Canada have begun to investigate and implement just transition policies.

In fact, Canada is one of the few countries that explicitly uses the language of just transition in the context of climate and labor policies. At the end of 2017, the Canadian federal government announced the Just Transition Task Force, co-chaired by the CLC President, to study coal phase-out and make recommendations for federal transition policy by the end of 2018 (Canada of Government 2018c). More specifically, in the fall of 2017, the Alberta Government announced a $5 million Coal Community Transition Fund (CCTF) and a $40 million Coal Workforce Transition Program (CWTP), designed in consultation with workers, municipal leaders and other stakeholders. The former funds help local governments develop community-level transition strategies, economic diversification plans, and prepare local economies for coal mine and power plant closures. The latter provides income support to coal workers. (through supplementation to the National Employment Insurance Program), relocation assistance, skills retraining and other resources to help workers find new jobs. Community engagement is essential for true climate justice and energy democracy, so developing a worker-participating Canadian just transition policy is critical.

In principle, the initiatives described above are good examples of legitimate transition strategies. However, their limited scope and ambitions

are likely to translate into limited impact in practice. First, Canada's legitimate transition programs are narrowly targeted to specific workers in highly vulnerable areas. For example, the CWTP includes a CAD$12,000 fund voucher available only to fired coal workers who meet certain criteria, while some other coal workers are not eligible. And workers in sectors indirectly connected to the coal industry, who are also at risk of losing their jobs if coal mines or power plants are shut down, are denied the assistance from these programs provide. Programs like CWTP risk exacerbating underlying inequalities in vulnerable areas, since women and immigrants are disproportionately represented in jobs supporting fossil fuel workers—such as accommodation and food services. (Mertins-Kirkwood 2018:19-20).

Second, these programs are reactive rather than proactive. The CWTP is designed to mitigate the damage by converting coal workers into new jobs or retirees, but there are no plans yet to expand alternative clean industries in affected areas. The CCTF is a step forward in this direction, but Canadian $5 million for community planning and investment promotion is no substitute for public investment in new industries. Failure to expand public ownership alternatives is a missed opportunity to democratize the energy system. The limited ambitions of these legitimate transition initiatives reflect the limited ambitions of the underlying climate policy.

The phasing out of coal-fired power in Canada is a positive and

necessary step in the transition to a low-carbon economy, and further action is needed to reduce the country's emissions to levels agreed under the Paris Agreement. If Canada is to meet its national and international goals, it will need to implement similarly stringent policies that address the oil and natural gas industry, a sector much larger than coal. A legitimate conversion of Canada's coal sector falls under the category of management reform. The primary goal of the transition is to limit the social and economic damage of specific climate policies to specific workers and communities through top-down government programs. If the experiment is successful, it could be a useful model for other sectors. However, Canada's coal transition should not distract from the continuing need for an ambitious, comprehensive, and justified transition that also includes Canada's oil and gas sector. This is because an energy transition on such a scale may require a different labor policy approach.

4.2.3. JT of Fort Collins, US, in terms of local government level

Next, I introduce an example of Just Transition at the local government level. Fort Collins is a small city where the Colorado State University I am studying located in Colorado state.

Fort Collins and the northern front range are changing at a

tremendous pace. The population of Fort Collins has grown by 30 thousand in the last ten years, and this growth brings new and unique challenges for the city in the face of climate change. Climate change has brought on a 2-degree Fahrenheit temperature increase on average statewide. Large scale natural disasters, like wildfires and droughts have threatened ecosystem and community access to vital resources like the Poudre Watershed.

In 2019, by request from the community, the City Council of Fort Collins passed a resolution that recognizes the global climate emergency and sets the stage for the “Our Climate Future Plan”. The plan, two years in the making, offers steps and actions that build resilient community partnerships to prepare for and protect against the events of climate change through a community centered approach that considers the needs of all community members, especially historically underrepresented groups. The Our Climate Future Plan is different from climate action plans the city had adopted in the past in that it goes beyond technical solutions and considers the needs of the people in the community at the center of the plan. The Climate Action Community Advisory Committee acknowledges that the technical solutions are important, however, they are only a steppingstone in their success of meeting their sustainability goals; the people and the community are the vital players in this action plan. While environmental sustainability and climate resiliency is an overarching goal of the Our Climate Future Plan, the

technical solutions offered by the plan are designed to serve and meet the needs of the community in all kinds of ways, such as affordable housing, local healthy food, and a thriving economy.

Fort Collins has always been a leader in implementing goals toward a more sustainable lifestyle and to ultimately curb the effects of climate change. In 1999, they created their first waste diversion goal of 50% by the year 2010 and in the same year, adopted the “Local Action Plan to Reduce Greenhouse Gas Emissions.” In 2000, the City of Fort Collins adopted their first “Affordable Housing Strategic Plan”. In 2003, the City implemented the Electric Energy Supply Policy and in 2009, they revised, updated, and renamed this policy to the Energy Policy. In 2015m the Council adopted the Climate goals 80% greenhouse gas reduction by 2030, carbon neutral by 2050, and revised the Energy Policy again to become more aligned to their Climate Action Plan.

Fort Collins has been awarded grants to create a program that creates energy-efficient upgrades for low and middle-income housing and the city has also been given awards and international recognition for being a forward-thinking city that is committed to addressing climate change. The Our Climate Future Plan is the city’s next step towards a fully sustainable community.

Figure 9. The Our Climate Future Plan, consist of 13 Big Moves (source: the City of Fort Collins website)

The Our Climate Future Plan is broken down into thirteen sections called “Big Moves” which are made up of Next Moves (Figure 9). The Big Moves are the transformational outcomes of the Our Climate Future Plan such as a climate resilient community, efficient and emission free buildings, and electric car fleets.

The Next Moves are the detailed strategies that will be put in place to result in the Big Move. For example, the Big Move “Efficient, Emission Free Buildings” contains Next Moves like expanding home and business efficiency programs and exploring models to support geo-exchange shared heating and cooling systems for multi-resident buildings. Each Next Move was evaluated for investment required, equity, mitigation, and resilience to help track the progress of the Big Move. The Big Moves approach in the Fort Collins Our Climate Future Plan shows how technical solutions will be the support needed to keep climate action focused on the needs of the community; climate action is not an either-or scenario, and both new technologies and continued communication with community members are needed to make the community resilient to climate change. The Our Climate Future Plan is intentionally broad with open ended questions and areas to continue to explore since climate change is an ever growing and changing problem just as the city is continuing to grow and change.

The City of Fort Collins and the Our Climate Future plan have set an

excellent example of a comprehensive and community owned climate strategy that addresses the threats of climate change as well as the needs of the people at the center of the community. And it is a typical example of the current progressive local government's response to the climate crisis. The three primary environmental goals within the 2030 timeframe of the Our Climate Future plan are: To reduce greenhouse gas emissions by 80% to below 2005 baseline, Provide 100% renewable electricity by 2030, and achieve zero waste or 100% landfill diversion. At first glance, you may face some criticism that these goals seem farfetched or purely ambitious.

However, it is important for Fort Collins, a sustainability leader among cities, to set bold goals that drive innovation from communities and stakeholders. The Climate Action Committee and the City of Fort Collins heard from a variety of community voices while developing the Our Climate Future plan, especially historically underrepresented groups. This was a critical step in ensuring that the entire community has buy in, co-creativity, and a sense of ownership over the outcomes of the plan. Ensuring that the community is the focus of the climate action plan was important because when bottom lines are faced, the members of the community are going to be the main drivers for change. New technologies and innovative ideas are a great start and a key component to implementing change in a community, but these technological advances would be nothing without the people that

they are going to affect. This plan will not be able to succeed in their future goals and aspirations if the people do not take pride and action in implementing these Next and Big Moves. The approach taken by Fort Collins to ensure historically underrepresented groups is a great example to set for other cities looking to create sustainable practices since these groups are often the ones with the most potential to be harmed by climate change.

It is important to acknowledge that some of the goals set out in the Our Climate Future Plan are purely aspirational goals; Morgan, the city officer who introduced it to my class, was very honest and transparent and stated that they do not truly know how to get to net zero emissions definitely. However, these aspirational plans are still integral to the overall Climate Future Plan because they are what drive the city and community member to continue to innovate and work together to continue to have technological advances.

For the longest time, the environmental movement has mainly focused on the technical solutions that if implemented, will bring us to carbon neutral and have 100% renewable electricity. However, there has always been this disconnect between creating these solutions and successfully implementing them due to the lack of total-community involvement. The Our Climate Future Plan not only seems to lay out what the city is hoping to do to be more sustainable but also is constantly driving

planners to stay involved in new technological innovations that are socially and economically feasible; it could be interpreted to be considering the triple bottom line: that is, how will climate change and the action plan effect For Collins economically, socially, and environmentally across all demographics here?

As you can find out already, a key feature of this plan is its focus on "inclusiveness" unlike other typical climate action plans. While the city of Fort Collins' previous climate action plan focused on technological measures like most other cities, the newest plan, called "Big Moves", focuses on long-underserved marginalized members of the community, such as people of color, LGBTQ, and young generations. This creates a space for all community members to participate in climate change action plan and encourages the development of more innovative and diverse policy means. In addition, technological measures such as electric vehicles and solar power supply will not only reduce greenhouse gas emissions, but also serve as social welfare means such as providing job opportunities or improved housing energy efficiency of marginalized communities. As such, Fort Collins' climate change action plan focused on the people who are the beneficiaries of the policy show a comprehensive and inclusive character.

This is very impressive for me worked in public sector, and I think it is a very right and successful policy direction because it makes the public aware

that climate change action plan is directly related to the lives of all of them. When I was working in the public sector in Korea, I saw many cases of policies that were changed or abolished due to lack of public support. No matter how perfectly designed a policy is, it is only a matter of time before it disappears into history if it does not gain public support. In this respect, the climate action plan that communicate with local members of Fort Collins can be evaluated as a sustainable policy.

Of course, there are many uncertainties that may be sparking doubts about whether it is possible to achieve the three goals (80% GHG reduction, 100% renewable electricity, zero waste) seemingly ambitious by 2030. However, as introduced in the "Ten Strategies for Climate Resilience in the Colorado River Basin," another lecture about sustainable development, previous water management strategies cannot adapt, respond to, and mitigate the persistent, complex, and extreme risks of climate change due to focusing only on managing water supply and demand in the context of drought and climate change. If we stick the conventional management, there is a risk of missing out on opportunities to explore multifaceted strategies for economic, community, landscaping, and water resources, the author claimed. Therefore, future climate change countermeasure policies will need to fully include and consider the broader economic, environmental, and social risks posed by climate change. Even if the current "Big Moves" plan seems a little

bit unproven and farfetched at a glance, the direction of the plan considering broader scale seems in a right way given the unprecedented dynamics of climate change. And if we gain strong public support, these criticisms will be faded out overtime. To this, it would be important to make the public aware that supporting the initiative is in the right direction and is beneficial to them. Therefore, I think informing the public continuously and broadly about the risks of climate change, and urging behavior change along with providing incentives such as tax cut, and promoting success story, even if it is small, over greenhouse gas reduction, are critical to engage residents' participation.

Another reason I support Fort Collins' policy is that it fits the "Just Transition" aspect. We have come to realize that a policy that considers JT is needed to solve a problem that is entangled with many stakeholders and on a large scale, such as climate change, through the speech of Dr. Dimitris Stevis. The city of Fort Collins' climate change action plan is a good example of JT on a local scale. They are starting to consider communities, especially those who are far from the center of power, in order to move forward truly sustainable development, not just only considering technological solutions.

