Can Planes Go Green?: Using the Multi-Level Perspective to Determine the Commercial Aviation Industry's Progress Towards Sustainability

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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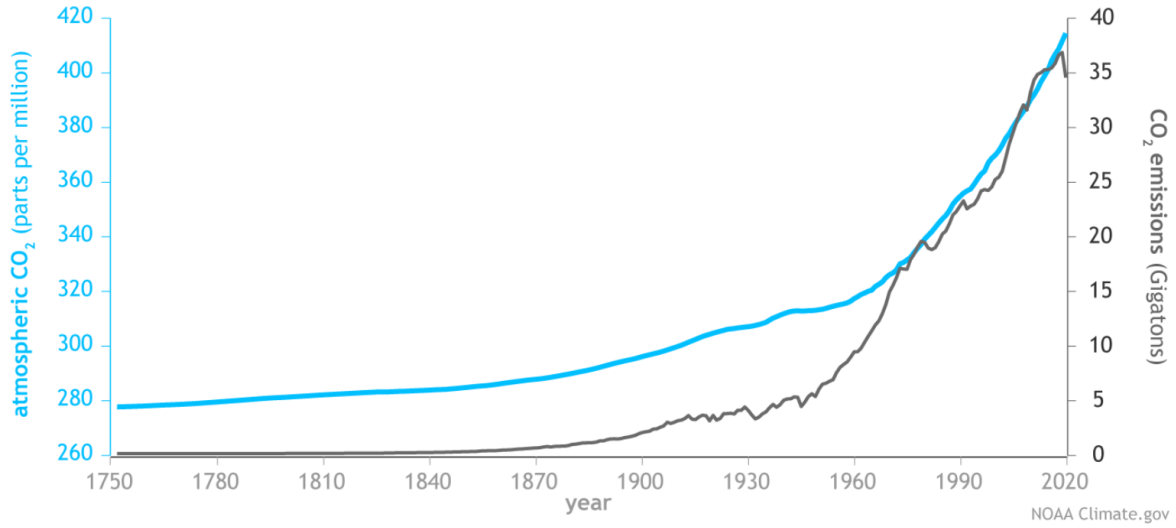
Introduction

"Taking bold action on climate change simply makes good business sense. It's also the right thing to do for people and the planet. Setting a net-zero GHG emissions target by 2050 will drive innovation, grow jobs, build prosperity, and secure a better world for what will soon be 9 billion people."

– Richard Branson, Founder of the Virgin Group, (Harvey, 2015, n.p.)

The global climate is drastically changing around us. People have known of climate change since the late 1800s, and it was officially named a national issue in 1988 (Brulle, 2018). Despite national recognition, there has been limited reduction in carbon emissions and the effects of climate change are starting to impact societies worldwide. According to the NOAA (Lindsey, 2021, n.p.) as shown in Figure 1, carbon dioxide emissions have grown exponentially since 1850.

Carbon dioxide emissions and atmospheric concentration (1750-2020) **Figure 1**



Extreme rise in carbon dioxide emissions and atmospheric concentration since the industrial revolution (NOAA, 2021, n.p.)

As CO_2 and other greenhouse gasses are released into the atmosphere, more thermal infrared energy is captured by the molecules in the atmosphere increasing the average

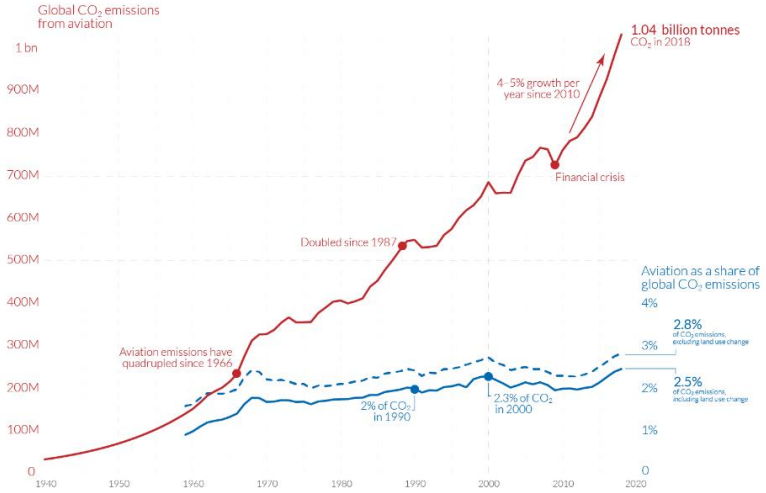
temperature of the planet. According to Huang (2016, p. 170), the impact of increased carbon emissions is likely to expand drylands 23 percent by 2100, at which point they would account for 56 percent of global land area. Increased desertification of land area reduces the amount of livable land and yearly crop yield. The U.S. Environmental Protection Agency (EPA) estimates that global wildfires are growing in intensity and frequency displacing millions worldwide (2021). Alan Buis (2019, n.p.) of NASA's Jet Propulsion Laboratory warns that, "in many regions, warming has already surpassed 1.5 degrees Celsius above pre-industrial levels", and this trend is projected to continue. Researchers have only recently started analyzing rising temperatures' contribution to extreme weather patterns, aridity, and wildfires (Liu et. al 2009, n.p.). Without quick changes made towards sustainability worldwide, global warming will compound in progression causing irreversible damages to our planet.

