

e-Mopoli Project

A Feasibility Study in Kainuu



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Invitation text

The Regional Council of Kainuu, project partner 6 of the Interreg Europe project eMopoli, is implementing a feasibility study (FS) focusing on the development of alternative mobility in Kainuu.

The purpose of the feasibility study is to reach insights and make recommendations about optimal options promoting the utilisation of electrical and in general alternative mobility.

The expert carrying out the feasibility study is the University of Oulu, MITY unit in Kainuu. The University of Oulu expert, Tuomas NISKANEN, will be contacting Kainuu stakeholders and will seek their inputs to the following issues:

- (1) Optimal solutions for planning a cost-efficient network of alternative fuels service stations, differentiating between through traffic and internal road networks, in view of integrating the alternative fuels network into the regional land-use guidelines.
- (2) Optimal solutions for promoting electrical and other types of alternative fuels vehicles in the public and private sectors.
- (3) Discussion of the environmental benefits and CO2 emissions savings from the utilisation of projected local and tourism-based alternative fuels.
- (4) Understanding the bottlenecks of Kainuu based actors to acquire and / or modify their current vehicles to utilise alternative fuels vehicles (electricity or bio-gas).

The Regional Council of Kainuu is requesting the cooperation of all the stakeholders that will be contacted to give contributions. The process and results of the feasibility study will be presented to the regional stakeholders and the options agreed, will become part of the regional strategy and of the forthcoming structural funds programme. The purpose is to attach concrete project criteria & funding to such recommendations.

1. Preview

This report is likely the first report in Kainuu after five years which collates data about alternative fuels vehicles and performs ideas and concepts how alternative fuels as driving power (transport fuels) can be promoted in Kainuu.(1-3) All vehicles from a farm tractor to a club car are observed. This report observes biodiesel, bioethanol, biogas, electricity and hydrogen as alternative fuels in Kainuu. Main focus is on biogas and electricity. This report presents many ideas how alternative fuels could be increased and carbon dioxide emissions could be decreased in Kainuu. The report presents how little carbon dioxide emissions has decreased in traffic in Kainuu from 2009 to 2020 but luckily the report gives a clear road map to save emissions in traffic from 2020 to 2030.

This report has been prepared in meetings with Kainuun Liitto on 31th of October and 3rd of December in 2019. The material of the report is based on public sources and interviews. Operators from farmers to semi-public institutions were interviewed in Kainuu by calls. Besides, stakeholders of this project were interviewed in the meeting at Kainuun Liitto on 14th of January in 2020. The feedback session of a draft report was with Kainuun Liitto on 5th of February in 2020.

This report is reader-friendly because important sentences has been jumped out from the text.

2. The desk research section

Alternative fuels vehicles in Kainuu

There are over 65 000 vehicles from a light club car to a heavy dumper in Kainuu and most of them use petrol or diesel fuel as driving power.(Table 1) There are over 80 plug-in hybrid electric vehicles (PHEV), 40 ethanol vehicles and 30 electric vehicles in Kainuu. Most of PHEV and ethanol vehicles are cars and 10 of electric vehicles are electric cars. There is not any heavy vehicle which uses alternative fuels in Kainuu.

Table 1. All vehicles and their driving powers in Kainuu. Source (4).

Fuel	The number of vehicles
Petrol	36362
Diesel fuel	29063
Petrol / Electricity	65
Petrol/Ethanol	41
Electricity	31
Diesel / Electricity	21
Light fuel oil (kerosene)	19
The others	21
Sum	65623

Alternative fuels stations in Kainuu

While the energy report of Kainuu was written in 2014, there were not any bioethanol, biogas or charging station in Kainuu.(2) Five years later, vehicles can be refilled with bioethanol in Kajaani and electric cars can be recharged in five municipalities in Kainuu.(Table 2) So alternative fuels are spreading into Kainuu but still there is not any biogas station and the charging network is small in 2020. East Kainuu is a black area still (Figure 1) but for example Kuhmo (a municipality in eastern Kainuu) is interested in charging points and potential of farm biogas.(5)

Table 2. Normal and alternative fuels stations/charging points in Kainuu. Sources (6-12).

Fuel	Hyryn-salmi	Kajaani	Kuhmo	Paltamo	Puolanka	Ristijärvi	Sotkamo	Suomus-salmi	Sum
Diesel, Petrol	2	13	2	2	2	1	8	4	34
Biodiesel	0	0	0	0	0	0	0	0	0
Bioethanol	0	1	0	0	0	0	0	0	1
Biogas	0	0	0	0	0	0	0	0	0
Electricity*	0	7	0	1	1	0	5	2	16
Hydrogen	0	0	0	0	0	0	0	0	0

*Numbers do not tell how many cars can be charged per charging point, usually it is 2 cars per point.



Figure 1. Only bioethanol station of Kainuu (the flower) is in Kajaani. Electric charging points (lightnings) are in five towns in Kainuu. Sources (8, 12).

Legislation relating to alternative fuels at national, regional and EU levels

The regulation plays a big role. The German E-mobility report in 2020 says: "So far, this structural change is driven mainly by government regulation and not so much by market forces".(13)

European Union. Directive 2014/94/EU (the deployment of alternative fuels infrastructure) recommends:

1. Public compressed gas stations in city clusters before the year 2021. Allowed maximum distance between stations is less than 150 kilometers.
2. Public liquefied gas stations on TEN-T roads. Allowed maximum distance between stations is less than 400 kilometers.
3. A methane station in every large harbor on sea and inland water.
4. One charging station per ten electric cars and 10% of charging stations are public.(14)

Sections 1-3 does not touch in Kainuu because there are not any city cluster, TEN-T road or large harbor in Kainuu. Section 4 has been carried out in Kainuu because there are almost as many charging stations as electric cars in Kainuu and over 10% of charging stations are public or semipublic.(4, 8)

Revised directive 2018/2001 (*RED II, the promotion of the use of energy from renewable sources*) sets: "The share of renewable energy within the final consumption of energy in the transport sector is at least 14 % from 2005 to 2030 (minimum share)" but Finland's goal is 30 % by 2030.(15, 16)

Revised directive 2009/33/EC (*the promotion of clean and energy-efficient road transport vehicles; shortly the clean vehicle directive*) is very ambitious.(17-19) This directive takes effect in the national law on the first of August in 2021 or earlier. This directive controls public purchases in municipalities, and it highlights electric vehicles. It shows that electric vehicles are in own category and the other alternative fuels (biodiesel, hydrogen, natural gas) are in another category. In principle, the directive touches every municipality in Finland but maybe small municipalities get relief in the countryside (20). If a municipality buys a passenger car, it must be a plug-in hybrid or an electric car, and only electric cars or hydrogen cars are allowed after 2025. If a municipality buys city buses before 2025, 41 % of buses must use 100 % alternative fuels and half of them must be electric buses. The percent is 59 % after 2025 and the demands are the same. If a municipality buys trucks before 2025, 9 % of trucks must use 100 % alternative fuels and the same number is 15 % after 2025. There are also similar targets for refuse trucks but the targets of refuse trucks are not known yet.

About public purchases in municipalities and their institutions like SOTE and KAO.
The clean vehicle directive demands that the part of vehicle investments is in electric vehicles after the year 2020. This demand brings a big challenge for

EU has also two very ambitious targets for the auto industry:

- By 2021 at the latest, the CO₂ emissions of all newly registered passenger cars in the EU are to be reduced to 95 g/km on average. This standard will already apply to 95% of all newly registered cars in 2020.
- By 2030, the average CO₂ target will be reduced by another 37.5% compared to 2021 (with an intermediate target of -15% by 2025). This is equivalent to just above 59 g/km¹ or an average consumption of 2.6 litres of petrol for a distance of 100 km.(13)

EU has the directive 2018/844 on the energy performance of buildings. This takes effect in the national law on March in 2020.(17) The directive sets when charging points must be installed on parking places of buildings. The directive causes an action if the size of a parking place is over 10 cars, the renovation touches the parking place or the electricity system of a building and the costs of charging places must be less than 7 % (all of these conditions must be met before the owner of building must think about charging points).

EU published *Green Deal* in the beginning of 2020 where EU want to be carbon neutral in 2050 and it uses money over one thousand billion euros for green technology.(21) Companies can utilize this money.

Finland. Finland has targets which have been written by law.(22) The distribution obligation of biocomponent in transport fuels has been set. The biofuels' share of transport fuels rises in a linear fashion from 20 % to 30 % from 2020 to 2030.

The previous Finnish Government (called Sipilä's Government, in 2015-2019) set a target for numbers of biogas cars (50 000) and electric cars (250 000) including battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV) and hydrogen vehicles (H₂V) in Finland by 2030.(14) If the target is shared to

Kainuu after population, it is 670 biogas cars and 3 350 electric cars approximately in Kainuu by 2030. The previous government decided to support buying of electric car and conversion of petrol car to a flexfuel (ethanol) car or gas car. The support is valid in 2018-2021.

Actually, Finland may have higher targets than written in the previous chapter. It is carbon neutral Finland, which The Finnish Government (in 2019) has written in the government program.(23, 24) If Finland want to be carbon neutral by 2035, it demands a lot of biogas, electric and even hydrogen passenger cars. Unfortunately, the Government does not define what carbon neutral Finland means in the program but luckily VTT presents a few scenarios. A scenario demands 138 000 biogas cars, 730 000 electric cars (included plug-in hybrids) and 20 000 hydrogen cars by 2030.(23) That means 1 850 biogas cars, 9 800 electric cars and 270 hydrogen cars in Kainuu by 2030.

If Kainuu wants to be carbon neutral by 2035, the target demands 1 850 biogas cars, 9 800 electric cars (included plug-in hybrids) and 270 hydrogen cars in Kainuu by 2030.

The Finnish Government (in 2019) set new targets (suggested only, not implemented) in traffic:

1. Sustainable biogas is accepted as biofuel in the biofuel commitment.
2. Housing companies must install a charging point of electric car while they have a large renovation in the building/buildings.
3. Whoever the resident of housing company or rental apartment demands a charging point, the company must install the charging point.
4. Refilling stations must install a certain number of charging points.
5. A biogas tractor can be registered as a traffic tractor.
6. Air traffic tries to achieve 30 % biofuel commitment by 2030.(24, 25)

These provisions contribute to strengthening the biogas alternative fuel market in Finland, therefore for the medium run, biogas, as an alternative fuel, appears a good investment option.

The Finnish Government planned a biogas program in 2019 (24) and the program was published in the beginning of 2020 (26). The program suggests more investment supports, more regulation, more standards, cooperation between biogas operators, biogas as biocomponent in the distribution obligation, a biogas tractor as an acceptable traffic tractor, biomethane tax and so on. This is a clear signal from the Finnish Government – biogas is one part of change towards alternative fuels in traffic.

Kainuu. Kainuu has a general target to decrease 25 % greenhouse gas emissions from 2009 to 2020 (27) and the emissions caused by traffic in Kainuu are expected to decrease approximately 17 000 tons CO₂ eq from 2009 to year 2020 (3). 17 000 tons CO₂ eq is ~7,7 % of traffic emissions in Kainuu in 2009 and it means 210 kg CO₂ eq per person. Kainuu has only reached the fraction of 17 000 tons CO₂ eq.(Chapter: CO₂ emissions by traffic in Kainuu in 2009, 2020 and 2030) Unfortunately, there has not been any real climate action to save traffic emissions in Kainuu between 2009-2020.