A policy that considers these socio-ecological relationships will be a steppingstone for Planetary Just Transition for a low-carbon world. Existing traditional approaches to tackling climate change, which are causing many social changes and conflicts today, are no longer effective because they may

not be able to address the widespread inequalities that are long-rooted in society, such as racism, sexism, and the gap between the rich and the poor. As suggested by the author, I think that it is necessary to actively review the approach of a just transition that pursues a more inclusive and transformative power relationship at the global level.

Finally, I think the “Big Moves” policy will be needed to evolve more widely. For example, the current plan does not include measures about land use. Given the rapidly expansion of residents, and land use change, I think that future land use policy development will be an important issue in climate change countermeasures. Through related lectures, I learned how humans and nature can share land in a sustainable way. The lectures emphasized the importance of cooperation with numerous stakeholders and education for changing public perception. Everyone may have different opinions on the methodology for wise land use, but what we all agree on is that the traditional way human treated nature only from a utilitarian point of view can no longer be a solution, and a way to mutualistic coexist with nature is needed. In the light of this point of view, I think we need to think about how to share land and live together wisely and sustainably with the various classes of residents in Fort Collins and with the beautiful flora and fauna around the city. If to do this, Big Moves, the climate action plan of FOCO, will be more perfect and leading exemplary for the world.

5. US Climate Change Preparedness based on Science

As now, we looked into the preparedness policies responding to climate change in the world and in terms of local government level of the US. Considering Just Transition when making climate action plan is a main feature in the current mainstream of measures against climate crisis. Another key function in the US climate action plan is for policy makers to make decisions through thoroughly objective data analysis.

5.1. The current trend of Climate Change Preparedness in US

In January of last year, as the new President of the United States, the Biden administration, took office, many policies in the US have changed. One of them has been to implement stronger measure to combat climate change. The perception of the former Trump administration, which viewed climate change as an unfounded claim, could lead to a misconception that the U.S. lacks policy or research in this area. However, America has been studying climate change in academies and research institutions for decades, building tremendous relevant data from surveys and field studies across the United States for decades to establish an inventory of U.S. greenhouse gases, which is used to study GHG trend and make mitigation policies. Over time, this research models have now become more sophisticated and are now

available across the United States and in some regions of the world. It is reaching the point of building a model that can predict the greenhouse gas emissions on a daily basis.

The last Trump administration withdrew from the Paris Agreement, but the new Biden administration rejoined the agreement on the day of his inauguration. It is contradictory but welcome, that the U.S., one of the main contributors to greenhouse gas emissions in the world, rejoined the agreement. However, on the other hand, it is worrying whether it is trying to reveal another aspect of a great power that is leading the countermeasures at the level of social change presented in this agreement under the name of responding climate change and forcing it on other countries. This is because, as mentioned earlier, the United States has already completed or is nearing completion of numerous scientific and technological innovation in preparation for greenhouse gas emission control and climate change.

As you may have already noticed, the core of the US disaster management policy in preparation for the greatest disaster facing mankind, climate change, is scientific research and the government's continuous investment in it. Leading universities in the United States that teach climate change have been conducting multi-disciplinary research in this field for a long time, and are gradually establishing themselves as independent academic fields. For example, In fact, many academic fields such as

atmospheric science, geography, biochemistry, environmental engineering, zoology, economics, and sociology are collaborating in the CSU (Colorado State University) ESS (Ecosystem Science & Sustainability) graduate program that I am attending. And Students are also made up of people with diverse backgrounds, such as MBA programs, civil servant, computer programmers, and veterinarians, etc.

The US is one of the countries that wastes many resources on the planet far from recycling or energy saving. According to one study, about over 40% of food waste comes from unwrapped off, untouched products. However, on the other hand, America is preparing for the future by building a more sophisticated climate change prediction model than any other country.

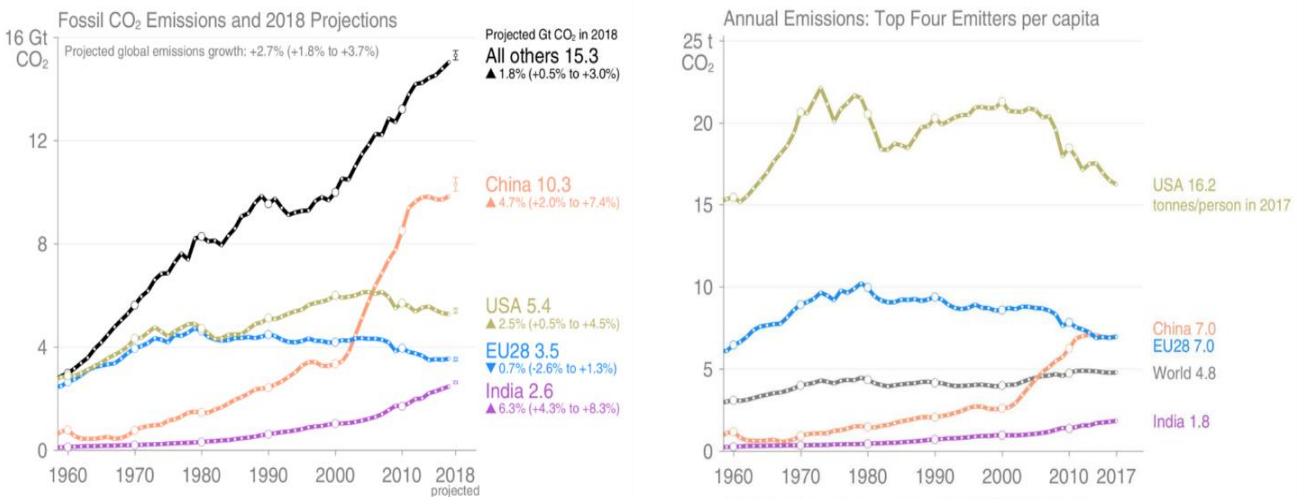


Figure 10. The GHG Emissions and what country is the biggest emitter? (source: CDIAC; Le Quéré et al 2018; Global Carbon Budget 2018, Dr. Conant presentation

And one of the interesting facts is that China, like the US, is expanding investment in this field and sending many students and researchers to the developed countries to raise future warriors in this field. It is bittersweet that the US and China, G2 countries, as the biggest competitors and culprits of global environment pollution, are competing fiercely to take the lead on climate change issue (Figure 10). It would be said to indicate that the day is not far away, controlling GHG emissions becomes the control of the world.

5.2. Data Analysis as a steppingstone for climate change policy

The United States has more satellites than any other country in the world. Therefore, it is equipped with an environment that predicts accurate weather forecast for every hour by region. And, as mentioned earlier, a model was built that shows the correlation between greenhouse gas concentrations and meteorological phenomena through the analysis of numerous data in the past glaciers. They are creating a scenario that predicts climate change by synthesizing it. If continued research is carried out, one day it will be possible to predict where and when a typhoon is coming due to the greenhouse gas emitted by a specific country, which from another point of view, it will ask the country's accountability as the disaster cause provider. It may become the seed of a new conflict.

As a country that trusts claims based on scientific facts, climate change policies also start with objective data on greenhouse gas emissions. At present, how much emission is generated in which sector, and if it is changed in what way, how much can be reduced, and for this purpose, many policies are suggested by the central and local governments. Therefore, the starting point and the most important part of this workflow is an acceptable estimate of greenhouse gas emissions.

It may be that not familiar with this field since I came here for the first time, but the method of estimating greenhouse gas emissions in the US was very detailed. Ecological environmental conditions such as temperature, precipitation, evapotranspiration, soil acidity (PH), soil particles, and geological conditions are detailed for almost all land surfaces such as forests, crop land, pastures, industrial complexes, residential areas, ranches, wetlands, and mountain areas. Emissions are estimated by calculating activity data (i.e., number of vehicles, number of people, number of livestock, tree type and quantity, crop type and yield, etc.) and each greenhouse gas emission value through several program models under these conditions. For example, in the case of livestock, depending on the type of livestock, growth conditions, and body weight, how much methane is generated by one livestock per year digesting feed, how much methane or nitrous oxide is excreted in excrement, all data has been establishing in the US GHG

inventory. And they have also built an environment that can program all of these things, such as whether the greenhouse gases are absorbed into the soil or leaked into rivers, and government agencies are sponsored to collect enough basic data related to this, and the results are provided publicly. And as measurable data continues to accumulate, it is becoming possible to present optimal alternatives such as livestock growth environment conditions, feed types, and excreta management environment.

In other words, government agencies collect and disclose sufficient data on the entire United States, and academia and research institutes present accurate prediction models and alternatives based on this data, and government agencies are forming a circular structure that reflects them in their policies. And the more data, the more sophisticated the model and the more optimal policy suggestion is creating a virtuous cycle (Plus feedback).

It is understood that Korea is also trying to develop a climate change prediction model suitable for the domestic situation by establishing the greenhouse gas inventory. Although the Ministry of Environment, the Ministry of Agriculture, Food and Rural Affairs, and Ministry of Trade, industry and Energy are conducting research for objective emission estimation in fields related to each institution, they do not have as many data or advanced models as in the US because we are still in the beginning stages. Moreover, as more accurate results can be obtained by dealing with

almost all areas in society, accurate estimation of greenhouse gas emission is expected to be possible only if all government agencies and academia in the natural and humanities fields cooperate and work together.

As anyone can easily predict, for correct data analysis, of course, high-quality data must be available. This may be obtained through direct field surveys or periodically by installing instruments such as sensors. Both the Korean and US governments sponsor various research institutes and universities to collect rich data. However, what surprised me here and what I felt was one of the big differences between the two countries was the enormous amount and variety of 'data opening'. Anyone interested can access and download data held by government agencies and other organizations (Figure 11).

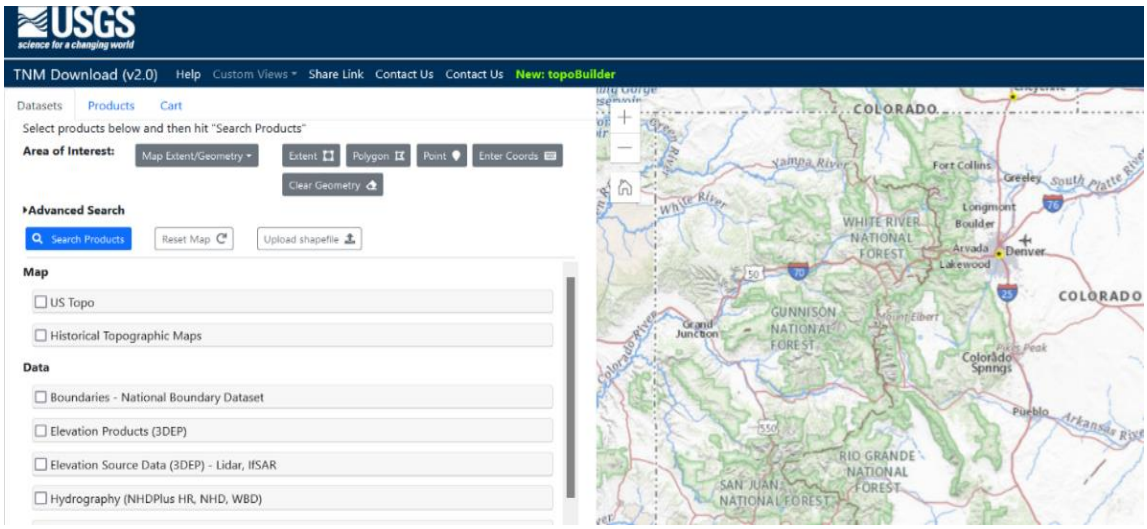


Figure 11. You can obtain various data such as The National Map Downloader operated by USGS and water resources information.