Emissions have largely increased due to the carbon emitting vehicles in the transportation industry. As a result, companies across all industries have attempted to find alternate solutions and more sustainable options. Most of these alternate solutions can be categorized as transitions towards sustainability. This paper will use Frank Geels' multi-level perspective model on sustainable transitions to identify the important actors and pressures involved in the current transition of the commercial aviation industry towards sustainable technology. Thorough analysis of the system will provide insight on the transition as well as identify the strengths, weaknesses, and overall progression of the active shift towards sustainable aviation in order to determine what actors could increase their presence in order to speed up the rate of transition.

How the Commercial Aviation Industry Was Compelled to Issue Emissions Reduction Targets

According to the University of Oxford, the commercial aviation industry accounts for 2.5% of the world's carbon emissions alone and, as shown in Figure 2, the rate has considerably increased and requires drastic measures to be turned around (Ritchie, 2020).

Figure 2: Global Carbon Dioxide Emissions from Aviation



Exponential growth of global carbon dioxide emissions from aviation according to Our World in Data run by Oxford University. (Ritchie, 2020, n.p.)

Citizens' Climate Lobby (CCL, 2021) pressures governments to impose economy-wide carbon fees and dividends. In a recent press release about proposed climate measures in a budget reconciliation bill, CCL stated: "volunteers continue to contact the President, Senators, and representatives about this crucial policy" (CCL, 2021, n.p.) ahead of the 26th annual Conference of Parties (COP26). Grassroots advocacies of increasing size have committed to boycotting traveling by plane (Irfan, 2019). In response to the pressures put on the commercial aviation industry, Boeing (2020) pledged a 50 percent reduction of carbon emissions by 2050 relative to 2005 levels. Other enterprises within the commercial aviation sector have also been compelled to set carbon emissions targets. Climate advocacies have been successful in reaching the ears of those in the industry, but have had limited success with politicians.

In another form of social crusading, Swedish activists introduced the term *flygskam* (flight shame) to deter travelers from flying. In 2018 Greta Thunberg and a

Swedish group called We Stay on the Ground began a movement to boycott commercial flights. The group wrote Flight Free 2020, a pledge publicizing refusal to fly. According to Maja Rosén, the founder of We Stay on the Ground: "That's really the most powerful way to make people change their minds" (Irfan, 2019, n.p.). Swedish and German airports have reported a decline in travelers, attributing it to the "Greta effect" (Krauss and Chokshi, 2021). Flight Free USA and Flight Free UK are continuations of the pledge worldwide to choose greener alternatives to flight further pressuring airlines to reduce emissions or lose business. One of the best ways to make an industry listen is by affecting their profits, and these groups trying to add a boycott to the pressure on the system.

Pressure has also been created internally within the commercial aviation industry. Virgin Atlantic applied choice architecture in an effort to coax its pilots to conserve fuel and thereby reduce carbon emissions (Mooney, 2016, n.p.). Choice architecture is a psychological method of limiting a person's rationality and subtly convincing them to pick the favorable option. In this situation, Virgin Atlantic provided monetary benefits for the pilots who had the least amount of fuel waste over a period of time to gently nudge their pilots towards a low emissions operating technique. Pilots saved 6,828 metric tons of fuel that would have emitted 21,507 tons of carbon dioxide. According to Mooney (2016), "the vast majority" of the reduction was "simply from the captains in the control group knowing that Virgin Atlantic was studying their behavior." Virgin proves that even little changes made can go a long way in reducing the emissions put out by the industry. Virgin claims it has achieved 20 percent fleet-wide emissions reductions over the last decade; it has also pledged to achieve net-zero emissions by 2050 (Clarkson, 2021, n.p.). The favorable publicity that Virgin's efforts have attracted increases the competitive pressure on other airlines.

