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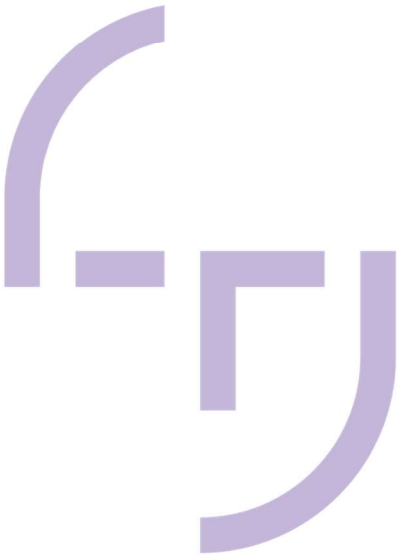

Assessment of climate change risks and impacts in investment opportunities

Master´s thesis
November 2020
Master´s Degree Programme
Risk Management and Circular Economy

ABSTRACT

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Climate change is one of the greatest risks by likelihood and by impact threating our future today. Impacts of the climate change are reaching all regions of the world and affect environment, society and economy. Purpose of this Master´s thesis was to investigate what kind of investment opportunities could arise from climate change and how these can be discovered. Aim was also to study how climate change impacts in different economic sectors and how countries can adapt and mitigate climate change by policies, regulation and actions. By understanding global climate politics and dependencies, it is easier to understand how transition from linear economy to circular low-carbon economy could change business opportunities and through that impact in investments.

The research method applied in this study was scenario analysis. Four plausible future trajectories for climate warming were outlined by emphasizing different level of climate policies and global co-operation. Renewable energy, circular economy, clean technology and the EU were the overarching implications of different scenarios that came up in the scenario analysis. Overall impacts of climate change to economic sectors and regional review were studied by close reading.

In conclusion of the results of the scenario analysis, investment opportunities can arise from renewable energy and battery development such as solar energy and wind power, battery storage technology, hydrogen, electric vehicles, biofuels and technologies which enhance energy efficiency. Also, circular economy solutions and clean technology could offer profitable investment opportunities by technologies which enhance efficient use of materials, renewable materials, food production technologies, nanotechnology and other technologies which enhance productivity and resource efficiency. In investment point of view, discussion was held about difficulty to valuate stocks in growth industries, to find suitable privately held and non-listed companies to invest in and risk of disruptive innovations that can change markets. On investment market wise, risk of sustainability bubble and effect of noise traders are good to consider when valuation level of stocks are assessed. Scenario analysis is important to update regularly, and it can be done also for existing portfolio to find out how climate change sensitive portfolio is. Individual stocks or other investment instruments can be also analysed by using scenario analysis.

Key words: climate change, investment risk, scenario analysis, transition risk, transition to low-carbon economy

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1 INTRODUCTION

1.1 Background of the topic

Climate change is one of the greatest risks by likelihood and by impact threating our future today. It is one of the global megatrends besides globalisation, demographic shifts (ageing population), urbanisation, technological development and resource scarcity. Climate change will affect widely nearly all sectors of economy and its implications are global, neither one region nor country can alone halt the climate change. Other megatrends, especially technological development, resource scarcity and globalisation are tightly interconnected to climate change and they can strengthen the effects of one another - either to positive or negative direction.

Due to far-reaching implications of climate change, economy, operating environment and business opportunities will change, and by that cause new investment risks and opportunities to investors. During past few years, sustainable investing has become more common. Environmental, social and governance (ESG) factors of company, government or certain investment instrument are taken into consideration in investment decisions. Environmental factors include environmental impacts of the operations and commitments such as emitted greenhouse gasses and ability to cut emissions and combat global warming. With sustainable investing, investment returns are reached by sustainable and climate-friendly way. The viewpoint of this study is different; scope is to find out how to consider climate change and its impacts and following risks in investment decisions and by understanding and analysing these, achieve better investment returns.

Investors need to see risks in long-term and be prepared to upcoming changes in good time advance. Impacts of the climate change are not only physical, but also environmental regulation targeting to climate change mitigation, new technology and market behaviour will change the markets and business opportunities. Transition phase to low-carbon economy has already begun and magnitude of it is likely to increase in this decade. Some sectors can come into turning point and

for investment risk management point of view, plausible future trajectories are important to assess to be able to adjust investment strategy accordingly.

1.2 Structure and scope of the thesis

At first, evidences of climate change are reviewed together with the implications, and how these are projected with climatic scenario analysis. Then physical and transition risks are reviewed together with climate politics and explained why climate change is such a complex issue and therefore hard to tackle.

In the chapter three, impacts of the climate change are reviewed by regions and by economic sectors. In the regional analysis, the world is dividend in the eight areas and in addition, certain countries are reviewed individually. Both physical impacts of climate change and nationally determined commitments, actions and future outlooks arising from these are studied. Same kind of analysis is done by economic sectors and closer look is taken to certain climate change sensitive industries.

This Master´s thesis answers to two research questions; how climate change impacts in different economic sectors and how countries can adapt and mitigate climate change-related impacts by policies, regulation and actions. Second research question is how to discover investment opportunities arising from climate change. The first research question is answered in the chapter three and second one is studied in the chapter five. Research strategy of the thesis is qualitative and applied data analysis method to answer the first research question is close reading.

The chapter five includes scenario analysis and investment opportunities arising from that. Scenario analysis consists of four different future trajectories and implications of plausible future events in each scenario are outlined by using longitudinal research strategy together with correlation analysis. Overarching implications of all four scenarios are reviewed closer and arising trajectories and business opportunities are studied in investment point of view. Restrictions and other investment related issues that would be good to consider are presented in the end of the chapter five.

1.3 Purpose, goals and constraints of the thesis

Purpose of this study is to give climate change perspective to investment decision-making by reviewing how climate change will affect to economy, what kind of investment opportunities can arise from that and how these opportunities can be found. The study is written for a small investment company, RA Capital Oy who has invested only in real estates until November 2019. At that time, they sold all real estates they owned and changed their investment strategy. Company owners are professional investors, so this study does not include details about fundamental analysis i.e. financial analysis of company or investment strategy creation as such. Any specific investment advises are not given to certain companies or other investment instruments. RA Capital currently invests in stocks, private equity, index funds and exchange traded funds (ETF).

Macroeconomic review by sectors and regions helps to understand better complexity of issues derived from climate change and causal connections of climate change, politics and global co-operation. Climate warming trajectories are not easy to project due to long-time span and uncertainties of socioeconomical and physical variables and their implications. Emissions come from plenty of different sources, impacts of the climate change are targeted unequally and countries ability to mitigate and adapt climate change varies greatly. Also economic reasons, global competition, energy politics and psychological reasons and attitudes have impact in climate change trajectories which makes the issue extremely complicate.

Scenario analysis is chosen as research method due to number of variables, multiple unexpected events and long-time span. Forecasting only one possible future trajectory would be too uncertain and unavailing in this case. Scenario planning gives view to multiple plausible future trajectories which is effective tool for the strategic decision making of the current time.

Subject is wide but in the global world with multinational companies, cross-border competition and far-reaching implications of climate change, subject cannot be limited only to certain continent or region. Even many local companies are impacted by global changes due to supply chains and logistics.

In conclusion, goal is to give climate change perspective to investment decision making and project which industries will succeed in the future. By this, new investment opportunities should be easier to find but at the same time understand the risks these might include.

2 CLIMATE CHANGE

2.1 Evidences of the climate change

The Earth´s surface temperature has changed throughout the history. At the mid-20th century, atmospheric carbon dioxide reached the level it has not exceeded for millennia and the level of carbon dioxide has continuously increased ever since. According to Nasa, most of the current warming trends are extremely likely (probability greater than 95 percent) caused by the human activity. Most of the warming has occurred in the past 35 years and since the late 19th century, the Earth´s average surface temperature has risen 0.9 degrees Celsius. Increased heat is absorbed much by the oceans which has caused rising temperature of oceans. Sea level rises due to the expansion of warming seawater and the added water from melting ice sheets and glaciers. The acidity of surface ocean waters has also increased by about 30 percent since the beginning of the Industrial Revolution. (NASA 2019a.)

Ice sheets of the Greenland and Antarctic have decreased in mass. Between 1993 – 2016, Greenland lost an average of 286 billion tons of ice per year and Antarctica lost 127 billion tons. Almost everywhere around the world glaciers are retreating and satellite observations have shown that spring snow cover is melting earlier, and overall snow level has decreased during the past five decades. Over the past decades, both the extent and thickness of Arctic sea ice have rapidly decreased. (NASA 2019a.)

Extreme weather events, such as heat waves, drought, wildfires, heavy downpours, floods, hurricanes and other storms have become more common. Warming and extreme weather events vary between different regions; some areas become more wetter whilst others become dryer. (NASA 2019b.)

2.2 Climate scenarios and implications

Future emissions of greenhouse gases, aerosols and other natural and man-made forcings determine partly the future climate. Different climatic scenarios and

climate model projections are developed based on assumptions about the magnitude and pace of the future emissions. Different models provide alternative representations of the Earth´s response to emissions and forcings, and of natural climate variability. Through these models, response of different scenarios can be simulated, range of possible futures can be mapped and uncertainties can be understood better. The United Nations Framework Convention on Climate Change (IPCC) has released the first global emission scenarios in 1992 and scenarios are update regularly since then. Today several other scenario analyses are based on IPCC scenarios (Figure 1) such as transition scenarios by the International Energy Agency (IEA) and different kind of 2°C transition scenarios to review which are the pathways to achieve the 2°C warming goal or fall below it. (Collins & Knutti 2013, 1036; TCFD 2017, 16.)

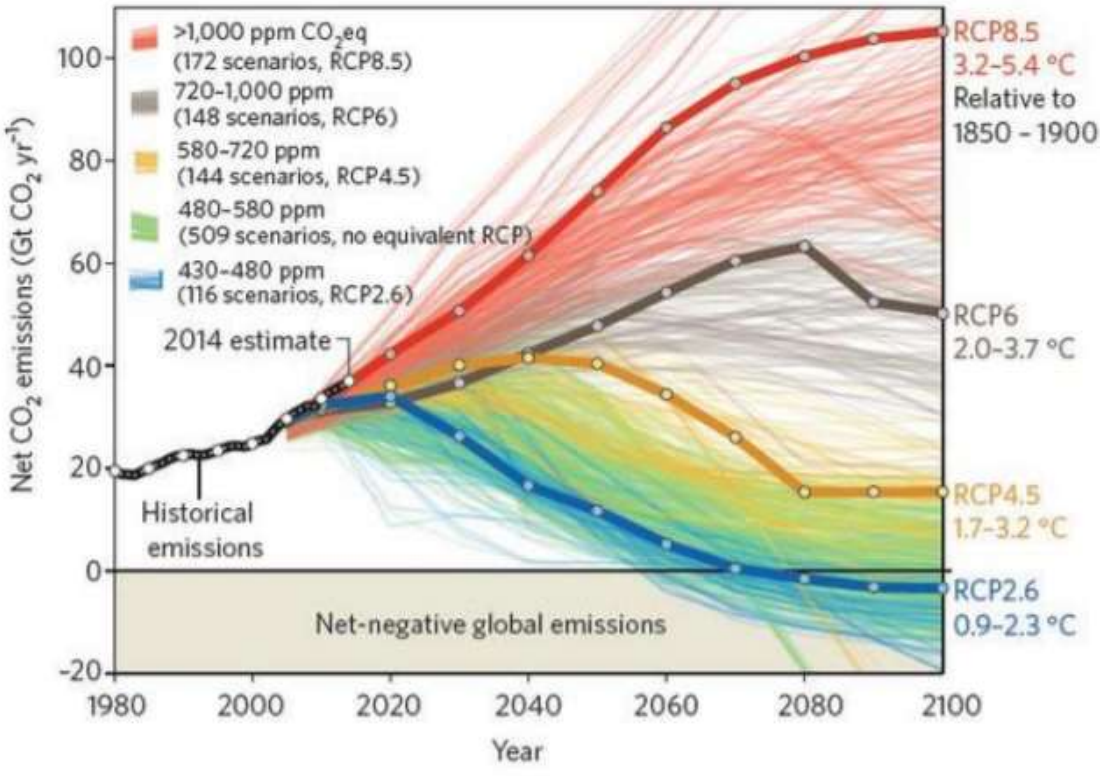


FIGURE 1. CO2 Emissions Pathways and Temperature Outcomes by IPCC scenarios (TCFD 2017, 25).

In addition to inevitable uncertainties about future external forcings, also the climate system´s response to them is unsure. **Climate feedback** is a process that can either increase or diminish the impacts of climate forcings. For example, ice is very reflective, because it is white and therefore does not absorb as much heat

as dark ocean. If global warming continues and sea ice melts, ocean would absorb more heat which would lead to ice melting more and eventually amplify overall warming of the Earth. This is very strong positive feedback. On the other hand, a warmer climate could cause evaporation of water to atmosphere which would lead to increasing cloudiness. More clouds project more sunlight back into space and therefore less heat would get absorbed. This could cause negative feedback and slow down the warming. (NASA 2019c.)

Even if average temperatures would be stabilized, some aspects of climate will continue to change if the climate **tipping point** is exceeded. In several studies, it has been found out that rapidly declining summer Arctic sea ice cover might reach or might have already passed a tipping point. When enough ice melts, causing Earth´s surface to absorb more and more heat, the point of no return might be exceeded. Melting of Arctic sea ice sheet may impact in ocean circulation which could cause significant changes to regional weather patterns. As an example, a signification cooling of Western Europe could be caused by a permanent change in the Gulf Stream. Level of the climate system´s responses, effects of the concurrent actions and delay of events are unclear which makes it difficult to predict the future climate accurately. (Collins & Knutti 2013, 1117 : NASA 2019c.)

Socioeconomic development has also wide impact to future climate and it is even more difficult to predict than the evolution of a psychical system. It requires predictions of human behavior, population growth rate, policy choices, technology advantages, international competition and cooperation. To create plausible climate scenarios, emissions of greenhouse gases for each socioeconomic development scenarios need to be estimated. Over recent years, many climate scenarios have been developed for different purposes and some of them have driven discussion among policymakers and the public by giving range of possible futures to consider. By understanding different rates and magnitudes of climate change scenarios, policy choices can be guided accordingly, and more specific risk assessment can be done. These contain means to mitigate climate change and adapt to impacts of the climate change. (Collins & Knutti 2013, 1036.) Interconnection between climate change and socioeconomic development together with adaptation and mitigation actions and their targets are shown in the figure 2.

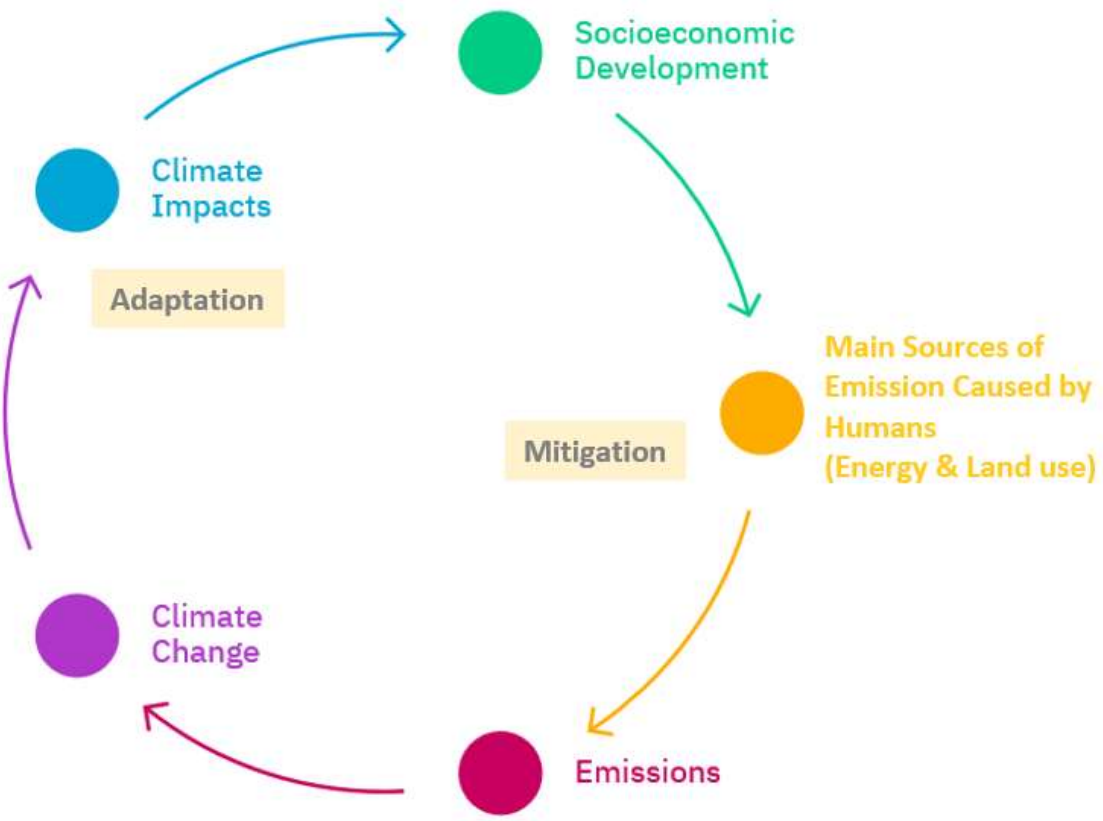


FIGURE 2. Interconnection between climate change and socioeconomic development (SENSES 2020, modified).

2.3 Climate change as a systemic risk

Climate change causes physical impacts to environment, human living, wealth, health, economy and business. Some of these risks have already begun to realize but others are estimated to occur after long period of time which makes projections uncertain and probability range of the occurrence wide. Climate policies have vast impact in these projections and governments can guide operations and actions of companies towards low-carbon business by legislation. Technological development can e.g. enhance utilisation of energy, reduce demand for raw materials and enable development of new materials. Transition towards low-carbon economy can change ascendancies in politics and competitive advantages of business which is causing new risks and opportunities for countries and companies already today. Overall can be thought that transition risk and physical risk of climate change are trade-offs (Figure 3). If efficient climate change mitigation takes place today, transition risk will be high, but eventually physical risks for climate change are lower and vice versa, if world continues like business as

usual, transition risk does not realize but physical risks of climate change will be eventually immense.