Since most of this raw data consists of a large number of worksheets, basic programming skills are required to refine it and perform the desired analysis. However, since GUI (Graphical User Interface)-based data analysis results are also often provided together, anyone can easily use them to simply obtain certain information.

In particular, as a country with the world's largest number satellites, remote sensing GIS, including satellites, can also be obtained, so anyone can obtain various data based on spatial information.

Not only affiliated organizations, but also corporations and NGOs provide public data, and there are many for-profit companies for the purpose of providing data.

I don't know what the data market in Korea is like, but it seems that collecting, analyzing, and utilizing data in almost all fields is an essential process here, US.

Accordingly, since manpower with data utilization ability is required in almost all fields, and basic program operation ability is becoming a required course in almost all majors in college. I have also learned various kinds of programs through the three-semester course so far, and I thought that if only high-quality data could be obtained, it would be useful in the future work in the field of disaster management (Figure 12).

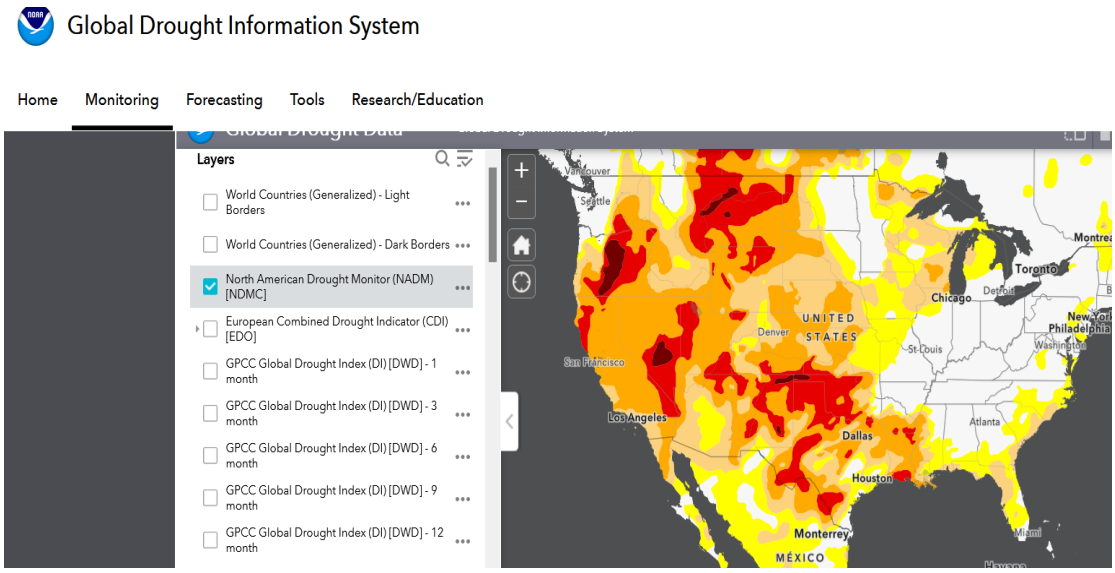


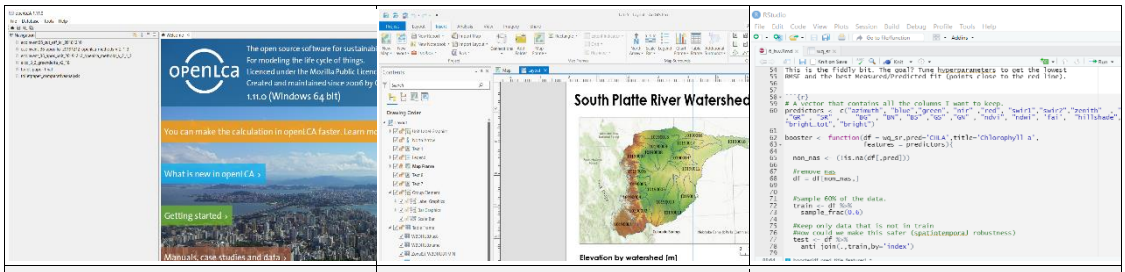
Figure 12. The world drought information system operated by NOAA, real-time confirmation of accumulated data, forecasting and analysis are all possible.

As diverse and rich data is open to the public and available for free, research using it is naturally activated and the way companies work is changing. All students of this graduate program in my school present opinions based on data and provide solutions based on data (Table 1). Of course, well-known papers and articles, opinions of authoritative professors, and expert experiences can also be the basis for suggesting a solution, but they are not as solid a basis as the difference in objective data analysis results.

In addition, this data-based solution presentation provides an opportunity for young students, who may be relatively inexperienced, to freely share their opinions on an equal footing with the expert group, and

provide a more objective policy direction without being bound by any external interests, and create an environment in which to present. Therefore, many of the projects discussed in this major course are often issues that are contemplated in the real world, and provide an opportunity to collaborate with actual stakeholders. And because students are sometimes very creative and come up with amazing solutions, city, county, state, federal government, and various companies' internship programs are offered to this graduate program year-round. And one of the main qualifications required by most internship programs is data analysis ability.

In a word, through a data-centered curriculum, students objectively analyze complex social and environmental problems and acquire the ability to develop actionable policies, and based on this, they will have the opportunity to advance into society.



Open LCA	*ArcGIS Pro*	*R studio*

Table 1. A representative data analysis program tool, which is also used in Korea, but it is characterized by the fact that these tools are learned in almost all major courses in US

And one of the fields in which the application of this data analysis is expected to be greatly expected is the field of 'disaster management'. Looking at some examples that can be applied to disaster management using the aforementioned data analysis, when Hurricane ‘Irma’ approached Florida in 2017, as part of a response to the hurricane Irma, safety vulnerabilities exposed to the predicted course of the hurricane were quickly identified with the location and number of Nursing Homes for the elderly (the elderly, the disabled, etc.) based on GIS and data analysis (Table 2). And it was possible to establish and implement an appropriate resource allocation and evacuation plan.

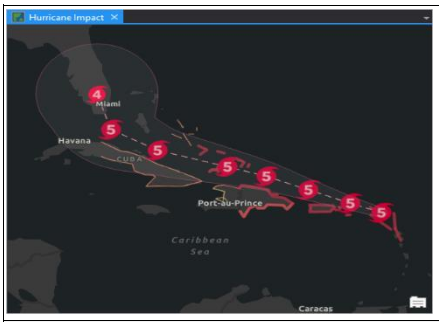
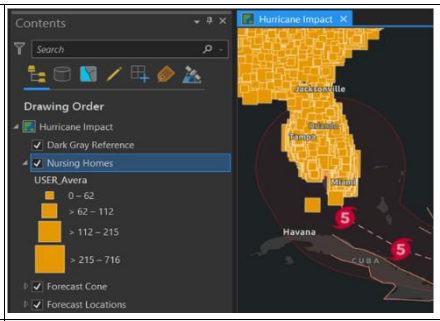
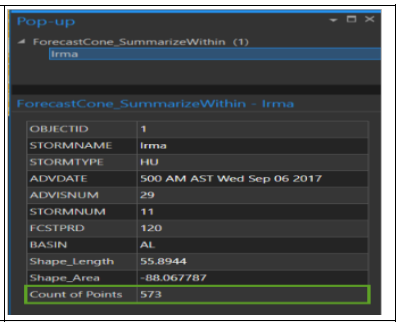
		
Analysis of hurricane path	*Analysis of vulnerable facilities within affected area*	*Identify the number of exposed facilities*

Table 2. An example of application of data analysis in Disaster management

In addition, various natural phenomena that may occur in the future can be predicted through machine learning or deep learning based on regression model (Figure 13). If a desired function is programmed based on

data open to the public, various predictive models with high accuracy can be created, and it can be continuously developed with higher accuracy along with data accumulation.

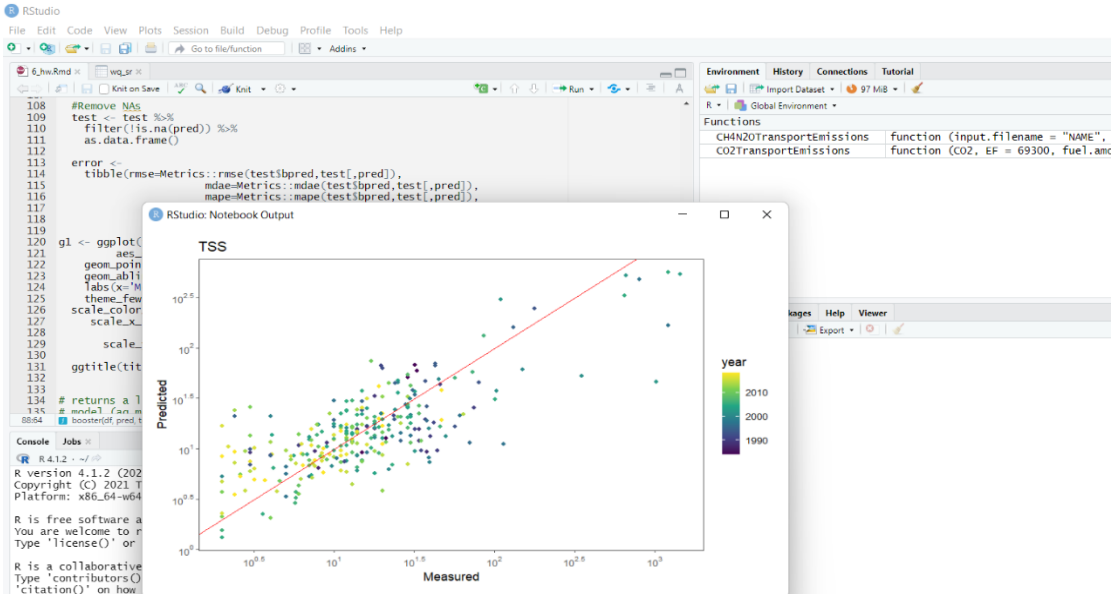


Figure 13. Development of Total Suspended Sediment Concentration Prediction Model in Water by Machine Learning using R program

5.3. The reason we should use data for disaster management

Although there are many circumstances in which disaster management must make quick decisions based on various information in a short time, in reality, no one can make decisions with confidence. The reason for this is that the political nature of Korea, which places a lot of responsibility for the outcome of decision-making, may also play a role, but

above all, it is because the accurate outcome is difficult to predict. This creates an environment in which commanders tend to follow past practices and decisions, already proved before, to make decisions as safe as possible. Under these conditions, only the opinions of experienced workers tend to be valued, and innovative changes in working methods are difficult to establish.

Although it will take time, if everyone in the field of disaster management has the ability to use and analyze data, a very objective and rapid decision-making system can be established and unnecessary disputes about responsibility can be avoided. And above all, it is expected that the role of the government in protecting the precious lives and property of the people will be greatly improved. Of course, even now, front-line disaster management agencies such as the Ministry of the Interior and Safety, National Fire Agency, Korea Forest Service are collecting, managing, and analyzing data.

However, so far, the data utilization is high only in some specific areas, and the role and responsibility for comprehensively accumulating and managing them has not been established. As a result, trust in data is still lacking, and even though it is a field that deals with life and property, subjective judgment frequently intervenes and there is a risk of making wrong decisions.

Of course, it is clear that the direction of data disclosure and use in

the United States is not necessarily the right one, and data analysis is not the key to solving everything. However, I think it will be undeniable that data analysis will become a powerful tool to help minimize social conflicts and make correct and quick decisions in the future.

