Final report

Green Methanol Infrastructure

Energy Efficiency

EUDP 2013-I

Project identification 64013-0137

Abbreviations and acronyms

- MEA Membrane Electrode Assembly
- CO Carbon Monoxide
- Pt Platinum
- PBI Poly Benz Imidazole
- HT PEM High Temperature Polymer Electrolyte Membrane
- RMFC Reformed Methanol Fuel Cell
- BOP Balance Of Plant
- TRL Technology Readiness Level
- RMFC Reformed Methanol Fuel Cell
- LPG Liquefied Petroleum Gas
- LT PEM Low Temperature Polymer Electrolyte Membrane
- SOFC Solid Oxide Fuel Cell
- USD United States Dollar
- DC Direct Current
- CAPEX Capital Expenditure
- OPEX Operational Expenditure
- TCO Total Cost of Ownership
- kW Kilo Watt
- kWh Kilo Watt Hour
- APU Auxiliary Power Unit
- OEM Original Equipment Manufacturer

Content

1. Project details

Project title	Green Methanol Infrastructure
Project identification (program abbrev. and file)	2013-I, Project ID 64013-0130
Name of the programme which has funded the project	EUDP
Project managing company/institution (name and address)	OK a.m.b.a. Åhave Parkvej 11 8260 Viby J
Project partners	Serenergy A/S Hamag A/S
CVR (central business register)	DK 39170418
Date for submission	22-12-2017

2. Short description of project objective and results

2.1. In English

The project has developed and built Europe's first methanol refuelling station, thereby making it possible for methanol-fuelled cars to fill up in a safe, reliable and simple manner. The methanol refuelling station is MID-approved by the National Measurement and Regulation Office (NMO), which means it is now possible to sell methanol fuel to the public and not only in closed fleets. The project has proved that the existing fuel infrastructure can be used. Several different vehicles have regularly been refuelled as needed, primarily created by internal testing of methanol fuel cell vehicles from SerEnergy. Transparency has also been established regarding the levying of taxes on the fuel by the Danish tax authorities.

The project has shown that the concept can be scaled as needed in relation to demand, as environmental approvals and permits have been obtained in connection with the construction of the methanol fuelling station.

In connection with the demonstration of the plant, we have encountered challenges with handling the methanol in its transport and storage at the refuelling station, which we are now working on solving outside of the project.

2.2. In Danish

Projeket har udviklet og bygget Europas første methanoltankstation, som har gjort det muligt for methanol biler at tanke på en simple, sikker og pålidelig måde. Methanoltankstation er MID godkendt hos National Measurement and Regulation Office (NMO), som betyder at man fremadrettet har mulighed for at sælge methanol til

offentligheden og ikke blot i lukkede flåder. Projektet har bevist at den eksisterende brændstof-infrakstruktur kan anvendes. Flere forskellige køretøjer er løbende blevet tanket efter behov, primært skabt af interne tests af Methanol brændselscelle køretøjer fra SerEnergy. Samtidig er der opnået klarhed omkring fastsætningen af afgifter på brændstoffet hos de danske skattemyndigheder.
Projektet har bevist at konceptet kan skaleres efter behov i takt med efterspørgslen, da der er blevet indhentet miljø-godkendelser og tilladelser i forbindelse med opførelsen af methanoltankstationen.
I forbindelse med demonstrationen af anlægget har vi oplevet udfordringer med håndtering af methanolen i forbindelse med transport og lagring på tankstationen, hvilket vi arbejder på at løse uden for projektet.

3. Executive summary

The Danish Government goal of a 100 % fossil free energy sector in 2050 is the main focus of the Green Methanol Infrastructure project. The key goal is to prove that Methanol can be an alternative to fossil fuels in the transportation sector to reach this goal.

Furthermore, the implementation of a fuel that will enable a highly efficient drivetrain concept based on fuel cells utilizing the same fuel. This concept, alongside an integrated Supply Chain Management and the supporting business needed to deliver it, will position Denmark in the forefront of technology R&D and business, within an area that is in strong growth both internationally and locally.

The focus of the project is also to offer a cost-efficient solution that can be implemented without a massive infrastructure cost for society. Furthermore, the concept offers a step-by-step plan with gradual implementation of the concept and change towards a transport sector without fossil fuels.

The development and conversion of a petrol station for use of the Methanol Mix fuel is one of the key points of the project. The partnership with HAMAG and OK made it possible and the first unit was inaugurated in August 2015 in Skalborg, Aalborg.

Through the CEESA project methanol is documented to be a superior way of storing, distributing and balancing the Danish energy system under a 100 % fossil fuel free regime. This is done by uniting biomass and electricity into one complete system. This is also the vision the Danish body responsible for the gas and electricity infrastructure, Energinet.dk.