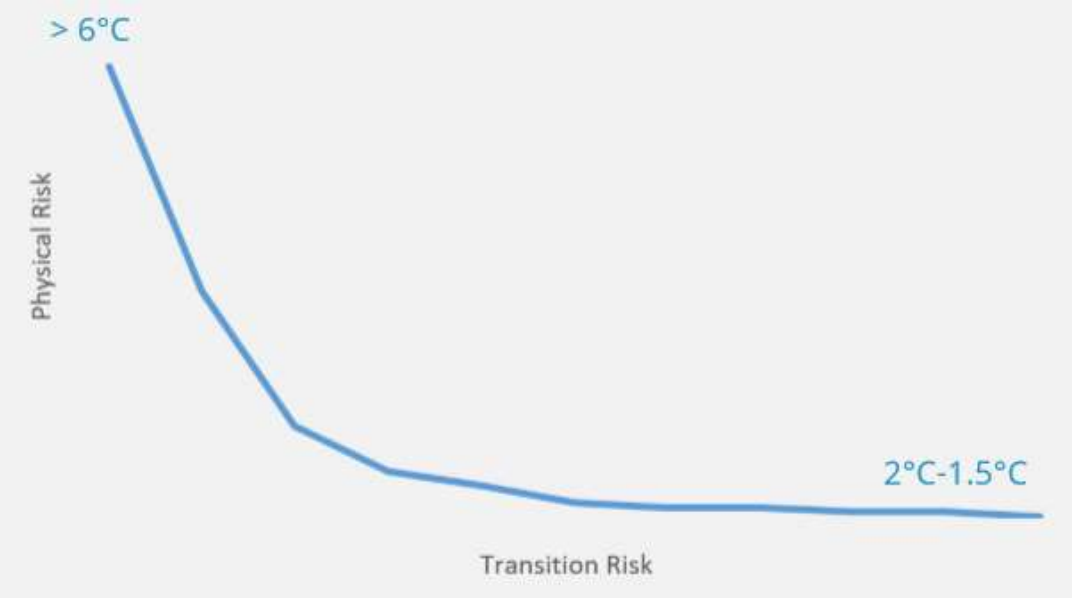


FIGURE 3. Trade-off between transition risk and physical risk (TCFD 2017, 13).

2.3.1 Physical risks

According to The Global Risk Report by World Economic Forum, climate change and other environment-related risks dominate the global risk listing for the third year in a row. Failure of the climate change mitigation and adaptation is listed as the second greatest risk by likelihood and by impact. Seven out of the top ten risks in both categories are related to impacts of the climate change, such as extreme weather events, natural disasters, water crisis, biodiversity loss and ecosystem collapse, man-made environmental disasters and large-scale involuntary migration. (World Economic Forum 2019a, 5, 15.)

Magnitude of the impacts of climate-change mitigation and adaptation failure are shown in the figure 4. Shown interconnections between risks help to understand why climate change is such an enormous global risk and how mitigation of it would diminish probability of most of the global top ten risks to realise. For example, rising sea levels and extreme weather events have wide effects to human living, roads, railways, ports, internet, sanitation, drinking water, energy, tourism and agriculture, to mention some. It is estimated that 570 coastal cities and around 800 million people, are vulnerable to a sea-level rise of 0.5 meter by 2050.

This would cause significant damage to properties such as homes and businesses, but also for critical infrastructure and public assets. (World Economic Forum 2019a, 7, 157–58.)

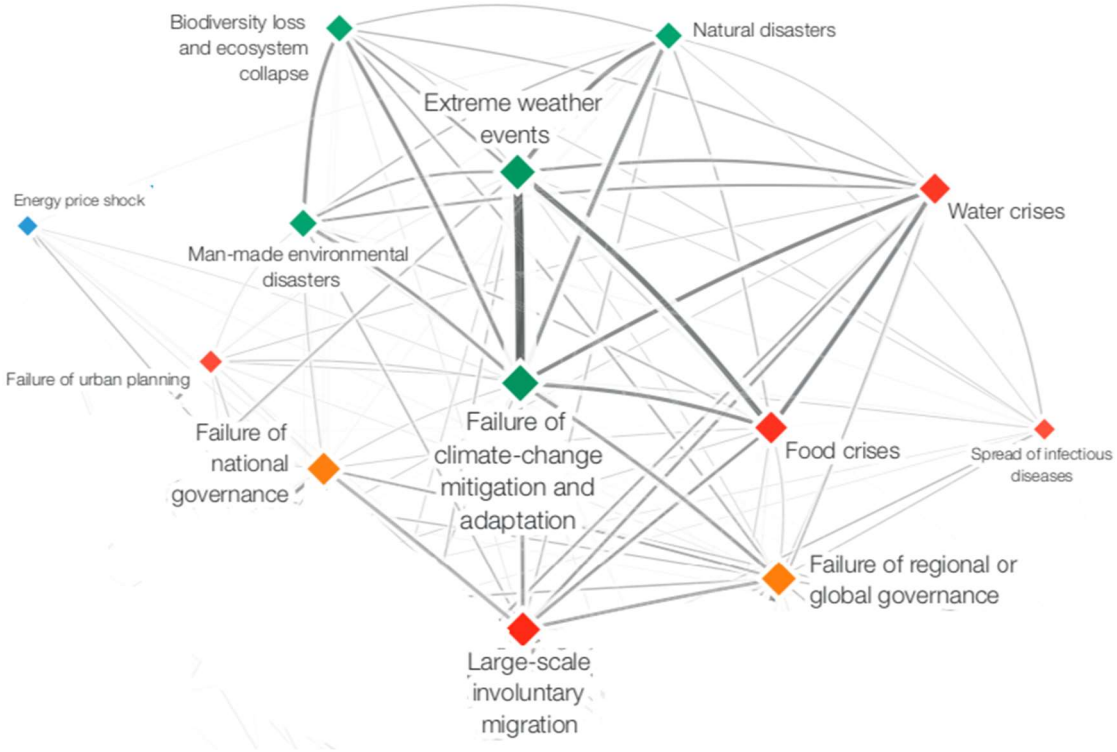


FIGURE 4. The climate-change risk interconnections map (World Economic Forum 2019a, 7, modified).

Biodiversity loss can eventually endanger the human food chain which would affect to socio-economic development, well-being, productivity and even regional security. Even today around 2 billion people suffer from micronutrient malnutrition which is usually caused by a shortage of food with sufficient variety and quality, and climate-change increases the risk that more people become affected. In 2017, approximately 39 million people in 23 countries suffered from acute food insecurity caused by climate-related disasters. Extreme heat and drought can turn certain areas unsuitable for any agricultural use and reduce drastically freshwater availability which would make the areas uninhabitable. Natural disasters strengthened by climate change could force over 140 million people to leave their homes and migrate within countries by 2050. Large-scale involuntary migration can lead to conflicts and political confrontations. More frequent and severe environmental disasters have increased also disruptions for the transportation and

production of goods and services up by 29 % since 2012. (World Economic Forum 2019a, 6, 15, 16; Rigaud & Kumari et al. 2018, xx–xxi.)

Most likely climate warming will increase risk for infectious diseases and bring new and existing diseases to new areas. World´s Health Organization (WHO) has modelled that seven hundred million people more will be at risk of malaria compared to 2003 if temperature increases of 2-3°C by 2100. Although WHO and UN have stated that changes in infectious diseases are likely, but as these include complex causal variables, more need to be studied to better understand these relationships. Ticks are emerging problem because the number of tics is growing and their geographical regions are expanding partly due to climate warming. Ticks are spreading tick borne encephalitis and Lyme disease. There exists also risks that ´sleeping diseases´ will return when glaciers melt. During past 30 years, temperatures have increased rapidly in the arctic regions which have led to melting of permafrost. Researches have studied that frozen virus and bacteria can come alive after melting and can transmit humans through animals and water. New diseases with no existing medicine can cause far-reaching consequences to human living, health, wealth and economy like was experienced in 2020 when Covid-19 spread rapidly to almost all countries in the World. (Fernando 2019; WHO 2003; Siltamäki 2020; Fears 2020.)

2.3.2 Transition risks and climate politics

Transition risk includes the policy and technology changes that enable transition to low-carbon economy and mitigation of additional climate warming. Risk can be either positive or negative, depending on the sector, nature of operations, management of change and ability to keep up with the transformation. Financial implications are strongly targeted to the energy sector, but all energy dependent and high emitting sectors of the economy are impacted by transformation. Transition risk will be negative for high carbon products and commodities whereas positive for energy-efficient, low-carbon products and services. By legislation and policies, operating costs of high carbon activities can be increased and licenses to operate can be limited. Clean technologies can speed up the transition and

might disrupt markets. Sustainable business model and values can be even opportunity to enhance reputation and brand value but includes also risk of reputation loss if sustainable values are not adhered to. (TCFD 2017, 6.)

The first assessment report by the Intergovernmental Panel on Climate Change (IPCC) was published in 1990 and led into the drafting of the United Nations Framework Convention on Climate Change (UNFCCC). The convention was signed by 166 nations at the Earth Summit in Rio de Janeiro in 1992 and it came into force in 1994. Any specific national or international targets to reduce greenhouse gas emissions was not included to the UNFCCC. The Kyoto Protocol, drafted in 1997, contain emission targets for developed countries but many countries such as the US and Australia refused to ratify the agreement, unless developing countries would be required to limit their emissions too. National governments were not ready to introduce national contributions to reduce greenhouse gas emissions for over a decade, due to the costs and fear of losing competitive advantages in international trade. In Cancun in 2010, step was taken forward and agreed of several important arrangements such as the Green Climate Fund, the Technology Mechanism, the Cancún Adaptation Framework and Forest Management Reference Levels. (Cherni, Daley, Dorward, Guendel, Macartney & Nelson 2020.)

Paris Climate agreement was accepted in 2015 by 55 united nations countries and it came into force in 2016. By the end of the 2019, 187 countries had ratified the agreement. All parties are required to set national targets for emission reductions, put forward nationally determined contributions (NDCs) and strengthen these efforts during upcoming years. Target of the agreement is to halt the climate change and limit the rise of global average temperature well below 2°C, preferably to 1.5°C degrees above preindustrial levels by 2100. Other aims are to look ahead the upcoming changes to be able to adapt to the impacts of the climate change and support the most vulnerable countries. (United Nations Framework Convention on Climate change 2019.)

The IPCC stated in 2018 that there is at most 12 years to make drastic changes to be able to stay below the Paris agreement target of 1.5°C degrees. Currently it seems increasingly unlikely that even the 2°C degrees upper limit defined in

Paris Agreement would be met, and 3.2°C degrees rise would be more likely trajectory. The Fourth National Climate Assessment has warned that average global temperatures could rise by 5°C degrees by the end of the century if no significant reductions in emission will be done. (World Economic Forum 2019a, 15, 56.)

Climate Action Tracker (CAT) grades countries based on how likely their commitments and actions would fulfil Paris agreement requirements to limit global warming to 1.5°C degrees if all other countries would act alike. A map (Picture 2) in the chapter 3.1 is updated on September 2020 and shows that with current commitments and actions, warming would not be limited to well-below 2°C degrees. (Climate Action Tracker 2019.)

Tax allowances are an example of how production and consumer behavior can be conducted by regulation. If taxation for electric cars was significantly lower than petrol engine cars, it would promote consumer demand for electric cars and through this could increase electric car production, further development of battery technology and push forward setting up charging stations.

Carbon emission trading is large-scale example of the policy decision that makes high emitting operations more expensive and drive transition towards low-carbon economy. A cap amount for certain greenhouse gases is set and it will be reduced over time so that total emissions fall. Emission allowances can be sold and bought by companies and limited amount of allowances available ensures that they have a value. A robust carbon price advances investments in clean technologies. (European Commission 2015.)

Transition to low-carbon business and renewable energy use are highly dependent on technological development. Technological development enables more efficient use and recycling of natural resources and raw materials, production and use of clean energy and enhances energy-efficiency. New technologies are prerequisite to allover transition to more sustainable operations and ways of doing business. Development of clean technology is expensive, and risk is how to turn new technologies profitable and cost-effective. If new technologies are widely adapted, forerunner`s risk will turn positive. Advanced technologies can disrupt

markets by displacing some established system with something better and unforeseen.

2.4 Complexity of the issue

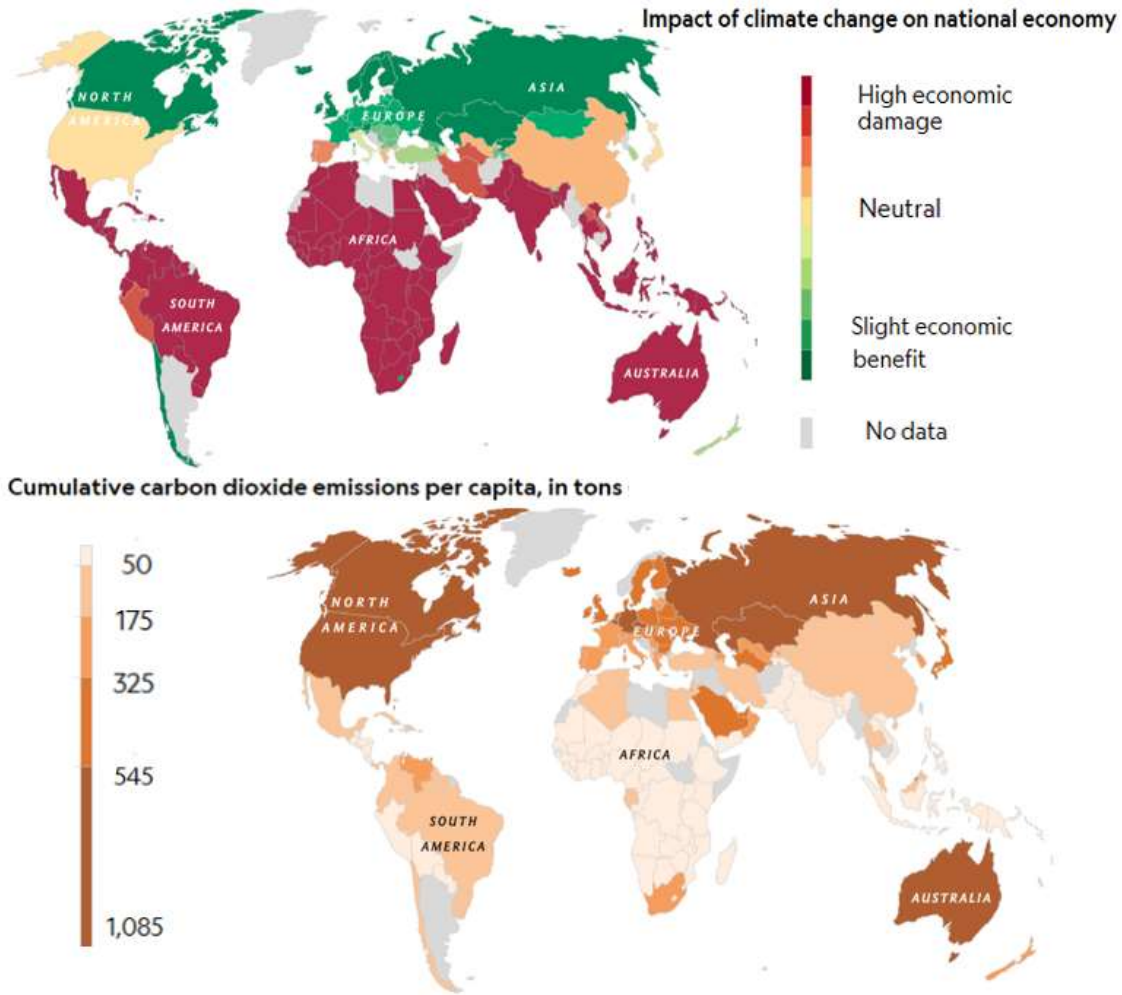
Even if the future climate cannot be accurately predicted, researches share common understanding that if we continue with no climate policies, results will be disastrous in long-term. “Of all risks, it is in relation to the environment that the world is most clearly sleepwalking into catastrophe” is stated in The Global Risks Report 2019 (World Economic Forum 2019a, 15). Negative consequences of climate change are clear, climate agreements are ratified, and most countries are committed to change. Why climate change is then so hard to tackle?

Climate change is a complex issue. **Emissions come from many different types of activities** such as transportation, energy production, agriculture, building and industrial processes across billions of individual sources around the world. All these activities and processes have long history and building current system has cost huge amounts and correspondingly re-building and replacing everything is immensely expensive. (The Economist 2018.)

People have used to their way of living and most of us are not willing to make drastic changes. There are several **psychological reasons** for this. People have no history of dealing such a large-scale problems or climate change issue specifically, and therefore people do not consider it as likely as something that has occurred earlier. Humans are also evolved to pay attention to immediate threats over threats in the far future and present is considered more important than the future. Complex issues which are not easy to understand are often felt less likely. It is also natural for people to think that someone else will do something, and on the other hand, if others do not do anything, then people are less willing to do anything either for the common good. With climate change, this has been seen even on the national level. (King 2019.)

Impacts of the climate change are targeted unequally. The richest countries are mainly located in the regions with greater year-to-year variability of weather and locations are adopted to changing temperatures, while in the tropics, average

temperatures are naturally high and even a small rise in temperature will cause immediate impacts. Whilst richest countries produce the most emissions, poor nations suffer the brunt of changing local climates and following consequences, at least if global average surface temperature reaches the 1.5 – 2 °C degrees. The following Picture 1 reflects inequality between different regions clearly. Rich countries are the ones who should act immediately, but as the threat is not immediate and targeted directly to rich countries, climate change consequences might be mentally felt less serious than they actually are. (King & Harrington 2018, 5031; King 2019.)



PICTURE 1. Impact of climate change on national economy and emitted carbon emissions geographically 1991-2010 (Borunda 2019, modified).

Attitudes have begun to change, and the EU is in the front line to tackle the climate change. The EU has set a binding target to cut emissions by 2030 at least

40 % of the levels in 1990 and in the end of 2019 suggested to raise the percentage up to 55 %. Legislation to increase the use of renewable energy, such as solar, wind, hydro and biomass, and to improve the energy efficiency of several equipment and household appliances are accepted. Aim is also to support the development of carbon capture and storage technologies to trap and store carbon dioxide emissions from power stations and other production plants. (EEA 2019.)

Global competition and fear of losing competitive advantages in international trade have restricted and slowed down climate change mitigation actions of national governments. For example, the US announced in 2019 that they will withdraw from the Paris agreement and the president Donald Trump argued this by saying that the US refuge to give competitive advantage to other countries, such as China, by constraining their own energy production (Harrabin 2019). If certain region, such as the EU, enacts strict environmental policies, production of high emission products, like cement, could be driven down in Europe and would be moved to other country or region with loose environmental policies. This would cause disadvantage to European companies and would reduce European self-sufficiency for certain products. Displacement of high emitting production causes also carbon leakage. Carbon leakage would be possible to prevent by setting up carbon tariffs, but risk for international disputes as a result is likely. (Valtioneuvoston kanslia 2020.)

Energy politics dominate the international climate discussion. Overall countries which economies rely on coal and oil production and export are not keen to cut out fossil energy sources and transit to renewables. Climate policies and targets of these countries do not follow Paris Agreement goals as closely as countries´ which economies are not dependent on fossil energy sources. Procrastination in transit towards renewables might give future competitive advantages to forerunner countries and turn ascendancies in the world politics upside down. (Elonen 2019).