There was not any “green vehicles” in Kainuu in 2009. There are over 80 plug-in hybrid electric vehicles (PHEV), 40 ethanol vehicles and 30 electric vehicles in Kainuu in 2020.(Table 1) That is only 0,23 % of vehicles in Kainuu. Kainuu does not have a new climate strategy after 2020. Could traffic play more

remarkable role in the next of climate strategy of Kainuu? The next climate strategy of Kainuu is preparing in 2020 by Kainuun Liitto.(28)

Kainuu is “a backrunner” of alternative fuels. Kainuu would be the forerunner if there were over 150 biogas cars and over 400 electric cars (included plug-in hybrids) in Kainuu.

The national law follows EU’s directives and sometimes the national law is more ambitious targets than EU. Are targets unpleasant rules for Kainuu or a nice driver towards alternative fuels in Kainuu? Two remarkable national laws are coming in 2020 and 2021 and they are caused by EU directives (Clean vehicle and Energy performance of buildings). The laws touch municipalities and their institutions, all kind of buildings and housing companies. The laws can mean a lot of new electric vehicles and new charging points in Kainuu in next decades. There are over 500 housing companies (writer’s estimation) in Kainuu which can mean 500 - 2 500 unpublic charging points in Kainuu in next decades if the plan of the Finnish government is implemented. A housing company can install even five charging points without any heavy change in the electric system.(29) EU directive recommends 10 % of charging points to be public.(14) If Kainuu follows the plan of the Government and unpublic charging points spread around Kainuu, that also means even 250 public charging points in Kainuu in the next decades because EU recommends 10 % of charging points are public. Whatever the truth, Kainuu needs all possible charging stations to fulfill the government target of 3 350 electric cars in Kainuu.

3. The field research section

About 50 people from a private person to a fuel retailer were interviewed about alternative fuels. It is difficult to draw strong conclusions because the sample is small but the survey produced many ideas to promote alternative fuels in Kainuu.

Private people. Private people were asked which is the most important factor them to invest an alternative fuel vehicle. Factors were costs, ecologic, local fuel, practicability and curiosity. Costs were the most important factor.(Figure 2) One of fifth of private people tells ecologic to be the most important factor. Nevertheless, private people are not curious about alternative fuels in Kainuu.

There was also the question to private people which factors promote and boost to invest alternative fuel vehicles. Factors were more news/info, better technology, more stations, tax free and better investment supports. Many private people wait the development of alternative fuels vehicles or “money carrots” (tax free, investment support). Of course, private people recognize there are not stations or charging points in Kainuu. Private people do not miss more news or information about alternative fuels. The small part of private people also hopes long-term decisions by politicians.

Farmers. While farmers are very interested in biogas production, they miss more money and more concrete information. There is not concrete information because there are few “biogas farmers” in Kainuu and no “biogas farmer” produces traffic biomethane. Farmers are exceptional group – they are very curious about biogas and traffic biomethane. That is seen in innovative ideas what they told in the survey. Innovative ideas are presented in 4th chapter (An analysis of data section).

KAO (Kainuun ammattiopisto). They see ecological imago as very important. (30) They think that it is good to invest electric cars. They think electric cars to be a good advertisement and to make imago good. They invest electric cars although they are not the cheapest choice. KAO was once the first technical colleges which educated to maintain electric cars.(31) KAO is interested to produce traffic biomethane in Seppälä but they know their volume is too small. KAO has had two biogas reviews.(30)

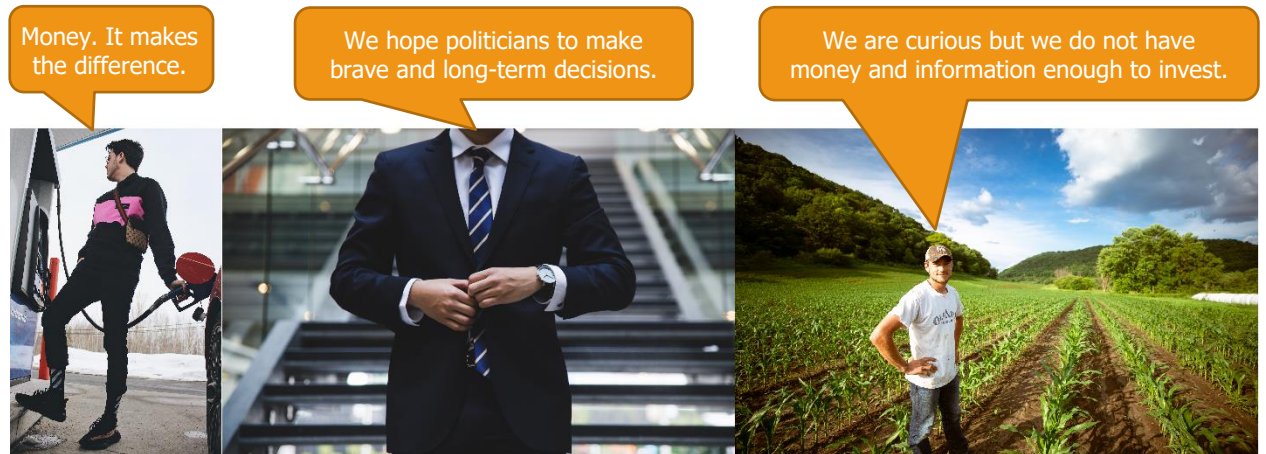


Figure 2. Consumers, biogas experts & a big fuel retailer and farmers in Kainuu and their opinions about alternative fuels. Source is the field research by this report. The picture source is unsplash.com.

Kainuu's SOTE (Kainuu Social Welfare and Health Care Joint Authority). They have thought about alternative fuels but it is very difficult to implement them because vehicles are driven around Kainuu and all the time.(32) SOTE has installed charging points on the new hospital and they have the expansion capacity of charging points if they become very popular. Only the food service is potential to use electric cars because driving range is not so large but the food service needs vans and electric vans are not so common. Biogas is not alternative because Kainuu's SOTE is in the front of revolution. Namely, the clean vehicle directive demands a passenger car to be a plug-in hybrid or an electric car, and only electric cars or hydrogen cars are allowed after 2025. It is the same situation with school taxis.

Transport companies and taxis. They are like private people. They are not interested in alternatives fuels and costs are the most important factor. Part of respondents are very skeptic and they said: "Electric vehicles are more common in Kainuu after 20 years". Only one heavy machine entrepreneur thought in a different way. He thinks that it is good to invest electric cars (light vehicles) because it makes imago good. Nevertheless, he thinks electricity not to work in heavy vehicles.

The mining company, Terrafame. They think costs to be the most important factor in alternative fuels.(33) The cost level must be predictable and this is linked to long-term tax incentives or another supports. Terrafame also values ecological issues, practicality and the technology level.

Tourism entrepreneurs. They are very interested in installing charging points and they have even installed them. Entrepreneurs miss more information about charging of electric cars and better an investment support. One of entrepreneurs said: "You must install charging points despite of all factors because tourists move with electric cars". Charging data in Kainuu confirms tourists to use electric cars really – There are charging peaks in holiday seasons.(29)

Biogas experts. In opinion of biogas experts, biogas technology is in a good level. They miss biogas stations in Kainuu. They wondered why electric cars are reported so much although technology is not fully developed. They think reporting to be important but it should be many-sided. There was a special hope: "Politicians should be brave and run a risk". For example, a long-term tax incentive could make alternative fuels more common. The Norway is the good example of heavy subsidies: "-- *almost 56% of total new car registrations during the first three quarters of 2019 were for electric cars, compared to only 2.6% in the EU as a whole* --".(13)

Politicians. This report sent questions about alternative fuels in traffic for 43 politicians in Kajaani city council. Only four politicians answered. The first respondent was careful and sceptic a little bit. The second respondent liked gas buses and traffic biomethane generally but he thought electric cars or buses do not work in cold are. The third answer was very positive and the writer felt the respondent to have read this report. The message was Kajaani city council included leading office-holders to have a positive attitude to gas buses. The fourth respondent see that biogas and electric vehicles comes sooner or later.

Fuel retailers. Answers depend on a respondent whether he/she represents a small entrepreneur or a big group.(34, 35) The small entrepreneur says: "There is not money to invest alternative fuels" and the big group says: "*Prices rise if we share our alternative fuels share around Kainuu*". And the big group continues: "*Electric car charging is not business. Electric car drivers only charges their cars in traditional filling stations in emergency cases. Electric car drivers charge their cars there where they stay for a long time like at home or in the workplace.*". The big company also looks at the world and political decisions globally. According to the big company, the political field is too turbulent nationally and globally which does not help to prevent the climate change. Unfortunately, the lack of long-term decisions causes the complete opposite as the fight against the climate change – Oil exploration investments are larger than biofuel investments globally.

St1. The report asked the big retailer called St1 about biogas station/production in Kainuu.(36) The clear message was: "*Gas vehicles must be before the station*". St1 would like to share biogas in Kainuu because ecological values are very important. St1 suggests: "*Let's make a gas vehicle deal (commitments) with transport companies and municipalities. This is way how it has been acted in Vaasa and in Hämeenlinna.*". St1 is finding out utilization of biogas in Kajaani and in Hämeenlinna which is formed by bioethanol production. Kajaani's bioethanol plant produces 1 100 000 m³ biogas per a year (37), which is equivalent to 550 000 m³ 100 % traffic biomethane (5,5 GWh) and this "feeds" ~550 passenger cars in a year (38).

How are St1 and bioethanol stations in Kainuu? St1 does not found new bioethanol stations in Kainuu in 2020s.(36)

The bioethanol plant of St1 produces 1 100 000 m³ biogas per a year and it would feed ~550 passenger cars in a year as refined into traffic biomethane.

Neste. Neste has a plan to bring biodiesel (Neste My) in Kainuu even in 2020.(39) Neste opened 70 new biodiesel stations in Finland in 2019 and they have the plan to spread biodiesel network still. Ecologic is the most important factor to spread biodiesel network by Neste. Neste hopes people could compare foot

prints of alternative fuels and choose suitable for themselves. Neste says: “*Investment supports must be equal for every alternative fuel and no support for projects which would not be implemented without supports*”. Neste refers to Sweden’s tax system which is more rewarding than Finland’s tax system, and hopes the same system into Finland.

Gasum. Gasum has surveyed the biogas situation in Kainuu pretty much.(40) According to Gasum, there is not enough raw material for biogas production. Gasum hopes whether St1 bioethanol factory grows or Kaicell Fibers is found in Paltamo. A biogas plant is profitable if its size is at least 30 GWh. The largest planned biogas plant is 15 GWh in Kainuu.(41) Gasum would found a biogas station in Kainuu if there were biogas vehicles which used 5 GWh biogas in a year [500 cars (38)]. Gasum encourages to found the biogas station in Kainuu by a third party and Gasum is ready to sell biogas the third party. Gasum referred to the infra support (42).