The Green Methanol Infrastructure project is closely connected to the initiatives in the EUDP project MECc (mecc.dk) in which the vehicle is developed and demonstrated. The Green Methanol Infrastructure Project will provide the refueling stations to support this and any other upcoming projects of the same kind.

A Fiat 500 was used as a demonstration platform, combining a battery pack and a methanol fuel cell range extender, creating effectively a plug-in hybrid electric vehicle with an initial battery-only range of 110 km. The integrated 5 kW reformed methanol fuel cell can add an additional 500 kilometers' range or more with a larger methanol fuel mix tank.

Although the project showed the feasibility of the concept, the practical market application needs to follow a different set of requirements in order to conquer a significant market share on relevant segments.

A 3 key-point strategy was designed to ensure that the usage of the vehicle is cost effective and the technology has a maximum positive effect over the utilization and environmental outcome:

- The vehicle must have a daily usage period of over 8 hours
- It must have a low power usage to allow the range extender to fill the gap and provide the extra needed power.
- Heavy duty vehicle, to accommodate the batteries and methanol fuel cell. As in a last mile service provider, the vehicle will reduce emissions on city centers, the extra cargo space will make it cost effective and the reduced service required adds to the competitive ROI.

The Serenus vehicle was designed and build by Serenergy as an evolution of this concept. It combines a Nissan Ev-200 van with a 5 Kw methanol generator as a range extender, with successful trials already performed and used as a showcase of the technology and all its potential.

To meet with the forecasted GMI roadmap, several initiatives were developed. For the last mile applications and, which includes small/medium vans, several automotive OEM have been approached in order to guarantee a strategic partnership for joint-development over a vehicle platform (EV), to ensure a normal look vehicle, integrating the components alongside the construction of the same, making impossible to distinguish it from a conventional vehicle currently available on the market.

This platform and size of vehicles have another set of applications, mainly taxis and heavy-duty vans, due to the zero emissions and the predominant usage of the vehicle in city centers and greater metropolitan belts. The development of the Serenus concept car, allowed Serenergy to initiate contacts towards this outcome since enough data has been generated and processed to make the proof of technology and concept a reality and economically feasible at the present/near future, promoting the GMI project further.

The development alongside the project partners of the Methanol Mix Station refueling station in Skalborg provided an invaluable data benchmark. The success of this project and the learning procedures and steps needed, from construction towards deployment and use, make it easier at this point to replicate the concept across the country, allowing for an organic growth of both the rolling fleets on the roads, and a matched refuel network to allow operations across the country, meeting the growing needs of companies and municipalities, ensuring a sustainable transition towards the Danish 2050 Energy Policy.

The development of a Methanol Mix dispenser for public use on fuelling stations is in severall points very different from dispensers used for dispensing fossile fuels. These are:

1. The protective measures to let public persons handle Methanol Mix
2. The hydraulic design to handle the liquid in the dispenser
3. The ability to mix methanol and water on site
4. MID approval to use the dispenser for sale in public enviroment

1. The best way to handle the person protective measures is to avoid persons getting in contact with the Methanol Mix as a liquid as well as the fumes. The solution regarding this challenge is to use dry disconnect couplings, which only open for flow through the nozzle if connected to a counterpart on the vehicle.

Besides, this solution secures from unwanted filling of ordinary car tanks. The dry disconnect coupling makes it necessary to stop overfilling the vehicle tank by a sensor device.

2. Clean Methanol as a liquid may not be that difficult to handle and normally you can use mild steel tanks to store clean Methanol. To be used in fuell cells, Methanol is mixed with deionised water 60%:40%. The clean water is the aggressive part in this mixture. All wetted parts in the dispenser are acid proof stainless steel or special rubber and plastic, restistant to the Methanol Water mixture. Keeping the Methanol Water Mix clean from pollution so it can be used in a fuel cell application is quite a challenge too, as we experienced with polluted product from the delivery chain as well as problems with the underground tank coating.

3. From earlier dispenser designs HAMAG A/S has experience with mixing fuels, which we base on digital pulse regulating principles. The dispensers can be manufactured in a version with only one meter circuit to handle premixed Methanol Water Mix and a version to with two meters and proportional valves to mix clean Methanol and clean Water on site. Of course the last version mentioned can deliver premixed Methanol Water Mix as well.

4. To be used as a commecial sales dispenser on a new gas station as well as a dispenser in a retrofit solution the dispenser need to be MID approved. This projects has been an ongoing job besides the practical test running on station Skalborg. This job, that received approval by november 2017. was the main reasonhandled by was

4. Project objectives

Denmark's goal is to be free of fossil fuels by 2050. The big question, though, is what will replace them. Methanol is one of many options, and it has the advantage of being a liquid and environmentally-friendly fuel, which makes it possible to utilise the infrastructure we've spent more than 100 years building up.