6. Conclusion: What we can get and What we should prepare?

As now, we have checked that the reasons of climate change and the difficulties of preventing it. And we looked at the ongoing efforts around the world to counter this formidable threat.

There are many lessons we can learn from the world, but to name a few key features, as we saw in the first energy sector, mankind is already technologically equipped to achieve toward carbon neutral society.

However, the cost of renewable energy is still not cheap enough for companies to earn economically, and it will take a lot of time for companies' investment to turn into profit. For these reasons, the transition to a carbon neutral society is not being made quickly. But, the price of solar thermal energy facilities is getting cheaper year by year, and various renewable

energy generation technologies such as tidal power and geothermal power are being developed. So, the cost of renewable energy could one day be significantly cheaper than fossil fuels and will soon become competitive.

Until then, it is necessary for the government and the society to support them so that companies can take an interest in the transition to carbon neutrality and make continuous investments.

Next, we saw the concept of Just Transition (JT) that is still unfamiliar to most people in Korea. We have looked at how JT started, what it is a concept, and how it is progressing around the world. Korea also declared that it would achieve carbon neutrality by 2050 and raised its Nationally Determined Contribution (NDC) to 40% by 2030. The plan to achieve carbon neutrality includes various strategies such as increasing the proportion of renewable energy and promoting the spread of electric vehicles.

However, as we have seen in the case of JT in various countries around the world, it may be difficult to succeed in carbon neutrality only centered on technological development without community support. The fact that countries around the world are considering and making efforts for

Just Transition means that they have realized the limitations of existing technology-focused policies. We will have to refer to the examples of other countries so that we do not go through the same mistakes.

Climate change is a catastrophe that no one can avoid, but the poor and marginalized communities are particularly affected. Therefore, various policies towards a carbon-neutral society must come up with ways to embrace these marginalized groups, and only when such inclusiveness is ensured can policy success be guaranteed. And these policies can be developed and implemented much more effectively at the local government level, which is well aware of the circumstance of each community, than at the central government level.

The people-centered and citizen-centered policies that public institutions always say do not just set high goals or wrap policies with fancy words, but accurately grasp the reality of policy beneficiaries and fully understand how they will be affected by the implementation of the policy.

It will take time, or may face different opposition from diverse communities. However, implementing a policy that fully considers all

communities particularly the underrepresented group would be a truly people-centered policy. Therefore, Just Transition is not a high goal that cannot be realized, but a value that we should consider and pursue.

Finally, we could see how important data are considered in the field of climate change in the United States. The US has long been collecting climate change-related data for research purpose in almost fields, including agriculture, forestry, and transportation. And they are using their strengths to make full use of satellite information, including GIS analysis.

And another surprising thing is that they are making these data opened to the public, so anyone interested can access this huge amount of data. Anyone can easily access verified data held by public institutions, whether for commercial or research goals, and can freely create another valuable analysis results based on it.

Universities are reorganizing the interdisciplinary course so that all students can freely analyze data, and internship programs are increasing in which students collaborate with companies and government agencies to conduct practical data analysis. In this way, students can naturally learn the

process of objectively and scientifically making policy decisions based on data analysis, and through this, it can be said that social conflicts are minimized, and the most effective decision-making process is pursued.

I think this can be a right direction for innovation given the disaster management environment in Korea where we have no choice but to pursue passive and proven past methods for fear of responsibility latter in the event of a disaster, as was revealed in the last Sewol-ho disaster.

A passive attitude, just praying that disasters do not occur while I am in the position of responsibility, will not make any progress in this area. This is nothing more than a denial of reality without trying to change anything, like an ostrich that hides with its head on the ground in fear of a predator.

Although it will take a lot of time and face many difficulties, but only when the decision-making process is established based on objective data analysis, we will be able to escape from the previous disaster management work environment that is fluctuating according to external political opinions like a swaying reed. And only in such an environment can more creative and effective policies emerge, and that will be the rightest way to protect the

lives and safety of the people that is one of the purposes of government existence.

In 2022, even if a murderous heat wave comes to Korea this year, it is not at all strange that we are working together with climate change. Although this is a serious disaster that all mankind faces, it has been accepted only as a natural phenomenon caused by all of us without revealing who is responsible for this.

However, as introduced earlier, the world's great powers are making objective indicators for greenhouse gases and climate change, and it is a self-evident situation that they will impose these indicators on neighboring countries, let alone the accuracy of these indicators.

If we dismiss it as just a story of the distant future without any preparation or understanding of climate change, there may come a day when we or our descendants will be charged with being the providers of disasters in other countries and have to pay compensation.

Facing the reality and maintaining a prepared attitude is the only way to prepare for climate change, and it will be the most effective way for our

Republic of Korea to continue to prosper and become a safe country in the future.

Acknowledgement

This report was made with the support of the Korean Government's long-term study abroad program for the government officers. I would like to thank the Korean Government for giving me a valuable opportunity to study in the United States for about two years. And I would like to thank Dr. Connant of Colorado State University for giving systematically understanding climate change, and providing directions on how to prepare for it to me who had felt climate change difficult before coming here. In addition, Dr. Stacey, who showed infinite love for students and presented numerous examples that humans and nature can coexist together, also thanks to her. And heartfelt thanks to my advisor, Dr. Ogle, who taught me how to establish climate change policies through objective data analysis and is now supporting my internship course in the final semester. And I would like to thank Matt, my only graduate classmate, for helping me a lot as student numbers plummet due to the pandemic. I encourage you to finish your doctoral course well and be reborn as a wonderful member of society. Finally, I would like to express my gratitude to my family for supporting me and accepting my stress of studying at a late age. Also, I thank all Korean students in CSU and their families who have supported and helped each other all the time. I wish everyone good health and achieve their goals.

References collected

This part has been prepared to introduce various policies in response to climate change that are being implemented or planned in the United States and around the world.

Because they were not included in the main body of this report due to the size, they are introduced as reference materials.

I hope that these can also be used as a reference for policy makers who are thinking about countermeasures against climate change at the central or local governments.

- **Carbon Pricing**

Carbon pricing literally means putting a price directly on carbon footprint. It is different from subsidy policies that support brownfield development after polluting hazardous substances or support renewable energy generation such as solar power.

Carbon pricing proponents argue that a major cause of climate agreement failure comes from market failure. In other words, if emitters such as factories can benefit from emitting greenhouse gases, they will never give up emissions or make efforts to reduce greenhouse gas emissions. Therefore, it is argued that it is necessary to induce emitter to reduce

greenhouse gas emissions or make efforts to reduce emissions in order to prevent their economic damage by charging a cost in proportion to the amount of carbon emitted.

There are two main ways to implement carbon pricing policies: Carbon Tax and Cap and Trade program.

Carbon Tax is similar to other taxes. In general, it is a method of charging a fixed cost for 1 ton of CO2 emitted.

Cap and Trade program, also known as Emissions Trading System, is that government caps annual GHG emissions and issued permits that can be used or traded to all emitters. So, by allowing each emitter to trade their permits, it is a way to limit overall greenhouse gas emissions without decreasing of economic development.

The benefits of carbon pricing are first low cost. There is no need of any cost input to put a tax. Rather it can generate revenue because it is a type of tax. The revenues of carbon pricing can be used to another climate policies that prompt to reduce GHG emissions (Figure 1).

As it relates to economic benefits, it forces each emitter to strive to find incremental and optimized solutions. In addition, this policy can be applied to large-scale emission sources that are difficult to transfer, such as power plants. Of course, government support may be needed to help these heavy emission industries adapt to that.

Finally, this policy can prevent increasing or new sources of greenhouse gas emissions. This is because expensive carbon costs will make companies reluctant to emit greenhouse gases.

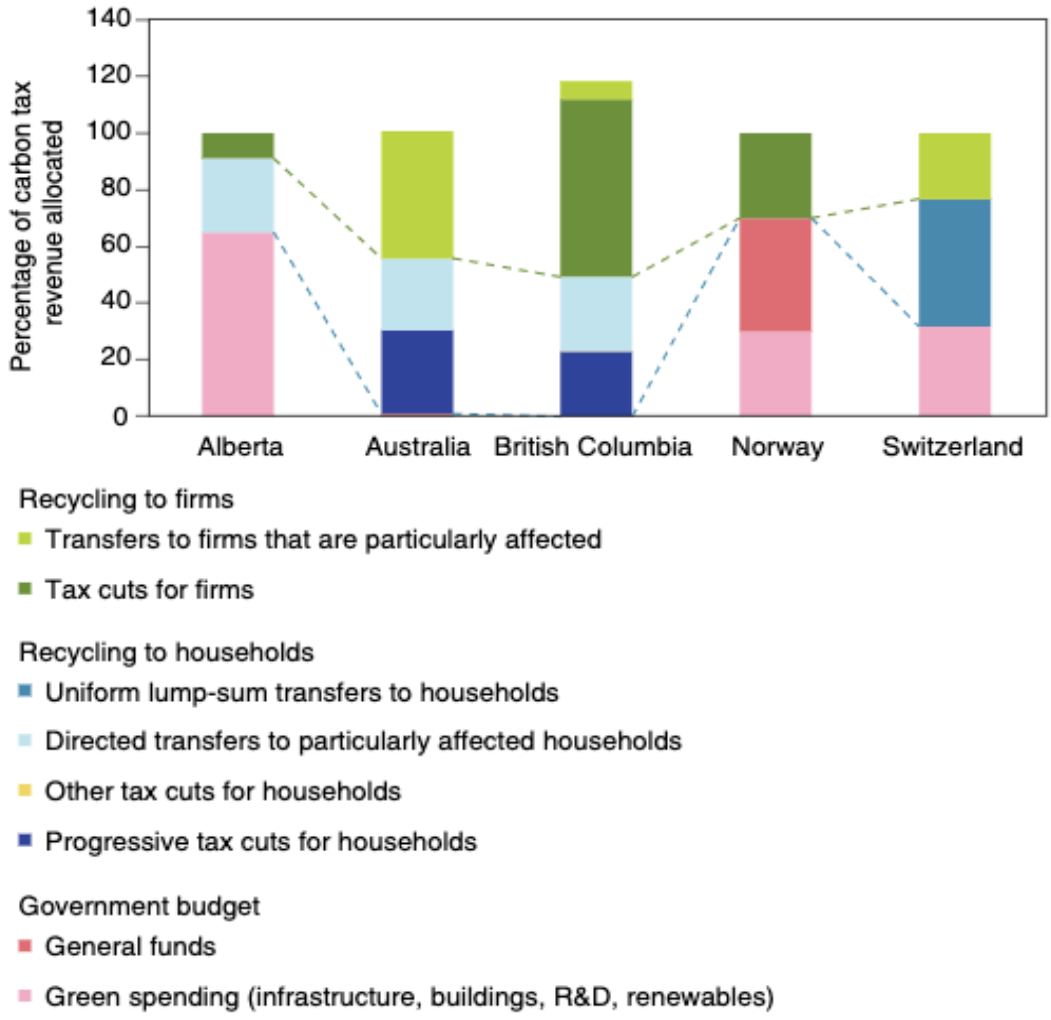
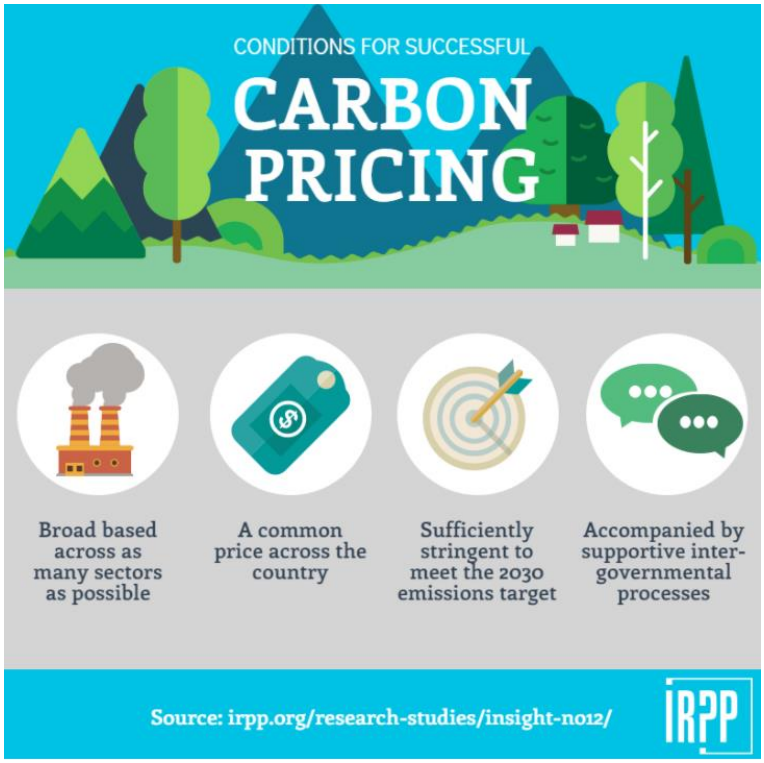