According to United Nation´s estimates, world´s population will be two billion larger by 2050 and three and a half billion larger by 2100 compared to 2017. Population and climate change are inevitably linked. **Population growth** and increasing global standard of living lead to increasing consumption and demand for

more natural resources which increases carbon emissions and accelerates climate change. Limiting population growth is difficult questions but girl´s education and ability to work and overall rising living standards have historically led to smaller families and stop the population growth in advanced countries. (United Nations Department of Economic and Social affairs 2019, 5; Population Matters 2019.)

Economic growth has raised living standards many decades around the world and economic slowdowns and recessions have been unwanted states due to unemployment rate rise and production level reduction. National governments and decision-makers are willing to maintain good economic state to avoid economic and societal issues which partly slows down actions to tackle climate-change. Economic growth and environmentally harmful impacts have not been able to be decoupled absolutely. Technological development has enhanced decoupling, but it is still relative; economic growth causes environmentally harmful impacts. For example, environmental Kuznets curve suggest that at first economic growth leads to increasing environmental damages, but after certain point, environmental degradation starts to reduce due to improved technology, shift from the industrial to the service sector, increasing role of government regulation and spare income to invest in environmental well-being. In practice, the link between income level and environmental degradation is quite weak and it would rather require strict policies and willingness to act the most sustainable way to absolutely decouple environmentally harmful impacts and economic growth. Lately it has been discussed broadly if economic growth is actually even needed for welfare. In that case, the key question instead of decoupling economic growth from harmful environmental impacts would be question about the possibility to decouple wellbeing from ecological crisis. (Hirvilammi 2016; Pettinger 2019.)

It is short-sighted to limit climate change mitigation actions because of the **expenses** they cause. Several researches have shown that simple adaptation strategy would be the costliest option in the end. Many older climate economic models tend to assume that regardless of the magnitude of climate change, the global economy will grow continuously. Today scientist have projected that cost of climate inaction will be tremendous, even if it is hard to estimate the eco-

nomic impacts resulting from unprecedented circumstances. According to estimates, global gross domestic product (GDP) would fall 15 % between 2010 and 2100 if temperatures rose 2°C degrees, 25 % if temperatures rose 3 °C degrees and more than 30 % if temperatures rose 4 °C degrees. Reasons for reduction in GDP are manifold and not everything can be evaluated based on economic costs alone, such as loss of human lives, cultural heritage and ecosystem services. Monetary loss of straight physical damages is easier to value. More frequent wildfires, hurricanes and other natural catastrophes cause rebuilding costs and might shut down economies temporarily. Droughts and floods decrease crop productivity, and scarcity of water resources has wide negative impacts to productivity and living. If some regions become uninhabitable, climate related migration would cause vast economic impacts. Stanford and UC Berkeley scientist have even found in their study that an average local temperature of 13°C is economically optimal, especially for agricultural productivity. They stated this to held true for both rich and poor countries. 13°C average is approximately current climate in countries like the US, Japan, France and China. In addition to physical impacts, climate change can lead to psychical affects such as stress, depression and insecurity which can weaken wellbeing and economic activity. (Burke, Davis & Diffenbaugh 2018; Nuccitelli 2019; Burke, Hsiang & Miguel 2015, 1.)

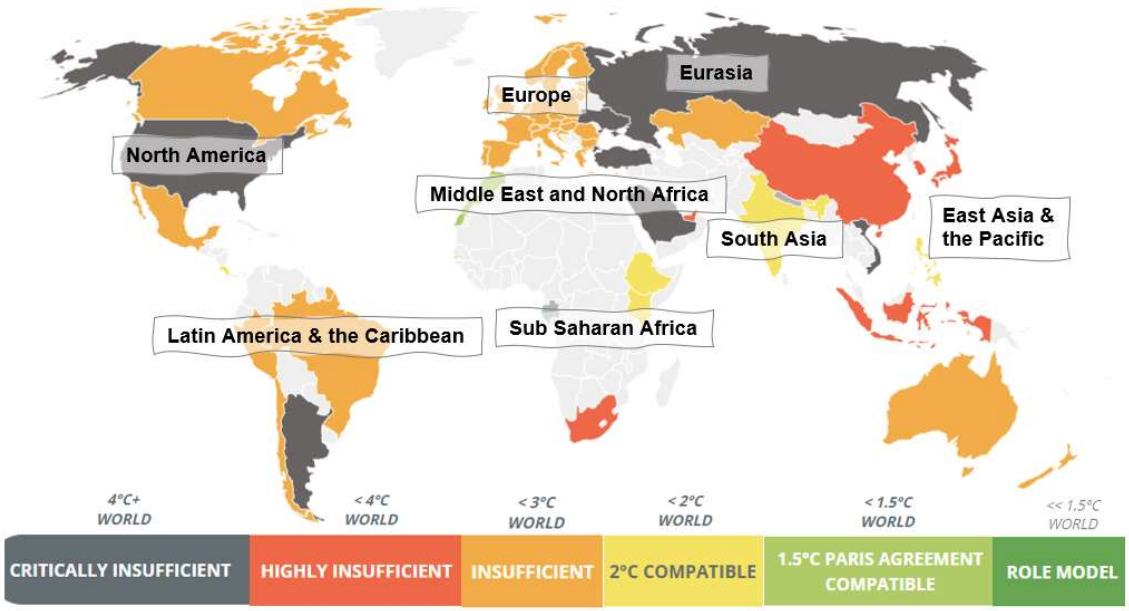
3 IMPACTS OF THE CLIMATE CHANGE BY REGIONS AND BY ECONOMIC SECTORS

3.1 Impacts of the climate change by regions

Throughout the times, extreme weather events and natural disasters have impacted human living and businesses. Today, it is not only weather-related physical risk to consider, but concerns over climate change have forced companies to adapt to growing regulatory and consumer pressures. Impacts of the climate change vary greatly between geographical areas and climate policies and general attitudes differ widely regionally.

All the countries that have ratified Paris Climate agreement, should have committed to long-term plans, goals and actions to keep the global average temperature well below 2°C degrees, and pursue efforts to limit warming to 1.5°C degrees above pre-industrial levels. As mentioned in the chapter 2.4, countries which economies are dependent on fossil resources production and export, do not principally have as ambitious plans as the countries which economy does not rely on fossils. In the following chapters, physical impacts of the climate change, ability to adapt to these impacts, and mitigation policies together with position and local attitudes are presented regionally and partly by countries. Some of the data is relative, for example China is the world´s largest greenhouse gas emitter due to its over 1 438 million population, but United States emit over double as much per capita. (United Nations Framework Convention on Climate change 2019; Dunne 2019c.)

The Climate Action Tracker (CAT) is independent scientific analysis, tracking how countries´ nationally determined contributions (NDCs) can achieve the Paris Agreement target. Sufficiency of country´s or region´s current NDCs is measured with in which level would warming reach by 2100 if all government NDCs were in the same range. The CAT´s assessments are included to this review and rating scale is shown on the below map (Picture 2). (Climate Action Tracker 2020.)



PICTURE 2. Effectiveness of nationally determined climate commitments by countries and regions (Climate Action Tracker 2020, modified).

3.1.1 Europe

According to IPCC´s future climate projections, temperature will increase throughout Europe, but rainfalls will decrease in Southern Europe and increase in Northern Europe. Increasing frequency and intensity of heat waves are likely especially in Southern Europe which affects to human and animal health, agriculture, forestry, energy production and use, transport, tourism, labour productivity and built environment. This can lead to hindering economic activity in Southern Europe more than in other sub-regions and might increase intra-regional disparity in the future. Future energy production and transmission are expected to be affected by climate change; extreme weather events will cause threats for physical energy infrastructure and negative impacts in the long term on the production of renewable energy. Impacts of climate change, such as rising sea level, floods, heavy snowfalls and strong winds, can cause damage to buildings and infrastructure because of their design or location. Sea level rise threaten populations and infrastructure in coastal areas, but risks can be reduced by adaptation actions. (IPCC 2014, 1271–1272; European Commission 2019a.)

Europe´s ability to adapt to climate change is high compared to other world regions, but differences in impacts and adaptation abilities are great between the

European sub-regions. Adaptation policies have been planned at the EU-, national and local government levels. Adaptation will incur costs, but implementation of plans has already started with coastal and water management and disaster risk management. The European Investment Bank (EIB) has announced their new climate strategy in 2018 and according to it, fossil fuel energy projects are not financed by EIB after the end of 2021. (IPCC 2014, 1273; Buck, Hagen, Höhne, Nascimento & Bals 2019, 7.)

In addition to economic damage and adaptation costs caused by climate change, there might be also some benefits especially in Northern Europe. When winters get warmer, it is projected that severe accidents in road transport will reduce. After 2050, tourism might decrease in Southern Europe but correspondingly increase in Northern Europe. Also warming climate is likely to increase cereal yields, wine production and forest productivity in Northern Europe. Due to climate change is global issue, impacts of climate change in other regions will affect indirectly Europe. For example, large-scale involuntary migration from other regions, such as Africa and Middle Est, is likely if climate warming complicates livelihoods in these regions. (IPCC 2014, 1271–1272.)

In December 2019, The European Commission presented the European Green Deal plan which includes action plans to boost the efficient use of resources by means of clean, circular economy and restore biodiversity and cut pollution. The heart of the Green Deal is Climate action which target is that Europe would become climate neutral by 2050. Sub-target is to reduce greenhouse gas emission at least 55 % by 2030. To be able to reach set targets, all sectors of economy are required to act accordingly. This means that investments for environmentally-friendly technologies are needed, industrial innovations are supported, private and public transportation should be rolled out cleaner, cheaper and healthier, energy sector should be decarbonized, more energy efficient buildings should be built and refurbished, and international co-operation is needed to improve global environmental standards. (European Commission 2019b.)

The Just Transition Mechanism and The Sustainable Europe Investment Plan are key tools to ensure that none is left behind in the green transition. The first one will provide support for those regions and companies who are the most affected

by the transition. The Sustainable Europe Investment Plan will mobilise public investment to support the transition. In addition to these, Green Deal includes set of policy initiatives such as EU energy system integration strategy, a hydrogen strategy for a climate neutral Europe, sustainable mobility plan, new industrial policy based on the circular economy, the zero pollution actions plan, initiative for cleaner construction sector, plan for sustainable agriculture and ways to ensure more sustainable food systems and protect biodiversity. (European Commission 2019b; European Commission 2020c.)

According to Climate Action Tracker (CAT), EU´s current climate commitments are insufficient i.e. global warming would reach over 2°C and up to 3°C if all government NDCs were in this range. Although, if reduction target of greenhouse gas emissions by 2030 would be 65 % instead of 55 %, CAT would have assessed EU´s commitments compatible with the Paris Agreement. (Climate Action Tracker 2020.)

Within the EU, there is large differences in the NDCs of member states. Countries like Sweden, Portugal, France, the Netherlands and Luxembourg have the most ambitious climate policies, whereas the most central and eastern European countries remain unambitious to achieve climate targets. When EU commission proposed to cut greenhouse gas emissions 55 % by 2030, eastern European member states Bulgaria, Czechia, Hungary, Poland, Romania and Slovakia opposed this by saying that the target is unrealistic. For example, Poland is still largely dependent on coal which is one reason for resisting stricter commitments. The country´s target is to phase out coal mining only by 2049. (Climate Action Network Europe 2018, 4; Farand 2020.)

3.1.2 North America

In many parts of North America, extreme weather events have caused significant damage to infrastructure already today, especially in Mexico but also in the US and Canada. In addition to more extreme events such as higher sea levels and associated storm surges and more intense droughts, more frequent heat events and wider-spread forest fires and daily precipitation extremes will be very likely consequences of global warming. In the Western US and Canada, there will be

more frequently low-snow years and shifts towards earlier snowmelt runoff. All together these climate hazards and changes are estimated to lead to increased stresses to water, ecosystems, agriculture, human health, infrastructure, economy and urban and rural settlement. North America is wide geographical area and rising temperatures have variable impacts in the yields of major crops, but it is projected that net productivity would decline by the end of the 21st century without adaptation. This might affect global food security due to North America is a significant source of global food supplies. Much of the transportation infrastructure in North America is aging, or even inadequate in Mexico, which may make it vulnerable to damages caused by extreme weather events. (IPCC 2014, 1443, 1444, 1467)

Future risks of climate change can be mitigated by adaptation; with innovations, institutional strengthening, economic diversification and infrastructure design. In North America, adaptation is stronger in the areas of technology more than in social, behavioral and institutional strategies. Adaptation engaging and planning processes are also stronger in municipal level than in government level. As mentioned in the chapter 2.4, **the US** have withdrawn from the Paris climate agreement by pleading to the disadvantage that constrains in energy productions would cause to US companies and their competitiveness. CO2 emissions of the US are the second highest after China which make the US withdraw particularly severe. Although newly selected president Joe Biden promised during his election campaign that the US will rejoin the Paris climate agreement if he got elected, and that the country will prioritise mitigation of climate change. It remains to be seen how change of presidency will affect the future of the US´s climate actions. The US´s current NDCs have been rated as critically insufficient by Climate Action Tracker, which means that if all countries would implement climate policies at same level as the US, warming would exceed 4°C. Despite of the government´s decision for withdrawal, in the subnational level 22 states, 550 cities and 900 companies operating in the US, have made climate commitments and all states have climate policies at some level to reduce emissions. However, the decision to withdraw from Paris climate agreement might lead to diplomatic tensions and make difficult for the US to take part of the global conversation, if they do not

rejoin. This can also weaken other countries´ willingness to implement environmental politics. (IPCC 2014, 1445; Climate Action Tracker 2020; Harrabin 2019; Biden Harris 2020.)

Canadian government is implementing coal-fired power plant phase-out by 2030 and transit to 100 % zero-emission passenger vehicles by 2040. According to Climate Action Tracker, warming would reach between 2-3°C with current Canadian government targets. Still the Canadian economy is heavily reliant on its carbon-based energy sector despite of the business concerns about climate change mitigation and extreme weather events. Canadian companies are still expanding the production despite of the foreign disinvestments from the sector and low oil prices. This trend can lead to an energy prices shocks. (Climate Action Tracker 2019; World Economic Forum 2019b, 23.)

According Global Attitudes Survey by Pew Research Center, Mexicans find the climate change as a major threat more often (80 %) than Canadians (66 %) and Americans (59 %). Mexican citizens may be more willing to mitigate the climate change impacts but economic possibilities for adaptation activities are lower in Mexico than in the Canada and the US. Though Mexico does not have short-term climate action plan nor the specific climate mitigation goals, and government is favouring fossil fuels over renewable energy. Important barriers, especially in energy sector, might be uncertainty about future climate change, insufficient knowledge on costs of adaptation and lack of climate resilient energy technologies. Overall, strategies to reduce energy demand would diminish GHG emissions and vulnerability to climate change. (Pew Research Center 2019; Climate Action Tracker 2019; IPCC 2014, 1445, 1467.)

3.1.3 Latin America and the Caribbean

IPCC´s climate projections show increase in temperature in Latin American and the Caribbean regions by 2100. Precipitation changes differ notably by regions; in Northeast Brazil reduction in rainfall is projected to be 22 % whilst increase up to 25 % in Southeastern Latin America. Increasing rainfalls will affect increasingly to agricultural productivity by the mid-century and on the contrary, crop productivity in dryer areas will decline. Dry spells may increase in tropical areas east of

the Andes. The Andean cryosphere will melt more causing the seasonal distribution of streamflows. La Plata river basin is projected to flood whilst in the Central Andes, runoffs will be decreasing. Risk of water supply shortages will increase, but adaptation strategies to reduce the mismatch between water supply and demand have been already introduced. Also more efficient water resources management and coordination would be important to develop to mitigate vulnerability. (IPCC 2014, 1502–1503.)

Productivity and production of sugarcane and soy are likely to increase when temperature rises even if water availability decreases. Both of the plants can be used as a biomass for renewable energy which is a good measure of climate change mitigation, but on the other hand, land use for cultivation can lead to deforestation in parts of the Amazon. Already increased extensive agriculture have led to deforestation and land degradation and this with changing climate have impacted fragile ecosystems such as the tropical Andes and the Amazon forest. The tropical forests constitute an important carbon sink due to their ability to store great amount of carbon dioxide. Therefore, rainforests have essential role in fighting against climate change. Public concern of deforestation activity in the Amazon is regionally and internationally rising. It can become a leading risk for doing business in the region if issue would be left unattended. Destruction of the rainforest can hinder climate, health and food security, complicate trade and cause reputation risks for business. (IPCC 2014, 1502–1503; World Economic Forum 2019b, 19.)

In many countries of Latin America and the Caribbean would be important to start adaptation to future climate change by reducing the vulnerability to present climate. Poverty level in most countries is high which lower the possibility to adapt to impacts of climate change. (IPCC 2014, 1503.)

Chilean President Sebastian Piñera has pushed ambitious legislation during past couple of years and set strong goals to reduce emissions. Short term goal is to reduce 20 % of carbon emissions within next five years and make Chile carbon neutral by 2050. In 2019 Chile´s NDCs were rated ´highly insufficient´ by Climate Action Tracker but were upgraded to ´insufficient´ in 2020. Both Climate Tracker analysis and Atlantic Council agrees that if current commitments are implemented

to action and new climate law “Framework law on climate change” will be accepted, Chile might become a front-runner on climate action in the next decade. (Strauss Zachary 2019; Climate Action Tracker 2020.)

Argentina took great steps towards emission reductions by adopting several renewable energy laws under the previous government term in 2015 – 2017. Since Argentina has been going through a severe economic crisis and government has changed, the development of the renewable energy policies is rather uncertain. In any case, Argentina would have the capacity to reduce emission significantly. (Climate Action Tracker 2019.)

Also in Brazil, political changes have impacted lately to climate and deforestation policies. Between 2005 and 2012 deforestation was reduced by about 80 percent and renewable energy sources got a major role in Brazil. Since president Jair Bolsanaro was elected, new climate policies have not been implemented to halt emissions growth and status of environmental institutions have been weakened. Willingness to capitalize rainforest and make gain of them is sad example of how small group of powerful people can affect to possibilities to mitigate climate change. Reducing deforestation is the most important contribution Brazil could do to mitigate the climate warming. (Climate Action Tracker 2019; Graham & Viscidi 2019.)

Less than 1 % of the planet´s total greenhouse gas emissions are produced in the Caribbean subregion, but the impacts of climate change will be far greater than that percentage would suggest. Therefore, the priority should be on building efficient adaptive measures more than on the mitigating activities. Although, for example Costa Rica has a climate plan for all sectors of the economy and Climate Action Tracker has estimated that if country can implement all planned policies, 1.5°C range goal would be achievable. (CEPAL 2015, 54; Climate Action Tracker 2019.)