Methanol is an outstanding energy delivery mechanism and may therefore be seen as a unique storage medium for sustainable energy. Because methanol is liquid – just like the other fuel types we know today – it is also relatively easy to handle in the existing infrastructure. It can be transported in the same tankers and be used in refuelling in the same way as petrol and diesel. Liquid methanol is thus much easier to handle than, for example, hydrogen, which must be stored under high pressure.

When we talk about a green transformation in the transport sector, electric cars are a key focal point. However, it is impossible to ignore the fact that one of the biggest challenges presented by electric cars is their limited range, which currently complicates longer trips. These problems can be solved by technology that gives any electric car a longer range of travel using a methanol-powered fuel cell.

Methanol fuel cells can solve the problem of electric cars' limited range

The fuel cell functions as a 'range extender' of sorts and, in principle, it can be installed in any electric vehicle. By fuelling up with liquid methanol to power the fuel cell, the range of the car can be significantly expanded.

This hybrid solution is a means of including the electric car in the transport sector, and we believe it is one of the ways to move forward.

In the project, we are focusing on finding out how we can use sustainable energy sources to replace fossil fuels. One of the advantages of using methanol is that it can be used in the distribution system that our motorists are already familiar with today.

With methanol, customers will be able to fill up in the same safe and easy way as they always have done.

In this connection, it makes good sense to reuse our comprehensive filling station network and the experience we already have, as opposed to gambling on something that requires a whole new infrastructure. This enables us to be both environmentally conscious and financially responsible, as a total restructuring would be much more costly and take far more time to complete.

4.1. Main objective

The objective of the project is the development and demonstration of a refuelling infrastructure for methanol which utilises the existing infrastructure for the distribution and refilling of liquid transportation fuels.

Biomethanol is a potential substitute for fossil fuels because it has both an environmental benefit (as it can be manufactured from almost any kind of biomass) and is a liquid fuel which can be used with existing distribution systems.

4.2. Objective

The primary goals of the project are:

4.2.1. Providing a sustainable and 100 % renewable solution for road transportation

Methanol is one of the largest commodities and methanol demand is expected to continue to grow, having at the present time, a well-established worldwide production. Nowadays you are able to buy methanol plants from Asia, North and South America, Europe, Africa and Middle East.

Green Methanol can be bought from European countries as well.

- In the Netherlands at **BioMCN,** which is making it from biogas.
- Sweden at **Chemrec**, where they are producing it from forest waste.
- Iceland from **Carbon Recycling International**. This methanol is produce from geosynthesis.

The Well to Wheel (WtW) analysis proves that the Methanol emissions are lower than comparable ICE fossil fuels and that the use of the Methanol Mix as fuel for HT-PEM Fuel Cells will have an important impact for the reduction of GHG emissions.

4.2.2. Providing a refueling concept for the QBRAK and other upcoming road vehicles powered by fuel cells and providing a refueling option for industrial vehicles.

The development and conversion of a petrol station for use of the Methanol Mix fuel is one of the key points of the project. The partnership with HAMAG and OK made it possible and the first unit was inaugurated in August 2015 in Skalborg, Aalborg.

4.2.3. Formulating a strategy, roadmap and action plan for methanol refueling solutions in the future

The WP 11 of this project summarizes the main directives highlighted on the Business Plan for the full development and deployment of a Methanol Mix network at the present and near future. Competition and parity status between technologies prevail in Denmark, leveling the competitive field for all involved R&D companies.

4.2.4. Building and testing a number of methanol refueling stations for the future coherent energy system

The pilot developed Methanol Mix Petrol Station was used as an experimental laboratory:

- Components, like the filling nozzle, to assess the needed learning curd to use it, alongside the sensors inbuilt to provide information and safety.
- Infrastructure development, such as project management, space, safety requirements and uniformization of service next to conventional Fossil Fuels already in use.
- Safety, concerning this point the refilling process of the underground tanks, handling procedures of hazardous materials, ventilation and other critical aspects relevant for operation and certification of the unit for normal and daily operations.

4.2.5. Testing the reformed methanol fuel cell platform within the concept framework

The refuel process was performed many times across the whole length of the project, using both mobility platforms developed by Serenergy. During the testing period, key members of the GMI consortium has the opportunity of testing each vehicle and refuel it several times, to gather data and see the needed learning curb to make this simple task as normal as refueling their private ICE car. Both the FIAT 500 FCV and the Serenus eV-200 EV ReX use the same nozzle, only varying the size of the vehicle tank.

4.2.6. Communicating the project with regard to reaching the relevant customer segments, ensuring political support and building confidence in the new refueling concepts.