Virgin is also the founding member of Sustainable Aviation, and it belongs to the Clean Skies for Tomorrow coalition. The coalition asserts that "aviation is a truly global industry, and we can't tackle this on our own" (Clarkson, 2021, n.p.). As other commercial aviation companies are making commitments towards sustainable practices, the progress made by Virgin Atlantic is a reason for climate advocates to choose their flights over comparative alternatives. Companies losing profits due to their slower transition towards sustainability is an effective way for them to increase their rate of transformation towards more sustainable practices. Another form of peer pressure within the industry comes from the oneworld group. Collectively, they have committed to net zero carbon emissions by 2050 including 14 total airline companies worldwide as well as Alaska and American Airlines who are 2 prominent leaders in the U.S. aviation industry. This collective goal makes it more likely that airlines will stick to their individual commitments and be more likely to help their partners at oneworld achieve their goals through shared innovation.

The pressure that has been built on the commercial aviation sector is unlike transformations towards sustainability found in the past since every transition is unique. The rate of adaptation of sustainable practices in the aviation industry is something that should be compared to previous technological transitions. While there is a large amount of pressure coming from the public on the commercial airline industry, it's uncertain if this pressure will do anything to enact change. Researchers Wynes, S., Kotcher, J., & Donner, S. D (2021, p.15) from the University of Vancouver contend that public pressure on politicians affects, "internal party negotiations about climate and energy policy". The environmental effects of a carbon tax on airlines have also been investigated. For example, Hofer, Dresner, and Windle (2009, p. 43) found that a carbon tax of 2 percent could reduce U.S. airlines' carbon emissions from domestic flights by 5 billion pounds per year. According to Brueckner and Zhang (2010, p. 970),

professors at UC Irvine and the University of British Columbia, airline emissions taxes tend to "raise fares, reduce flight frequency, increase load factors, and raise aircraft fuel efficiency". Even though a reduction in emissions can be achieved through the use of a carbon tax, the United States has not implemented any regulatory policy, effectively protecting the consumer from an increase in fares.

Without government contribution, the transformation of the commercial aviation industry relies on promises implemented by the companies who make a direct profit off of their actions. Currently, according to *Forbes* (Goldstein, 2021, p. 1), sustainable jet fuel (SJF) is 8x the operation cost compared to the use of fossil fuels in current airplanes creating minimal incentives for companies to rush their transition towards reduced emissions. Without the incentive to shift towards SJFs, they are less likely to uphold their promises towards carbon reductions and instead delay as long as they can causing tons of carbon to be emitted that could have been avoided.

A comparison to previous technical transformations is useful to analyze the likelihood of this one's success (Gearino, 2021, n.p.). Looking at the transition of Norway's transportation sector from combustion-engine cars to electric vehicles (EVs) provides an interesting comparison. EVs reached 54% market share in Norway as of 2021 but this was achieved mainly through government intervention instead of external pressures developed through the general Norwegian population. As a nation they have a goal of ending the sale of combustion-engine cars by 2025. Tesla, and other automobile manufacturers began releasing more competitive EVs at the perfect time for stylish adoption in Norway. Their government has provided temporary tax exemptions on the purchase of EVs, lower road taxes, free parking, free charging, exemption from road and ferry tolls, and public money being used to develop charging infrastructure since