Figure 1. Compare of Carbon tax revenue allocated to another green policies. (source: "Making Carbon Pricing Work for Citizens" https://www.nature.com/articles/s41558-018-0201-2

However, there are also disadvantages. The carbon price can miss the whole system of reducing greenhouse gas emissions. Driving a hybrid vehicle doesn't stop the development of the chaotic suburbs sprawl.

Next, it's too slow. A more effective policy is needed to achieve the goal of limiting the rise of 2 degrees Celsius set by the Paris Agreement. And the price is too low. The current carbon price is set at a low cost due to concerns about economic downturn or political burden. Finally, this policy could unfairly burden the less affluent individuals.

Here are some conditions for a carbon pricing policy to succeed. First, the profits generated from the carbon price are 100% recycled for citizens. And politicians and governments should strive for transparency in these tax revenues. Next, increase the carbon price per ton of CO2 to increase efficiency. And renaming carbon taxes to “environmental fees” or “climate contributions” to reduce public dislike and shift perspective. Finally, focusing on making it as fair as possible and combine it with other mechanisms to increase efficiency.

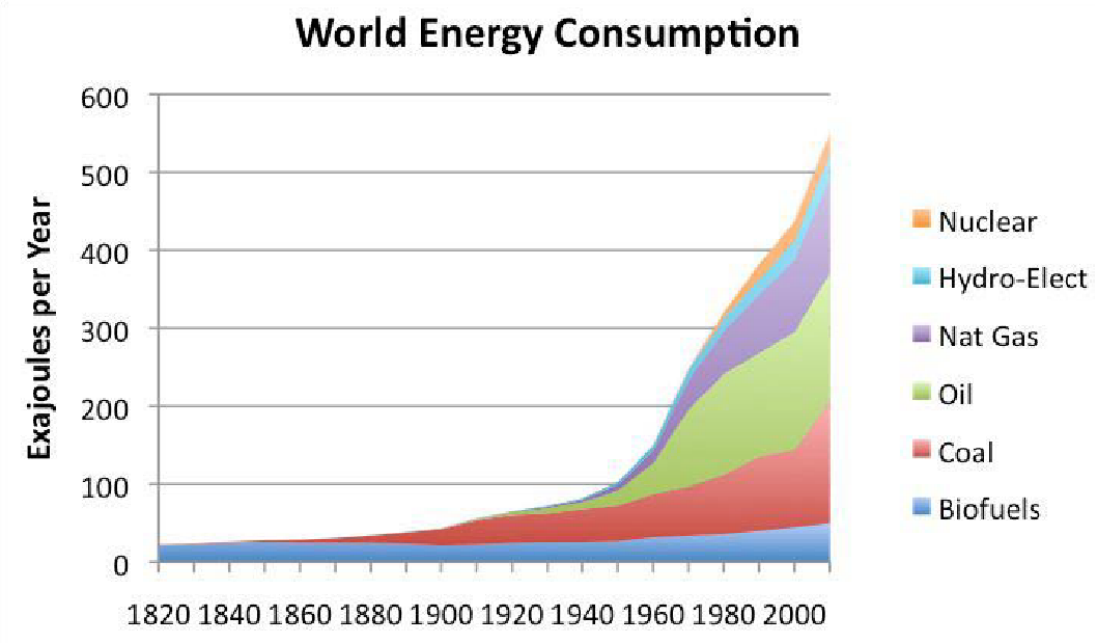


- **Biofuel**

Biofuel is any fuel that is derived from biomass which is renewable organic material that comes from plants and animals.

Biomass is the oldest fuel in human history (wood, charcoal, crop residue, dung). It was predominant before industrial revolution. First Diesel engine used Biofuel from peanuts. Henry Ford Model T car also used 100% hemp-derived biofuel. Primarily for transportation because they are readily available in automobile internal combustion engines.

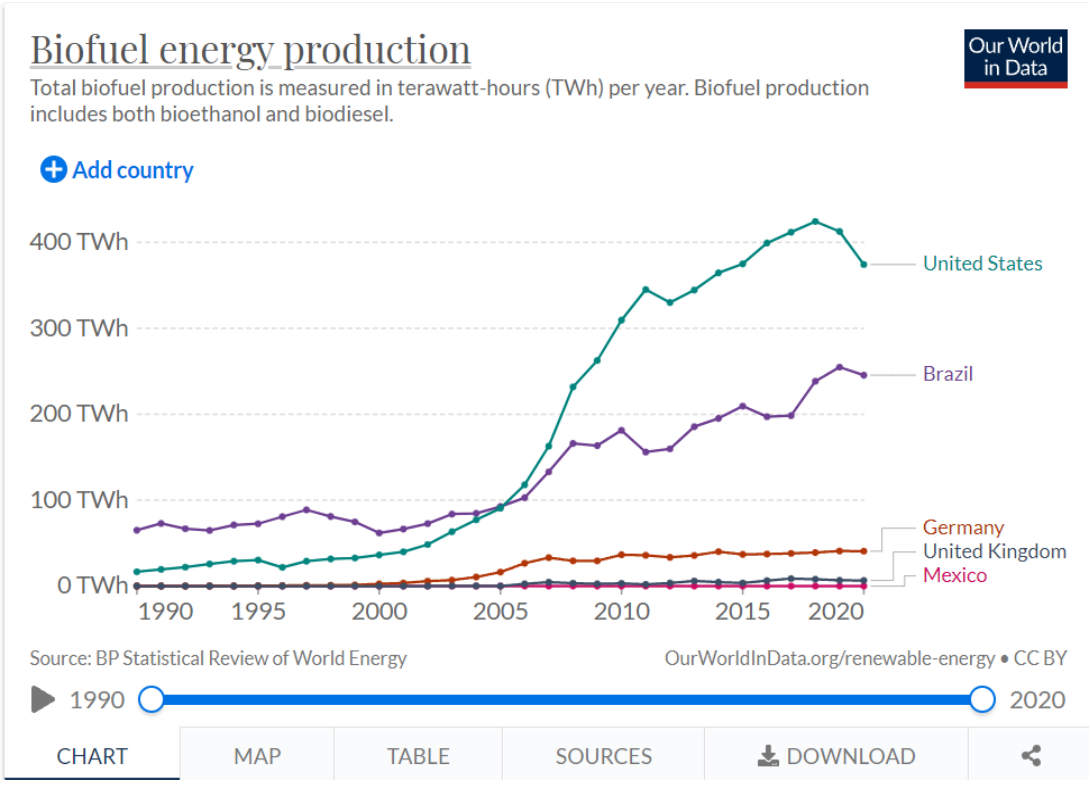
Fossil fuel leads reduction of biofuel production. However, the World War 2, oil shock made biofuel demand increased. Recently, rising prices of oil and greenhouse gas emission lead increasing of Biofuel use. 2.4 billion people still rely on biomass for cooking and heating.



Source : EIA (https://www.eia.gov/energyexplained/biomass/)

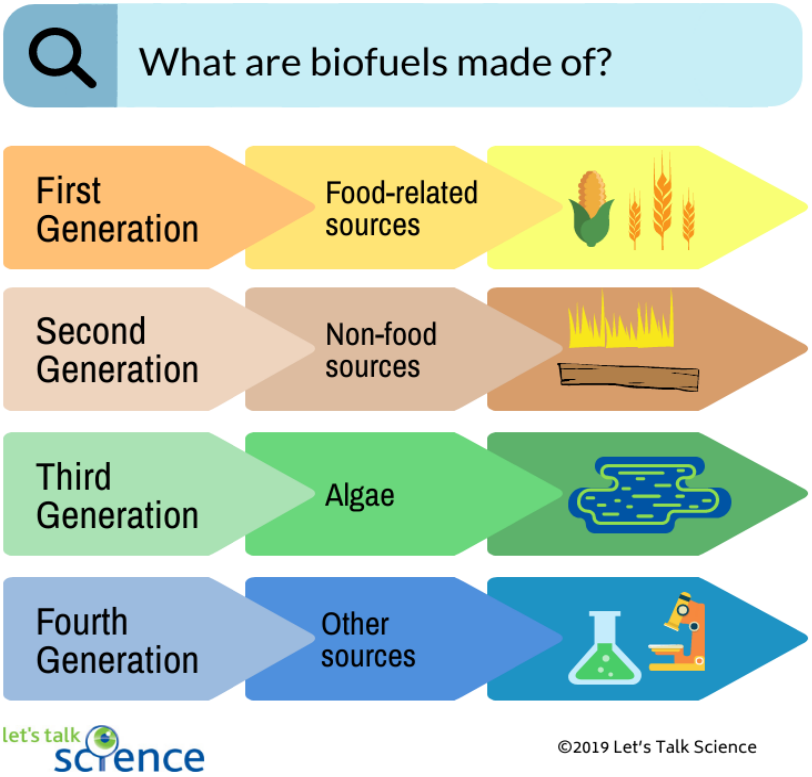
Unlike other materials, Biofuel is a type of fuel. It meets the needs of transportation fuel, so it is easy to see that biofuel mixed with gas or diesel in gas stations in the US. According to the research of EIA (US Energy Information Administration), biofuel accounted for about 10% of the total volume of finished motor gasoline consumption in 2020.

The U.S. and Brazil, which increasingly use biofuels as a fuel for transportation, are aiming to increase their use of biofuels in the future because of their low emissions and pollution and abundant domestic production.



Source : Our World in Data (https://ourworldindata.org)

There are several benefits to use biofuels. Biofuel is also a fuel so require combustion, but it is lower GHG intensity than fossil fuels. And thanks to technological advances, each generation of biofuel production is becoming more efficient and someday could achieve carbon neutral.



Source : Biofuel generation (https://letstalkscience.ca)

Next, algae-based biofuels do not require ILUC (Indirect Land Use Change impacts of biofuels) or conflict with human/animal food sources. ILUC means that the unintended consequence of releasing more carbon emissions due to land-use changes around the world induced by the expansion of croplands for ethanol or biodiesel production in response to

the increased global demands for biofuels. Also, biofuels can be applied to hard-to-electrify sector like aviation and ocean freight that are the one of the largest GHG emission sources.