- Consortium member of the GMI project, developing the Mobility solutions, using the HT-PEM Fuel Cell as primary propulsion system (FIAT 500 FCV) and range extender (ReX – Serenus eV-200 EV).
- H2FC fair participation and the center pieces were the Methanol 2020 Vision and the Serenus eV-200 ReX vehicle.
- Export markets - Serenergy has been very active in the Asian markets, with special relevance in the Chinese Market. Significant activity has had happen and conversations to expand further the reach of the developed solutions, both Infrastructure retrofitting and conversion of vehicles are ongoing, having a positive feedback as an outcome, giving good perspectives for the next and coming years.

4.3. Prospects

The project is helping to pave the way for future alternative transportation fuels as well as providing a sustainable, sensible and cost-effective way for Denmark to contribute to meeting its commitments for CO2 reduction via a green methanol infrastructure. GMI will demonstrate a solution to this challenge.

4.4. Milestones

M1 – Analysis report finalized

M2 – Refuelling system prototype

M3 - Start-up of fuelling stations

M4 – Final report/results

4.5. Commercial milestones

CM1 - Product package

CM2 - Total solution offering

4.6. Work packages

WP1 - Project Management

WP2 – Analysis of Methanol infrastructure and feasibility study

WP3 – Specification of fuel, methanol and water quality metrics

WP4 – Specification of refuelling station concept

WP5 – Development of retrofit concept

WP6 – Development of mixing unit

WP7 – Development of rapid deployment solution

WP8 – Deployment of refuelling solutions

WP9 – Test of Methanol mix in fuel cell solution

WP10 – Test and demonstration of refuelling station concepts

WP11 – Strategy and roadmap development

WP12 - Dissemination and communication

5. Project results and dissemination of results

5.1. Project results

5.1.1. Milestones

M1 - Analysis report finalized		
Lead	Serenergy A/S	
Description	The milestone marks the completion of the initial analysis report, which contributes with specific measurements/results for later WP's. The results of the analysis will document the advantages as well as disadvantages with regard to the preferable methods for the implementation of for instance the methanol filling station.	
Link		**Due**
Products	• Methanol feasibility study • Comparative analysis	

Feasibility study:

As a starting point, it is expected that we are going to acquire methanol on the local market in Denmark to ensure the cheapest purchases and distribution possible. The tax has been calculated as an energy tax relative to petrol, cf. the letter from SKAT, dated from March 8th 2014 and the telephone confirmation from SKAT June 10th 2014.

Recent changes on legislation regarding the double taxation of the methanol mix (water tax) for use in Fuel Cells has been removed, increasing the competitivity level of the project and opening new prospects for further integration of the fuel in the commercial circuit.

Comparative analysis:

The comparative analysis shows an advantage of the Methanol concept in terms of infrastructure re-use and achieved savings. This point is critical for the success since the retrofit of current units and others in disuse, will, in a near future, expand the final delivery points at a fraction of the cost of other dedicated platforms (hydrogen). Furthermore, it shows that the Well-To-Wheel emission of a Methanol based drivetrain is comparable with that of pure Battery electric vehicles and Hydrogen fuel cell vehicles.

Conclusion

The Milestone concludes the initial work of ensuring clear metrics and understanding of the area with a Methanol feasibility study in terms of infrastructure and a comparative analysis in terms of other alternative drivetrain scenarios for the future. Both areas are subject to further studies in WP 11 and beyond the project scope in various initiatives such as the Technology catalogue in the "Analysis for Commercialization of Hydrogen Technologies" project under EUDP.

M2 - Refueling system prototype		
Lead	Hamag A/S	
Description	The milestone marks the completion of the first prototype of the methanol filling station, which works on internal lab settings. The ambition is to build, demonstrate and test a prototype, which will later on be placed on the demonstration site.	
Link		**Due**
Products	• Fuel system design specification • Working prototype	

Fuel System Design Specification

See WP4.

Working Prototype

A prototype is manufactured according to WP5. With the exception of the mainboard, which is missing the MID approval for public sales, the dispenser is ready for release to service and ready to be installed at a test site. The MID approval for the mainboard is applied and the methanol dispenser will be updated later. All necessary functions of the mainboard are satisfying.

Conclusion

Above picture shows the methanol dispenser design. The lower cabinet contains the hydraulic parts. The upper cabinet contains the electronic mainboard and other electrical components. The lower red part is the card and payment terminal with secure keyboard and receipt printer. The customer interface to the dispenser is the touch screen in the mid section. The two small displays at the top are price displays. The hose and nozzle boot will be mounted on right side of the vertical riser. All cabinet parts are stainless steel and the dispenser frame is galvanized steel.

M3 - Start-up of filling station		
Lead	OK a.m.b.a.	
Description	The milestone marks the deployment of a working filling station. The ambition is also to mark the beginning of the demonstration and test period, which includes testing and demonstrating a methanol fuel cell vehicle.	
Link	WP8	**Due**
Product	• Filling station	

The methanol fuelling station is to be constructed in accordance with applicable legislation for petrol installations and carried out in accordance with Danish directives applying to oil tanks and the requirements laid down in Statutory Order no. 555 on the prevention of soil and groundwater contamination from service stations.