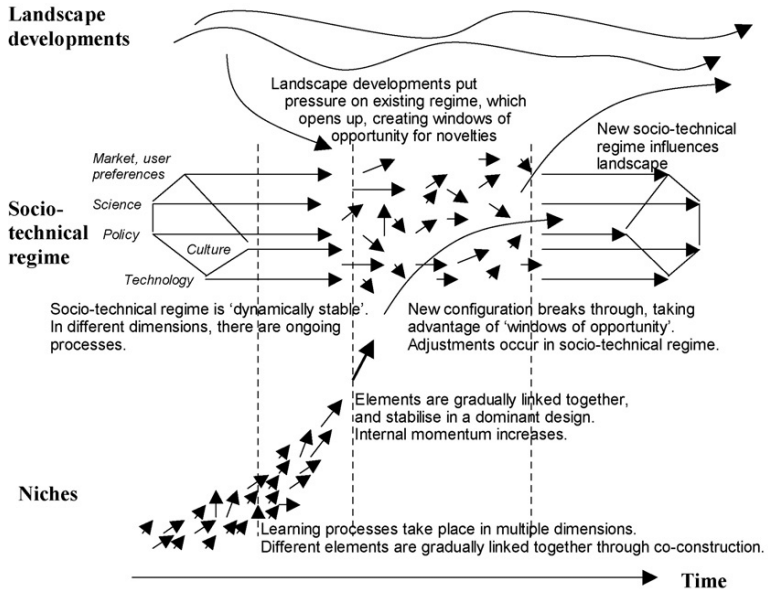
the 1990s in order to promote the adoption of EVs (Board, T. editorial., 2021). However, this model is expensive and wouldn't be possible for Norway if it weren't for their offshore publicly owned oil reserves. Additionally, the system of infrastructure in Norway lends itself well towards adopting EVs for local transportation. In all, the transformation to an EV majority market in Norway was largely fueled by public policy whereas the shift towards sustainability in the U.S. commercial aviation industry is largely fueled by external public groups pressuring airlines and manufacturers. It's unclear if the system of built-up pressure on the industry will actually work at incentivizing the transformation towards sustainability.

Multi-level Perspective Model on Technological Transitions Towards Sustainability

Frank W. Geels published a paper in 2006 titled, "Multi-level Perspective on System Innovation: Relevance for Industrial Transformation," expanding further on the multi-level perspective (MLP) model that was originally invented by Arie Rip and Rene Kemp (1998). The Multi-level Perspective (MLP) is a multi-dimensional model that postulates that sustainability transitions come about through pressures that are built up in three different levels (El Bilali, 2019, pp. 1). The three different levels consist of the sociotechnical landscape, sociotechnical regimes, and niche-innovations. The sociotechnical landscape is the broadest level of the MLP encapsulating overall trends in society, culture, and the world at the time of the transition. The sociotechnical regime refers to the agents that have brought the system into its current state. Niche innovations are generated due to opportunities of change in the regime seen by the general public. The groups within the MLP apply pressure on each other in order to push the sociotechnical system forward towards more sustainable practices. One of the main strengths of the MLP model is that it allows people to see the circular causality within the system where every regime in the model influences the other as well as cross-talk exiting across regimes.

Figure 3 shows a diagram representation of the multi-level perspective on transitions towards sustainability. There are a total of four phases of the transition represented by the vertical dashes in Figure 3. In the first phase, each of the levels are acting independently. In the second phase, the sociotechnical regime begins to open up due to landscape pressures on the system, and by the third phase you can see that the developments have fully opened up the sociotechnical regime allowing for the niche innovations to come up and proliferate developing a "new" sociotechnical regime utilizing the new sustainable technology. The fourth phase is the continuation of development until the system is fully sustainable and then starts influencing the landscape itself.

Figure 3: Frank Geels Multi-Level Perspective Model



MLP Model on Transitions Showing the Circular Causality and Interconnected Levels (Geels, 2006)

The system that is being studied is a direct transition towards sustainable practices within the commercial aviation sector. I used MLP to model recurrent patterns, mechanisms, and relationships between variables in multiple stages of the transition towards sustainable practices within the commercial aviation sector in the United States, as well as the transition towards electric vehicles in Norway. The analogy will help compare each transition to determine whether the commercial aviation industry will be successful in fulfilling their sustainable promises. Using the successful example of Norway will help identify key groups that are missing as well as

establishing how sustainability changes occur in different ways. The MLP has been used thoroughly over time and received many reviews of its strengths and weaknesses. While it can be used effectively, there are still limitations within the model that have been pointed out in the past.

In a 2011 article by Geels titled, "The Multi-level Perspective on Sustainability Transitions: Responses to seven criticisms, (Geels, 2011)" he goes through 7 different constructive criticisms regarding his Multi-level Perspective for analyzing sustainable transitions in history and formulates thorough responses to each. Critics claim that the MLP has a lack of agency, a bias towards bottom-up change models, and that the sociotechnical landscape level is a residual category among many others (Geels, 2011). In the publication, however, Geels identifies each of the criticisms and thoroughly refutes them with specific examples. The thorough rebuttal by the primary author of the methodology proves its validity while still having some limitations.