Biofuels also have concerns. Ethanol itself is considered carbon neutral. But the process of producing it is not. Fossil fuels are often used throughout the process of producing biofuels. For example, a farmer's tractor or a truck that transports feedstock to a biorefinery uses diesel fuel.

And biomass relates to food security. Critics of first-generation biofuels argue that the use of food crops for fuel production increases food prices, and makes it more difficult for people to afford to eat healthy.

Biofuels can also affect the food and resources of other organisms. It takes a lot of land to produce biofuels. Land reclamation for agriculture can have a major impact on the environment and the flora and fauna that live there.

When it comes to the debate between fossil fuels and biofuels, there are certainly no easy answers. The global food chain and the biofuel industry are interconnected in complex ways. But people are increasingly aware of the downsides that first-generation food crop-based biofuels can cause. That's why we should work towards second-generation biofuels rather than food crops. These are non-food feedstocks such as agriculture, restaurants, and municipal waste.

- **Climate Intervention**

Climate Intervention can be defined that deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change. This term is preferred in place of Geoengineering. Academy felt that engineering applied a level of control that was elusory. Intervention means an action meant to improve, but the outcomes are uncertain. Climate Geoengineering implies more precious outcomes. More recent research has shown it is possible to set specific climate goals then adjust “Intervention” strategies to achieve those goals, it is very much “climate engineering”.

Climate Intervention stems from the perception that progress in responding to climate change is slow. Current Nationally Determined Contributions (NDCs) remain seriously inadequate to achieve the climate goals of the Paris Agreement and would lead to a temperature increase of at least 3 degrees Celsius by 2100. Recently announced net-zero emissions goals could reduce this to about 2.5 ℃ by 2100. A dramatic strengthening of ambition is needed if the Paris Agreement goals are to be met. Experts argue that countries must collectively increase their NDC ambitions threefold to get on track to a 2 ℃ goal and more than fivefold to get on track to the 1.5 ℃ goal.

And Climate Intervention (CI) research may be critical to a more just

and safety society. “To protect the most vulnerable and ensure justice for those who are faced with the devastating consequences of climate change, it may crucial that we invest in research in interventions (published during U.N. Climate Week)”.

There is potential role of climate intervention in mitigation strategies as below. There are significant near-term risks and challenges in both climate adaptation and in limiting global mean temperature increases. Consequently, it is important to explore additional measures designed to reduce climate change impacts through other actions. These are often referred to as geoengineering or climate intervention actions – both Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM) or Solar Climate Intervention (SCI).

CDR: is the removal and long-term sequestration of CO2 from the atmosphere in order to reduce global warming. There are several CDR approaches that seek to amplify the rates of processes that are already occurring as part of the natural carbon cycle. Gross CO2 emissions from land and the ocean are more than 20 times larger than anthropogenic emissions. Actions that enhance the reduction of these natural emissions or that increase the natural CO2 removal from air have the potential to lower atmospheric CO2. These strategies are variously employed in land management practices, such as low-till agriculture, reforestation and

afforestation, ocean iron fertilization, and land- and ocean- based accelerated weathering.

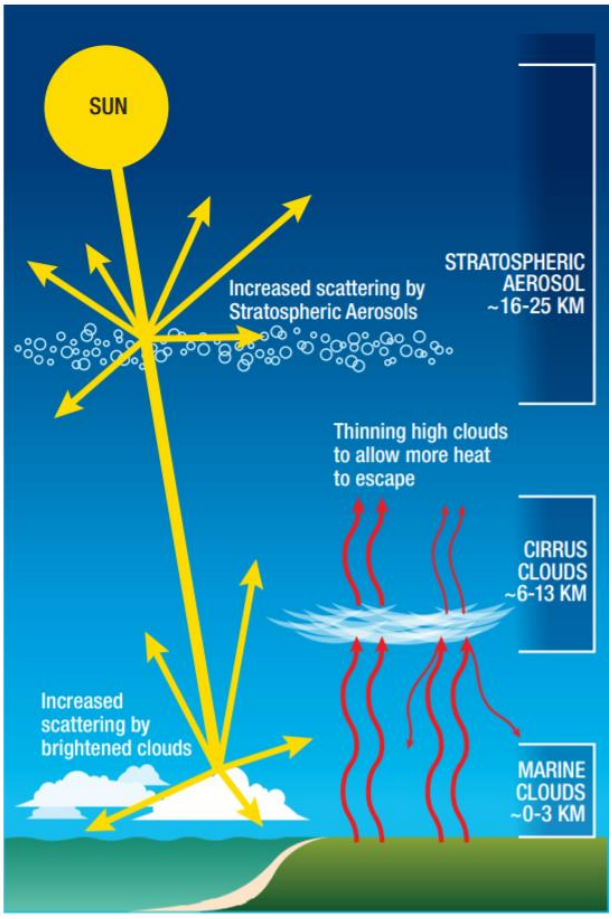
Source: James W. Hurrell presentation in ESS524 lecture, CSU

BECCS (Bioenergy with carbon capture and sequestration) is also a kind of CDR. It is the extraction of energy from biomass through oxidation or gasification (i.e., “bioenergy”) combined with the capture and sequestration of the CO2 generated. Direct air capture and sequestration (DACS), chemical separation methods that directly capture CO2 from ambient air combined with long-term CO2 disposal, and Traditional carbon capture and sequestration (CCS) are included CDR method, too.

CDR appears feasible to remove CO2 from the atmosphere by enhancing nature sinks, as well as through carbon capture and sequestration in geological reservoirs. However, most CDR options are either limited in capacity or are expensive to deploy at the scale required. Research is needed to evaluate the permanence and capacity of storage, the speed at which systems can be deployed, and potential adverse side effects. But CDR approaches do address the climate change problem by reducing atmospheric

CO_2 concentrations. If used on a sufficiently large scale, and other mitigation approaches toward reduced CO_2 emissions are taken, CDR options create the possibility of negative global net emissions. This is critical if we are to not only reduce CO_2 emissions, but actually lower CO_2 concentrations in the atmosphere and begin to restore climate to its natural state.

SCI: is attempts to moderate warming by increasing the amount of sunlight that atmosphere reflects back to space or by reducing the trapping of outgoing thermal radiation. Even though it is not a solution to anthropogenic climate change, much more research is needed to understand feasibility and especially impacts.



Generally, Stratospheric Aerosol Injection (SAI), Marine Cloud Brightening (MCB), and Cirrus Cloud Thinning (CCT) are known as main representative of SCI.

Source: James W. Hurrell presentation in ESS524 lecture, CSU

SAI is the most studied and perhaps best understood of proposed SCI approaches. Large volcanic eruption adds SO2 to stratosphere, where it oxidizes and forms sulfate aerosols that reflect sunlight back to space. Global distribution of aerosol can result in pronounced global cooling (0.3-0.5 ℃) for 12-18 months. A similar effect could be achieved by injecting SO2, sulfate particles, or solid particles such as calcite. However, there is limited understanding of how cooling potential varies with injection amount, location, and type, and large uncertainties in climate response and resulting impacts.

MCB is a idea to cool Earth by increasing reflecting of clouds over the oceans. An analog is “ship tracks”. Adding aerosols-spraying a fine mist of salt water-would produce more water droplets, brightening the clouds. Details of cloud-aerosol interactions are not well understood, however, so it is currently unclear where and when cloud albedo could be modified and by how much. These processes are poorly represented in current climate models because difficult to develop reliable projections of impacts.

CCT is the idea that is to reduce the formation/extent/optical thickness of cirrus clouds that retain heat radiating upward from Earth’s surface. It is very little research exists on this potential strategy, so the efficacy of CCT is unknown, very limited understanding of cirrus cloud

properties and the microphysical processes determining how cirrus may be altered. The few, existing climate model simulations sometimes have yielded contradictory results. Thus, it is difficult to quantify potential impacts at this point.

Given the urgent and growing risks of climate change, it is important to understand the feasibility, risks, and benefits of solar climate intervention as a possible addition to a portfolio of response strategies. Our current understanding of SCI is insufficient to support an informed decision. The United States, leading country in this field, must also work with other countries to establish interdisciplinary SCI research programs. The US Global Change Studies Program must provide coordination and oversight for this program. The program should focus on developing policy-related knowledge rather than advancing path of deployment, and research should operate under strong research governance.

- **WUI (Wildland – Urban Interface)**

In the United States, wildfires have been considered a common enemy for over a century. Large-scale wildfires in the early 1900s, such as the Big Blowup of 1910, which burned 3 million acres and killed 85 people, devastated communities, and the timber industry. In 1935, the U.S. Forest Service adopted a policy to completely extinguish all wildfires. This policy, widely known as the '10 am policy', states that 'all fires must be extinguished by 10:00 am the day after the first report'.

Tremendous efforts to fully extinguish wildfires and public support campaigns such as Smokey Bear have effectively eliminated wildfires from the American landscape. This would become known as the "fire exclusion paradigm".

And the “burn policy” allowed naturally ignited fires to burn in places such as moorland areas where property and life were not threatened. But the fire exclusion paradigm, which has dominated policy for nearly a century, has resulted in massive accumulation of fuel in complex arrangements with more extreme behavior. Human development patterns in fire-prone areas have led to more devastating fires, such as the California's deadliest burns, California's Camp Fire, and Colorado's largest burn, at Cameron Peak. .

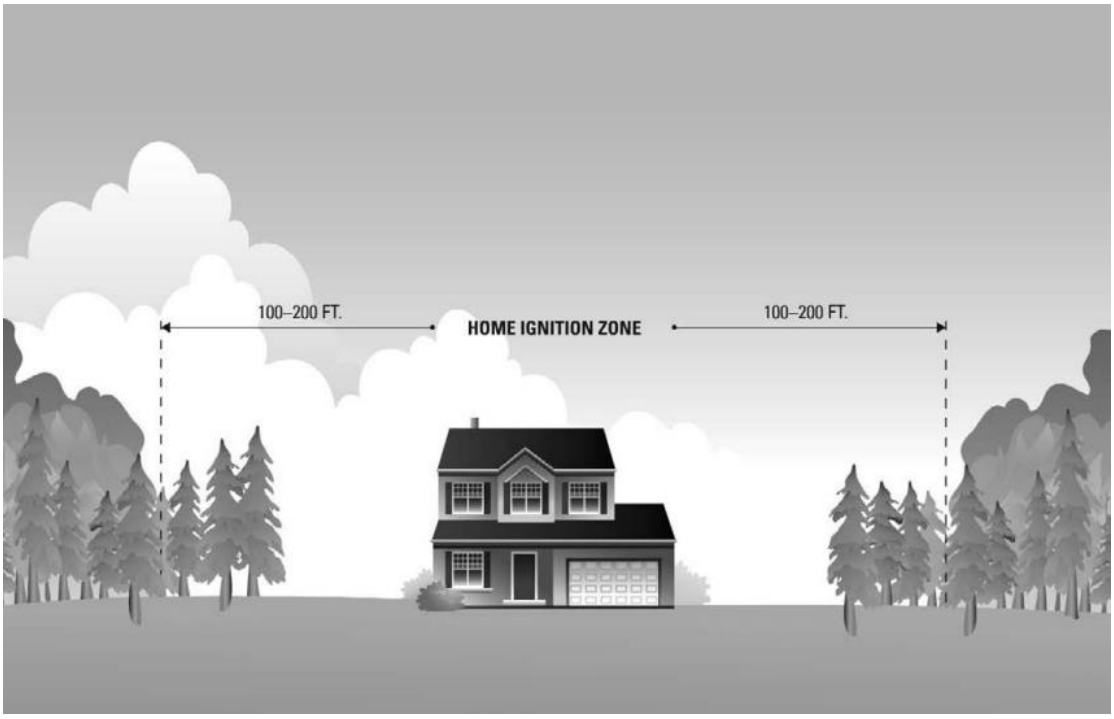
Home destruction from wildfires is an exacerbated and recurring problem due to increased development, climate change, and poor

management of wildfire suppression. Rising temperatures and varying levels of precipitation can cause severe drought and severe burns. For example, in 2020, more than 10 million acres were burned, making it the worst wildfire in U.S. history. Decades of fire suppression and poor land management have further exacerbated the vulnerability and exposure of the Wildland-Urban Interface (WUI).