Description of the methanol fuelling concept:

Compared to petrol fuelling stands, the following adaptations are required for methanol stands. In order to be able to handle the product, any parts that come into contact with the liquid must be made of steel, plastic and rubber.

- The methanol tank at the station is constructed from a special coated black steel with vacuum leakage monitoring, a level meter and overfill protection.
- The pump used to deliver the methanol is not located in the stand, but in the tank. The pump and pressurised pipes are submerged in the tank, and the electric motor is located in the tank well with a drive shaft down to the pump. Approved pump and sealed connection in the tank cover.
- Pressurised pipe from tank to stand with leakage monitoring.
- Stainless steel flow meter and pulse generator mounted in the stand.
- Stainless steel magnetic valve, used for starting and stopping, mounted in the stand.
- A chemically treated rubber hose that is resistant to methanol is used as the delivery hose.
- The fuelling gun is made of stainless steel, and it is fitted with a stainless steel dry connection to the vehicle to be fuelled, which has a corresponding dry connection piece. This ensures that other vehicles cannot be filled with methanol and that the pistol cannot be inserted into other tanks.
- The vehicle's tank is also fitted with an electric overfill protection device. A plug on the vehicle connects with a cable to the stand while fuelling. If the stand does not receive a signal from a connected vehicle, the fuelling procedure cannot begin. A signal is sent to the stand when the

vehicle’s tank is full. As soon as the vehicle’s overfill protection is activated, the magnetic valve closes to stop the fuelling and the pump is stopped.

The fuel stand is supplied by an underground methanol tank that has a double wall with built-in monitoring of the cavity. The pipework is also double-walled, and each pipe cavity is also monitored. Electronic direction calculations are logged, along with a level meter and overfill protection based on the same principles that are used in traditional petrol stations.

A fire safety permit was obtained from Aalborg Emergency Management Centre, and a permit was applied for from the Danish Environmental Protection Agency for the wholesale distribution of methanol from the filling station. And now, Europe's first methanol station is set to open. The consortium Green Methanol Infrastructure, a partnership between the Danish companies OK, Hamag and Serenergy, will open the first methanol station in Europe on 26 August 2015.

The fuelling station, which is located on Hobrovej in Aalborg, Denmark, is to be inaugurated as part of an innovation project under the Danish Energy Agency. The purpose is to make use of existing infrastructure for the distribution and filling of sustainable, liquid transport fuel, such as methanol.

M4 - Final report		
Lead	Serenergy A/S	
Description	The milestone marks the completion of the project including the demonstration results and the strategy and roadmap for further works.	
Link		**Due**
Product	• Final report • Methanol Strategy and roadmap	

The final Report work has started in June 2016. Several meetings and documents were shared to jointly evaluate the progression of the work packages and deliverables. The Methanol Strategy was designed to encompass the key aspects that Mobility solutions need to obey (WP11). The final Roadmap for deployment of new Methanol Refueling units on the market will follow the current course of development of E-Mobility Projects, to adjust the initial offer to the forecasted demand (WP11). The Serenus EV MFC ReX vehicle and the new Bus EV MFC ReX projects will address the key market targets for E-Mobility and the demonstration phase within the next 2 years will see an increase of available petrol stations to follow the Project Management goals and match the market presence of the testing units.

5.1.2. Commercial Milestones

CM1 – Product package		
Lead	OK a.m.b.a.	
Description	The milestone marks the completion of a product package incorporating a refuelling station, fuelling service and vehicles. The main target group is professional users and demonstration/test fleets with a strategic importance. The concept will be based on results from the demonstration project and will be combined with related activities in current business models and project activities.	
Link		
Object	• Business plan • Product package soft launch	

Business Plan

The identified key end users for the developed solutions are.

1. Municipalities
2. Postal service
3. Professional Cleaning services
4. Last Mile delivery services – focus on city center operations.

The added value of employing a refueling service based on methanol and vehicles that operate on this fuel is a 50% reduced energy consumption this coupled with a lower fuel cost ensures a significant operations expense saving. In addition to this the end user will have the clean, quiet and powerful attributes of an Electric vehicle while maintaining fast, simple and safe refueling.