3.1.4 East Asia and the Pacific

According to Regional risks for doing business 2019 report by World Economic Forum, environmental risks are the main concerns for doing business across East

Asia and the Pacific. During 2018, this area witnessed half of the all natural disasters in the World. Indonesia was struck by the devastating earthquake and tsunami in September 2018 and Japan was hit by the flash floods earlier that year, just to mention two cases. Natural disasters in Asia and the Pacific area have become increasingly frequent and this emphasis the need to strengthen resilience against future catastrophes. Natural disasters have caused massive economic losses and loss of human lives in the area. Further changes in climate are projected to have crucial impacts on water resources, coastal ecosystems, infrastructure, health, agriculture and biodiversity. (World Economic Forum 2019b, 12; IPCC 2014, 1374.)

Adaptive capacity in **Australia** is generally high, but constraints in climate policy implementation are faced especially at local and community levels. These constraints are estimated to arise from lack of sufficient knowledge and uncertainty about the impacts, limited integration of different levels of governance, lack of binding guidelines on principles and priorities, and attitudes towards climate change. According to Global Attitudes Survey by Pew Research Center, only 60 % of Australians see the climate change as a major threat. At the same time impacts of the climate change are rising, for example in late 2019 and early 2020 severe drought and record-breaking heat fuelled catastrophic bushfires across the Australia. Australia is the world's largest exporter of coal and gas and the government is still supporting the continuance of the coal industry. Due to high emission dependency of Australia, Swedish central bank has decided to divest from Australian government bonds. Australian government published new "Climate solution package" in 2019 but it does not include intents to implement any serious climate policy endeavours. Included renewable energy target is focused more on gas-led recovery than a green recovery. A step away from coal can actualise vast transition risk due to the closure of coal-based energy sources is one of the main reasons for energy price shocks in Australia. According to the Regional risks for doing business 2019 report, energy price shocks were the highest ranked business risk in Australia in 2019. (IPCC 2014, 1375; Pew Research Center 2019; Buck et al. 2019, 7; Climate Action Tracker 2020; World Economic Forum 2019b, 12.)

China is the world´s largest greenhouse gas emitter by its 27 % share of global GHG emissions at home and abroad. Climate Action Tracker has estimated that China´s contribution to Paris climate target is ´highly insufficient´ which means that with current policies and actions, warming could reach between 3°C and 4°C by 2100. China is the world´s largest consumer and producer of coal and therefore its economy is not dependent on coal prices. Construction ban on new coal plants was drafted in 2018 but has been postponed ever since. By mid-2020, China has permitted more new coal plant capacity than altogether in 2018 and 2019. Paradoxically, China is also the largest developer of renewable energy, and thereby the choices the country makes, have substantial impact in the world´s ability to limit warming to 1.5°C. By developing clean technology solutions, China can benefit economically, and it is in the position where it can strongly impact in global energy security and use the means of energy diplomacy. China can import its technology with the prices a lot lower than average market price and acquire vast amounts of scarce raw materials that other countries would also need. (Climate Action Tracker 2020; Elonen 2019)

Despite of the natural disasters and the climate costs **Japan** has already faced, country´s climate commitments are highly insufficient to mitigate impacts of the climate change. Main concern is Japan´s coal policy. Whilst many other countries have set target to be coal-free by 2030, it is projected that a third of Japan´s electricity sources will be based on coal still in 2030. Japan is also funding largely coal-fired power plants abroad. Technical innovations are heavily emphasized in Japan´s long-term climate strategy. Green institutions have criticized this kind of strategy to be just an excuse to avoid the implementation of reduction measures by existing technologies. (Climate Action Tracker 2019; Sauer 2019.)

Such as Japan, Indonesia is also highly vulnerable to climate change and country´s climate policies are rated ´highly insufficient´ by Climate Action analysis team. Though issues and causes vary a lot between these two countries. In 2015, Indonesia was the world´s fourth largest emitter of greenhouse cases due to deforestation and peatland megafires. Increasing temperatures raise the risk of further forest fires, which release more emissions and climate keeps warming even faster. This is classical example of the climate feedback phenomena. Indonesia

is also the fifth largest producer of coal in the world and its emissions are increasing in all sectors, but climate-related legislation and mitigation actions are mainly directed towards forest sector. 10 % of the world´s tropical rainforests and 36 % of tropical peatlands are in Indonesia. Overall, Indonesia has committed to cut emissions by 29-41 % by 2030 in comparison to 2018 – but only if it is supported by international cooperation. (Climate Action Tracker 2019; Dunne 2019a.)

The Philippines is vulnerable to extreme weather, and challenges for adaptation is caused by their geographical position with over 7000 islands and relatively weak economic situation. Philippines joined the Paris agreement only in 2017 and they rely heavily on coal as an energy source. However, in 2019 president Duterte has signed into law ´the Energy Efficiency and Conservation Act´ to improve the energy use and transit rapidly from traditional energy sources to renewable ones. Country´s commitments are estimated to be 2°C compatible. (Climate Action Tracker 2019.)

3.1.5 South Asia

According to Regional Risks for Doing Business 2019 report by World Economic Forum, the main risks for doing business in South Asia countries are water risks and manmade environmental crises. South Asia is one of World´s water-scarce regions. Around a quarter of the global population live in this region but there are less than 5 % of the world´s renewable water resources. Floods and droughts, which are expected to become more frequent with climate change, will exacerbate water storage – and even today water storage is low by global standards.
In India, more than 20 cities will be at risks of running out of groundwater already by 2020 which would affect 100 million people. Water-scarcity might lead also to geopolitical challenges in the region. Rivers such as Indus (India and Pakistan) and Ganges (India and Bangladesh) can be used as ´a weapon´, to cut off flows, in cross-border disputes. (World Economic Forum 2019b, 24.)

Three out of four most polluted countries in the World; Bangladesh, India and Pakistan, are located in the South Asia. Pollution, which leads to environmental degradation, poses health and economic risks to these countries. As population and economies grow in South Asia, demand for energy increases and energy

price shocks cause major risks, especially in Pakistan and Bangladesh. This risk concerns also governments because energy sector is highly subsidized. (World Economic Forum 2019b, 25.)

India is the world´s third largest emitter of greenhouse gases, after China and the US. At the same time India is also very vulnerable to climate change due to changes to the monsoon and melting of the Himalayan glaciers. The country has pledged a 33 % to 35 % reduction in the emission intensity of its GDP by 2030 compared to 2005 levels. India´s commitments are rated as 2°C compatible by Climate Action Tracker. India is still the second largest coal producer after China, but it has also rapidly introduced renewables in recent years. It is good to notice that due to poverty and low living standards in India, average Indian citizen uses a lot less energy than those in other countries. When living standards rise, also total energy consumption increases which might make it difficult for India to reach to their climate targets. (Climate Action Tracker 2019; Dunne 2019b.)

3.1.6 Eurasia

The increase in annual average temperature is expected to be much larger in Eurasia compared to the global average warming. Especially the Arctic is extremely vulnerable to climate change and the high increase in wintertime temperature in eastern Europe and **Russia** is most likely connected to the melting snow cover. According to the Pew Research study of how people around the world experience climate change, only 43 % of Russians see it as a major threat which is the third lowest percentage after Israel and Nigeria. Government´s climate targets and commitments are rated ´critically insufficient´ by Climate Action Tracker which means that warming would exceed 4°C with current policies. Russia formally ratified the Paris agreement only in October 2019, but it has been seen more like a symbolic gesture than substantive act. Russia have not announced any new climate policies or emission reduction targets, nor it has not really implemented existing climate actions. According to Climate Action analysis, with current implemented policies, Russian´s emission levels will be roughly the same in 2030 than in 2017. Russia has no system to monitor and regulate companies´ greenhouse gas emissions and in November 2019, after lobbying by large com-

panies, government informed they are going to abandon plans to set any emission targets for companies. Russian economy is heavily dependent on oil and gas production and mining, and 15 % of Russia´s oil and 80 % its gas operations locate on the permafrost area. These explain largely Russian´s unwillingness to move from fossil fuels to renewable ones and why country sees also advantages in climate warming. (Pew Research Center 2019; Climate Action Tracker 2019; Doff 2019.)

Also other Eastern European countries such as Ukraine and Kazakhstan are highly dependent on fossil fuels. Kazakhstan has a conditional target to reduce emissions by 25 % by 2030 compared to 1990 levels, but still it has further planned to expand coal and oil production. Situation with Ukraine is even worse, it does not have set real targets to aim at. If all government targets were in this range, warming would exceed 4°C by 2100. (Climate Action Tracker 2019.)

3.1.7 Middle East and North Africa

Rising temperatures are already affecting Middle East and North Africa. Extreme heat has spread across wider areas for longer periods of time whilst rainfall decline which is causing longer and more frequent droughts. This might eventually make some regions uninhabitable and reduce growing period and areas for agriculture. Together with scarce water resources, these will cause risk of conflicts and increase migration to other regions. Middle East and North Africa countries are aware of these dangers but attitudes and actions among countries are contradictory. Some of the countries such as Saudi Arabia, the United Arab Emirates, Qatar and Kuwait are highly dependent on the export of oil and gas and therefore climate change issues are considered more as an energy politic matter. These countries rather concentrate to mitigate impacts of the climate change in their countries than are willing to prevent global warming. For example, Saudi-Arabia is the second largest producer of oil and the world´s leading oil exported which explains its unwillingness to transit towards renewables instead of utilizing the oil reserves first. Climate commitment of Saudi Arabia is highly unclear due to country has not published the baseline corresponding to its Paris Agreement target nor any national emission projections plans. (The World Bank 2019; Elonen 2019; Climate Action Tracker 2019.)

Middle East and North African countries have high potential for wind and solar energy productions. By utilizing this potential, countries could increase their electricity production and also decrease the vulnerability of their existing energy systems. Morocco has installed one of the largest solar farms in the world in 2016 and country is region´s leader by the efforts to combat climate change. (The World Bank 2019.)

3.1.8 Sub-Saharan Africa

Africa is one of the most vulnerable continents due to its high exposure to impacts of the climate change and low adaptive capacity. Global warming causes higher temperature increases in sub-Saharan Africa than the global mean temperature increase. Therefore, additional warming adds greater risks in the form of greater droughts, more frequent heat waves and more potential crop failures. Risks differ between sub-Saharan Africa; IPCC´s projections show that the Western Sahel region will experience the strong drying with significantly prolonged dry spells whilst Central Africa to see a decrease in the length of wet spells, but still slightly increasing heavy rainfalls. It is likely that crop yields and production will lessen especially in West Africa and Sahel region which will impact on people´s food security. This can exacerbate existing issues such as conflicts. Already now, drought, scarcity of resources and desertification have led to conflicts between cattle herders and crop farmers. Loss of livelihood can lead not only to poverty but also to agitation, large-scale involuntary migration to other regions and increase crime and terrorism. Insufficient access to safe water and improved sanitation, food insecurity and lack of health care will endanger people´s health and wealth. Diseases such as malaria epidemics can increase due to climate change. (Shepard 2018; IPCC 2014, 1203, 1205.)

National governments in Africa are initiating governance systems to adapt and respond to climate change, but overall adaptive capacity is considered as low. Also institutional frameworks are considered as incomplete, under-resourced and fragmented which makes it difficult to manage complex socio-ecological changes in large scale. Isolated initiatives such as disaster risk reduction, social protection, technological and infrastructural adaptation, ecosystem-based approaches and

livelihood diversification are reducing vulnerability, but most adaptations remain autonomous and are reactive to short-term motivations (IPCC 2014, 1203)

South Africa is one of the most industrialised countries of Africa and it is heavily dependent on coal. Recent policy turns refer to a possibility to a major transition toward gas and renewables, but country´s goals to reduce emissions are not ambitious and are rated ´highly insufficient´ by Climate Action Tracker. South Africa has pledged to peak its emission by 2025, but if its economy were to grow at a higher rate, emissions may increase still by 2030. Climate change would reduce country´s already depleted water resources and exacerbate droughts causing extremely harmful impacts to climate-sensitive sectors such as agriculture and forestry which South Africa´s development is highly dependent on. Despite of this, only 59 % of South Africans consider climate change as a major threat to their country according to Global Attitudes Survey. (Dunne 2019c; Climate Action Tracker 2019; UNDP 2019; Pew Research Center 2019.)

3.2 Impacts of the climate change by economic sectors

Just like certain regions will be much more impacted by the changing climate, also certain sectors and sub-industries are more sensitive than others. Certain industries are impacted more by physical impacts whereas legislative changes and climate policies have effect to certain other industries. Within one sector, impacts differ also regionally and vary between different warming scenarios. In the following sub-chapters, the most climate sensitive sectors are reviewed in the general level.

Physical risks of the changing climate will be realised in different periods of time. Some of them have already begun to happen, such as more frequent natural disasters and heat waves whereas most impacts will come true during next decades and after. Even if climate change is serious and frightening threat and its consequences are mainly negative, some sectors and companies can also benefit. Transition risks, positive as well as negative depending on the sector, arise from changing legislation and consumer habits, developing technology and mitigation and adaptation policies and actions against climate change.

3.2.1 Energy

Discussions about sustainable development, climate change mitigation and emission reduction are often related to energy sector; its planning, analysis and policy making. Energy accounts for two-thirds of global greenhouse gas emissions if both ends, energy supply and energy demand, are included. Energy plays an important role in all industries and in many aspects of everyday life. Energy is used for cooling and heating, lightning, fuel for transportation, cooking, water consumption, use of goods and services and land use. Therefore, changes on energy production and use have great impact in total greenhouse gas emissions. The figure 5 below shows that economic growth and increasing consumption of energy have increased carbon dioxide emissions in 2018 despite of the energy efficiency improvements, low-carbon options and introduced new technology. To decouple economic growth and greenhouse gas emissions, a lot more need to be done on energy sector. (EPA 2020; IEA 2019a.)

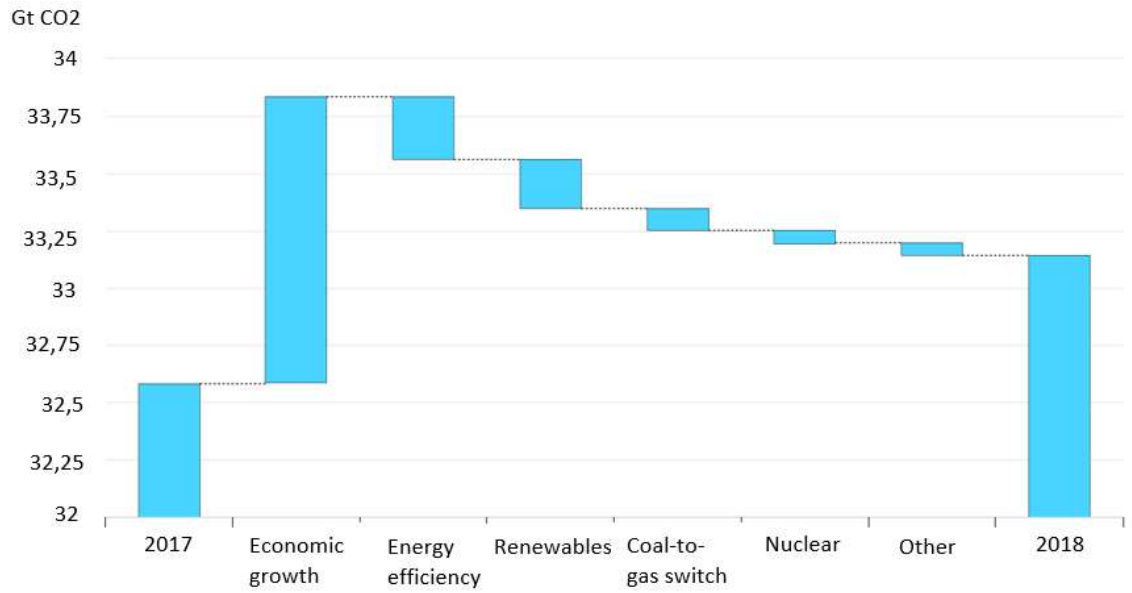


FIGURE 5. Global energy-related carbon dioxide emissions in 2017 and 2018 and avoided emissions by classes in 2018. (IEA 2019a, modified.)

Warming climate and extreme weather events can physically affect energy sector by reducing need for heating, increasing demand for cooling, shifting energy supply and demand patterns and threating physical energy infrastructure. Changing weather can disturb production of renewable energy if amount of sun and wind would diminish in the areas where there is usually more of

these and facilities to produce renewable energy are built accordingly. (European Commission 2019a.)

Regulation on fossil fuels are likely to increase, concerning oil, gas and coal industries. According to Paris agreement and other climate commitments, tremendous transit from fossil fuels to renewable low-carbon energy sources should take place. Countries which have become wealthy due to their oil, gas and coal resources, such as Russia, the US, China and certain countries in the Middle East, are not willing to leave these resources unutilized. Demand for oil is not projected to decrease in the near future. Kerosene, gasoline and diesel oil used in airplanes, ships and trucks are not rapidly replaceable. Oil is also used as a raw material for plastics, fertilisers and other products. (Elonen 2019.)

International Energy Agency (IEA 2019a) has assessed that coal combustion has been responsible for one third of the increase in global average annual surface temperature since pre-industrial levels to 2018. This makes coal the worst troublemaker from climate point of view, as it is the largest single source of global temperature increase. Therefore, there has been strong endeavor to replace coal on renewable energy sources or gas globally. Finland will forbid by law the coal-fired power and heating generation as of 1st May 2029. Belgium has been forerunner and closed its last coal-fired power station already in 2016. France and Sweden will abandon coal-fired power in 2022. Overall, mainly Western European countries have committed to close coal-fired power stations by 2030 and Bloomberg´s researchers have estimated that 12 % of worlds electricity would be coal-fire generated by 2050. In 2019, percentage was 37. Globally peak in coal-fired power use is estimated to be reached in 2026. In Asian countries, especially in China and India, coal is the main fuel used in industry and use of coal-fired power is estimated to increase at least by 2028. (BloombergNEF 2019b; Elonen 2019; Hukkanen 2019.)

In the New Energy Outlook report by Bloomberg, it is projected that gas-fired power will grow till 2050. In the next decade gas will have important role in replacing coal-fired power and consumption of gas might overtake that for coal in ten years. Transit from coal to gas is relatively easy when compared to renewa-

bles, and gas production emit nearly half less carbon dioxide emissions than production of coal. But even if gas is the cleanest burning and fastest growing fossil fuel, it is still finite resource and cause more emissions than most renewables. Transportation and storage of gas increase costs; building transportation pipelines underseas is extremely expensive and due to gas´s lower energy density, transportation by pipeline takes a relatively high share of the delivered cost. Gas is considered as a transitory solution in transit towards increasing production of renewable energy sources. It can also complement wind and solar power in certain situations, such as peak winter heating, seasonal storage and high-temperature heat for industry, when energy cannot be cost-effectively provided by renewables. (BloombergNEF 2019a; IEA 2019a; IEA 2019b.)