Doranova. Doranova is on the background of Jepuan biokaasu which is the largest biogas plant in Finland.(43, 44) Doranova was interested in the plan of Ekokymppi’s biogas plant in Kajaani in 2015 (41) and it is still interested in the plan because the amount of raw material is almost 20 000 tons (15 GWh) which is the minimum amount of a profitable biogas plant.(43)

Loiste. They like electric cars, of course.(29) They hopes the attitude to electric cars changes in Kainuu. They remind the battery technology and battery recycling develop all the time and new battery chemical sources are found in the world. The energy company knows the Palopuro case (Figure 7) and they have thought about that but LUKE’s experiences in Sotkamo slow down to make a decision.

4. An analysis of data section

Ideas and concepts (Figure 3) are presented to promote alternative fuels and to produce carbon dioxide emissions savings in Kainuu in this chapter. The chapter also gives the small review of alternative fuels.

Biodiesel vehicles in Kainuu

My-biodiesel (Neste My) can be refilled into every diesel car but Kainuu is still waiting a biodiesel station – Maybe it is coming in 2020.(6, 39) Part of normal diesel is biodiesel which is 60 % foreign biodiesel and it can even be palm oil biodiesel which is not ecological.(35, 45, 46) My-biodiesel is also problematic.(47) The more My-biodiesel is used, the less ‘normal diesel’ includes biodiesel. Why? Since pure biofuels are translated as biocomponent in the distribution obligation. It is known that fuel retailers do not exceed the distribution obligation and they sell extra biodiesel abroad. There is also another questionable thing in My-biodiesel and it is its raw material called PFAD, Palm Fatty Acid Distillate.(48) PFAD is a by-product of palm oil production. My-biodiesel is more expensive than normal diesel.(49)

It is difficult to present a road map of biodiesel cars in Kainuu because it is dependent on Neste. There is not any biodiesel station in Kainuu (Table 2) but it is coming into Kainuu in 2020 or later by Neste (39). Biodiesel could be a good alternative fuel in heavy vehicles like buses and trucks.

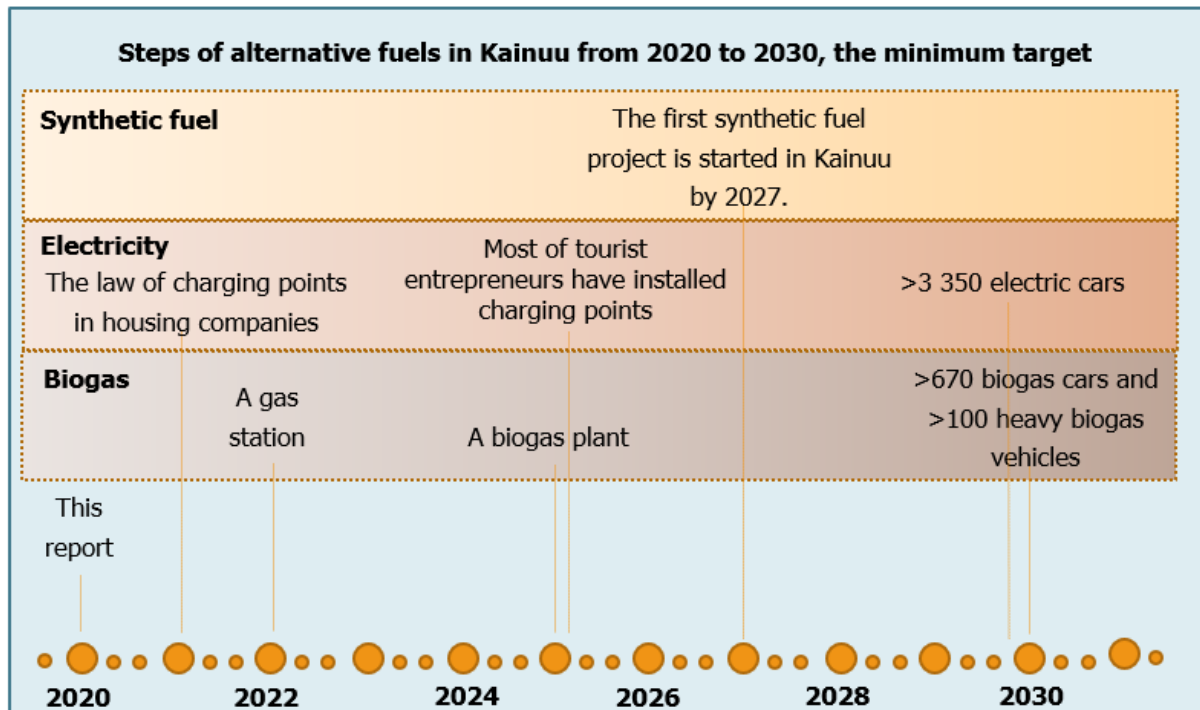


Figure 3. The timeline of alternative fuels in Kainuu from 2020 to 2030.

Bioethanol vehicles in Kainuu

Bioethanol is the most important biofuel in the Europe and in the world.⁽⁵⁰⁾ Unfortunately, most of bioethanol is produced from corn. Luckily, there is innovative bioethanol (RE85) in Finland.⁽⁵¹⁾ That is biowaste-based or even wood-based. The situation is changing in Europe now because EU's directive does not like food-based bioethanol.^(16, 50) This causes a new market potential in the bioethanol production and it might speed up the extension of Kajaani's bioethanol plant (the writer's speculation). Earlier bioethanol has only been used in light vehicles but now it can also be used in trucks.⁽⁵⁰⁾ ED95 bioethanol fuel can be used in trucks and the ethanol content is 92 %.⁽⁵²⁾

The writer of this report lives in Kainuu and has driven a bioethanol car over one year. Bioethanol (RE85) is not 100 % ethanol, it includes 20 % petrol. Ethanol is a Finnish and waste-based component in RE85.⁽⁵¹⁾ The writer has converted his car from petrol to bioethanol. The investment was small: the car of 1 200 euro and the conversion of 200 euro. So the budget is very suitable for most people in Kainuu. Why bioethanol cars are not common in Kainuu although there is a bioethanol station in Kajaani, it is easy to use a bioethanol car and the investment is cheap? The writer refers to the survey in this report. Ecology are the third important factor averagely, after costs and practicality. Since the ethanol car demands a little bit learning about conversion and driving costs are almost same with diesel fuel or petrol cars, it is not attractive choice to people in Kainuu. Ecology do not win little efforts.

The Finnish Climate Change Panel published the car calculator in 2019 which counts greenhouse emissions and costs of all kinds of cars. The calculator shows a bioethanol car to be more ecological than a petrol car but only a little bit because the bioethanol car is regarded as "the diesel car" by the calculator.⁽⁵³⁾ Why is the ethanol car like the diesel car? The more bioethanol is refilled, the less biodiesel is refilled. Finally reason is same as with biodiesel or bioethanol "replaces" biocomponent in the

distribution obligation. There are still something good in RE85 – bioethanol replaces vegetable oil based biodiesel like palm oil biodiesel and supports national employment.

It is difficult to present a road map of bioethanol cars in Kainuu. There are only 41 bioethanol cars in Kainuu although there is the bioethanol station in Kajaani where there are about 37 000 citizens.(Table 1) It is questionable how ecological and economical bioethanol cars are really. St1 is not bringing a new bioethanol station in Kainuu in 2020s.(36)

Biogas vehicles and next steps in Kainuu

Biogas is a big potential in passenger cars.(53, 54) The Finnish Climate Change Panel says that even 1 500 000 passenger cars could be refilled in Finland by biogas, which is 55 % of passenger cars in traffic. According to Helsingin Sanomat, theoretical maximum is 900 000 passenger cars and realistic number of cars is 270 000 or 10 % of cars in Finland.(55) The writer estimates the number (10 % of cars by biogas) is same in Kainuu. Anyway biogas is a big chance for Finnish economy – Ethically sustainable, money is kept in Finland and you are free from the strategy competition of battery chemicals with China, for example.

Biogas is a big potential in passenger cars. At least 10 % of passenger cars could be driven by biogas in Finland.

Biogas vehicles are ecological and economical.(53, 56) The cumulative biogas car emissions (included manufacturing emissions) are 40-50 % of diesel and petrol car emissions after 15 years (210 000 km). Biogas driver can save 30-40 % money compared to a diesel or petrol driver because biogas (traffic biomethane) is cheaper than equivalent diesel or petrol. Biogas is a wonderful product – it is a local fuel, economical for a driver, improves nutrient cycle in farms, technology is ready and it is as easy to refill as petrol or diesel.

The last “traffic biomethane forecast of Kainuu” published in 2015 and the forecast says there are four biogas producers and filling stations in Kainuu (Kajaani, Puolanka, Sotkamo, Suomussalmi) in 2020 (1) but there is nothing in the beginning of 2020 (Figure 1). Kajaani’s biogas plant was prevented in Kajaani’s political machine.(57) Sotkamo’s project was a bad example how you can build a biogas plant.(58) Suomussalmi forecast touched the farmer Markus Moilanen if he starts to produce traffic biomethane. Actually Markus Moilanen is constructing the biogas filling station in Suomussalmi.(59) Markus also estimated there would be about ten farmers who would produce traffic biomethane in Kainuu if there was not sanctions against Russia. Puolanka is developing the biocentre but it is questionable when they share traffic biogas.(60) Maybe Kainuu has been unlucky with traffic biomethane but now it is time to forget bad experiences and turn over a new “biogas leaf” in Kainuu.

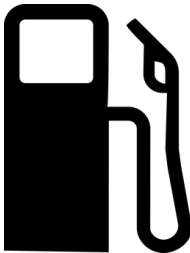
Many respondents in the survey of this report see biogas as potential driving power in passenger cars and in trucks and they told good ideas to remove a chicken and egg situation in Kainuu. Biogas is also potential in farm tractors and hopefully the Finnish government removes legal problems of farm tractors soon.(24)

Maybe Kainuu has been unlucky with traffic biomethane but now it is time to forget bad experiences and turn over a new “biogas leaf” in Kainuu.

The writer asked two biogas car drivers their experiences and they were satisfied. Only disadvantage was the driving range of biogas cars – It is between 300-500 km. How about heavy vehicles? It is not so clear case. The writer has heard heavy vehicles like gas buses to be very accuracy of methane content (>98 %). Gas buses lose their power if the methane content is too little (<98 %). The life cycle of gas buses and gas trucks are more expensive than the life cycle of diesel buses.(61, 62) It is also good to know the refilling of heavy vehicles does not always happen quickly. For example, the gas buses can be refilled overnight.(63)

The profitable biogas station. How does Kainuu get a biomethane station/stations? The answer is commitments with transport companies and “moving” institutions, and the governmental infra support.(40, 64) The profitable biogas station needs 20 refuse trucks or 30 buses or for example 10 refuse trucks and 15 buses (Table 3), and the number of vehicles can be lower in the beginning of station life. There is a nice bonus in the investment of biogas station because the infra support can be applied from Energy Authority.(42, 65) The infra support is given where there is not the natural gas network. The support is 35 % of the investment mostly. Stations, which serve both light and heavy vehicles, get the support easier than basic stations.(66) The investment of a full scale biogas station is about half million euro (67, 68) but the station of this size can only serve passenger cars or few heavy vehicles (63, 66). If the station (compressed gas) want to serve heavy vehicles like refuse trucks too, the investment is about 1-1,5 million euro.(63, 66)

Table 3. The profitable gas station demands next conditions. The investment of the station, which serves light and heavy vehicles, is 1-1,5 million euro.