Identifying the Actors in Play in Each Technical Transition According to the MLP

Categorizing the agents found in each system into the levels of MLP will allow a clearer picture of how the MLP will be used in relation to the system. Landscape pressures include macro level things like global warming, gas prices for both normal and sustainable jet fuel, political regulations, war, economic growth, etc. The sociotechnical regimes of the system include the commercial aviation industry (airlines, manufacturers, and regulators), the United States economy, travel culture, aviation technology, and the markets that use aviation the most frequently. There are limited niche innovations within the system. The largest innovation involves drop-in sustainable jet fuel, or sustainable aviation fuel (SJF or SAF), which allows for the use of existing engine models running on a bio-fuel that has fewer aromatic components, enabling them to burn cleaner reducing local emissions of harmful compounds during takeoff

and landing (Bioenergy Technology Office, n.d.). SJFs are made using sustainable resources such as waste oils from biological origin, agri residues, non-fossil CO_2, or renewable feedstock. The biological component of SJFs allows for the burning of recycled CO_2 emissions instead of creating new CO_2 compounds from the burning of petroleum (SkyNRG, n.d.). However, SJFs are only minimally used since they currently cost 8x as much as conventional jet fuel. A secondary niche innovation is fully electric aircraft but is on a much smaller scale and would most likely be used for local travel instead of interstate and international until batteries are improved allowing for larger capacity and use in large airlines.

In order to properly compare each of the transitions it's crucial to categorize the actors involved in Norway's transition toward electric vehicle. The main landscape pressures came from the same places as the commercial aviation industry: mainly global warming, gas and electricity prices, political regulations, war, economic growth. The sociotechnical regime in this situation includes the automobile market, government policies, electric vehicle technology, and a strong culture dedicated towards sustainability. The largest niche innovation at the time includes the improvement of the lithium-ion battery allowing for better EVs that have longer range and are more competitive with gasoline counterparts. Another niche innovation involved the improvement of portable charging stations that were able to be put in various locations around Norway.

Table 1 shows the main actors involved in each situation and puts them into the three main levels of the MLP framework. Comparing each transition in this figure shows how many different pressures are involved in each situation and allows for easier comparison.

Table 1: Actors Involved in Each Transition Categorized Into MLP Levels			
	Niche-Innovations	**Sociotechnical Regime**	**Sociotechnical Landscape**
Commercial Aviation	-SJFs/SAFs -Electric capabilities -Hydrogen fuel cells	Aviation industry, FAA, ICAO, oneworld, Travel culture, Economic climate, Aviation technology	FAA Regulations, Travel culture, Climate change, Gas prices, Market strength, Job market, Government regulation
Norway's Shift to EV	-Lithium-Ion battery -Portable charging stations -Tesla	Car market, Norwegian culture, Public policy, Regulatory agencies, EV Technology	Private Investment, Tax regulations, Gas prices, Electricity prices, Norway's geography

Chart displaying the actors involved in each transition (Created by Author)

From Table 1, on a purely quantitative level, there seems to be an equal number of agents involved in each transition. However, while the number of agents involved in each situation is similar, the extent of involvement for each actor drastically varies between the transitions.

Determining Progress Towards Full Transition for Each System

Norway's transition to EVs had heavy policy pressures starting with investment into new infrastructure that was paid for by the government starting very early on in the 1990s. Additionally, adding tax incentives for people who switch to EVs provides a pressure on the general public to choose the more sustainable option. There was also attention on the issue from one of Norway's most popular bands A-ha who partnered with Bellona, a Norwegian environmental advocacy, to promote alternatives to gasoline vehicles (Gearino, 2021, n.p.). Norway's environment and geography was also an important landscape player in the transition as most people only use cars for personal local transportation and can use EVs even if their total range is less than that of gasoline cars.