Nuclear power accounts for 18 % of electricity generation in advanced economies such as the US, Canada, Australia, Japan and the 27 members of the European Union, and is the largest low-carbon source of electricity. In recent years, nuclear power´s share of global electricity supply has decreased, partly due to concerns about its safety. Nuclear fleets are ageing, and some plants have been already retired. It is estimated that 25 % of existing nuclear capacity will be shut down by 2025 in advanced economies. This trajectory can slow the transition towards a clean energy system and lead to billions of tons of additional carbon emissions. Even if supply of solar and wind power has developed greatly, the clean energy transition might become more difficult and expensive without additional nuclear. Overall, it seems likely that the nuclear power production will decline steeply during next decades in advanced economies. (IEA 2019a.)

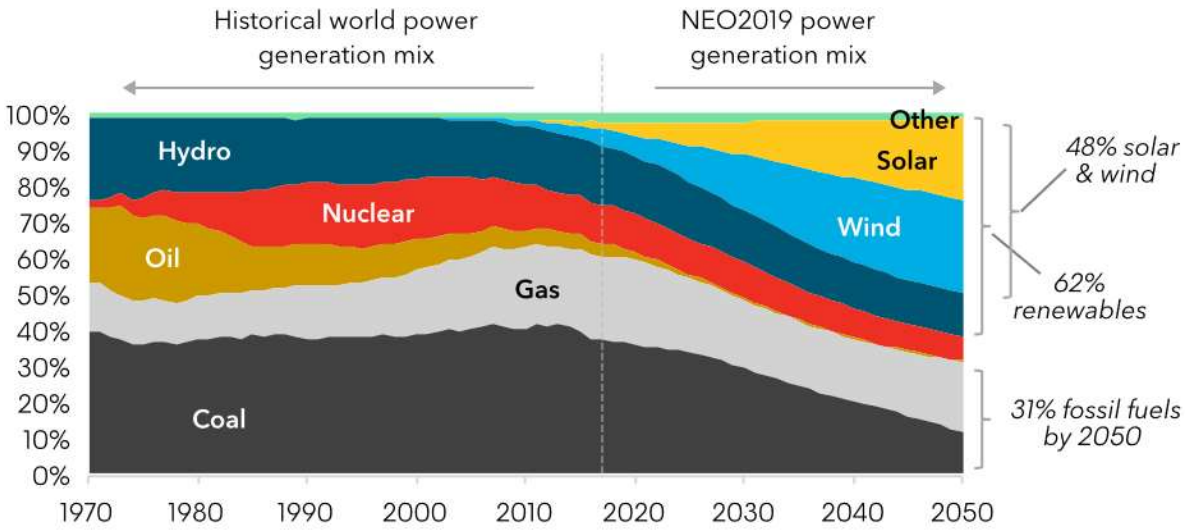


FIGURE 6. Projected power generation mix 2019 – 2050 (BloombergNEF 2019a).

The figure 6 above shows the historical and projected power generation mix from 1970 to 2050 estimated by Bloomberg. Share of renewable energy sources is estimated to rise from one-thirds to two-thirds of all energy sources. Countries which have technological know-how about renewable energy or raw materials to be able to build needed technology, can benefit in transit from fossils to renewable energy resources and are able to build new business around it. In addition to the European Union, also China and the US have invested in these technologies. Production of renewables is mainly local and multipolar. Bloomberg has estimated share of solar power to be 22 % and wind power 26 % of all energy sources by 2050. Hydro power is projected to increase only some due to resource availability. Already today solar or wind are the cheapest source of new energy generation for the two-thirds of the global population and by 2030, solar and wind are estimated to be cheaper than coal or gas almost everywhere. Technological development of batteries, and dynamic demand can increase market share of wind and solar over 80 % in some markets. (BloombergNEF 2019b.)

Bioenergy can be dividend in two categories: traditional and modern. Traditional bioenergy refers to the use of biomass such as wood, animal waste or traditional charcoal. Modern bioenergy refers to new technologies which enable to convert biomass into biofuels. In populous countries with rising demand of energy, biomass has significant potential to increase energy supplies. Although different kind

of biomasses are renewables and even if production would not cause high emissions, consumption of these could emit greenhouse gasses as much as fossil fuels which is not sustainable in climate point of view. (IRENA 2020a; Hukkanen 2019.)

3.2.2 Agriculture and food industry

Agriculture and fisheries are highly dependent on the climate. Changing climate will have a substantial impact on crop yield, length of growing season and locations where crops can be grown. The crop season is estimated to become longer which may allow warm-season crops to expand on northward. For example, wine grapes are very sensitive to even slight changes in climate which might lead to dramatic change in the wine business. Within Middle-Europa´s traditional wine regions, even a two-third of wine grape production may drop when temperatures rise. At the same time wine industry could move to certain northern regions such as southern England and greater Seattle. (European Commission 2019a.)

Overall, warming climate is expected to cause negative impacts on agriculture and southern regions will suffer hardest. Extreme weather, high temperature and water shortage is projected to reduce yields and suitable areas for cultivation. For example, growing potential of coffee, tea, cocoa and many spices will decrease. This may lead to increasing prices of imported foods and increase risk of product counterfeits. Scarcity of one raw material might affect to price and quality of many end products. (European Commission 2019a; Deloitte 2020, 34.)

The fishing industry will be also affected by the climate change because the world´s oceans are becoming warmer and more acid. Shellfish, like clams and oysters, suffer most of the acid sea water. Higher water temperatures will harm cold-water fish species such as Arctic char, Atlantic salmon, brown trout, burbot and grayling. Many species can find colder areas by moving north but might face competition with other species over food and other resources. This might lead to changes in the fish population and affect the value of the catches with commercial fishing. Fishes moving to new regions can also cause fishing permit conflicts between countries. Some marine disease outbreaks have been linked to climate

change such as salmon disease which might reduce salmon population. Warm-water fish species will most likely benefit from the warming due to extended growing season. (Luke 2020; EPA 2016.)

Climate change threats livestock productivity, animal health and pasture especially in Sub-Sarahan Africa and South Asia where rural communities and farmers rely the most on livestock for income and livelihood (FAO 2020). Still, livestock production foster climate change more than any other food production and livestock production likely causes bigger threat to climate warming than actual climate warming causes to possibility for livestock production. Livestock produces only 18 % of food calories worldwide, but 80 % of farmlands are used as a livestock pasture, which makes production of meat and milk high in greenhouse gas emissions. Production of meat, milk and eggs has increased 65 % from 1990 to 2017 and with current population growth projections, food demand is expected to increase massively. Consumption of meat have not decreased yet but lobbying against meat consumption is increasing. For example, group of scientists have invoked high-income and middle-income countries to renew their Paris agreement pledges to limit livestock production so that world could reach ´peak meat´ by 2030. (Harwatt, Ripple, Chaudhary, Betts & Hayek 2019.) The European Green deal includes ´From Farm to Fork` project which promotes a healthier and more sustainable food system for the European union. Attitudes and consumer habits are slowly changing, but there are no meat taxes or subsidy cuts in horizon, even if sustainability tax of meat was presented by members of the European Parliament on February 2020. (Keating 2020.)

Increasing water shortages could be a threat for beverage industry, such as soft drink and bottled-water companies already in the near future. Rising risk of competition for scarce water resources might have an effect on cost, reputation and social license to operate. For example Coca-Cola´s bottling plant was closed in India by government authorities in 2014 after the company was accused of extracting too much groundwater. (Duva 2014.)

Estimated impacts of climate change to main crops; wheat, rice, corn and soybean, vary between studies. Some researchers have projected decrease in yield whilst others estimate that some of these crops might benefit from climate

change. There are multiple variables, warming scenarios, regional differences and possible diseases to consider in these studies which makes it hard to estimate the future impacts of climate change. (PNAS 2017.) Not alone climatic changes impact crops and food production in the future, but also political decisions and shift to new agricultural practices will affect. The winners will be the farmers who are able to adjust, diversify their field and introduce modern farming methods.

3.2.3 Financials

Companies in financial sector provide bank-, insurance- and investment services for their clients. Phenomena of real economy are reflected to financial sector rapidly and financial state of financial companies is sensitive for macroeconomic cycles. Including climate risks into financial costs is efficient way to guide behavior and actions towards climate change mitigation. (Deloitte 2020, 35.) Institutional investors such as pension funds can influence the companies which stocks they own and can vote for more sustainable and climate-friendly ways of doing business.

Climate change causes risks for insurance companies due to increasing frequency and intensity of several types of extreme weather events. This has key implications to valuation and profitability e.g. rising sea levels and extreme flooding will likely raise both premium and payouts. If due allowance is not made continuously according to the underlying trend, it can lead to jumps in premium prices over a short period of time. Often risk knowledge develop in steps which might lead to pricing disruption in the insurance market and corrode an insurer´s solvency if it fails to adjust its risk management. In the long term, insurance of business, living and housing might become impossible in the areas where risk for extreme weather events is high. Insurance premiums in these areas may become unaffordable for many people and companies which would increase social disparity. Moreover, insurance companies also start to withdraw altogether from providing insurance to the riskiest markets. Inability to get assets insured might even make these assets valueless and lead to migration to less risky areas. (European Commission 2019a; Deloitte 2020, 35; Arent, Tol, Faust, Hella, Kumar, Strzepek, Tóth & Yan 2014, 683.)

3.2.4 Tourism

Tourism is one of the largest sectors of the world economy employing 260 million people and in many regional economies, supply of tourism services is the dominant activity. Climate change will impact in the place, time and nature of tourism activities, and some of them are more sensitive to weather and climate than others. Climate change would drive tourists to northward, and tourists from northwestern Europe would spend their holidays more often in their home country which may lead to declining number of international tourists. For example, Mediterranean might become less attractive to tourists but on the other hand, tourism season there could move from summer to the other seasons. Also French Riviera is slightly cooler than similar coastal resorts in Spain and Italy which could be beneficial for France when temperatures rise. In the research by Perch-Nielsen, beach resorts in 51 countries were compared and as a result India was rated the most vulnerable and Cyprus as the least vulnerable destinations for the climate warming effects. (Arent et al. 2014, 677–678.)

Global warming will raise the altitude of snow-reliable ski resorts which decrease the number of ski-resorts with natural snow. Artificial snow can be made but water scarcity and costs will limit the snowmaking, and skiers usually prefer the natural snow. Climate change and tourism researcher Daniel Scott has estimated that two-thirds of European ski resorts might be closed by 2100. (Arent et al. 2014, 679; Duva 2014.)

Tourism accounts for about 8 % of global greenhouse gas emissions. Percentage has risen during the past decade and tourism is projected to grow about 4 % annually in the next decade due to a growing middle-class. Air travel prices have been relatively low in recent years which has encouraged to air travelling. World Tourism Organization (UNWTO) has suggested two strategies to reduce tourism-related emissions. Tourists should prefer public transportation and short-haul destination, and narrow down air travelling. Also, tourism operators should be encouraged to improve their energy and carbon efficiency. However, this kind of incentives have been insufficient and travel behaviour have not changed so the next step might be carbon tax or carbon trading, especially for aviation services. (Lenzen, Sun, Faturay, Lenzen, Ting, Geschke & Malik 2018, 522, 525–527.)

3.2.5 Transportation

Climate change will affect different sectors in wide scale and most of the industries are affected also by changes in other sectors. Transportation is good example of this. Changes in transportation sector does not concern only transportation of goods and people, but also indirectly all kinds of travelling and tourism, trade, manufacturing and insurance. (European Commission 2019a.)

Physical impacts of the climate change affect transportation sector through roadways, ice roads, vehicles, railways, airplanes, airports, infrastructure, marine transportation and logistics and ports. Extreme weather events can damage infrastructure and complicate transports by increasing risk of delays, disruptions and damages. In certain areas, transportation might become easier due to decreasing snowstorms and ice, and cold-weather damages to vehicles will decrease. Roadways, coastal railways and subways are exposed to flooding, heavy rainstorms and sea level rise. Air transportation will be also increasingly disrupted by extreme weather events, but more than physical impacts, regulation may have stronger influence on air traffic. (EPA 2016; IPCC 2014, 674–676.)

Aviation alone causes more than 2 % of global emissions and since 2005 to 2020, air transportation emissions have increased 70 %. To stabilise carbon dioxide emissions at 2020 levels, The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) has required airlines to offset their emissions after 2020. Airlines should monitor emissions on all international routes and offset emissions by emission trading. All the EU countries have joined the scheme, but until 2027, carbon offsetting is not compulsory for all countries. This and other regulation can raise air transportation prices and guide ways of transport accordingly. This can also urge forward development of new plane technology, sustainable fuels, energy-efficient aviation and use of airspace. Yet this kind of solutions are not developed enough to stop the increase of total aviation emissions alone without emissions trading. (Traficom 2019; European Commission. 2020b.)

Legislation and regulation to diminish the use of fossil fuels will also guide other industries than air transportation. Vehicles such as trucks and ships might need to be updated accordingly, and new requirements need to be considered in the

design of new vehicles. Trains, electric cars and other relatively low emission vehicles will be developed further and more loading stations will be needed. Automotive industry is reviewed more closely in the chapter ´3.2.9 Industry and manufacturing´.

3.2.6 Real estate and construction

Climate change affects to build environment like real estates, physically and indirectly through policies and legislation in the transition phase towards a low carbon emissions economy. According to reinsurance companies, the quantity and intensity of extreme weather events have increased by 250 percent in Europa during the past three decades. Extreme weather events such as storms, rising sea levels and flooding will cause damage to real estate especially near the sea and tightly built cities where capacity for flood water retention is limited. Value of the real estates can be reduced and in the worst case, be completely written off. Also having an insurance for real estate in the most vulnerable regions might get impossible or at least highly expensive. Estimates of the sea level rise vary a lot depending on the warming scenario and other variables. From 2000 to 2100 the global sea level rise estimate is 33 – 156 cm with confidence interval of 5 - 96 % which reflects the uncertainty of the consequences of climate warming. For example, in Finland recommendations to safe building heights are defined based on future scenarios. 40 % of the world´s capital cities are located on the coastline. In many regions, the most expensive residential areas and holiday premises are built on the vulnerable seashore which in long-term might affect to valuation and desirability of these real estates. (Sjöblom, Palomäki, Halonen & Lankiniemi 2018, 14, 15, 18.)

Construction is often local business and long supply chains are rare when compared to other industries. If climate change would raise a demand of raw materials, such as steal, market price would increase, and availability would weaken which would complicate the use of steal as a raw material in construction business. Concrete is the world´s widest used building material and its carbon dioxide emissions are huge; if the cement industry were a country, it would be the third largest emitter after China and the US. If use of concrete would be limited due its

emissions by global regulation, such as taxation, it would affect heavily to construction industry. Today the EU´s environmental legislation has forced cement companies to shut down plants in Europe which have only moved production to countries with loose environmental legislation. It would be beneficial to develop means of re-use and circulate materials to get better protected from fluctuations of raw material prices and availability. Overall, climate change probably increases the need for construction and re-construction services in the future. (Deloitte 2020, 38; Watts 2019.)

At least in short-term, transition risk is higher for real estate owners and investors compared to physical risks. Policy changes are already causing transition costs to real estate owners and construction companies. For example, stricter regulation for energy efficiency drives real estate companies to invest in a new technology and use different construction materials. Other policy instruments such as taxation, zoning and land use regulation will not change only the means of building and refurbishment, but also consumer preferences and behavior. Green mortgages are granted for energy efficient homes which can make consumers to prefer energy efficient residential buildings or renovate accordingly. For real estate investor and construction company point of view, forerunners in transitions can eventually result in higher returns when energy efficient buildings become more mainstream. Accepting the transition risk in early phase can also provide other opportunities for companies, such as positive reputation and risk mitigation against the actual physical damage of the climate change. (Sjöblom et al. 2018, 17; UN environment programme 2020.)

3.2.7 Technology and chemical industries

Technological development and clean technology solutions are the key drivers to be able to stay in 1.5 °C warming trajectory. Clean technology i.e. cleantech means technologies that can either reduce or optimize the use of natural resources and through that reduce emissions, diminish demand for raw materials and overall reduce the negative effects to environment and ecosystems. Clean technology solutions are prerequisite to be able to get through the transit phase successfully and basically these are at some level related to all sectors reviewed

in this thesis. Many clean technologies are combination of technology and chemistry innovation which can open large global opportunities for low-carbon solutions. Demand for circular economy solutions, low-carbon processes and energy-efficient technologies has started to increase and will most likely increase even more in the future. If prices of raw materials would rise or fluctuate recklessly, demand for material efficiency and circular economy solutions would increase. (Deloitte 2020, 39; Sjöstedt 2018.)

Chemical industry will have important role globally in the battle against climate change. Solutions of chemical industry enable to remove carbon dioxide from a stream of air and utilize it further as a raw material. Also biobased raw materials can be refined efficiently into different value-adding end products with the help of chemistry solutions. Chemistry can also enhance recycling which could enable full reuse of materials. New innovations for energy production, processes and reducing emissions of raw materials can be also found in chemical sector. New water cleansing technologies combine chemistry and high-tech and are essential in the future when scarce water resources need to be recycled more efficiently. Also other fields of technology such as industrial biotechnology and biomimicry require highly advanced chemistry know-how. (Deloitte 2020, 37.)

3.2.8 Trade and service sector

Companies in the trade sector are dependent on road transportation which is substantial source of carbon dioxide emissions. Need for transportation does not considerably change even if stores shift online and trading platforms will become more common; just logistic routes and needs will change. Currently environmental and product legislation are stricter in the EU than e.g. in China or the US. Online shopping has broadened the selection of stores where European consumers can order products which gives unfair competitive advantage to the online stores outside the EU region. To help forward low-carbon economy and production, the EU could set carbon tariffs to products which are produced by using coal. However, this could end up to trade war and limit global trade. On the other hand, if climate change policies and legislation would be made more stringent and coherent globally e.g. by introducing emission trading or common carbon levy, it would secure fair competitiveness. (Deloitte 2020, 37–38; Suominen 2019.)

Consumer attitudes and behavior can shape trade sector towards low-carbon products and ways of doing business. Via platforms, a shift from trade sector to service sector could come true if renting products instead of buying them becomes more common. This trend can be supported for example by taxation. Effects of the climate change are indirect within the service sector: demand for services is dependent on purchasing power which varies in different phases of economic cycle. Global physical and societal changes determine direction of economic fluctuation. Through digitalisation a need for physical presence will diminish and certain services such as consultancy, medical care and sport instructing might move to lower income countries, likewise has happened with certain subsectors of trade during the past two decades. (Deloitte 2020, 37–38.)

3.2.9 Industry and manufacturing

Manufacturing refers to industrial design where raw materials are transformed into end-products and components on a large scale. There are several sub-industries under manufacturing such as food, beverage and tobacco processing and production, textiles, chemical industry, wood processing and paper, vehicles manufacturing, petroleum processing and so on. (Kenton 2020.) Food and beverage industry is reviewed in the agriculture chapter, chemicals together with new technologies and fuels in the energy chapter due to eligible context.