The quality of commitment	Commitment target	
The gas supplier	5 GWh	
End-users	>20 refuse truck * or >30 buses ** or >500 passenger cars ***	
*70 000 km/year/truck; diesel fuel consumption 40 L/100km (70)		
**44 000 km/year/bus; diesel fuel consumption 40 L/100km (1)		
***1 000 m³ gas/year/car (38); ~14 000 km/year/car		

About city buses. And now it is good to remember that EU directive of “clean vehicles” can direct buses towards electric buses. Kajaani organizes a tender competition for public transport in 2021 or 2022.(69) This report got a message from Kajaani city council that politicians and office-holders have a positive attitude to (bio)gas buses but unfortunately, the clean vehicle directive can destroy this attitude because the directive obligate to invest some electric city bus anyway (19). It is not economic to buy few electric buses. It is smart to invest many electric buses once and maybe even all of them.

The location of the gas station could be in Kettu in Kajaani because it is close to main road (Road 5) and still close to Kajaani’s centre (about 3 km).(Figure 4) The location does not disturb the resettlement area. The ground should be easy to be prepared to the station. The location is only 10 km from Majasaari’s landfill where there could be a biogas plant in the future. The location is 3 km from the bioethanol factory of St1 where biogas is also formed all the time. Besides, the gas station would serve through traffic because the station is in the important road junction (tourists, heavy traffic).(Figure 5)

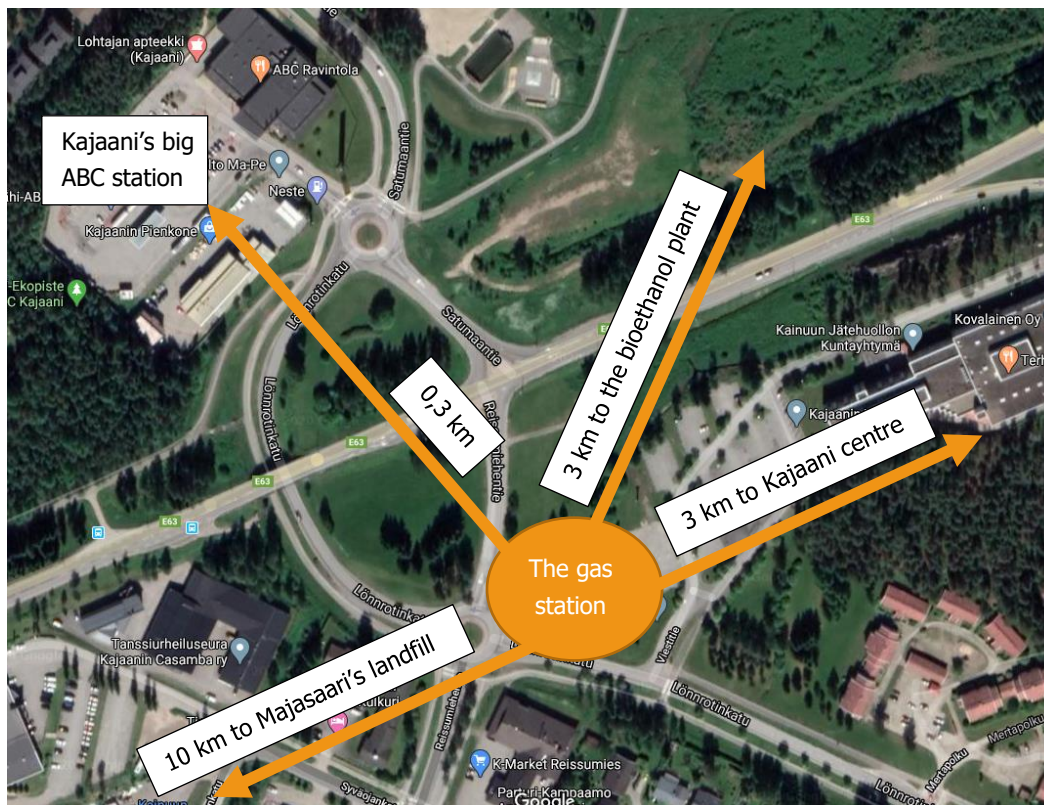


Figure 4. A good location of a gas station could be in Kettu, Kajaani. A big ABC station is very close and it is popular with tourists. A potential big biogas plant is 10 km from here in Majasaari's landfill. The bioethanol factory of St1 produces biogas 3 km from here. And finally this is enough close to Kajaani's centre so that buses, refuse trucks, taxis and local people could refill biogas. The picture is a Google satellite picture.

Could St1 be one shareholder in the gas station? How about Osuuskauppa Maakunta? St1 and Osuuskauppa Maakunta are strong operators in Kainuu and that makes the infra support application reliable. Energy companies have also been activity to found gas stations in Finland.(65) If Loiste does not found any farm biogas plant, could a gas station be a smaller challenge and an easier way to start biogas business in Kainuu?

Natural gas. If Kainuu cannot attract any biogas supplier or found the station and buy biogas, a natural gas station is the last chance. It is not ecological but it removes a chicken and egg situation in gas in Kainuu. Of course, natural gas would be the temporary solution. Since natural gas is a cheaper fuel than diesel and petrol, it makes natural gas very attractive. Natural gas would bring gas vehicles into Kainuu and gas vehicles could bring biogas suppliers and producers into Kainuu.

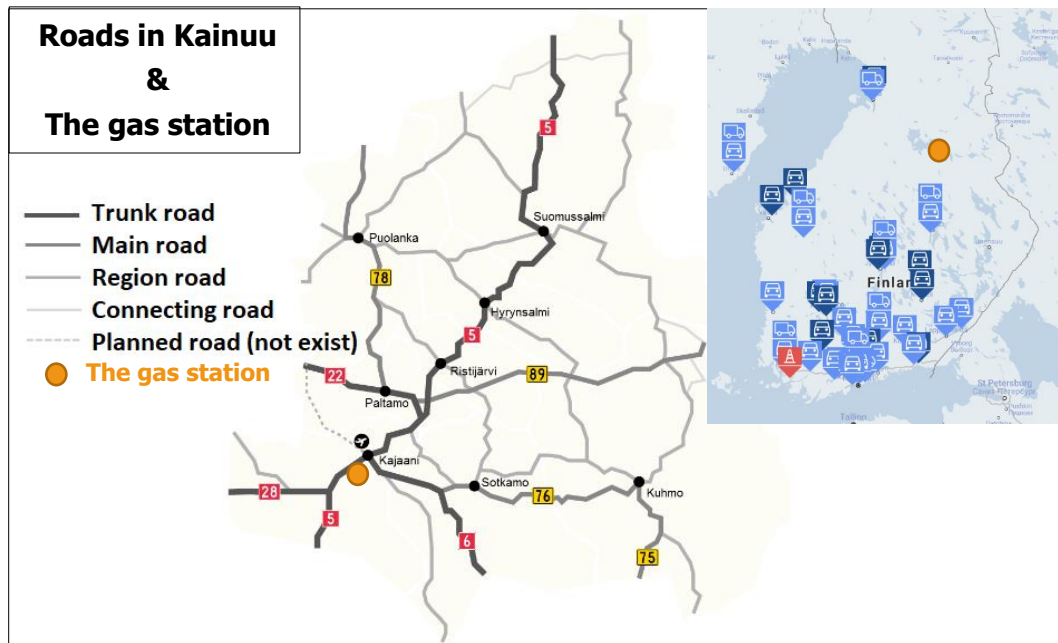


Figure 5. The gas station of Kajaani would be in the important road junction regionally and nationally. The map sources are (7, 72).

A profitable biogas plant in Kainuu. A big competition is starting in the latitudes of Kainuu. The competition is a big biogas plant (>15 GWh). Only one big biogas plant can be found in the latitudes of Kainuu because there is only a limited raw material available (the writer's estimation). If Kainuu is a loser, Kainuu's raw materials, money and fertilizers are transported outside Kainuu. If Kainuu is a winner, Kainuu's raw material, money and fertilizers are kept inside Kainuu.

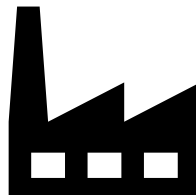
Only one big biogas plant can be found in the latitudes of Kainuu because there is only a limited raw material available. Hopefully, the location of biogas plant would be in Kainuu.

It would have been possible to found a profitable biogas plant in Kainuu (Majasaari's landfill in Kajaani, Ekokymppi) in 2015.(41) The plant would have utilized biowaste and sludge and the investment would have been 10 million euro. The investment cost can be compared to the deal of biowaste and sludge between Kainuu and Gasum. Biowaste and sludge are exported from Kainuu to Oulu and exportation costs are over 1 000 000 euro per year. Let's compared to planned Kajaani's theatre renovation which could be 10 million euro (same costs as the investment of biogas plant).(71) Since the deal between Kainuu and Gasum ends in 2025, it is good to start planning and negotiations of the biogas plant as soon as possible and to start up the plant in 2025. It is known biogas technology has developed much after the investment plan in 2015, so the risk of biogas plant investment is smaller than five years ago. Table 4 presents general numbers which a profitable biogas plant needs.

The original investigation of profitable biogas plant in Majasaari (Ekokymppi) in 2015 is very high-quality and it is modern because for example the part of the decomposition residue would have worked as fertilizer in organic farms.(41) The small problem of the investigation was the normal decomposition residue – The investment report did not find the field area enough where to the decomposition residue could spread. The decomposition residue could solve the "mismatch problem" between animal farmers and plant farmers. The mismatch problem means that animal farmers have too much dung, and plant

farmers do not have dung and they must buy expensive commercial fertilizers. It would be easy to update the investigation and the writer believes farms, Ekokymppi, Envitecpolis (the investigator) and biogas technology supplier/s like Doranova to be still interested in the case.

Table 4. The profitable biogas plant demands next conditions.

The quality of commitment	Commitment target	
Raw material producers	>20 000 tons	
The biogas producer	>15 GWh	
End-users	>60 refuse truck * or >90 buses ** or >1 500 passenger cars ***	
*70 000 km/year/truck; diesel fuel consumption 40 L/100km (70) **44 000 km/year/bus; diesel fuel consumption 40 L/100km (1) ***1 000 m³/year/car (38); ~14 000 km/year/car		

It is a good to remember biowaste and sludge would not be only raw materials in the biogas plant in Majasaari. There is still landfill gas source in Majasaari and gas pipelines are ready there. Dung from farms might be one extra potential and it is good to remember The Finnish Government is encouraging the biogas production towards dung based biogas (43). By the way, there is the dung biogas support in Denmark and in Sweden. It is possible there is the dung biogas support in Finland in 2025 when the plant is found hopefully. Could St1 gas be one of raw materials? Could biowaste and sludge be transported outside Kainuu like from North-Savo?