Traditional approaches to forest management and urban development must be redesigned to address growing fire pressures and risks to social and environmental resilience. Experts stress the need to rethink the way society assesses fire risks and disasters. Essentially, the WUI fire problem must be reconstructed in terms of the potential to ignite a home, not in the context of wildfire control. A WUI fire hazard depends on two main conditions: 1.) the home ignites and 2.) the point at which firefighting resources are overwhelmed and the structure cannot be protected.

It is important to note that WUI fires can result in extreme wildfire behavior in residential areas without disaster, so WUI disasters depend primarily on the ignitability of a home. It is characterized by external materials and design, as well as response to burning objects within the home ignition zone (100 feet around) and embers. In WUI, the requirements for combustion arise from maintaining sufficient fuel (the house and surrounding plants), a heat source (to set nearby objects on fire), and oxygen.

This home ignition zone is a key factor in determining the likelihood of a WUI disaster.



Source: The wildland-Urban Interface Fire Problem by Jack Cohen, 2008

Spatial databases and maps of WUI disasters generated to identify these problem areas generally focus on areas close to vegetation and housing. Studies have shown that WUI disasters occur most frequently in areas with low building density, high vegetation cover, and factors located near large, vegetated wastelands.

Despite a growing awareness of the important role that a home's ignition zone plays in WUI disasters, fire management policies still emphasize fire suppression as a primary goal. Because home ignition zones primarily fall within the realm of private property, the responsibility for preventing home

ignition lies primarily with the property owner.

WUI fire problem pervasive matter as a result of the nation's reluctance to shift away from the fire exclusion paradigm. Proactive solutions must focus on mitigating the vulnerability of structures and their ignition zones, which will require the collaboration of fire agencies and private property owners.

Integrating detailed geospatial data into maps, such as points-based WUI maps, will be another integral tool to confront wildfire risks. This improved approach will lead to better land-use planning and management, effective risk assessments, and more responsive mitigation strategies.

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< 훈련결과보고서 요약서 >

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<tr><td>훈련과제</td><td colspan="5">지자체 역량을 고려한 통합적 재난관리체계 발전방안 연구
(기후변화 문제를 중심으로)</td></tr>
<tr><td>보고서 제목</td><td colspan="5">통합적 재난관리체계 발전방안 연구
(기후변화 대응을 위한 중앙·지방 정부의 역할 중심)</td></tr>
<tr><td>내용요약</td><td colspan="5">본 보고서는 인류가 직면한 가장 큰 재난인 ‘기후변화’에 대하여 미국을 비롯한 전 세계가 어떠한 노력을 기울이고 있는지, 이를 통해 우리 대한민국은 어떠한 교훈을 얻을 수 있는지에 대하여 다루었음.

보고서 주요 내용의 구성은 다음과 같음
1. 서론
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4.1.2. 정의로운 전환의 이해</td></tr>
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차례에서 알 수 있듯이 기후변화 대응을 위해 여러 노력들이 진행되고 있지만 그 중 '정의로운 전환(Just Transition)'과 '데이터 분석'에 기반한 재난관리의 중요성을 강조함. 지금부터 간략하게 본 보고서의 내용을 살펴보겠음.

1. 서론

과거 코카콜라 광고에 등장하던 북극곰의 이미지는 귀엽고 크리스마스가 얼마 남지 않았다는 설렘을 안겨주었으나, 현재 북극곰의 이미지는 기후변화로 인해 위험에 처한 멸종위기종으로 대표되고 있음. 이처럼 불과 몇 십년 만에 북극곰에 대한 사람들의 이미지가 바뀐 것처럼, 인류는 과거에는 없었던 급격한 기후위기에 직면하고 있음.

한국의 폭염과 돌발성 홍수, 미 캘리포니아의 기록적인 산불과 텍사스의 폭설 등 기후변화의 심각성을 보여주는 뉴스는 이제는 일상이 되어 가고 있음. 특히 여러 전문가들은 이러한 현상이 시작단계에 지나지 않으며, 앞으로 더 끔찍한 재난에 직면하게 될 것이라는 암울한 전망을 내놓고 있음. 또한 기후변화는 세대, 지역, 경제적 상태 등 개인이 처한 환경에 따라 이를 인식하는 정도가

다름. 젊은 세대는 기후변화 대응을 위해 보다 적극적인 정책 추진과 기성세대의 행동변화를 촉구하지만, 기성세대는 그동안 자신들이 향유하고 옳다고 검증되었던 경제발전의 방식을 쉽게 바꾸지 못하는 실정임. 이처럼 매우 복잡하고 심각한 문제인 기후변화로 인해 많은 이들이 절망하기도 하지만 세계 곳곳에서는 이를 해결하기 위한 노력도 끊임없이 진행되고 있음.

2. 이론적 배경

기후변화는 말 그대로 기존의 기후패턴이 바뀜으로 인해 야기되는 여러 자연현상의 변화를 말함. 일반적으로 모든 행성은 태양처럼 에너지를 자체적으로 발산하지 못하기 때문에 에너지 보존 법칙에 따라 태양으로부터 받은 에너지와 동일한 양의 에너지를 배출해야 함. 그러나 행성주변에 대기(atmosphere)가 있을 경우, 지구에서 배출되는 에너지가 우주로 나가지 못하고 대기층에 갇히게 됨. 이것이 온실과 같은 효과를 일으킨다 해서 이 대기층을 구성하는 가스를 온실가스라고 부름. 온실효과는 지구에 급격한 온도 변화가 아닌 적정수준의 온도를 유지할 수 있게 함에 따라 생명체가 살수 있는 환경이 조성됨.

지구가 생성된 이래 오랫동안 이 온실가스는 증감을 반복해 왔으며 이로 인해 빙하기 등이 초래되기도 했음. 하지만 이 온실가스의 농도는 그동안 일정한 수준의 상한선과 하한선을 유지해 왔으나, 산업혁명 이후 지금까지 계속해서 인간이 만들어 내는 인위적인 온실가스로 인해 그 농도가 기존의 상한선을 초과하여 계속 상승하고 있음. 따라서 상승되는 온실가스 농도로 인해 지구의 평균 온도는 과거에는 경험해보지 못했던 속도로 올라가고 있음. 더욱이 한번 배출된 온실가스는 대기에서 사라지는데 오랜 시간이 걸리기 때문에 지금 당장 전 세계가 온실가스 배출을 멈추어도 앞으로 수 백 년간의 지구온도 상승은

피할 수 없음. 이러한 우울한 전망으로 인해 전 세계는 온실가스 감축을 위한 협의체를 구성하여 노력해 왔음. 1992년 UNFCC, 1997년 교토의정서, 2015년 파리협약까지 많은 시행착오 끝에 세계는 2100년까지 지구온도 상승을 섭씨 2도로 (보다 높은 목표는 1.5도) 제한하는 것을 목표로 삼고, 이를 위해 여러 나라들이 2050년까지 탄소중립을 달성하기로 합의하였음. 그러나 이러한 합의에도 불구하고 예측하지 못했던 코로나 팬더믹과 우크라이나 전쟁 등의 외부변수로 인해 지금까지 세계 각국은 자신들이 약속했던 온실가스 감축목표 (NDC)를 달성하지 못하고 있음.

3. 기후변화 방지를 위한 노력들

전 세계의 온실가스 배출량의 상당부분은 에너지 분야에서 발생함. 산업이나 교통부분에서 사용되는 화석연료의 연소가 온실가스 발생의 주요 원인임. 따라서 온실가스 감축의 노력은 이 에너지 분야에서 가장 큰 효과를 발휘할 수 있음. 그리고 당연히 재생에너지 사용의 확대가 대책이 될 수 있으나 산업분야의 온실가스 발생의 45%는 연료를 바꾼다고 해서 줄일 수 없으며, 공정을 변화시켜야 함. 그리고 거대한 산업시설에서 어느 하나의 공정변화는 전체 공정변화를 초래할 수 있으며, 많은 비용과 기간의 투자를 초래하며, 기업입장에서는 이러한 대책을 추진하지 않을 가능성이 큼.

하지만 이러한 도전에도 불구하고 전문가들은 에너지 효율증대, 수소전기를 활용한 열에너지 공급, 바이오메스 연료공급 확대, 탄소포집 및 이용(CCS, CCU) 기술의 적용으로 주요 산업부문에서 탄소제로를 달성할 수 있다고 주장함. 그리고 이러한 대책의 성공을 결정짓는 주요 요인은 탄소발생제로 에너지원, 즉 재생에너지 발전비용 단가의 하락과 연관되어 있음. 재생에너지

	발전비용 단가가 화석연료보다 저렴해지는 순간이 오면 에너지 분야에서의 온실가스 저감이 크게 확대될 전망이며, 희망적인 것은 태양열 발전비용의 추세에서 확인할 수 있듯이 시간이 갈수록 재생에너지 발전비용 단가는 계속해서 하락하고 있음. 따라서 기업들이 계속해서 온실가스 저감에 관심을 기울이고 지속적인 투자를 진행할 수 있도록 정부는 전환점이 도래할 때까지 기업들을 지원해주는 환경을 조성해야 할 것임. 다음으로 온실가스 저감은 정부만이 아니라 기업이나 시민단체 등 비정부기구의 노력도 필요함. 정부가 기후변화 대응의 주요 주체이긴 하지만 법령 제개정에 소요되는 기간과 여러 정치적 환경에 의해 오락가락 하는 정책환경을 고려할 때, 시급한 기후변화 문제에 대처하는데 유능한 주체라고는 보기 어려움. 따라서 비정부기구들의 노력도 뒷받침되어 야만 효과적인 온실가스 저감을 달성할 수 있음. 미국의 대기업인 '아마존'의 경우 2040년까지 탄소중립을 달성하기 위한 계획을 발표했으며, 구글과 유투브의 경우 자신들의 플랫폼에서 기후변화와 관련하여 잘못된 정보를 유포하는 행위를 금지하겠다고 선언함. 비정부 기구의 기후변화 대응 노력은 점점 증가하고 있으며 중요해지고 있음. 4. 저탄소 사회로의 정의로운 전환 (Just Transition) 또 하나 세계의 기후변화 대응 노력의 특징은 정의로운 전환(Just Transition)으로 대표되는 사회변혁 운동임. 미국의 노동 및 환경운동으로 시작된 정의로운 전환(이하 JT) 운동은 파리기후변화 협약에도 명시될 만큼 여러 나라들이 채택한 기후변화 대응기조임. 이것은 쉽게 말해 기후변화 대응을 단순히 온실가스 감축이나 재생에너지 개발과 같은 기술중심의 정책에만 중점을 두는 것이 아니라, 정책으로 영향을 받는 사람들과 공동체, 자연환경 등 모든 것을 포용하고 고려해야만 기후변화 대책이

동력을 얻고 저탄소 사회로의 전환이 가능하다는 주장임.