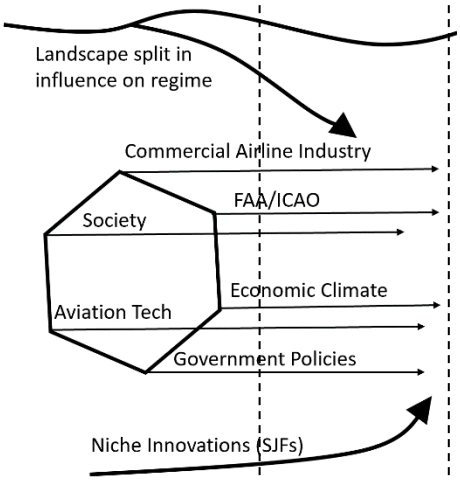
However, the transition did not happen overnight. They began working on increasing the number of charging stations in the 1990s meaning that the shift to their EV majority has taken about 29 years just to have EVs get a majority of the market share for vehicles sold in 2019. As a country they determined in 2017 that they wanted to make all cars sold after 2025 electric, a similar promise like the commercial airline industry in the United States. Denmark, France, and the Netherlands are following suit of Norway's example providing significant tax exemptions and one-time benefits for the purchase of EVs. The direct success of increasing the market share in a relatively short time is already well regarded by European peers and is trying to be emulated in order to improve their own transition's towards EVs.

There were significant niche-innovations that occurred during the transition involving the improvement of the lithium-ion battery. With the improvement of electric batteries, the range for EVs increased allowing them to be more widely adopted and seen as a viable option for consumers. Additionally, Tesla's EVs created a shift in consumers from gasoline to electric as they developed multiple luxury EVs which had never been done previously. This cultural shift made it more acceptable and stylish to be driving an EV which most likely helped increase the rate at which the transition occurred in Norway.

Comparing Norway with the commercial aviation industry, the main landscape level pressures come from global warming and gas prices, however, they act against each other. The heightened awareness of global warming and the active changes it's having on our world pushes people to want to remove carbon emissions from airplanes as a whole, but with the current prices for normal jet fuel compared to SJFs the transition will not be simple. The current thought within the aviation market seems to be that drop-in sustainable aviation fuels are the way towards cutting emissions with Alaska Air CEO Ben Minicucci directly stating, "sustainable aviation

fuels [are] probably the biggest enabler to get to 2040 (Reichmann, 2021, n.p.).” Another pressure comes from the United Nations’ International Civil Aviation Organization (ICAO) when they adopted the first ever global design certification in 2017 governing CO_2 emissions for any industry sector to be used on planes developed after 2020 (Philbin, 2017, n.p.). The ICAO originally planned on having carbon offsets be part of a plan, but that never came to fruition (Hodgkinson & Johnston, 2016). Carbon offsets would provide the opportunity for airlines to be “carbon neutral” by completing other tasks like planting trees to offset their emissions. Within the sociotechnical regime there are internal pressures that have developed on the system through Flygskam, Virgin Atlantic’s model behavior, and the joint emissions reductions goals of the entire industry racing towards sustainability. The internal and external pressures that have been built up surrounding the aviation industry provides windows of opportunity for companies to adopt niche innovations and meet their goals to reduce their carbon footprint.

Figure 4: MLP Model Adapted for the Commercial Aviation Industry



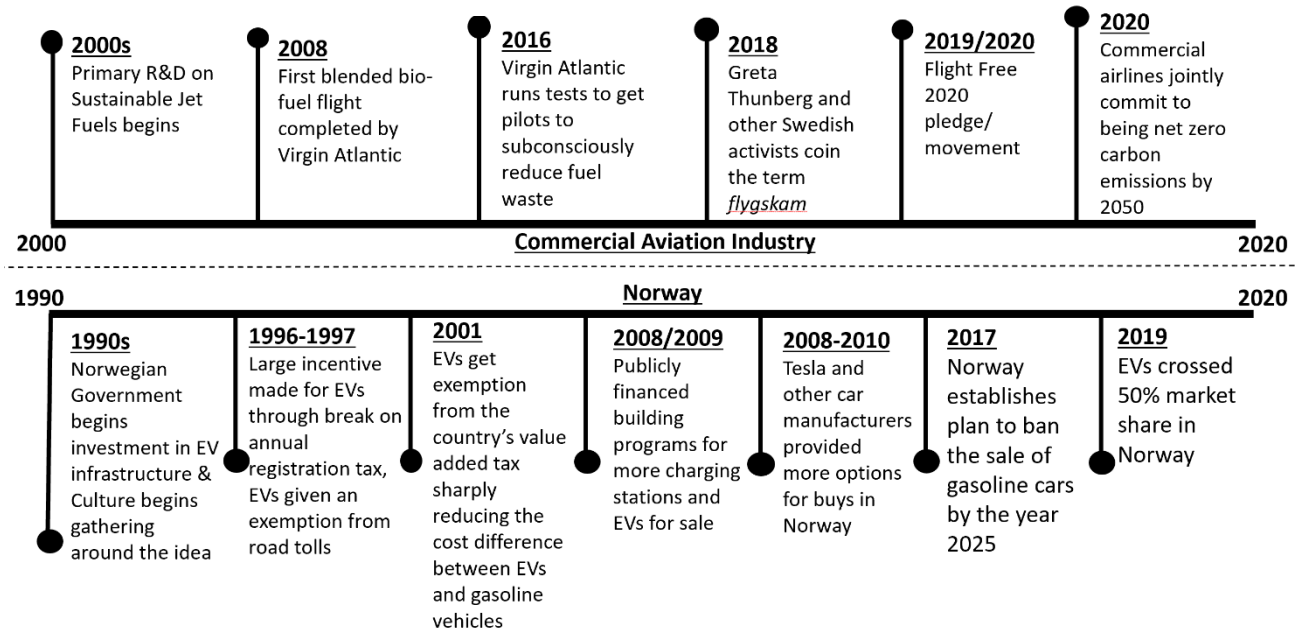
Illustrates position of the commercial aviation industry’s transition towards sustainable practices (Created by Author)