Transition to renewable energy forms will have wide impacts in manufacturing sector and changes the demand for materials. For example, demand for certain raw materials such as concrete, aluminium, steel, copper, lithium and cobalt will rise as deployment of solar panels, wind turbines and batteries for energy storage increases. Countries with large lithium reserves and other minerals needed in the production of energy storing batteries, can benefit if production of batteries increase greatly. (BloombergNEF 2019b; Elonen 2019.)

Battery storage systems can be considered as one of the key solutions to effectively take advantage of high shares of wind and solar energy. These technologies can be used for several applications in the power sector. Utility-scale batteries can store excess energy generation and firm renewable energy output which enable a greater feed-in into the grid. Especially in isolated grids and off-

grid communities, batteries can provide more affordable and reliable electricity. In emerging markets, yearly increase of energy storage deployment is estimated to be over 40 % during next five years. By 2030, small-scale battery storage is expected to increase significantly and thereby complement utility-scale applications. The behind-the-meter (BTM) batteries are for commercial, industrial and residential customers, mainly targeting at electricity cost savings. Demand for these has been rising and costs of battery storage technology falling due to growing consumer market and the development of electric and hybrid vehicles. (IRENA 2020b.)

Transition to low-carbon fuels together with considerably improved battery technology, changes also **automotive industry**. Over the past ten years, electric car deployment has been growing rapidly and today the world´s largest electric car market is in China, following by Europe and the US. Policies and taxation play critical role in guiding production and demand towards low-emissions vehicles. Incentives for zero- and low-emission vehicles help bridge the cost gap between conventional and electric vehicles and enhance the charging infrastructure. The development of comprehensive charging infrastructure is crucial requirement for rapidly growing markets of the electric vehicles. Comparing emissions between electric cars and conventional internal combustion engine ones is not easy and results vary depending on the power mix used; coal or low-carbon sources. Also weather conditions, such as cold weather, impact in the durability of batteries. If car manufacturers show only best-case-scenario emissions or distort test results for their own good, this kind of green washing might cause reputation risk to manufacturer if it is revealed. (IEA 2019c.)

Plastic production is one of the largest global greenhouse gas emitters in the industrial sector. Over 99 % of plastics are derived from fossil fuels and greenhouse gases are emitted at each stage of plastic lifecycle: from fossil fuel extractions and transport to plastic refining and manufacturing, and from managing plastic waste to ongoing impact in oceans and landscape. Plastic is multi-function material and it has become an inseparable part of the material world. Plastic packaging represents 40 percent of total production of plastic products but also car parts, construction materials, clothing to prosthetics and many other products and components are made of plastics. According the EU´s plastic strategy, single

use plastics will be banned by regulation by 2021 and all plastic packaging should be recyclable, reusable and compostable by 2030. This will reduce marine litter because decomposition time of bio-based plastics is relatively short, but greenhouse gas emissions of entire plastic lifecycle may not significantly decrease. (CIEL 2019, 1, 5, 7, 8, 11, 57, 84; European Parliament 2019.) Still, the regulation change will cause transition risk for companies by forcing them to adjust the production of single use plastics accordingly.

Fast fashion has become prevalent in recent years and environmental impact of fashion industry is huge: around 5 % of total carbon dioxide emissions come from fashion industry. New designs are introduced every few weeks and clothing prices have not risen concurrently with prices of other consumer goods. Fast fashion clothes have short lifespan and therefore manufacturing emissions are relatively higher and textile waste amounts are massive. Traditionally many textiles and clothes are manufactured out of cotton but today polyester is the most commonly used fabric in clothing. Neither one of these are trouble-free in relation to climate change. Polyester is synthetic material produced from fossil fuel which is more difficult to recycle and releases microfibers into the environment. Production of cotton causes only 5 - 10 % of its entire value chain emissions but growing requires huge amounts of water. Cotton is commercially grown in over 70 countries and many of these countries will suffer diminishing rainfalls caused by climate warming. However, in cooler areas warming could benefit cotton yield due to longer growing season and overall the future of cotton yield under climate change remains uncertain. (The price of fast fashion 2018, Cotton and climate change 2011, 9–10.)

According to Ellen MacArthur Foundation, recycled materials were utilised in production of clothing only in less than 1 % of cases in 2015 (Ellen MacArthur Foundation. 2017, 20). Use of recycled materials could increase in the future if raw material prices will increase due to availability disruptions, new regulation or product standardisation. Disadvantages of using recycled materials in cloth production can be for example lower durability of fabrics and through that shorter mileage of cloth. New bio-based materials can be developed with help of technology. It is also possible that new circular economy service models such as clothing and design interior textile rental will increase. (Deloitte 2020, 40.)

The forestry sector plays important role in the work for climate change mitigation but the forests' role in climate change is two-fold. Forest degradation and deforestation cause around 12 % of global greenhouse gas emissions but forests also absorb one-third of the carbon dioxide emission released from burning fossil fuels. Forests are source of renewable raw material: maintaining and increasing forests ensure continuous income and livelihood to forestry sector and stabilize climate by playing a vital part in the carbon cycle, protecting biodiversity, regulating ecosystems and helping to drive sustainable growth. Renewable energy can be also derived from wood. (IUCN 2020.)

Through digitalization and environmentally aware consumers, demand for paper have decreased since 2008. At the same time demand for environmentally friendly packaging materials have increased which have led to increasing consumption of paperboard. This shows how legislation, consumer attitudes and purchasing behavior guide supplied items and change industries. Not only that customers are willing to move from the use of plastics to **renewable materials** such as wood but also forerunners demand forest products from sustainable sources. Technology together with demand for renewable materials boost new innovations for example by combining electronics with products made of paperboard and by developing new durable materials from nano pulp. Together with new technology, wood-based materials can be used as raw material for clothes, plastics, biofuels, asphalt and even cosmetics. Actions against climate change and transit from fossil fuels and materials to renewable ones benefit forestry and paper industries. New regulation for sustainable forestry and land use will be enacted by the EU to reduce emissions and to stay below the 2°C degrees warming trajectory. (IUCN 2020; Paperiliitto 2019; European Commission 2020a.)

Industrial production is often water- and energy-intensive so developing more efficient water and energy solution and production methods can bring major cost savings. Introduction of different kind of methods of circular economy can diminish dependency of raw material availability and risk of price fluctuations. Companies should assess in good time advance how climate change will impact their business within next ten to twenty years and get prepared because availability of raw materials, logistics and location of optimal production may change. (Deloitte 2020, 4.)

4 RESEARCH QUESTIONS AND METHODOLOGY

4.1 Research questions and strategies

First research question of this Master´s thesis is to review how climate change impacts in different economic sectors and how countries can adapt and mitigate climate change-related impacts by policies, regulation and actions. Certain economic sectors and sub-industries are more sensitive to the impacts of climate change than others. There are also vast differences between countries and regions in the resilience against physical impacts of climate change, but also countries´ willingness to set guiding policies to enable transition towards low-carbon economy. Reasons behind these differences are studied and explained. By understanding these mainly political and economic reasons, it is easier to estimate what could be the future trajectories in different scenarios and understand the causal relations between actions, events and decisions. These climate change related macroeconomic variables and implications were studied by close reading; reviewing researches and comparative studies, climate policies and future outlooks from experts. Research strategy of the thesis is qualitative and applied data analysis method to answer the first research question was close reading.

Second research question is how to discover investment opportunities arising from climate change. Investment decisions cannot be based only to climate related risks measures, but by including climate change point of view to decision making, overall better view can be built for the future outlooks. Future is composed of multiple variables and cannot be forecasted, but by creating plausible scenarios, different kind of future projections can be seen, and these outlooks can be utilised in long-term investment decision-making. Longitudinal research strategy together with correlation analysis help to review how climate change will affect certain factors and what can be the consequences in each scenario over a long period of time. Scenario analysis used in this Master´s thesis consists of four different trajectories.

4.2 Scenario analysis as a research methodology

Scenarios can be used in all kinds of strategy work to assist decision making and to find a way to test assumptions about the complex and uncertain future. Scenario planning creates a framework for recognizing upcoming change and adapting to it in advance. It helps to notice new viewpoints and opportunities that might have been left unnoticed otherwise. The goal of scenario planning is to create a map of uncertainty instead of finding certainty. Scenario work offers ways to structure information and create systematicity of it by structuring comprehensive entities. This helps to see connections between different events and phenomena even if at first sight they seem to be completely independent variables. One of the key advantages is that scenario planning allows to question established beliefs which is relevant for the creative problem-solving. Scenario analysis can be used also to assess the validity of the past choices and decisions and to analyse the strategies and policies made based on them in long term or if the circumstances change. (Rubin 2004.)

Scenario method is an effective way to assess how different kind of processes and logical chain of events can lead step by step from the present state to the possible, either probable, desirable or threatening future state or from the future state back to the present. A good future scenario is insightful and free-form, but strongly based on facts currently available. A scenario consists of the analysis of the current situation, logical chain of events and processes which leads to future state and a chronological description of relevant actors and the consequences of decision-making. Scenario planning process should be started by setting a focal question about the issue. Then driving forces and trends that would likely impact in the issue should be identified and prioritized according to the biggest impact. Driving forces are fundamental sources of future change including political, social, economic, technological, environmental and regulatory factors. Trends are more dynamic and based on observed changes in the present. Scenario should be clear, comprehensive and logically consistent – it should be possible in terms of the events, and socially and psychologically logical. In addition, the scenario should be also interesting and introduce something new and essential about the future to be able to have impact in the strategic decision making. Meaningful

number of scenarios is three to five. Good scenarios should differ from each other in some relevant area. (Rubin 2004; Nagarajan 2020.)

Researches from different fields of studies should be used as a background material for scenarios and then build scenarios by using author´s own views together with background material. Different kind of methods such as time series and statistical calculation methods can be used for building trend estimates e.g. graphs. (Rubin 2004.)

Not only current state and trends should be studied but also look for weak signals and give a thought for black swans aka wild cards. A weak signal is a sign of an upcoming issue or a change which might become significant in the future. Weak signals seem often new, minor and surprising issues today but can challenge current ways of thinking. In scenario analysis, weak signals can be used for outlining future development paths and also to complement and challenge existing scenarios. A black swan is a rare and unpredictable event with wide-spread, severe consequences. Black swans cannot be predicted by using scientific method because these incidents are statistically random for which reason black swans are often excluded from risk scenarios. (Dufva 2018; Taleb 2007, 15–16.)

The time span of the scenarios varies depending on the purpose of the subject. Scenario analysis created for 10-20 years' time period are often exploratory and normative if the time period is 20-50 years. Scenario methods are more useful when the time span is long, even decades. Amount of information and unexpected events and changes increase when more time passes which makes forecasting too uncertain and scenario analysis more effective option. Unlike forecasting, scenario planning does not try to predict one right answer about the upcoming future, but it helps to understand multiple plausible futures. (Rubin 2004.)

Different scenarios show risks and opportunities in the certain path. Various implications and impacts of each scenario should be discussed and strategy should be compiled by taking into account every scenario (Figure 7). This kind of integrated approach enables success and risk consciousness across scenarios. Scenario work should be continuous process instead of once wrote out picture of couple of possible future scenarios. Existing scenarios should be gone through

when the operational environment and framework change or when new views come out, and then scenarios should be updated accordingly. (Nagarajan 2020; Rubin 2004.)

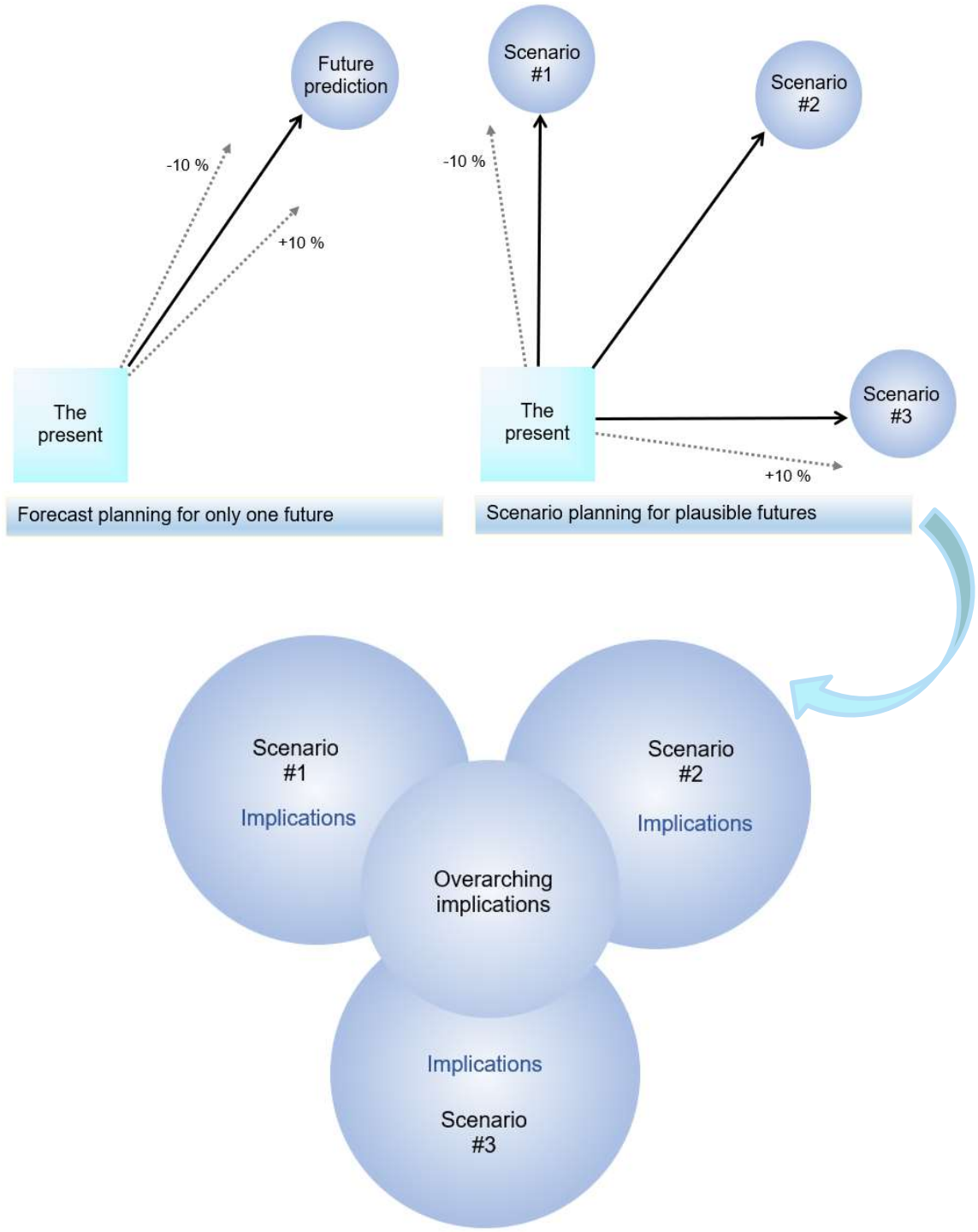


FIGURE 7. Every scenario should be taken into account when strategy is reconsidered (Nagarajan 2020, modified).

Scenario cannot be judged as good or bad based on whether the future comes true accordingly. Scenario is good if it is a helpful tool in the strategic decision

making of the current time. In certain situations, presented scenario may itself have an impact in the future as it reveals existing options. For example, ´the Limits to Growth´ report by Meadows (written in 1972) has been criticized heavily over the years because under its worst-case scenario, some of the World´s natural resources would have ended by 2000 and population would have grown too much for the ecological and food sustainability of the globe. It is impossible to measure how much the report itself has impacted in the decision making after its publication and prevented this kind of future to come true. (Rubin 2004.)

Scenarios can be seen as a result of inductive or deductive process. In inductive scenario building, key features of scenarios are taken as a given and only activities, decisions and synergies are assessed by scenario work participants. This helps to understand and clarify especially the consequences of the most likely trajectories, their side effects and the decision-making chains that can lead to certain state of future. Deductive scenario work searches for different phenomena and weak signals and by using different kind of working methods, consequences, implications to decisions, surprising synergies and thus overall impacts to the future are studied. Deductive scenarios are often exploratory i.e. scenarios are directed from present to future, whereas inductive scenarios are more like proactive, directing from future to present which can be called also backcasting. In inductive scenario work, certain future state is assumed to be realized and logical path from there to the present is outlined. (Rubin 2004.)

5 ASSESSMENT OF INVESTMENT OPPORTUNITIES BY USING SCENARIO ANALYSIS

5.1 Scenario analysis

The purpose of this scenario analysis is to consider and better understand what kind of investment opportunities climate-related events and physical and transition risks may cause over time. Timespan of this analysis is 30 years which is in line with long-term investment plan of RA Capital Oy.

The following scenarios are built by using inductive scenario work process. Assumption is that temperature will reach 1.5°C above pre-industrial levels by 2100 in scenario 1, 2°C above pre-industrial levels in scenario 2, 3.2°C above pre-industrials levels in scenario 3 and 4°C above pre-industrial levels in scenario 4. Possible future paths from 2020 to 2050 are outlined by using backcasting method. Climate warming scenarios are presented (Figure 8) until 2100 even if end-analysis reaches only till 2050 due to comparability to well-known climate scenarios and cumulative long-term impacts of the scenarios.

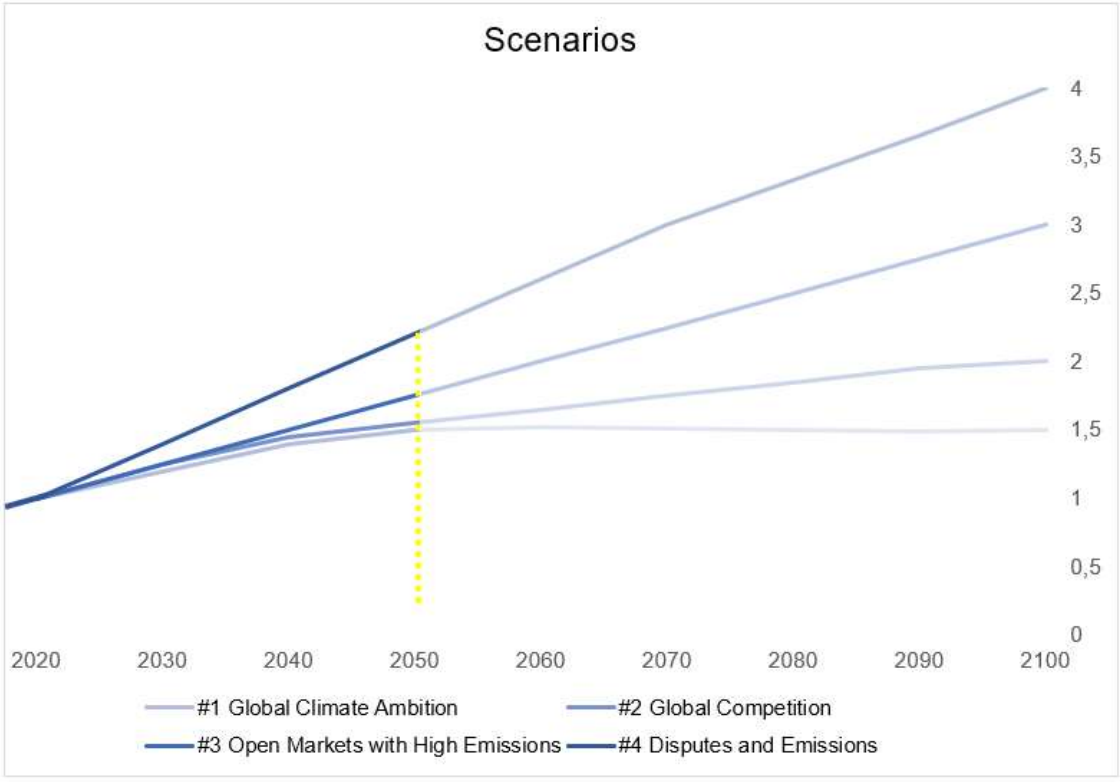


FIGURE 8. Four scenarios.