남아프리카나 캐나다 등에서 녹색에너지로의 전환을 위해, 기존 석탄광산의 폐쇄로 일자리를 잃게 되는 노동자들에 대한 경제적 지원, 재교육 및 직업 알선 등이 추진되는 것이 JT의 한 예라고 할 수 있음.

본인이 있는 이곳 Fort Collins 또한 기존의 기술중심의 기후변화 대책에서 탈피하여 이 도시의 공동체, 특히 그동안 정책결정과정에서 소외되어 왔던 유색인종, LGBTQ 등과 같은 공동체의 의견을 적극적으로 반영하여 이른바 '우리의 기후미래 (The Our Climate Future Plan)'라는 새로운 기후변화 대책을 수립하였음.

소외계층의 거주구역에 태양열 전지 등 에너지 지원시설을 설치해 주고 이 사업에 해당구역에 거주하는 실직자들에게 일할 기회를 줌으로써 일자리 창출과 거주가능한 주거공간 보급 등 기존의 사회복지 사업과 유사한 정책목표를 가짐. 또한 지역의 농산물과 지역의 마켓을 연결하여 주기적인 판매행사를 지원함으로써 식량자립과 지역 주민의 소득 증대를 함께 도모함. 이러한 여러가지 운동을 'Big Move'라 명명하여 진행하고 있으며, 2년 마다 진행상황을 확인하여 다음의 운동 'Next Move'를 수립함. 그리고 이 모든 활동이 우리의 기후미래 계획에 포함된 기후변화 대응책으로 추진됨.

이처럼 포괄적이고 포용적인 기후변화 대책이 바로 정의로운 전환(JT)이며, 이 운동은 Fort Collins의 사례처럼 지역의 여건을 정확히 파악할 수 있는 지방정부 단위에서 진행될 때야 말로 구체적이고 효과적인 정책성과를 도모할 수 있을 것임.

5. 과학에 근거한 미국의 기후변화 대비

또 하나 미국의 기후변화 대책의 특징은 바로 과학을 기반으로

하는 정책 수립임. 철저한 자료수집과 데이터 분석을 통해 정책의 방향을 결정 짓는 의사결정 과정은 기후변화처럼 복잡하고 예측이 어려운 문제일 수록 더 효과적이고 적절한 대책 수립에 도움이 될 것임.

지난 1월 새로 출범한 바이든 행정부는 취임과 동시에 지난 트럼프 행정부가 탈퇴했던 파리기후협약에 재가입함으로써 미국의 적극적인 기후변화 대책 추진의 의지를 피력함. 지난 트럼프 행정부에서는 기후변화를 사기(fraud)로 취급하던 분위기로 인해 흔히들 미국이 이 분야에 관심이 없을 것이라고 오판하기 쉽겠지만, 미국의 대학과 많은 연구소 등 학계는 오래전부터 기후변화 문제를 인식하고 이 분야에 대한 자료수집과 연구를 꾸준히 진행해 왔음. 기후변화를 처음 세상에 알린 것도 하와이에 있던 미국의 연구소였음. 이러한 연구 분위기와 세계 최대 위성보유국이라는 장점을 활용하여 미국은 미국 전역에 대한 토질, 기후, 강우량, 토지이용도, 가축분포 등 온실가스 측정과 관련된 여러 정보를 구축하고 있으며, 이 정보를 바탕으로 정확한 온실가스 배출량 측정과 기후변화 예측 모델을 발전시켜 나가고 있음.

그리고 실시간으로 수많은 정보가 수집됨에 따라 이 분야에서는 복잡한 데이터를 정리하고 분석하여 유의미한 결과를 도출할 수 있는 능력이 점점 중요해지고 있음. 이에 따라 많은 대학에서 Data Science라는 프로그램 수업이 진행되고 있으며 전공과 상관없이 거의 모든 전공분야에서 프로그래밍을 적용한 수업이 진행 중임. 데이터 분석 중심의 의사결정 과정은 상대적으로 경험이나 전문지식이 부족한 학생 같은 사회 초년생도 객관적인 결과를 도출하여 의사결정 과정에 참여할 수 있는 기회를 제공함. 이에 따라 창의적인 생각들이 도출될 수 있는 환경이 조성되고, 권위나 외부의 압력 등에 의해 때로는 어이없는 결론이 도출되는 기존의

잘못된 의사결정 과정을 원천적으로 차단함.

학생들은 대학에서 각종 데이터 분석도구를 습득하게 되고, 지방정부나 기업 또는 시민단체 등은 자신들이 직면한 실제 문제들을 대학과 협력하여 해결하고자 노력함. 이 과정에서 데이터 분석의 능력을 쌓은 학생들에게 다양한 형태의 인턴쉽 과정이 제공되어, 학생들은 경험을 쌓고 외부기관은 대학의 우수인력을 활용하는 상호이익의 환경이 구축됨. 시간이 갈수록 데이터 분석의 능력은 점점 중요해지고 있으며, 많은 인턴쉽 과정 등이 이 능력을 요구하고 있음. 공공기관, 산업계, 시민단체 등 많은 곳에서 이루어지는 실제 활동과 문제 해결 과정 또한 데이터 분석을 통한 객관적인 의사결정 과정으로 전환되고 있음.

이러한 데이터 분석기반 의사결정 과정이 효과적으로 적용될 수 있는 분야 중 하나는 재난관리 분야일 것임. 과거 수많은 재난사례에서도 알 수 있듯이 대형재난은 언제 어디서 발생할 것인지 충분히 예측할 수 없으며, 이로 인해 일단 발생하면 의사결정 책임자는 재난수습 후 각종 책임과 비판이라는 후폭풍에 휩싸이게 됨. 특히 한국의 정치환경으로 인해 재난발생은 정부를 무조건적으로 비판할 수 있는 절호의 기회로 인식되는 경향도 있음. 이에 따라 의사결정 책임자는 재난 발생 시 향후 짊어져야 할 책임 부담으로 인해 과감한 의사결정이나 조치에 소극적일 수밖에 없으며, 전임자들이 했던, 이미 검증 받았던 대책만을 답습하게 됨에 따라 매우 소극적이고 수동적인 재난관리가 이루어지게 됨. 시대나 상황변화에 따라 과거의 대책이 다른 결과를 초래할 수 있음에도 불구하고 위험부담을 떠안기 보다는 비판을 최소화할 수 있는 대책에만 집중하게 되어 '특별할 거 없이 뻔한 말만 하는 회의만 계속되는' 비판에 직면하기도 함. 이것은 개인의 문제가 아닌 한국의 재난관리 의사결정 과정의 정책환경 문제에서 기인한 것이라 할 수 있음. 따라서 의사결정 책임자가 향후 문책에 대한

부담 없이 과감한 조치를 추진할 수 있도록 하기 위해서는 앞서 소개한 데이터 분석 기반의 정책환경이 조성되어야 함. 모두가 납득할 수 있는 객관적인 데이터 분석결과를 토대로 수립된 대책은 그 누가 책임자라 하더라도 똑같은 의사결정을 하게 됨에 따라 쉽사리 외부의 압력이나 비판에 흔들리지 않게 됨.

6. 결 론

앞서 소개한 것처럼 인류는 지금 당장 온실가스 배출을 멈춘 다 해도 지구의 평균 온도 상승을 피할 수 없는 상황임. 더욱이 우크라이나 전쟁과 코로나 공포가 사라진 후 폭발적으로 증가하는 경제활동으로 인해 온실가스는 줄어들기 보다는 더욱더 증가하고 있는 실정임. 어떤 이들은 파리기후협약의 목표인 2도씨 상승제한은 달성하기 어려울 것이라고 전망하기도 함.

하지만 세계 곳곳에서 기후변화에 대응하기 위한 노력들도 이루어지고 있음. 기후변화는 막을 수 없기 때문에 엄밀히 말하면 기후변화에 적응하고 피해를 최소화할 수 있는 대책을 강구하는 것이 기후변화에 대한 대응이라고 할 수 있을 것임. 재생에너지의 발전비용 단가를 저렴하게 하고 바이오메스나 지열과 같은 기존에 주목받지 못했던 무탄소 발생 에너지원에 대한 기술개발과 함께, 기후변화로 가장 큰 피해를 입게 되는 소외계층을 포용하고 지원하는 정의로운 전환 운동도 점차 확산되고 있음. 특히 이 정책방향은 지역과 사회 구성원의 여건을 잘 아는 지방정부 차원에서 효과적으로 추진되고 있음. 대한민국의 지방정부도 이를 참고 삼아 정의로운 전환을 토대로 한 다양한 기후변화 대책을 추진한다면 효과적인 저탄소 사회로의 이행을 이룰 수 있을 것으로 기대됨.

미국의 객관적인 데이터 분석을 기반으로 한 의사결정 과정은 복잡다단하게 얽힌 기후변화 문제 해결에 있어서 태생적인

	문제와도 같은 사회적 혼란과 충돌을 최소화할 수 있는 가장 현실적인 대책이라 할 수 있음. 이를 위해 대학을 비롯하여 산업계 등에서 데이터 분석은 필수 능력으로 자리잡아 가고 있으며, 많은 이들이 이 능력을 갖추기 위해 노력하고 있음. 한국의 재난관리 분야도 이러한 과학적인 의사결정 과정이 자리잡게 된다면 보다 신속하고 효과적으로 재난에 대응할 수 있을 것으로 기대되며, 무엇보다 국민의 생명과 안전을 보다 잘 지킬 수 있을 것임. 미국의 기후변화에 대비한 오랜 시간의 노력은 정확도가 높은 기후예측 모델을 고안해 나가고 있으며, 미국 전역, 거의 모든 분야에 대한 온실가스 배출량 측정 등의 환경을 만들어 나가고 있음. 특히 자신들이 보유한 수많은 위성정보를 바탕으로 미국뿐 아니라 주변국들에 대한 온실가스 정보도 수집, 분석하고 있는 실정임. 멀지 않아 이러한 데이터를 근거로 주변국들의 온실가스 저감 노력을 평가하고 때로는 실력을 행사하는 또 다른 강대국의 모습을 보일 우려가 있음. 더욱이 미국만큼 이 분야에 대한 연구와 기술개발에 집중하고 있는 나라는 중국임. 미국과 중국, G2 국가는 세계 최대 온실가스 배출국이면서 동시에 모순적이게도 기후변화에 대한 연구를 가장 활발히 진행하는 국가들임. 이것은 기후변화가 향후 전 세계의 파워게임을 촉발하는 또 다른 불씨가 될 수 있음을 인식하고 준비하는 것이라 볼 수 있음. 한국 또한 파리기후협약의 참여국으로서 2050년까지 탄소중립을 실현할 것을 약속하였으며, 2030년까지 약 40% 탄소배출량을 감축하겠다고 약속하였음. 이를 실현하기 위한 많은 대책과 투자 그리고 기술적인 능력개발이 진행되고 있음. 하지만 정의로운 전환과 같은 세계의 기후변화 대책과 미국의 데이터 공유와 개방의 환경, 그리고 기후변화에 대한 미국·중국의 또 다른 속내 등을 잘 인식하여 보다 현명한 대책을 고안해 낼 수 있다면, 극심한

	기후위기의 환경에서도 국민의 생명과 안전을 보다 잘 지켜낼 수 있을 것임. 그리고 이것은 가장 기본적인 정부의 존재 이유임.