Looking at the phases of the multi-level perspective theory it’s useful to compare the stage each transition is in and the time that each has taken to reach that stage. The commercial aviation industry has the niche innovations, but is lacking a reason to adopt them into the current system. From the original MLP model and more clearly defined in Figure 4, that places the commercial aviation industry’s transition in stage 2 right before the sociotechnical regime opens up to allow for the new innovations to proliferate. That being said, since the barrier to feasibly use SJFs is high, once

they industry reaches stage three (easy adoption of SJFs), the transition should happen rapidly until every commercial airline is using SJFs and has a negligible carbon footprint. The transitory period really began in the early 2000s with the first blended bio-fuel flight being completed by Virgin Atlantic in 2008 (Squatriglia, C., 2008 n.p.). Another large step was taken in 2020 when most of the major airline corporations were pushed to set complete emissions reductions goals of having a net 0 carbon footprint, most of them targeted at 2050. With the first flight being in 2008 we can generally put the beginning of the transition in 2000 and say that it has been going on for 22 years.

Norway, on the other hand, has a market share of EVs that is larger than its gasoline counterpart since 2019. Seeing as it started in the 1990s, the 32-year transition in Norway to being in the fourth stage of the MLP, you can see that the commercial aviation industry is progressing at a slower rate. Figure 5 is a timeline illustration to more clearly depict the ordering of events within each system. While the time lines aren't synced up, it is still useful to have a visual of each of the progressive actions within each system and how long it took to get to the stage they are at now. From the analysis of the overall timeframes, Norway transitioned into stage 4 after 29 years of progression. In order to have the same rate of transition, the commercial aviation industry has 7 years until SJFs would need to proliferate through the industry to about a 50% level.

Figure 5: Timeline of Each Transitory System



The events listed in the previous paragraph gathered into an illustration (Created by Author)

Analysis Derived from MLP and Analogy

Pulling directly from Figure 5, the transition in Norway has a quantitative lead on the commercial aviation industry. Additionally, a majority of the situations are publicly financed by the government or some sort of monetary incentive provided by the government. In each system, there are societal pressures acting in the landscape. In Norway, the government took action on these pressures whereas in the commercial aviation industry's transition, there is no government involvement. This is mainly due to the bipartisanship found in the United States government. There is collective knowledge within most politicians that something needs to be done regarding climate change. The dispute comes whenever politicians try to decide how they are going to achieve that reduction. Some argue that industry regulations are the best way to provide incentives for companies to adopt the niche innovations in the system. The other side thinks that industry regulations only truly hurt the impoverished people within our country and provide

minimal incentive that wasn't already there for the companies. This divide has been prevalent in U.S. history since its inception. Instead of working together to find compromises, the stalemate often forces inaction on controversial issues until there is a forced response at a later time instead of being proactive. Many precedents have been set in the U.S. based off reactionary policy instead of proactive policy. In this situation, the rate at which our climate has been changing should be enough to start making proactive policies and regulations to accelerate the transition of the commercial aviation industry before irreparable damage is done to our planet.