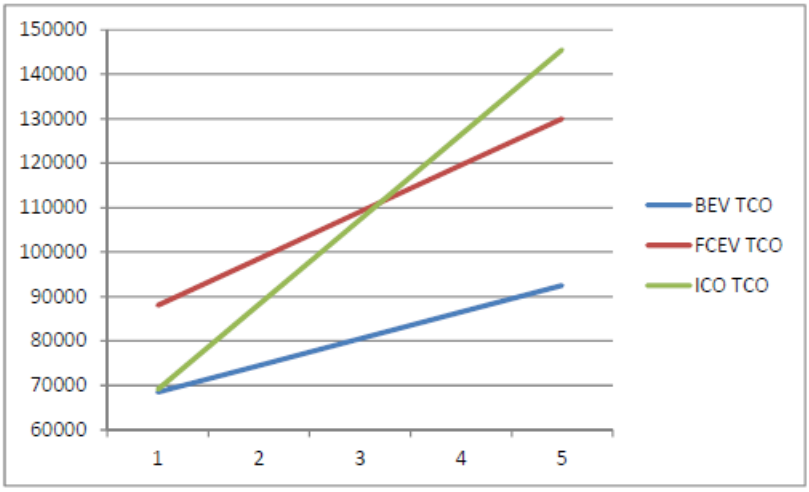
- Economic Analysis

Refueling infrastructure case

A rough estimate by OK/HAMAG of a changing a pump/station from gasoline to Methanol is 100.000 to 150.000 DKK in a reasonable volume enabling a minimum infrastructure. This is a pump that can handle more than 100 vehicles per day – unlike alternatives; Swapping fast charging or Hydrogen based on the estimate of 350 refueling option for a DK wide infrastructure the cost would be ~50 MDKK, this is a cost that will be covered by the revenue from operation meaning no investment from society. This is to be compared with e.g. 3 BDKK for Hydrogen refueling infrastructure and support per kWh consumed.

TCO

The analysis shows that in 2020 the concept will reach a commercial stage relative to that of a generic ICE vehicle. There are numerous factors not considered in the analysis, partly due to complexity and partly due to uncertainty. However, the trends and basic understanding remains the same. Fossil fuels will increase in price and focus is on implementing electrical propulsion in the transportation area. The BEV advantage is clear and the FC configuration shows the feasibility over ICE variants when range and fast refueling is needed.



TCO running costs comparison analysis

Based on the 2020 car models and a given operation time the following picture emerges. The ROI is close to three years for the fuel cell concept relative to the ICE concept. This is typical leasing period and a driver for cost effective operation considerations.

The TCO is a simple summation of vehicle cost as a starting point and fuel seen as a running cost.

The soft launch consists on the public presentation and use of the developed product packages:

- Infrastructure Launch - refueling Methanol Mix Petrol Station
- Methanol Fuel Cell Vehicles

Infrastructure Launch

The Green Methanol Infrastructure Consortium formed by Serenergy, OK and HAMAG, with sponsoring from Energistyrelsen, opened in August 26, 2015, Europe's first methanol filling station. The filling station in Aalborg is the first and more of its kind is on its way. The purpose is to demonstrate an infrastructure reutilizing the existing infrastructure and the flexibility of the solution and its easy deployment in similar petrol stations across Denmark and Europe.

Inauguration of the world's first Methanol Mix Fuel station

Methanol Fuel Cell vehicles

The vehicles developed in MECC represent a first generation that is used solely for limited testing and validation. Then, a generation 2 will be developed that extends from vans to more specialized vehicles and operating patterns - for example. for craftsmen, package delivery and delivery.

The above stated principles lead to the development of the 3-point strategy. Currently, Serenergy has developed and tested successfully several types of vehicles:

- In December 2016, Serenergy registered the world's first methanol-driven fuel cell car. The range of the vehicle is groundbreaking 800km without recharging and this range-extension on the basis of an Fiat 500 has been made possible with the collaboration of project partners in 'Modular Energy Carrier Concept' (MECc); Insero and EUDP in Denmark.

MECc Fiat 500

- Serenus eV200 – Using a Nissan eV200 EV as a base, it was fitted a 5kW HT-PEM Fuel Cell as a range extender. This second-generation vehicle has proven itself as a reliable and convenient platform to showcase the potential of the technology in the Light Commercial Vehicle (LCV) segment. The same range of 800 kms. was achieved in this vehicle, being able to charge the 24 kW batteries fitted as standard on the vehicle, together with a 70-liter tank deposit for the Methanol mix fuel.

Serenus eV200 EV MFC ReX vehicle

Both vehicles, although belonging to different market segments, obey to the same principles of use and have all the advantages of using a Methanol Fuel Cell:

- Zero particle emissions.
- No noise and vibrations.
- It is 30% cheaper to drive methanol hybrid car compared to diesel cars.
- Waste heat is used for cabin heating.
- Reliable system – maintenance is up to 75% cheaper compared to diesel engines;
- Scalability – fuel system can be scaled.