The following scenarios do not include a full description of the future, but rather highlight core elements of plausible future paths. Key drivers that will drive climate-change related future developments are climate policies of certain regions, regulation and level of global co-operation. The focal question of the scenario analysis is “what kind of implications of certain events and decisions will be faced in each scenario and in which investment risks and opportunities these may lead to”.

5.1.1 Scenario 1: Global climate ambition (1.5°C trajectory)

By 2020, global average surface temperature has already risen 0.9 °C above pre-industrial levels which would leave space only for 0.6°C increase for next 80 years in this scenario. Sticking on this warming path would require very strict climate policies, global co-operation with climate-related questions, rapidly developing clean technology and immediate transit to renewable energy sources together with introducing means to capture carbon dioxide out of the atmosphere.

Nearly all countries including the US, China and middle eastern countries have been committed to follow terms of the Paris agreement and implemented it ambitiously. Use of coal as energy source has diminished sharply already in 2020s and in early 2030s transit to renewable energy sources has taken place worldwide. Price of oil did crash in the mid-2020s and did not recovered since. This has been partial reason for leaving part of the oil reserves unutilized. Most countries which economy was earlier dependent on fossil fuels, have been able to change structure of their economies and introduce other sources of energy.

Global pandemic Covid-19 which emerged in 2020, pushed countries eventually co-operate closer and create new strategies for common safety and global well-being. This woken up decision-makers all around the world to notice the necessity of the global co-operation in the work against climate change and prevent climate situation to escalate till climatic tipping points. Successful global co-operation has increased and eased further co-operation which has enabled enacting consistent global climate regulation. Co-operation between countries and governments has also contributed export of clean technology via open markets.

Mitigation and adaptation operations have been done in good time which has been less expensive strategy than if adaptation would has taken place only when compulsory. Overall living standards are on good level and population growth has turned to decline at late 2030s. Nevertheless, extreme weather events, drought and starvation are still inevitable threat for Africa, middle East and several other countries in the southern hemisphere. Migration due to climate warming is still moderate and do not cause extensive conflicts.

Development of technology to capture and store carbon dioxide out of the atmosphere has leaped in 2020s and turned to cost-effective. Also battery storage systems are highly developed which has enabled storing electricity from renewable energy sources and removed dependency on energy production fluctuations. Battery development has fastened also transit to electric vehicles when batteries can be loaded faster and duration is longer.

People and goods can move quite freely due to open and conflict-free global markets, but on the other hand increasing use of simulated experiences (virtual reality) and 3D printing have reduced global logistics on behalf. Circular economy principles have been adopted and many things are bought as a service instead of buying them. The platform economy is here to stay despite of the issues it has caused over the years. Recycling of materials has not advanced as well as conditions would have allowed. In this scenario, transition risk is globally high, but eventually physical risks for climate change are lower than the ones on the following scenarios.

5.1.2 Scenario 2: Global competition (2°C trajectory)

Nearly all countries have implemented ambitious climate policy according to Paris Agreement. By this, use of coal as an energy source is mainly given up in early 2030s worldwide and transit to renewable energy sources has taken place. Especially fusion energy production has increased its share of renewable energy sources since its development hugely step forward at late 2030s.

Political disputes and trade wars have divided world into blocks. Prolonged economic conflicts between China and the US has led to highly inflamed relationship

between countries. Political tensions between Australia and China have escalated to trade war and limited movement between countries. Also, global pandemics have showed how governments only take care of their own citizens and co-operation for common safety and well-being is forgotten. This has reflected also to climate work; tariffs and concentration of regionally essential issues have made mitigation and adaptation to climate change more expensive. Low-emission production has not only located inefficiently, but it also increases inequality between countries. Although competition between countries has taken climate ambition to new levels when countries can truly benefit of their inventions and reduce their own costs for emissions and carbon tariffs.

Recycling processes are highly developed because of the costs and tariffs of the imported raw materials. Locality of items and services are highly valuated, and many things are bought as a service in the spirit of circular economy. The platform economy has expanded to new sectors and many people are working as entrepreneurs.

Development of carbon capture and storage technology has leaped in 2020s and is available for developed countries in the mid-2030s. In the divided world, where regional interests are having the priority, benefits of the climate warming mitigation work are not always targeted to the countries that would need them most. This has increased inequality and caused conflicts between regions and countries. Extreme weather events, drought and starvation are still real problems in Africa and certain countries in the southern hemisphere and due this climate related migration has increased and is likely to increase even more on the second half of the century.

5.1.3 Scenario 3: Open markets with high emissions (3.2°C trajectory)

Global pandemics and economic crisis have overshadowed the importance of the mitigation actions for climate warming during 2020s and in the beginning of the 2030s. The EU countries have still implemented ambitious climate policy according to Paris Agreement, but most of the other countries have put off the implementation. Global economy growth stopped in the mid-2020s due to weak economic situation, and since that investments to clean technology and introduction

of new renewable energy forms were limited in many countries. Oil and natural gas resources will be utilized fully. In certain areas, overconsumption of natural resources together with warming climate has led to shortage of natural resources and reduced crop which has again raised prices of food and natural resources. Costs of adaptation actions for climate change and dwindling natural resources will eventually lead to shrinking global economy.

Shortage of natural resources has caused inequality between countries which still have resources left or are wealthy enough to buy them and those who has no scarce resources left. Warming climate has increased frequency of extreme weather events and exacerbated drought and starvation. These together with increased emissions, will lead in long run to significate health issues, rising mortality rate, conflicts and widescale emigration especially from the southern hemisphere to other regions.

Countries and regions could not have implemented global, common climate policies and agreements but cross-border trade is quite free. Although regions which have implemented strict climate policies, have set carbon tariffs for imported goods and materials to prevent carbon leakage. In the long run companies will move their production to less risky and less polluted regions and carbon tariffs become meaningless. Clean technology can be exported easily thanks to free trade areas but due to lacking climate legislation in many countries, wide-scale export of clean tech starts only too late. In the 2020s and in the beginning of 2030, advanced technologies such as carbon capture technology cannot be produced cost-effectively due to limited export markets.

Outside of Europe, circular economy principles and advanced recycling processes are truly adopted only as a result of coercion when prices of scarce resources have gone up. In the polluted future of this scenario, appreciation of nature and clean environment will eventually be high.

5.1.4 Scenario 4: Disputes and emissions (4°C trajectory)

Ambitious climate policy is implemented in the EU region, but most of the other countries have not engaged to implement policies by Paris agreement. Following

global climate agreements cannot be ratified as widely as Paris agreement due to escalated power politics of the world. Disputes between great powers have divided world into blocks where most actions are driven by regional interests. After prolonged economic conflicts between China and the US, the dispute has led to complete break between countries. Also political tensions between Australia and China have escalated to extremely limited export and movement between countries. Russia has been isolated from other countries after having continuous conflicts with several countries. Government actions during past crisis and global pandemics have shown that in the end countries and regions take care of their own citizen only. Regional self-supply has risen into important role and therefore many countries have kept up with use of domestic energy sources to secure supply in the possible future crisis. As a result, renewable energy development and use are in high level in certain areas, but at the same time oil and natural gas resources are fully utilized in other regions.

Tariffs and restrictions with cross-border trading have increased the costs of mitigation and adaptation to climate change. Even if new clean technologies are developed in the EU region, it has taken more time before inventions have turned profitable due to limited export to other areas. Loose climate legislation in many countries has delayed transit to use of renewables and cleaner solutions. The EU´s strict climate policy has been extremely expensive to implement nearly alone but in the later phase, adaptation operations around the world will be even more costly when these have to be done at the point when countries are running out of choices.

Climate warming on the 4°C trajectory will cause eventually extreme weather events and more frequent natural disasters. Change is so drastic that some regions in the southern hemisphere will become uninhabitable which will cause massive migration. Conflicts are inevitable if less suffered countries are not willing to open their boarders to climate refugees which is likely in this scenario. Warming causes negative impacts on agriculture, especially in the southern regions. Shortage of food and natural resources will lead to starvation and decreasing living standards in the countries which are most affected by climate change or were not able to do mitigation and adaptation actions early enough. Economic structure of countries and power dynamics can change in an unprecedented way

when some countries are highly depended on the help of other countries. Eventually all possible adaptation operations are taken place all over the world but at that time too many tipping points are exceeded which makes recovery impossible on certain parts.

Circular economy and enhanced recycling are natural consequences of the need for self-sufficiency and the high import costs at the point when natural resources are diminishing. In this scenario, transition risk is lower, except for the EU, but eventually physical risk for climate change is much higher.

5.1.5 Overarching implications of scenarios and conclusions

All scenarios presented above differ from each other and lead to the different kind of plausible future states. In the scenarios 1 and 2, strict climate policies and legislation guide companies and societies to develop and adapt new technologies and sustainable operations with no delays which limit climate warming efficiently. In these scenarios with moderate warming (1.5 - 2°C), transition risk is higher and physical risk lower whereas in the scenarios 3 and 4 with greater warming (3.2 - 4°C), physical risk will be eventually higher and transition risk is lower. In the latter scenarios, loose climate policies and insufficient environmental legislation are the main reasons for greater warming. Combining success factor within the scenarios 1 and 3 is global co-operation which has led to cost benefits and enabled clean technology solutions to turn cost-effective in the shorter period of time when compared to scenarios with limited cross-border trade and more closed economies. Open markets which enable import and sales around the world, together with global development projects, help forward wide-scale introduction of clean technologies and renewable energy forms.

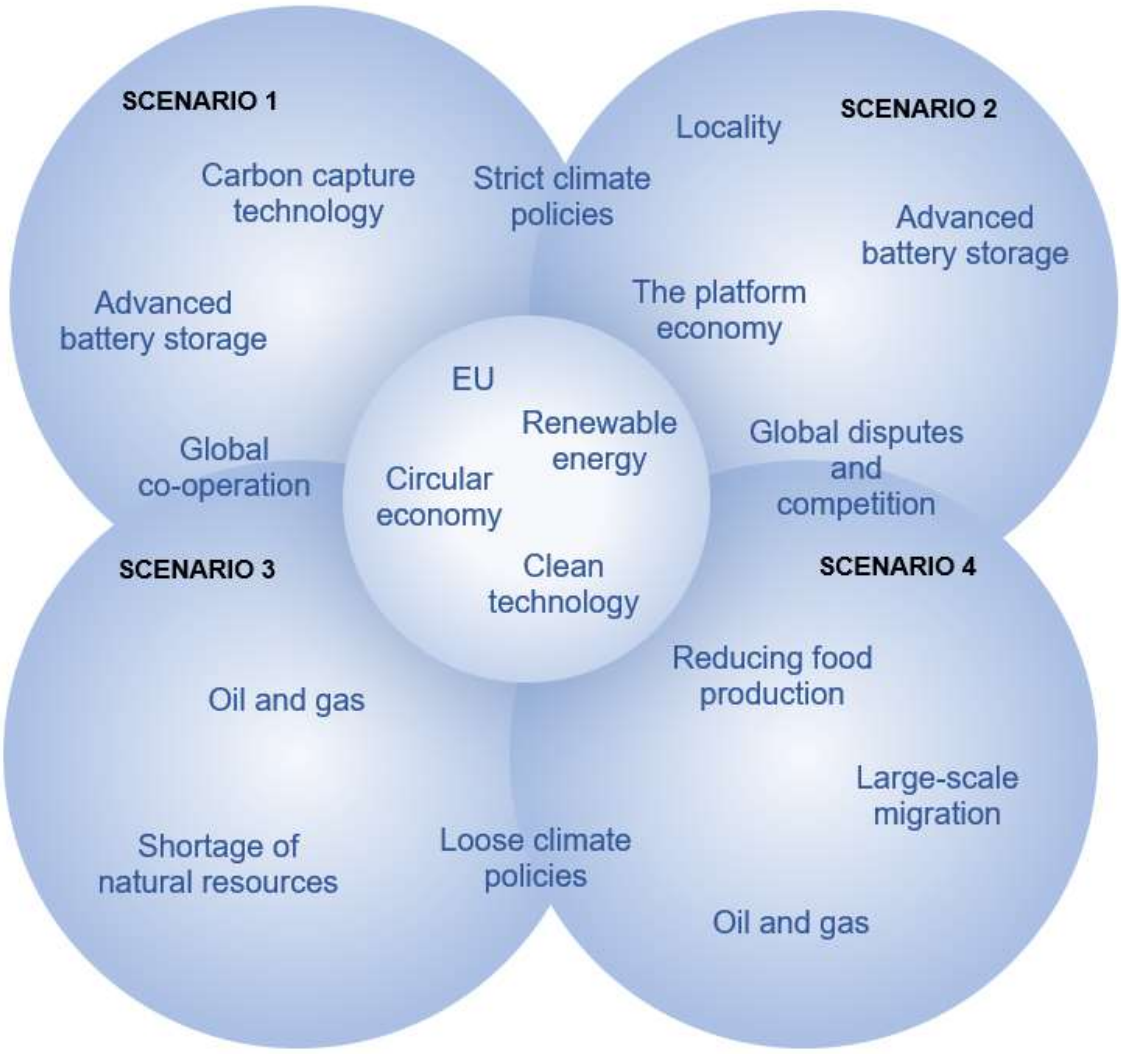


FIGURE 9. Scenarios 1-4 and their overarching implications.

Transition risk is already actualizing and the trend will continue within next decades whereas most physical risks of climate change will realize and worsen on the second half of the century. Timeframe of this scenario analysis is 30 years and therefore focus will be more on transition risks. Risk levels of transition and physical impacts differ regionally and geographically within all four scenarios. In all scenarios, strict policies and climate legislation are enacted and implemented in the EU region by developing and introducing clean solutions for ambitious climate change mitigation. The EU is projected to adhere climate commitments in all four scenarios due to following reasons. Compared to other regions, there are less oil and gas resources in the EU region and therefore the EU countries are not excessively dependent on export of oil and gas. The EU countries have economic opportunities to invest in renewable energy production and infrastructure and clean technology development. Some climate change mitigation projects are

already initiated, and climate policies enacted. Within a democracy, it is not easy to change policy lines as rapidly as might be possible in a country governed by communist party or with other non-democratic political system. Even if long-term physical risks of climate change are most likely less disastrous in the EU region than in other regions of the World in average, climate change is seen as a common threat which could lead to wide-scale political and economic crisis.

Positive and negative transition risks fall hardest to industries which businesses are targeted by environmental regulation i.e. some industries are more sensitive than others. Within one industry, there might be a big difference how sub-industries and different companies meet the transition risk. Automotive industry is good example of this; tax reliefs are targeted to electric car purchasing, and consumption of crude oil and petroleum products are planned to be cut by regulation. This does not impact only manufacturing and sales of new vehicles, but also sales of used cars, vehicle repair and maintenance and changes demand for charging points and gas stations. This in the reason why economic sectors and industries cannot by divided into winners and losers as such but rather these need to be reviewed by sub-industries and on company level. In all four scenarios, growing fields are renewable energy such as wind and solar power, different fields of circular economy such as more efficient use of natural resources and technological development which supports these fields and overall means to enable low-carbon transit.

In conclusion, industries and companies which create solutions, services or products to solve problems of the sustainable development and help forward means to mitigate climate change, will benefit of transition and can succeed. Investment opportunities are reviewed more closely in the following chapter. Legislation, policies, consumer behavior and advanced technology enhance growth in these fields.

5.2 Investment opportunities arising from scenario analysis

The business fields which should be overweight in investment strategy according to presented scenario analysis are studied closer in this chapter. These are di-

vided in two chapters; at first is reviewed renewable energy and battery development and this sub-chapter includes investment opportunities in solar- and wind energy, hydrogen, advanced battery technology, electric vehicles and energy efficiency. Second sub-chapter includes circular economy solutions and technologies for material-efficiency, renewable materials and recycling, productivity enhancement and food production.

The EU´s role as a forerunner of climate work rose in all scenarios but it still does not mean that investments to the EU region or to European companies should be specifically preferred. In the global world companies are multinational and products and services are often bought all around the world. According to scenario analysis, the EU region could become the biggest market of renewable energy or clean technologies but the companies that develop and offer these technologies, services or products, can be located anywhere in the most cases.

In the industry analysis, development state and structure of industry should be reviewed; certain industry can be growing, mature or regressive and on the other hand it can be fragmented or concentrated. Dynamics of the industry and competition are also important to review. These define how much negotiation power each counterparty; companies, customers and subcontractors, can have. Possibility to entry an industry, phenomena and events and different kind of factors that trigger changes, determine and can change the structure, dynamics and future outlooks of certain industry. (Kallunki & Niemelä 2012, 80.) Most of the reviewed fields are either changing or quite new and these are projected to grow in the future. Development of new technologies require investments and time which limits the number of companies that are able to entry market and gives competition advantage for forerunner companies which have taken the risk of transition at the early phase.

In the end of this chapter, are studied other issues, restrictions and concerns which may have impact in investment decisions. These should be considered when possible investment options are investigated.

5.2.1 Renewable energy and battery development

Renewable energy is highly growing field of business and legislation in Europe is strongly supporting transition from fossil fuels to renewable ones. **Solar energy** offers investment opportunities such as energy production itself, solar panel manufacturing and development and new technological innovations. In addition to traditional solar panels, solar energy can be utilized via floating solar farms, solar fabrics and solar technology integrated seamlessly into built environment.

The global solar power market share is fragmented, and overall market is growing. In Europe and the EU, the new growth phase of solar energy started in 2017 and has gained huge momentum in 2019. In 2019, Europa was the second largest solar market in the world. Although largest producers of solar power were China, the US and Japan. (Solar Power Europe 2020, 17.)