According to the investigation in 2015, one profitable biogas plant could be found in Kajaani, Kainuu. Now the investigation should be updated because a profitable biogas plant demands a fact-based investigation.

Landfill gas and St1 gas. It is good to remember there are landfills in Kainuu and they release gas all the time. The largest landfill gas source is Majasaarin Kaatopaikka in Kajaani. It releases 5 GWh gas per a year (41), which would feed 500 passenger cars in a year as refined to traffic biomethane (38). The second landfill gas source is Parkinmäen Kaatopaikka in Kajaani (Kuusakoski owns) and it would feed 250 passenger cars in a year as refined to traffic biomethane.(38, 73) Besides, the bioethanol plant of St1 produces biogas in Renforsin ranta all the time which is equivalent to 550 passenger cars (5,5 GWh).(37, 38) Now all of landfill gas and St1 biogas are burnt and that is a cost for companies.

How easy landfill gas and St1 biogas are refined into traffic biomethane? It is problematic a little bit. For example, sulphur content in landfill gas is one problem.(74) Anyway, landfill gas is refined to electricity power in the world and there is a plan to refine landfill gas into traffic biomethane in Finland.(74, 75) Generally, both landfill gas and St1 biogas are too small sources alone for the profitable action.(1, 76)

Two landfills and the bioethanol plant (in Kajaani, Kainuu) produce the amount of gas which would feed 1 300 passenger cars as refined to traffic biomethane.

Farmers as traffic biomethane producers. Farmers are curious about biogas production. Actually farmers are the special group because the other respondents are not curious about alternative fuels. A lack of money and information slow down real actions. Specially traffic biomethane is a big question. A farmer suggested an idea to produce traffic biomethane in Kainuu by farmers and the idea has been supported by the other farmers.(59, 77, 78) The idea is to produce raw biogas in many farms around Kainuu and raw biogas would be transported into a refining plant where raw biogas is refined into traffic biomethane.(Figure 6) The advantage of idea is no farmer to build an expensive refinery unit and filling station but still all of raw gas would be utilized and farmers would get all advantages of biogas production like fertilizer benefits. The problem of idea may be long distances between farmers and the refinery. According to Gasum, raw biogas destroys transport containers and it cannot be compressed.(40) Maybe the next idea is a solution:

There is almost a similar idea in Lapland but collected biogas would refine in the truck which would go round farms.(79) The profitability of the idea is finding out in the project called BiTool.

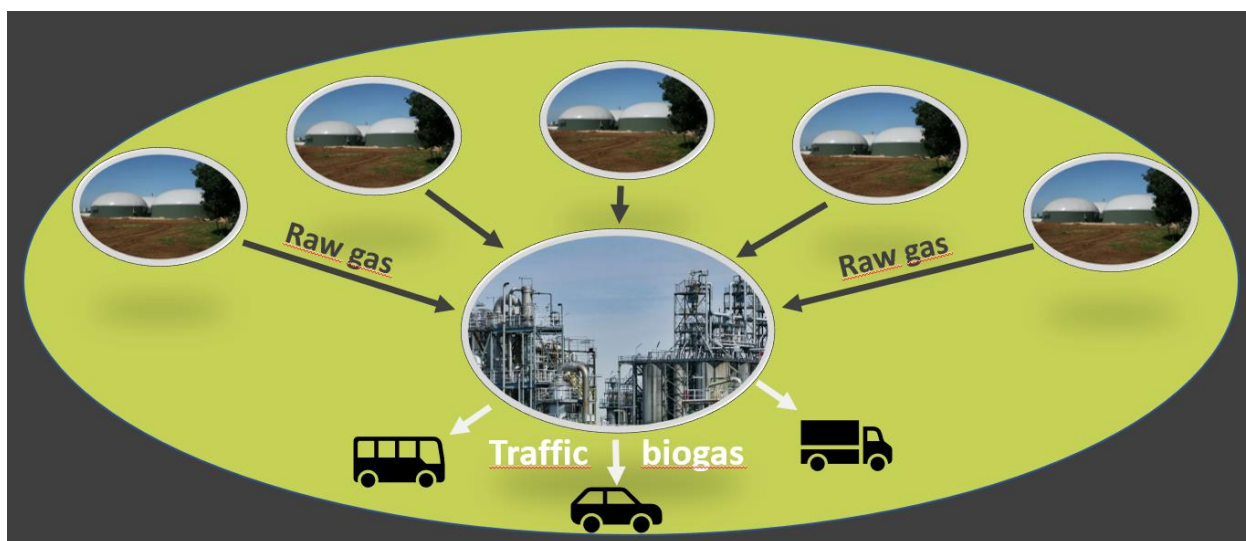


Figure 6. The idea to produce raw gas in many farms and refine the raw gas in one refinery.

The energy company called Nivos Oy and the farmer called Knehtilän tila carried out the biogas plant project together in Hyvinkää in southern Finland in 2018. (80) This case is known as the Palopuro case. Could the Palopuro case be possible in Kainuu? This is a unique case in Finland. Since the system is a circular economy, the term *agroecological symbiosis* is used.(Figure 7) A farmer in Kainuu suggested cooperation between energy companies and farmers although he did not know the Palopuro case. That tells farmers to be ready for cooperation with energy companies and to carry out biogas plants. Are energy companies ready to make a new Palopuro in Kainuu? Palopuro case is known in Loiste (Kainuu's energy company).(29) Palopuro is not only biogas case in Finland where an energy company has been activity.(55)

Municipalities and a concept. Puolanka is a very good example of courage of a municipality in Kainuu.(81) Puolanka has a biocentre project where is a goal to produce biorefinery action in a certain area. One of plans is a biogas plant in the biocentre. The writer hopes the other municipalities of Kainuu to be as active as Puolanka in alternative fuels. If the neighbour country Sweden is looked at, it is

common a municipality to found a biogas plant and invest biogas buses at the same time.(14) That is the secret why traffic biomethane is so common in Sweden. It is good to remember that likely EU demands greener public transport soon.(82) Is there political courage in Kainuu? Could Puolanka be the first municipality which shares traffic biomethane in Kainuu? Unfortunately, the clean vehicle directive highlights electric vehicles and this can leave only one alternative for municipalities.

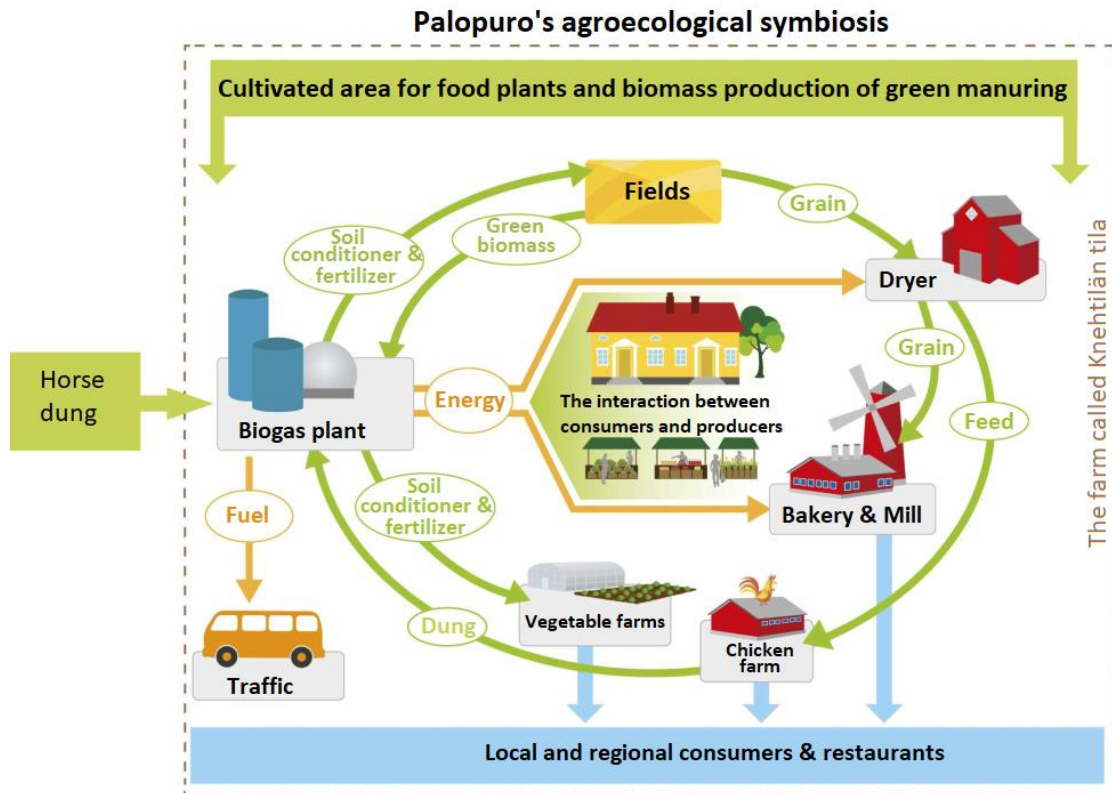


Figure 7. The energy company (Nivos Oy) and the farmer (Knehtilän tila) carried out a biogas plant in Hyvinkää in southern Finland in 2018. The case is unique in Finland – it is agroecological symbiosis. The picture is from Elina Virkkunen, LUKE.

Electric vehicles and next steps in Kainuu

According to the Finnish Climate Change Panel, cumulative electric car emissions are 40-50 % of diesel and petrol car emissions.(53) On the other hand, there are more critical estimations of electric car emissions. One estimation says that cumulative electric car emissions can be same as fuel-efficient diesel car emissions.(83) Electric car driving produces emissions because electricity is not zero-emissions. How ecological electric car is, it is dependent on how electricity has been produced. Average electricity emissions are 200 g/kWh in Finland.(84) Renewable electricity is zero-emissions like solar, wind and water power. Correspondingly, electricity emissions can be awful if it is produced by fossil fuels. Another problem with electric cars is ethic because most of cobalt is mined in Africa by child labor.(85) Cobalt is also a strategy question for western countries because China owns African cobalt mines. The third problem with electric cars is the amount of battery chemicals. If the present battery technology does not change, present battery chemicals run out sometime in the future.(86)

Cumulative electric car emissions are 40-100 % of diesel and petrol car emissions depending on the calculation. It is good to remember that electric cars also includes ethic problems.