Currently, the aviation industry is run by a small number of companies that are highly regulated by the FAA. Some of the regulations and airplane certifications act in opposition of the transition towards sustainability making it less likely for aviation companies to adopt niche innovations. For example, the only current regulation on fuel by the FAA is in regards to lead in fuel (FAA, n.d.). If there were additional regulations regarding the emissions put out by each aircraft or company, there would be a much larger policy pressure to make a shift towards SJFs. Without a change in regulation, tax exemptions or benefits, and pricing of SJFs, the transition to sustainable aviation will take a considerable amount of time.

The success of the transition in Norway is largely due to the significant amount of public money that was spent on developing the infrastructure and providing tax relief as well as conveniently timed niche-innovations and the backup support of the culture. The support of the Norwegian people enhanced the transition as their system of regional travel made it easier to adopt, and their smaller scale as a country made it more achievable. In the United States, there are pockets of people and specific groups fighting for changes in the commercial airline industry, but there isn't widespread support for decarbonization. The sheer geographic size of the U.S. makes travel by plane the only option for many families living in opposite sides of the country.

Providing tax discounts to customers who choose airlines that have fewer emissions could be a reasonable solution to this issue. However, the large use of public money to spur the transition may not be a possible model in the United States. Norway gains significant public money from their offshore oil operations, which the U.S. does not have, meaning they would need to increase budgets towards providing these incentives for the industry. With the current pace of climate change, it may be worth the investment to have larger government oversight during the transition in order to speed it up and cut emissions significantly.

To increase the rate of transition from the bottom up, significant niche innovations would need to occur which could allow for a cheaper alternative to SJF. However, as shown in Figures 4 and 5 above, the niche-innovations are ready to be used, there's simply more drawbacks than benefits for making the switch. Other ways that SJFs could be realized involve significant changes to policy incentives, capital investments, time, and infrastructure overhaul. Currently, there are no policy incentives for airlines to change their ways from using conventional jet fuel. This could shift in the near future due to the work of social groups lobbying politicians for new policy developments. A working paper on emerging trends in sustainability transitions from the University of East Anglia determined, "civil society groups [are] crucially important actors in sustainability transitions alongside market and state actors" (Hargreaves et. al, 2011, n.p.). The commercial aviation system receives a heavy amount of societal pressure, but is lacking in landscape pressures such as market and state actors, causing the transformation to happen slower than it could be. The addition of stronger landscape pressure could be just what the system needs to jump to the next stage of the MLP allowing for widespread adoption of SJFs.

One major landscape change that's currently happening is the war between Russia and Ukraine. The war has caused Russia's oil supply to be removed from the market, driving up gas

prices globally as the supply has significantly decreased. The increasing gas prices could open up an opportunity for commercial airlines to test out new SJF technology as shown at the top of phase 2 in figure 3. This could push the aviation industry towards SJF as the prices equalize with that of generic jet fuel allowing for airline companies to test the use of SJFs in their aircraft allowing them to develop better budgets for the future and therefore make the transition at a quicker pace. The pressure put on the gas market currently could provide enough pressure to increase the rate of the transition towards SJFs significantly especially depending on how long the gas prices remain at such a high level.

Conclusion

The transition of the commercial aviation industry seems to be in the 2nd stage of the MLP theory whereas Norway's transition to EVs is in the 4th and final stage. The quick transition seen in Norway was largely funded by public money and government tax exemptions providing incentives for both car producers and consumers to make the switch to EVs. Without significant changes to the regulations within the commercial aviation industry or other larger landscape pressures, SJFs will remain an unfeasible option for a while. Currently, there are no real incentives for the aviation industry to switch to sustainable practices other than brand image and identity. The main leader in this front is Virgin Atlantic, making large strides towards sustainability and creating an internal pressure on the market to make changes sooner.

As the system is constantly fluctuating, factors could change at any moment in time that could create large jumps in the transition. This paper can be used to provide a measuring point and analysis of the current actors pushing the transition of the commercial aviation industry forward and those not currently involved. The industry is on the verge of adopting SJFs at a higher extent than in the past but it still needs a pushing factor to get into the next stage of the

MLP. Hopefully the analysis provided can get the conversation started to generate more pressure on the industry or get the government to provide incentives in order to accelerate the transition. Similar transitions need to occur in all industries in order to counteract the effects of global warming and using this paper and past transitions can help accelerate those that are happening now and will be in the future.

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