CM2 – Total solution offering		
Lead	OK a.m.b.a.	
Description	The millstone marks the launch of a total solution enabling both vehicles in various forms to refuel and providing the supporting infrastructure. The model will be applied to early market concepts such as auxiliary vehicles as well as niche application for road transportation.	
Link		**Due**
Object	• Solution launch	

On December 15th 2016, Serenergy announced the world's first registered methanol-driven fuel cell car. Over the period of 2 months, the ReX electric vehicle has been successfully tested in Aalborg, Denmark by Just Eat – a major online takeaway ordering service operating in 13 markets.

FIAT 500 FCV & JustEat Partnership - vehicle delivery for continuous road-test

The choose of partner fitted the application intended for the vehicle. To operate in the urban, city-center environment, to relieve the driver from range anxiety issues due to the short range provided by the batteries. Combining the batteries with the Methanol Fuel cell, the vehicle has an outstanding driving range of 800kms, without recharging.

This range-extension on the basis of a Fiat 500 platform has been made possible with the collaboration of our project partners in 'Modular Energy Carrier Concept' (MECc); Insero and EUDP in Denmark. Just Eat has been satisfied with the vehicle and decided to continue delivering food in the methanol-driven fuel cell car, enabling Serenergy to continue to test new solutions and configurations in real world conditions, in a multitude of routes, speeds and drivers. Only one driver was trained for the refueling process in the OK petrol station in Skalborg. The knowledge was passed inside of the company and currently, 5 different drivers take the car on a daily service basis.

5.1.3. Work packages

WP1 – Project Management		
Lead	OK a.m.b.a. & Serenergy A/S	
Description	Project management including coordination of steering committee meetings and summaries and the half yearly reporting to ENS. The technical project management and administration is coordinated by SE on behalf of OK.	
Link	All WP	**Due**
Objects	• Quarterly statements • Progress report • Final report	

Regular steering committee meetings have been held throughout the project, in which progress has been discussed and reported, resources and scheduling addressed, and the open questions and deliverables discussed. Weekly status meetings were held by telephone/e-mail throughout the entire project between project managers from OK, Serenergy and Hamag. This has ensured a stable framework for the project. As project leaders, OK and Serenergy have been responsible for the start-up of the project, regular contact to EUDP, holding a kick-off meeting, establishing a steering committee and ensuring that regular reporting is an integral part of the project.

In addition to OK, Serenergy and Hamag, Methanex and CRI have served as important sounding boards in the project.

Over the course of the project, the project partners have wanted to make changes to delivery dates of individual work packages and milestones, as well as for the project's completion. An overview of the project with the timing of milestones after approved changes can be found in Table 4.

Along the way, the project partners have adapted the project's work packages and results in relation to the market situation.

WP2 - Analysis of Methanol infrastructure and feasibility study		
Lead	OK a.m.b.a.	
Description	The objective is to conduct further studies on the feasibility regarding methanol infrastructure in Denmark. The main goal is to prove the cost effectiveness of implementing bio-methanol as a liquid energy carrier into the current infrastructure and gradually changing the energy used in the infrastructure from fossil gasoline to renewable methanol. The Analysis of the value chain from producer to filling station: • Import methods • Storage possibilities • Blending • CO2 abatement cost • Distribution from storage to filling station and among storage facilities • Taxes	
Link	WP3-WP4-WP5	**Due**
Objects	• Feasibility study • Infrastructure design	

Results from the Feasibility study:

Import methods:

Currently, Denmark has not a national production setup of Methanol that would suit the current and forecasted needs in the near future, as the network keeps developing and being deployed across the country.

Import, therefore, is the solution to get the fuel needed to power this transition towards a more sustainable and clean future. Since the source of Methanol is conditioned by the international markets, since it is a commodity, availability might determine the source and supplier selected, having in mind some constraints such as current price market, availability of stock, and time, both in immediate need and shipping/delivery. Different methods can be used to import and deliver the Methanol, each one having inherent advantages and disadvantages regarding time and the overall CO2 footprint that is generated on the process.

Being the environment one of the scopes of this project, recognizing the environmental issues demands a better understanding of CO2 emissions relating specifically to volatile liquids transportation, based on WTW (Well-To-Wheel) emission factors, including upstream emissions/energy from “production” of fuel and infrastructure, all the way to the final delivery of the product to the end-user.

The estimated calculations are based on transportation between nodal points (generally ports or railheads). The user then enters the road distance to the origin node from the loading point, and from the destination node to the final delivery point.