Private people and electric cars. It shows electric cars to be the easiest and fastest way to decrease CO₂ emissions in light traffic because only electric cars are needed and you can charge them with a normal electric plug anywhere you can find plug point at home, in the workplace and so on.(87) Electric cars are a niche phenomenon in Europe apart from Norway where the government uses heavy subsidies.(13) The German e-mobility report (in 2020) claims the popularity of electric cars to be very dependent on governmental subsidies. The writer of this report also sees another chance: increasing cheap electric cars like Seat Mii Electric of 16 000 euro (88) can change the situation totally from a niche phenomenon to a real phenomenon. It is good to remember driving and maintaining costs of electric cars are very small compared to diesel or petrol cars. 'Electric fuel' is ~70 % cheaper than diesel or petrol, and for example there are not oil change costs in electric cars. Private people follow costs independent on what kind of car is. Of course, the driving range of electric car follows the price. The cheapest electric car works 250 km with one charging in easy conditions. Another disadvantage of cheaper electric cars is towing a trailer – That is not possible.(89) By the way, annual kilometers of electric car drivers are bigger than annual kilometers of petrol car drivers but not so much as diesel drivers'.(90)

About charging electric cars. 40 % of electric car drivers charge their cars along a normal plug at home.(90) Electric cars are wise - They take power as much as possible but not too much or fuses do not blow. The newest Finnish e-mobility survey (in 2020) reveals that private people hates public and commercial charging points and they charge their cars at home or in the workplace.(90) Actually, the most important reasons to buy an electric car is charging at home and ecologic. Public charging points does not play remarkable role with electric car drivers. People hates public charging points because points are very complicated to use.(90) Money is not problem but it is that you must register in somewhere and give your credit card information. It shows people needs charging points there where they stay for a long time (many hours). The plan of the Finnish Government to oblige housing companies installing charging points is very welcome. The writer asks if charging points are in right places in Kainuu. The writer also asks where tourists need charging points – Only there where they stay overnight?

Tourism entrepreneurs and charging points. There are few tourism entrepreneurs in Kainuu who have installed charging points. Are charging point installations late in tourist centres in Kainuu and Kainuu is losing tourists? An entrepreneur estimated charging points can bring tourists more into Kainuu because Kainuu may be a rest stop before Lapland.(91) Tourist entrepreneurs have to also serve electric snowmobiles in the future. Why do not tourist entrepreneurs install charging points? Tourist entrepreneurs do not install charging points because they do not know about charging and charging points enough. A solution idea: the meeting where an entrepreneur told the other entrepreneurs about experiences of charging points. And besides the joint procurement of charging points could be organized into tourist entrepreneurs in Kainuu. Two birds would be killed with one stone: more information and a lot of new charging points in tourist centres in Kainuu.

Electric vehicles in municipalities and a EU's directive. The directive on *the promotion of clean and energy-efficient road transport vehicles* sets interesting challenges in municipalities and their

institutions like SOTE and KAO. Municipalities and their institutions must invest electric cars, electric vans and electric city buses after the year 2020.(17-19) Hopefully, this directive brings electric vehicles into Kainuu as soon as possible because experiences of electric vehicles are needed in Kainuu. The writer sees the lack of experiences with electric cars as the barrier of coming of electric cars in Kainuu. That is why the clean vehicle directive is good. It obligates municipalities and public/semipublic institutions to invest electric cars, which removes myth of electric cars and increase experiences with electric cars in Kainuu. People can see themselves if electric cars work in winters and it is easy to use them.

Let's observe city buses a little bit. The first electric buses can be seen in Kajaani in 2020s because Kajaani organizes a tender competition for public transport in 2021 or 2022 and the clean vehicle directive is valid in 2021.(69) The price of an European electric bus is ~420 000 euro (diesel bus is ~240 000 euro) but the price of Chinese electric bus is between 260 000 and 320 000 euro (92). Chinese electric buses has been bought into Finland.(93) The range of Chinese electric bus is 200 km in difficult conditions (cold winter).(94) The conversion from a diesel bus to an electric bus costs as much as a new diesel bus.(95) One charging point of buses costs 250 000.(61) By the way, a gas bus costs 270 000 euro and a gas station of buses costs 1 500 000 euro.(61) If the life cycle costs with operation costs (salaries, motor vehicle insurance, etc.) of alternative fuel buses (biodiesel, biogas, hybrid, electricity) are compared to traditional solution (diesel buses), they are 1-11 % higher than traditional one .(61) The European electric buses are about 5-6 % more expensive than diesel buses. The biogas buses are about 11 % more expensive than diesel buses unless the number of biogas buses is dozens.

Chinese electric vehicles and the clean vehicle directive have shaken alternative fuel market and they can cause the new revolution of electric traffic.

Hydrogen vehicles in Kainuu

Hydrogen is coming as driving power in light and heavy vehicles but nobody knows what is real timetable at the big scale.(96-98) Hydrogen can be refilled in Sweden (Figure 8). Hydrogen is also a component in synthetic fuel production and synthetic fuel technology are developed in Finland.(99) Many things slows down hydrogen coming and it is not used much in vehicles because it is not cheap and particularly traffic hydrogen technology is not ready. Hydrogen is not ecological because most of it are prepared by fossil fuels but the European Green Deal can change the situation in Europe (100) and the situation is changing (101). The clean vehicle directive does not highlight hydrogen – Hydrogen is one of alternative fuels like natural gas.(17) Nonetheless, hydrogen is seen as a potential driving power in heavy vehicles.(97, 102)

VTT has planned in the national road map of traffic hydrogen in 2013 where is one hydrogen station in Kajaani in Kainuu.(103) The road map is still a road map and there is not any public hydrogen station in Finland.(102) There is not the word *hydrogen* in the program of the Finnish Government in 2019 although Finland has promoted hydrogen in EU, and VTT (Technical Research Centre of Finland Ltd) develops hydrogen technology.(24, 104, 105) It shows that hydrogen as driving power is faraway in Kainuu and even in Finland in 2020s. Nonetheless, hydrogen cars are mentioned in scenarios of carbon neutral Finland by VTT.(23)

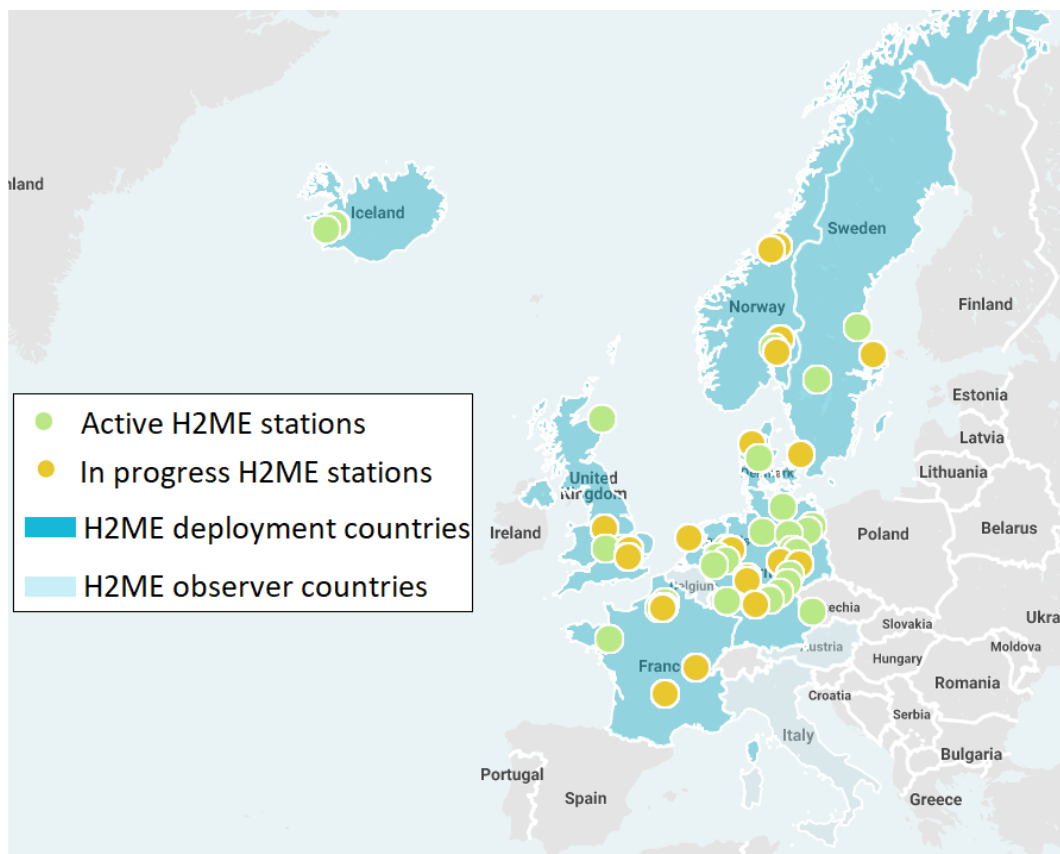


Figure 8. Hydrogen stations in Europe now and in the foreseeable future. Source is <https://h2me.eu/>.

CO₂ emissions by traffic in Kainuu in 2009, 2020 and 2030

From 2009 to 2020. The emissions caused by traffic in Kainuu were expected to decrease approximately 210 kg CO₂ eq per person from 2009 to year 2020.^(3, 106) 210 kg CO₂ eq per person is ~7,7 % of traffic emissions in Kainuu in 2009. It is difficult to assay CO₂ equivalent savings in traffic totally but some number can be presented. Kainuu has reached about 8 % of the expectation of emissions savings (17 kg per person) in car traffic from 2009 to 2020.^(Table 5) The calculation is close to the official number.⁽¹⁰⁷⁾ Kainuu has saved 9 % CO₂ eq emissions in traffic (per person) from 2007 to 2017 by SYKE (Finnish Environment Institute). Table 5 opens in a good way what are real factors in the achievement of emissions savings. ~8 % of the expectation has been reached by the new car generation (and alternative fuels cars).

Was the expectation to decrease approximately 210 kg CO₂ eq per person from 2009 to year 2020 realistic? One of background assumption was biogas.⁽³⁾ It would have been possible to built a biogas plant in Kajaani whose capacity had been ~800 passenger cars and over 100 biogas buses.⁽¹⁾ Thanks to the biogas plant and biogas vehicles Kainuu could have decreased 80 kg per person CO₂ eq emissions.^(APPENDIX II) That would have been ~38 % of the expectation. It is difficult to estimate the other background assumptions of the expectation clearly. It can be concluded Kainuu's target for emissions savings in traffic was maybe realistic but unfortunately no real climate action has been done during the last decade.

Table 5. Kainuu's emissions savings in traffic from 2009 to 2020 by passenger cars. Exact calculations in APPENDIX I.

CO₂ eq missions savings of passenger cars in Kainuu from 2009 to 2020	
The expectation	210 kg CO₂ eq per person
The result (compared to the expectation)	17 kg per person (~8 %)
- Alternative fuels cars	- 1,5 kg per person (~0,7 %)
- A new car generation	- 15,5 kg per person (~7,3 %)

From 2020 to 2030. What are emissions savings in traffic in Kainuu from 2020 to 2030? Kainuu can save 288 kg per person CO₂ eq emissions in traffic from 2020 to 2030 but this demands real climate actions.(Table 6) This save is bigger and more realistic than the previous target 2009-2020 because the next decade includes more "automatic action". People and companies buy newer and newer vehicles, the law demands larger and larger biocomponent share of fuel (108) and the Government is designing the law which obligate to install charging points in housing companies (24) and so on.