Outlooks of the industry looks good and there is a room for new operators. Research and development of solar technology requires big investments which limits the entry possibilities of new competitors. Storage of solar power, and renewable energy overall, is crucial to solve and will be a real breakthrough for them who invent sustainable solutions for it. Also, other kind of disruptive innovation could overtake the place of market leader with unforeseen technological invention. Due to industry is rapidly developing and growing, most of the companies does not have a long business history on the solar power sector or truly leading market position. There are outstanding listed companies which can be invested in via stock exchange, and investment funds and ETFs which invest in solar power or renewable energy companies in a wider scale. Also some private equity investments are possible when non-listed companies are seeking funding for their growth.

Wind power is another growing field of renewable energy business and it offers investment opportunities to companies which distribute the energy produced by wind farms, companies which are capable of producing large amounts of energy by their offshore and onshore wind farms and companies that manufacture, install and sell wind turbines. Regulation supports transit to renewable energy and this

together with introduction of advanced technology, increasing efficiency of offshore wind power and diminishing installation costs of turbines, project significant growth for wind power market within next decade. The global market of offshore wind power is highly fragmented, but certain major companies are dominating the market. (Fortune Business Insights 2019.) Straight equity investments to the listed wind power companies is one option to invest in wind power. For wider diversification, there are also investment funds and ETFs available which invest in wind power, and also renewable energy companies in a wider scale.

Advanced **battery storage technology** is prerequisite and one of the key solutions to efficiently utilize high shares of solar and wind power worldwide. This together with growing use of electric and hybrid electric vehicles, are driving growth of the battery technology market. Battery storage industry offers investment opportunities at multiple levels of the electricity value chain; research and development, manufacturing, transmission, distribution and consumer goods and services. The global battery technology market is expected to grow 65 % by 2025 from 2020 levels, and the lithium-ion battery segment is projected to increase even faster. Lithium-ion batteries are used mainly for automotive applications and consumer electronics. There are several key market players which are dominating the global battery technology market, many of them operating in Asia-Pacific region. (IRENA 2020b ; MarketsandMarkets Research 2020.) Listed companies can be invested in by straight investments in stocks or via investments funds and ETFs.

Hydrogen use today is dominated by industry; in fields such as oil refining and production of ammonia, methanol and steel. Hydrogen is worth to review even if its potential to support clean energy transitions has not realized yet. In the future scenario, hydrogen could be created by electrolysis fueled by surplus wind and solar powered electricity production. When hydrogen is produced by renewable energy, it will turn to carbon-free green hydrogen. This could be transported as a gas or in liquid and it bears a long-term storage. Eventually green hydrogen could be transformed into electricity and methane to power homes and industry and fuel cars, trucks, ships and planes. As an example, first trials of a hydrogen-powered train are initiated successfully in the U.K. in 2020 and retrofitting this tech-

nology to trains is estimated to be available earliest by 2023. Technology combines a hydrogen fuel tank with lithium-ion batteries for storage, so in this case the use of hydrogen does not exclude a need for advanced battery storage technology. (IEA 2019d; Hay 2020; Frangoul 2020.) State of market is developing, but still uncertain, so investing in it might be quite uncertain, risky and requires long-term investment horizon. Some of the main concerns are costliness of the production process and fuel cell engines, and on a large scale, the infrastructure. Current regulation does not specifically support the clean hydrogen industry. If investor sees that long-term outlooks of some specific hydrogen company or fuel cells manufacturer is promising, there are few listed companies available. Also some clean energy funds and ETFs have allocated part of the investments to hydrogen.

The **electric vehicle** market is going through a rapid evolution. Regulation and government policies boosts transition to renewable energy forms and through that to introduction of electric vehicles. Support is given in terms of subsidies and grants, tax rebates and better availability of charging infrastructure. Electric vehicle development is also dependent on advanced battery storage technology mentioned earlier in this chapter. Good example of how closely these two fields are tied to each other, is that lithium-ion batteries account approximately 30 % of electric vehicle costs. Electric car manufacturer Tesla has even announced to start in-house production of electric vehicle batteries. Electric vehicle market is projected to grow rapidly; annual growth rate for next ten-year period is estimated to be 21 %. Market is dominated by global automotive companies; some of them manufacturing only electric cars and part of them traditional gasoline car manufacturers that have made a shift to electric and hybrid car manufacturing at early phase. (MarketsandMarkets Research 2019; Shiraishi 2020.) In addition to stocks of electric car manufacturers, for example charging point network and other electric vehicles are available for investments.

In opposite to above mentioned renewable energy related investment opportunities, fossils fuels as such are not recommended to invest according to scenario analysis. Although it is important to notice that some of the traditional companies producing or refining oil, gas or coal, has stepped into field of **biofuels** on side

and are on transit phase. This kind of companies can be still profitable investments even if they initial business have been based on fossil fuels. For example, Finnish oil refining company Neste has launched their first ´Green diesel´ already in 2008. Back in 2008 only 10 % of Green diesel was made of renewables, but in 2017 launched low-carbon biofuel ´MY Renewable Diesel´ is fully renewable as it is produced only of waste vegetable oils and animal fats (Neste 2020).

Energy efficiency reduces need for fossil fuels together with renewable energy technologies. Improvements of energy efficiency can be done in every field of economy; in manufacturing industry, energy sector, transportation or building. The EU has implemented Energy Efficiency Act and Energy Efficiency Directive which include energy efficiency target for 2030 and ways to promote energy efficiency. Consumption of energy is high especially in manufacturing industry and by introducing means to enhance energy-efficiency, great amounts can be saved. This can increase demand for AI-based energy management system and other energy efficiency software. Energy performance of buildings directive within the EU region push construction companies build and refurbish energy efficient buildings and add smart building technologies. (Työ- ja elinkeinoministeriö 2020; Ympäristöministeriö 2020.) Companies that produce and develop products and technologies such as energy management software and smart building systems are able to grow and success when demand for energy-efficiency solutions increase.

5.2.2 Circular economy and clean technology

Most innovations that enable economy and processes to turn circular, require solutions of advanced technology. Therefore, investment opportunities of circular economy are closely related to clean technology development and innovations, and these two are presented together in this chapter. Clean technology is also tightly related to renewable energy and energy-efficiency, electric motors development and green transportation which were reviewed in the previous chapter.

Efficient use of materials diminishes dependency of scarce natural resources and can bring cost savings. Material efficiency can be carried out by implementing advanced recycling and production methods, by developing and using new kind

of materials and by open eco-system or big-data platforms. As an example of advanced recycling, component parts can be separated and recycled into usable materials with help of robotics. Apple´s used iPhones are broken apart by robots and 14 different minerals, including lithium, are extracted and recycled (Scheyder & Nellis 2020). When minerals can be recovered and reused, company is less sensitive for mineral price fluctuations caused by demand shocks. Introducing effective automated recycling processes can be expensive and impossible for small companies, but in long term automations can bring vast cost savings. Investor might not have detailed information about processes of specific companies, but technology or electric companies that offer innovative solutions for automation and robotics, are worth to consider. There are also automation and robotics themed ETFs and funds available on the market. Companies which refine waste materials for industrial reuse can grow their business in the future and succeed.

Just like with energy transition, **renewable materials** will replace some of the currently existing materials. Fossil-based plastic made of petroleum will be replaced by bioplastics made from sustainable biomass such as wood. According the EU´s plastic strategy, single use plastics will be banned by regulation by 2021 and all plastic packaging should be recyclable, reusable and compostable by 2030 (European Parliament 2019). This supports development and fastens introduction of bioplastics such as biopolymers. As today many products and components are made of fossil-based plastics, this regulatory trend projects significant growth for markets of biobased materials and bio-plastics within next ten years. Bright outlooks and growth can be predicted for companies developing and producing biobased materials that replace fossil-based plastics.

Technology and optimized, circular product design can enable also more productive and faster manufacturing with less raw materials, less waste, less water and less electricity. New kind of materials such as thermocomposites, can save both energy and materials. By using **nanotechnology**, not only raw material is needed less, but materials can be made stronger, lighter, more durable, more reactive and better electric conductivity. Nanotechnology is utilized also to enhance energy storage and to capture sunlight with solar cells efficiently as well as to reduce the size of electrical circuitry ever smaller. (Pistilli 2020.)

Nanotechnology can be used also to filter contaminated water and to improve air quality (Pistilli 2020). These both will become more important when climate gets warmer and impact of the climate change will actualize. **Food production** and processing can be also enhanced with nanotechnology. Overall food technologies are becoming more common and enable for example vertical farming (photonics and hydroponics), plant-based meat and sea-food substitutes and other plant-based proteins and food-products, and lab-grown products. Current the EU regulation does not support production of plant-based food products over meat by lower taxation or better subsidies. Although when rising global middle class together with population growth will increase demand for meat and food overall, less carbon-intensive production methods and foods will be likely required. (CB Insights 2020.)

Overall technological development and solutions have key role in material, water and energy efficiency and productivity enhancement. These offer a wide range of investment opportunities. Disruptions of production caused by breakdowns can be reduced with automated maintenance scheduling enabled by **machine-to-machine communications** and **artificial intelligence**. Productivity can be also enhanced by **big data analysis and cloud computing. 3D printing** can remove some work stages such as need for assembly and reduce warehouse costs and logistics. (OECD 2016, 9–10.)

5.2.3 Restrictions and other issues to consider from investment point of view

It is important to keep in mind that **diversification of investments** is key factor of the successful long-term investing and climate change is only one megatrend among others. Even if investment opportunities arising from scenario analysis were reviewed in climate change perspective, results of it cover also partly other megatrends such as globalization, technological development and resource scarcity. Still some other megatrends like demographic shifts and urbanization, which can also offer good investment opportunities, were not included to this review. Purpose of this study is to give insights how climate change impacts in economy and business opportunities, and some set of assets in investment strategy can be over-weighted or under-weighted according to results of the scenario analysis,

but entire investment strategy should not be based on this. Geographical diversification of investments is also important to pay attention to. For example, if political tensions between countries and regions worsen, it can impact business opportunities regionally. Today several countries such as Australia, New Zealand, Japan, Taiwan, the US, UK and Sweden have banned Chinese technology companies Huawei and ZTE from gaining access to their 5G wireless network due to security concerns.

Most of the reviewed industries are going through a transition towards low-carbon direction. Past performance of a company is never guarantee of future results but in this situation, it is even less so. Capability to foresee the upcoming changes and adapt demands of the future are key success factor in the transition phase. Situation for competition of certain fields is changing which can lead to displacement of current market leaders and open markets for new companies.

Companies are not threated only by companies on the same field but also by companies who offer new innovative, better solutions to meet the customer demand. Good examples of the past **disruptive innovations** are cell phone cameras which have disrupted the photography market, streaming services such as Spotify and Netflix which have disrupted CD and DVD markets, and platforms, such as Airbnb, which enable peer-to-peer commerce i.e. sell, buy and rent products and services directly from an individual to another. Future disruptive innovations cannot be projected in advance but businesses which are dependent on infrastructure cannot be disrupted as rapidly as the fields which does not have such interdependences. For example, if hydrogen technology would take a great leap forward and hydrogen cars would turn easier, cheaper and cleaner for consumers to use than electric cars, interdependencies of hydrogen stations and long mileage of cars would still slowdown the transition. Advanced, low-cost 3D printing could plausibly disrupt traditional manufacturing in the future or even change the entire life cycle of a product from manufacturing to distribution if 3D printers owned by households would become more common. Overall, rapidly rising new innovations speeded up by technology, can change the course of development and future of certain industry and companies operating in that field. Continuous follow-up and analysis on market situation, upcoming regulation and achievements of technology is important, to be able to keep on track where the

industry is heading and what might be the next big thing on the market and through that a profitable investment.

Many companies whose products or services provide solutions to mitigate climate change are **privately held and non-listed companies**. Straight investments to non-listed companies are far more difficult to achieve, especially for small investor, than investing in listed companies. Although, markets are growing on these fields and regulation might also support the business developing further, which enhance growth of the companies. When business is growing, funding is often needed, and companies might seek new investors to finance the growth. From investor point of view, this might require relatively large investment for one company and opportune timing, and investment might be not only illiquid but also highly risky. If investor has strong faith in business idea and founders and management of the company and he/she has deep knowledge of the markets, investing in growth company can be profitable investment in a long run.

Listed companies are larger and more stable in general than unlisted ones. Still, when investments are focused on the businesses which are going through a transformation or are growing rapidly, **valuation of shares** cannot be assessed with the same analysis than is used for more conventional companies operating on stable markets. Analysis of key figures and ratios from past years do not necessarily give at all comprehensive picture of company´s profitability in the future. It is far more complicated to estimate if current valuation reflects the growth speed and profitability of the future. So again, investing in transforming and growing businesses includes high risks which is not acceptable for all investors, such as risk-aversive ones. Company risk can be diversified by investing in the funds and ETFs which invest several companies on the certain sector or replicate and track certain benchmark index.

ESG investing has been trending during past few years and today many asset managers, investment funds and pension funds take into consideration environmental, social and corporate governance factors in their investment decisions. Investing against of the publicly available ESG principles might be even reputation risk for example for a pension fund. When large institutional investors with great investment assets overweight certain companies, funds and bonds in their

investment strategies according to the similar kind of ESG principles as all other fund managers, these set of assets might become over-valuated in the time-being. Most environmental principles of ESG strategies favour investments in low-carbon products and services and technologies that support the transition. This is in line with the results of the scenario analysis of this study and therefore there is a slight risk that some companies operating in the reviewed industries are over-valued because of the ESG trend. In long term this could possibly lead to ´**sustainability bubble**´ if companies in these fields would be highly overvalued in a wide scale.

Share of individual investors in stock market has increased during past ten years. In the US stock market, trading by individuals has doubled in ten years and in the first six-month of 2020, individual investors accounted nearly 20 % of the traded shares. Investors who does not base their investment decisions fully to fundamental values, so called **noise traders**, can move markets by psychological reasoning which can lead to mispricing of shares. Noise traders often trade based on incomplete or inaccurate data such as rumours or hype. This increases volatility of market prices and trading volumes of the shares of the companies that get a lot of publicity, either positive or negative. (Osipovich 2020; Bloomberg Portal 2020.)

6 CONCLUSIONS AND DISCUSSION

Climate change will affect widely nearly all sectors of economy and its implications are global, neither one region nor country can alone halt the climate change. Risks of climate change can be separated to physical impacts and transition phase related implications. Transition to low-carbon economy is initiated and the trend will continue within next decades whereas most physical risks of climate change will realize and worsen in a later phase. History has shown that markets are changing mainly based on enacted laws and regulation when it comes to emission reduction and transition to low-carbon economy. Inevitably regulation forces markets to change and by that also business opportunities change which raises new risks and opportunities for investors.

In conclusion of the scenario analysis, investment opportunities can arise from renewable energy and battery development such as solar energy and wind power, battery storage technology, hydrogen, electric vehicles, biofuels and technologies which enhance energy efficiency. Also, circular economy solutions and clean technology could offer profitable investment opportunities by technologies which enhance efficient use of materials, renewable materials, food production technologies, nanotechnology and other technologies which enhance productivity and resource efficiency.

Energy transformation is already going on strong and therefore different forms of renewable energy and development of battery technology are already here today – not just plausible future opportunities. This reduces investment risk in a sense of uncertainty level, but from valuation level perspective, some of the stocks might be already costly due to high investment rate to these fields and companies.

Transit from linear economy to circular economy is initiated but not such a big scale than energy transition. As technology is important part of enhancement of material-, water- and energy-efficiency, clean technology development is rapidly growing field of business and can offer good investment opportunities. Although use of technology is increasing significantly in all fields of business which makes technology companies desirable investments for many.

Even if results of the scenario analysis were based on transition risks and their drivers such as regulation and clean technology, physical impacts of climate change are also important to be aware of to be able to see the big picture. Physical impacts will strengthen in the future, so these cannot be forgotten even if transition risks are more important to consider at this moment. Physical impacts are not easy to estimate, because of the number of affecting variables and long timespan. Results between different studies vary quite a lot and different means of classification make comparison of results difficult. Still, physical impacts are the base reason for climate regulation and justification for the transition.

In the global world with multinational companies and far-reaching impact of climate change, it is good to understand also regional differences and inequalities related to climate change. Regional review shows why certain countries are less willing to make commitments for climate change mitigation. Mainly these reasons arise from energy politics i.e. countries which have major oil, gas and coal resources, are not willing to leave those unutilized. Overall, the countries which opportunity costs for climate change mitigation are high, are less willing to make climate commitments. Another important viewpoint which rose from geographical review is, how small group of people can have vast impact in climate actions and commitments. Several cases have shown that when president or other decision-makers of a country or federation change, climate politics can change accordingly. This does not necessarily affect only national commitments of one country but can also affect other countries´ willingness to introduce their commitments due to fear of losses in global competition.

For investor, it is important to follow the overall market situation continuously and status of the companies which are in their investment portfolio. If scenario analysis is in use, it should be updated on a regular basis. Outlooks of industries, world´s economic state, regulative changes and possible upcoming changes, and trending topics should be gathered to be able see which direction plausible scenarios will turn to. Some thoughts should be given to weak signals, and possible implications, width and probability of them should be analysed. Disruptions and black swans are not easy to see coming but to these can get prepared for at least with sufficient diversification of investments. Investment strategy can be then updated according to newly updated scenario analysis.

In addition to fundamental analysis, individual investment instruments, such as stocks and private equity, can be also assessed by using scenario analysis. This kind of sensitivity analysis can be done also for instruments in current investment portfolio to find out how climate change sensitive portfolio is. It is good to note that cases reviewed in the chapter 5.2 are only examples of certain matters, not recommendations to invest in the specific companies or stocks.

According to results of the scenario analysis, industries and companies which create solutions, services or products to solve problems of the sustainable development and help forward means to mitigate climate change, will benefit on transition phase and can succeed. According to this conclusion, sustainable investing should be profitable investment strategy, at least for environmental (E) part of ESG mentioned in the introduction. Despite of the different initial viewpoints, both climate risk management of investments and sustainable investment strategy in the end seek investment returns from businesses that mitigate climate change, target to reduction of greenhouse gas emissions and pollution and aim at resource efficiency.

The Paris Climate Agreement and thereafter made nationally determined commitments, enacted climate and environmental regulation and global discussion have urged forward actions for climate change mitigation. Maybe by this, the megatrend of climate change will turn to the megatrend of ´Fight Against Climate Change´ during this decade. This would turn transition risk larger and change current infrastructure, ascendancies, global competition and business opportunities – and through these investment opportunities, even more.

The EU´s status of global climate leader raised further questions of future of European companies and competitiveness. The EU has planned to enact additional climate regulation but most likely the union is not willing to cause global disputes or even trade war by setting up carbon tariffs to countries with less strict climate policies. It would be interesting to study further what could be the plausible future trajectories of European competitiveness and how would this impact in such investment strategy that is focused only on European companies and infrastructure.

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