There are a lot of potential to save emissions. For example, the target of the Finnish Government (settled by the government 2015-2019) is 670 new biogas cars and 3 260 new electric cars in Kainuu by 2030.(14) That means it is good to construct a biogas plant in Kainuu. The biogas plant effect would be 80 kg per person CO₂ eq emissions savings and 3 260 new electric cars (included plug-in hybrids) means 56 kg per person CO₂ eq emissions savings in traffic in Kainuu.(APPENDIX II & III) Cars are ten years younger in 2030 which causes 147 kg per person CO₂ eq emissions savings. It is a good question how a good climate action a new car is because the new car means manufacturing emissions too. It depends on the case but it can takes over ten years to compensate manufacturing emissions of the new car (the writer's estimation). Actually, the organization called Transport & Environment says: "A vehicle lifetime of 15-20 years is optimal to minimize lifecycle emissions - A vehicle lifetime of 15-20 years is optimal to minimize lifecycle emissions – the typical lifetime of cars today. Lifetimes shorter than 15 years are only lower carbon if there is a very rapid improvement in in-use emissions.".(109)

Table 6. Kainuu's emissions savings potential in traffic from 2020 to 2030 by passenger cars and buses. Exact calculations in APPENDIX II & III.

The expectation of CO₂ eq missions savings of cars and buses in Kainuu from 2020 to 2030	
The expectation	283 kg CO₂ eq per person
- 3 260 new electric cars (included plug-in hybrids)	- 56 kg per person (~20 %)
- The biogas plant in Kajaani	- 80 kg per person (~28 %)
- A new car generation	- 147 kg per person (~52 %)

5. The viewpoint of an engineer

Generally, when the subject of conversation is alternative fuels, alternative fuels are seen a tool against the climate change. So that people could perceive the big picture, it is good to observe energies (Table 7). It is important to understand the big picture because understanding of the big picture directs the action towards a right way. Table 7 proves that the biogas potential can only be a part solution in traffic.

It is good to remember that biogas is also used for heat, electricity or cogeneration of heat and electricity, which decreases biogas potential as traffic fuel. Table 7 also proves that electric cars creates a big challenge for electricity generation but it is good to remember the efficiency of electric cars. An electric car can be three times more efficient than a petrol car.(110) If the efficiency of electric cars is estimated very critically and the reference point is a diesel car, the electric car is only 20 % more efficient than the diesel car.(83, 111) Where is a real truth? Anyway, if road traffic works with electricity in Finland in the future, it demands 15-37 TWh more the electric production and/or exportation. 15 TWh means 2 nuclear power plants (Loviisa size) or 1 830 wind power plants of 3,5 MW.(112, 113) These numbers do not message that electric traffic is impossible – It tells the change to take for a long time.

Unfortunately, the climate change does not wait. While alternative fuels are implemented in traffic, it is good to do more impressive actions. The writer drives with a bioethanol car but still he has compensated his emissions by reconstructing swamps. If one hectare swamp is reconstructed (filling ditches), it saves 2 778 kg emissions in every year and the cost is 800 euro, that is it.(114) That means almost 20 000 km driving per year (140 g/km). Think about it – If you reconstruct swamp instead of you buy an electric car of 50 000 euro, your "swamp euro" can save emissions over 60 times more than "electric car euro" (20 000 km per year).

Table 7. The big picture in Finland – Biogas, electricity and road traffic.

The unit	Energy (TWh)	Reference
Road traffic in 2018	45	(115)
Passenger cars	24	
Buses, trucks and Vans	21	
Theoretical biogas potential *	10,9 - 40,2	(54)
Techno-economic potential	5,1–13,9	
Electricity		
Total production	67,5	(106, 116)
Total consumption	86,5	
Bioethanol and Biodiesel **	-	Nothing found
*Includes biowaste, dung, plant biomass and sludges. This potential also means heat and electricity energy. **Nobody has calculated the potential as TWh but biodiesel and bioethanol needs partly same raw materials as biogas production.		

6. Recommendations

The previous Finnish Government (called Sipilä's Government, in 2015-2019) set the target for numbers of biogas cars (50 000) and electric cars (250 000) including plug-in hybrids in Finland by 2030 (14). Same numbers after the population are 670 biogas cars and 3 350 electric cars approximately in Kainuu by 2030. This report recommends that a biogas station is found in Kajaani. This report also suggests that the plan of a profitable biogas plant in Majasaari (Ekokymppi) is updated. If facts show green light to found the biogas plant, then it is strongly recommended to create it by 2025. The report recommends that municipalities and their institutions wake up as soon as possible because the clean vehicle directive

demands electric vehicles after the year 2020. This report strongly suggests that people look to the future and seeing synthetic fuel as potential fuel in Kainuu.

Alternative fuels must be made possible in Kainuu. There are no excuses because the level of biogas technology is good and electric cars are still cheaper and better. Biogas cars and electric cars are a real climate action because they are not translated as biocomponent in the distribution obligation, which means real emissions savings regionally and nationally. Since it is time to act quickly, this report presents the minimum target and the further target.

The minimum target in Kainuu

Kainuu must catch up rest of Finland. This chapter presents steps how this happens.

Biogas. A versatile biogas project or projects is/are needed in Kainuu. The project could promote a gas station, farm biogas plants and a big biogas plant in Kainuu. The project could cooperate with many operators. St1, Osuuskauppa Maakunta and Loiste could be co-operators in the gas station case. University of Vaasa and the project called BiTool could be co-operators in the farm biogas case. Doranova, Ekokymppi and Envitecpolis could be co-operators in the big biogas plant case.

The first biogas step – A biogas station or a natural gas station and let's prefer to the biogas station. Let's collect commitments from transport companies, institutions and municipalities so that they invest heavy gas vehicles as soon as possible there is a gas station in Kainuu. Commitments only needs 20-30 heavy vehicles which work continuously in Kainuu. The need can be smaller in the beginning of the gas station.(67) After commitments let's negotiate with gas dealers and at least one station is founded in 2021 in Kainuu (likely in Kajaani). The project of 100 000 euro is enough to form commitment papers, collect commitments, collect co-operators and applicate the infra support (the writer's estimation).

The second biogas step – Farm biogas. Let's co-operate with the project of BiTool (1.10.2018–30.4.2021) which is organised by University of Vaasa (79). The project would scan farmers who want to produce biogas. The project would organize the system where a refinery truck drives around farms and biogas would be refined to traffic biomethane. The BiTool project II in Kainuu could be as same as BiTool budget (~200 000 euro).

The third biogas step – The original investigation of the biogas plant in Ekokymppi in 2015 must be updated because a profitable biogas plant demands a fact-based investigation. There are too many expensive biogas plants in Finland where citizens of municipalities pay extra costs finally because the investment has not been fact-based enough. Update of the original investigation could be less than the project of 30 000 euro (the writer's estimation).

While the investigation of the biogas plant is updated, different commitments must be collected. Producers of raw material like Ekokymppi commit their materials available to the biogas plant in Kainuu in 2025 and correspondently a biogas producer commits to found the biogas plant if there are raw material commitments enough. Let's collect commitments with biogas retailers and receivers of decomposition residues. Commitments can be collected by a project or inside a project. The project of 50 000 euro is enough to form commitment papers and collect commitments (the writer's estimation).

Electricity. Traffic biomethane is not only solution in alternative fuels because for example more and more tourists drive by electric cars in Kainuu. Tourist entrepreneurs must be supported to install

charging points by local projects. Actually, this plan is implementing in the project called Carbon neutral Kainuu and Koillismaa. The project presents carbon neutral and energy savings solutions in every sector in Kainuu and in Koillismaa and it starts in the beginning of March in 2020.

Public/semipublic institutions and municipalities have a very important role to produce experiences of electric cars, which means they must buy electric cars. Increasing number of electric cars brings experiences and removes myth of electric cars, and more private people buy a new electric car in Kainuu along 2020s. Actually, the clean vehicle directive will demand municipalities to invest electric vehicles (cars, school buses, city buses) after 2020.(19) The directive touches SOTE and KAO too.

Generally, people in Kainuu need experiences of alternative fuels. For example, public and semi-public institutions could produce these experiences buying of electric cars.

Hydrogen. This report does not recommend any hydrogen action because the writer see synthetic fuel as advanced hydrogen which is easier and cheaper to be implanted into present infra than hydrogen solutions.

The further target - Kainuu as the forerunner in Finland

This report want to present an ambitious target too. Kainuu is the “backrunner” in alternative fuels in Finland but if Kainuu implements the minimum target (the previous chapter) and the next plan (this chapter), Kainuu is the forerunner in Finland.

Synthetic fuel. There is the company called Q Power Oy in Finland which develops synthetic fuel technology and it has almost 50 patents around the world.(99, 117) It already has a mobile pilot plant. The product of Q Power Oy is the methanation service and the company owns plants because it want to protect their knowledge. The company makes biomethane from carbon dioxide of smoke gas and hydrogen.

Why synthetic fuel is potential really? Present infra and car technology is suitable for synthetic fuel and that makes the change cheaper than to construct totally a new system like hydrogen infra. Money – The research of synthetic fuel is getting more and more money because big oil companies are interested in synthetic fuel.(118) The Icelandic company called Carbon Recycling International (CRI), which produces synthetic methanol, starts the project in Sweden in 2020 and the goal of this project is CO₂ utilisation from steel manufacturing in Sweden and finally methanol is marine fuel.(119) The project belongs to Horizon 2020.

Now the writer suggests that Kainuu starts the project of synthetic fuel as soon as possible and produces synthetic fuel wherever carbon dioxide is spewed out with smoke gas. Produced synthetic could be used locally like in vehicles in the factory area. Kainuu’s factories could advertise them to be carbon neutral because they capture carbon dioxide from smoke. The writer does not know where the best smoke source is in Kainuu but a project could find out that. The project could co-operate with Q Power Oy or CRI. The budget of the project could be from hundreds thousands euro to millions euro (the writer’s estimation). The fund source could be some EU fund. If Horizon Fund gets a new period, it could be one of EU funds. How realistic Just Transition Fund (JTF) is?

7. Conclusion

Biodiesel, bioethanol, biogas, electricity, hydrogen or synthetic fuel – What is the best solution? No one – It can be a synthetic fuel. Biogas can only be a part solution (a potential limit). Electricity and clean electricity plays a remarkable role in the future because electricity, hydrogen and synthetic fuel, all of them needs electricity. The second reality is costs – The alternative fuel is almost always more expensive option than fossil fuel. Unfortunately, energy price (fossil fuel price) is low and that brakes investments of alternative fuels. The alternative fuel is a green choice – No economic choice. The third reality is changing ecosystem (market, laws, etc). For example, the clean vehicle directive changes the ecosystem after the year 2020 because it attaches importance to electric vehicles. Unfortunately, the directive can destroy biogas plans partly in Kainuu because potential biogas users (cars, vans and city buses of municipalities) are obligated to use electricity or hydrogen.

Bioethanol and biodiesel. Bioethanol and biodiesel are dependent on big fuel retailers in Kainuu. Bioethanol can be already refilled, and biodiesel is likely in Kainuu after 2020. Bioethanol and biodiesel are/will be real alternative for light and heavy vehicles, at least in Kajaani. Biodiesel can be a big save to Kajaani City. Kajaani City can invest diesel buses before the clean vehicle directive stands in Finland but buses can use biodiesel. Unfortunately, biodiesel is questionable ecologically because one component of biodiesel is the by-product of palm oil production. Anyway, biodiesel buses would be greener solution than diesel buses, and maybe the cheapest alternative fuel solution.

Biogas. The biogas station is likely to be found in Kainuu in 2020s. If the bioethanol factory of St1 is expanded, the biogas plant is very likely in Kainuu in 2020s. Unfortunately, the clean vehicle directive can brake the arrival of biogas because the directive highlights electric vehicles. Although biogas did not play a big role with together electricity and synthetic fuel in traffic, it could be sold as biomethane outside Kainuu or used as green fuel for heat, electricity or cogeneration of heat and electricity too.

Electricity. Electricity comes into road traffic – the clean vehicle directive makes that sure. The clean vehicle directive with together cheap Chinese electric vehicles can electrify public transport in Kainuu and in Finland. For example, SOTE is in the front of revolution. They have a lot of passenger cars and vans, and SOTE must follow the directive. Increasing experiences of electric cars and cheaper electric cars makes the investment attractive for private people in Kainuu too.

Synthetic fuel. Synthetic fuel is the advanced version of hydrogen. It is easier and cheaper to implement into present infra than hydrogen. Synthetic fuel can make Kainuu a forerunner as the alternative fuel region. It can also bring a big EU projects (millions euro) into Kainuu.

In 2030. Every person or her/his friend or her/his work mate owns a biogas or electric car (included plug-in hybrids) in Kainuu in 2030. Synthetic fuel is more known in 2030 than now and it is used locally somewhere in Kainuu. Kainuu has remarkably saved CO₂ eq emissions in traffic in the first time in history of Kainuu in 2030 by real climate actions.

Summa summarum: the alternative fuels strategy for Kainuu appears to be inextricably linked to alternative energy strategy as a whole. This is because Kainuu is not only end user , it is also supplier of alternative energy. From the preceding discussion it follows that An optimum strategy for reaching and maintaining the decarbonization standards appears to be a combination of further research into biogas (projects which pledge commitments as security for real operators), acquirement of electric vehicles

through public procurement, ensuring charging and refill stations for alternative fuel cars, especially the through traffic, and action on synthetic fuels can make Kainuu the forerunner of alternative fuels. For example, heating plants combined with wind or solar power could be good places for synthetic fuel production.

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APPENDIX I Calculations of CO₂ emissions savings of cars in Kainuu from 2009 to 2020

This appendix calculates how much CO₂ emissions savings are caused by a new car generation and new alternative fuels cars from 2009 to 2030.

CO₂ equivalent numbers. CO₂ emissions numbers of all car types are based on the calculator of the Finnish Climate Change Panel (FCCP).(53) FCCP thinks CO₂ emissions of a bioethanol car to be same as emissions of a diesel car and their argument is: "The more bioethanol is refilled, the less biodiesel is refilled".(53) Background values of the calculator of FCCP is not changed. So the manufacturing emissions are also observed. The effect of the car age on CO₂ emissions are based on VTT database called Lipasto.(115) The calculation stares at the car age more than biocomponent of fuel because the effect of biocomponent has been questionable.(45, 108)

Numbers of cars in Kainuu. The data is based on Traficom's data.(4) There are about 12 700 diesel cars and 14 300 petrol cars in Kainuu in 2020. There are 26 ethanol cars and 21 electric cars in Kainuu 2020. The average age of cars is 13,5 years.(120) The average driving kilometres per year are 14 000.(4) The ratio of petrol and diesel cars is supposed to be independent on years (2009, 2020). Besides, the average age of cars is supposed to be independent on years. It is supposed bioethanol cars to have only replaced petrol cars. Electric cars replace diesel and petrol cars equally.

There was not any alternative fuel vehicle in Kainuu in 2009.(4) There were about 2650 cars less in 2020 than in 2009 in Kainuu because the population has dropped 5 275 people from 2009 to 2017 (2017 is the newest calculated year).(106) It is supposed the number of cars to follow the population.

CO₂ eg emissions savings from 2009 to 2020

The reason of CO ₂ eg emissions savings	CO ₂ eg emissions savings
11 younger (average age) diesel car (from EURO1 to 2006)	NO savings, more emissions 20 g/km*
11 younger (average age) petrol car (from EURO1 to 2006)	12 g/km
2650 cars less in 2020 than in 2009 (EURO1)	5 160 tn per year
From a diesel car to an electric car	1,36 tn per year (average during 15 years)
From a diesel car to plug-in hybrid	0,51 tn per year (average during 15 years)
From a petrol car to a bioethanol car	0,23 tn per year (average during 15 years)
From a petrol car to an electric car	2,06 tn per year (average during 15 years)
From a petrol car to plug-in hybrid	1,15 tn per year (average during 15 years)

* The motor size of diesel cars is larger than in 1990s which increases emissions.(121)

Total CO₂ eg emissions savings from 2009 to 2020 by a new car generation and alternative fuels cars.

$$C_{2009-2020} = d * (Y_{D2020} * N_D + Y_{P2020} * N_P) - C_B * E_{PtoB} - \frac{C_E}{2} * (E_{DtoE} + E_{PtoE}) - C_{PH} * E_{PtoH} - C_{DH} * E_{DtoH}$$

where $C_{2009-2020}$ = the change of CO₂ eq emissions of cars in 2020 compared to 2009 (-1 266 tn/year),

d = driving kilometres in year (14 000 km per year),

Y_{D2020} = the average change of CO₂ emissions of diesel cars from 2009 to 2020 ($+2 \cdot 10^{-5}$ tn/km),

Y_{P2020} = the average change of CO₂ emissions of petrol cars from 2009 to 2020 ($-1,2 \cdot 10^{-5}$ tn/km),

N_D = the number of dieses cars in 2009 and 2020(12 700),

N_P = the number of petrol cars in 2009 and 2020 (14 300),

C_B = the change of number of bioethanol cars from 2009 to 2020 (+41),

C_E = the change of number of electric cars from 2009 to 2020 (+10),

C_{PH} = the change of number of petrol/electric cars from 2009 to 2020 (+65),

C_{DH} = the change of number of diesel/electric cars from 2009 to 2020 (+21),

E_{PtoB} = emissions savings when a bioethanol car replaces a petrol car (0,23 tn/year),

E_{DtoE} = emissions savings when an electric car replaces a diesel car (1,36 tn/year),

E_{PtoE} = emissions savings when an electric car replaces a petrol car (2,06 tn/year),

E_{PtoH} = emissions savings when a plug-in hybrid replaces a petrol car (1,15 tn/year),

E_{DtoH} = emissions savings when a plug-in hybrid replaces a diesel car (0,51 tn/year).

The result is divided by the population in 2017 (73 959) and the final result is less 0,017 tons CO₂ eq per person in 2020 than in 2009.

APPENDIX II savings

A biogas plant and calculations of CO₂ emissions

This appendix calculates how much CO₂ emissions savings are caused by a certain biogas plant in Kainuu.

The capacity of a biogas plant is based on Envitecpolis's report in 2015.(1) The capacity of a biogas plant means how many cars and buses can be refilled by the biggest potential biogas plant. Envitecpolis's report gives the number of driving kilometres (20 000 km), car types and so on. CO₂ emissions number of the biogas car is based the calculation by Kaasuautoilijat Ry which is a corrected calculator of FCCP.(56) So the emissions of an electric car are supposed to be same as the emissions of biogas car. Numbers of emissions savings are from the same source as in APPENDIX I. The manufacturing emissions of buses is not observed. The emissions of buses are supposed to be the level of 2016 without travellers. The extra data has been found about biogas buses too.(122)

$$E_{plant} = d_{buses} * (N_{gasBuses} * E_{DtoG} + N_{dualBuses} * E_{DtoG60}) + N_{cars} * E_{PtoE}$$

where E_{plant} = CO₂ eq emissions savings in traffic if the biogas plant works (5 900 tons per year),

d_{buses} = driving kilometres of buses in year (44 000 km per year),

$N_{gasBuses}$ = the number of gas buses (57),

$N_{dualBuses}$ = the number of dual buses (96; they use 60% gas and 40% diesel fuel),

E_{DtoG} = emissionns savings when a biogas bus replaces a diesel bus ($6,7 \cdot 10^{-4}$ tn/km),

E_{DtoG60} = emissions savings when a dual bus replaces a diesel bus ($4 \cdot 10^{-4}$ tn/km),

N_{cars} = the number of biogas cars (810),

E_{PtoE} = the emission change when a biogas car replaces a petrol car (3,13 tn/year; NB: 20 000 km per year).

The result is divided by the population in 2017 (73 959) and the final result is less 80 kg CO₂ eq per person.

APPENDIX III

A new car generation in 2030 and emissions savings

This appendix calculates how much CO₂ emissions savings are caused by a new car generation from 2020 to 2030.

There are four big sources of emissions savings before 2030: biogas (cars, buses), electric cars, a new car generation and biocomponent of fuel. See biogas in APPENDIX II.

Electric cars. Let's use values from APPENDIX I:

E_{DtoE} = emissions savings when an electric car replaces a diesel car (1,36 tn/year),

E_{PtoE} = emissions savings when an electric car replaces a petrol car (2,06 tn/year)

E_{PtoH} = emissions savings when a plug-in hybrid replaces a petrol car (1,15 tn/year),

E_{DtoH} = emissions savings when a plug-in hybrid replaces a diesel car (0,51 tn/year).

Since the target of the Finnish Government is 3 260 new electric cars in Kainuu by 2030 (Chapter: Legislation relating to alternative fuels at national, regional and EU levels), the equation is:

$$E_{Electric2030} = \frac{E_{DtoE} + E_{PtoE} + E_{DtoH} + E_{PtoH}}{2} * \frac{3260}{2}$$

where there are next assumptions:

- Half and half of new electric cars are electric and plug-in hybrid cars.
- Diesel and petrol cars are replaced with electric cars equally.

The result is about 4 140 tons CO₂ eq emissions savings. The result is divided by the population in 2017 (73 959) and the final result is less 63 kg CO₂ eq per person.

A new car generation. Since cars are ten years younger in 2030, their average emissions follow the emissions value of 2016 in LIPASTO database. The emissions class changes from 2006 to 2016. That means next emissions savings:

- 42 g/km in diesel cars
- 26 g/km in petrol cars.

Let's suppose the number of cars to be same in Kainuu in 2030 as now (27 000 cars). Let's decrease new biogas and electric cars (4 020 cars). Let's suppose the number of bioethanol cars to be same in 2030 as now. The equation:

$$E_{nexGener2030} = \frac{(42 + 26) * 10^{-5} tn/km}{2} * (27000 - 4020) * 14000 km/year$$

The result is about 10 900 tons CO₂ eq emissions savings. The result is divided by the population in 2017 (73 959) and the final result is less 145 kg CO₂ eq per person.

A biocomponent of fuel. The law says: "30 % of traffic fuel must be biocomponent and 10 % of traffic fuel must be advanced biocomponent in 2030. Unfortunately, it is difficult to estimate the effect of biocomponent because biogas can be interpreted as biocomponent of fuel in 2030.(24) If biogas is interpreted as biocomponent of fuel in 2030, the law does not increase real obligation. The effect of biocomponent, biodiesel and bioethanol is not calculated.