Different mode of transportation considerations:

- **Ship** - Currently, the methanol acquired for operations comes from Methanex, global leader in the sector, and CRI, Carbon Recycling International from Iceland. The de-bunkering of the Methanol is a relatively safe procedure due to the fact that is carried in IBC containers, simplifying the handling and storage of the material. 1 MT (Metric Ton) of Methanol equals 1265 lts. The Methanol is carried on ventilated containers on the vessel, being later on transferred to a truck by a fork lifter. The WTW CO2 emissions are, by average, around 40 gr CO2/TEU.km. 1 TEU unit equals 10 tonnes.
- **Train** – As previously mentioned, market constrains and availability, might lead to procurement of Methanol in different markets, mainly Continental Europe or a different ship bunkering port. Due to the high level of connectivity of Intermodal connection hubs across Europe and the railway connections established with Germany and Sweden, train is a cost-effective transportation mode for containers. After delivery, transfer for a truck is needed and a fork-lift to unload the cargo on final destination. The WTW CO2 emissions are, by average, around 22.6gr CO2/t.km (per ton, per kilometer).
- **Trucking** – Trucks are the most common delivery method of the Methanol to the final client. But on itself, it presents different options:
    - **RORO (ro**-ro) – Roll-on and Roll-off ships are vessels designed to transport wheeled cargo such as cars, trucks, railroad cars, among others. Meaning that the cargo is directly loaded on the truck, carried by sea-freight and after docking, road driven directly to the final client. A fork-lift is needed to unload the cargo on final destination. The WTW CO2 emissions are, by average, around 59.2gr CO2/t.km (per ton, per kilometer).
    - **Direct Road transport** – either from the Port of from the refinery/deposit to the final client. A fork-lift is needed to unload the cargo on final destination. The WTW CO2 emissions are, by average, around 59.8gr CO2/t.km (per ton, per kilometer).

Danish Market Context:

In the first period (2012-2015), there will be only a requirement for the purchase of methanol in IBC containers, since the volumes are not so large that we can use ship import. In the long term - during the second period of 2015-2025 we will gradually be able to start distributing in bulk (tankers) and at the end of the period, ship imports should be considered.

For purchases in small quantities -> min. 5 IBC per Procurement, thereby minimizing capital ties and price risk. The product is hazard class II and this means that we cannot store the IBCs at the stations without special poison permission as well as a fire approval. The product is classified as toxic and highly flammable. (Inhalation, skin and ingestion) Road transport must accompany hazardous papers - UN 3473. It is the local fire manager who decides how much we own at the individual station (in IBCs)

Ship imports will require approved Hazard Class II in respect of Samtank's facilities. Should a change be made in the current tank application (petrol -> methanol), a new EIA screening and investigation must be prepared. Costs for this are estimated at approx. 200,000 kr.

Tank capacity will be around 5000 m3 for the best possible shipping. However, it would be advisable to have 2 smaller tanks available instead of 1 large, since tanks should be cleaned and maintained, cf. Legislation every 5 years. In addition, there may be a risk of shutdown if unforeseen problems with a tank occur. We work through OK's EOF Association to challenge SKAT's previous settings on charges for methanol for transport.

Blending:

The scope of the project is to enable and establish a fully operational network of Methanol fuel station s across the Danish territory. Therefore, in order to ensure that the distribution operations are performed according with the current practices/routing of normal fuels, the blending of the fuel (60% methanol + 40% demineralized water) must be performed at the terminal where its stored and then, from the terminal, distributed across the supply chain for the end-user. Other options would add more costs and complexity to an operation that is already implemented on the market and whose cost structure is known to the involved partners.

CO2 abatement cost/Taxes:

The project partners represent a strong and dedicated effort in bringing Danish research, development and demonstration within the area of fuel cell technology, as well as integrating solutions, infrastructure and technologies in a working environment.

The project supports the strategy for liquid biofuels especially the main focus on:

- Ensuring a cost effective long term energy supply
- Ensuring growth potential for Danish companies
- Ensuring the fulfillment of Danish goals in sustainable fuel development

- Maintaining and develop the Danish research platform

The CO2 emissions are in line with the Danish Energy National policy. **Carbon emissions trading** is a form of trading that specifically focuses on carbon dioxide emissions (calculated in tonnes of carbon dioxide equivalent or tCO_2e) and it represents the majority of emissions trading. This form of permit trading is a common method country utilize in order to meet their obligations according to the Kyoto Protocol to increase the reduction of carbon emissions to stop the global warming process and climate change.

Distribution and profits

Methanol is distributed exactly the same way as diesel and gasoline. That is – transport from plant to storage facilities on harbors using anchored vessels, huge storage tanks storing several thousands of tons at a time, distribution by trucks (normally up to 28 tons at a time) and storage in underground or above-ground tanks at petrol stations.[1]

Methanol is used in fuel cells, making twice as good use of energy as a combustion engine. It is considered to be an alternative sustainable fuel, even though methanol is a green fuel only if it is produced from renewable resources such as biomass or the biodegradable element of waste (Aricò,2010, pp. 10-20). There are several ways to produce methanol.

By a production method methanol is classified into 3 groups:

Black methanol	Green methanol - CO2 neutral	Grey methanol
•Produced from coal, it is most popular in China	•Produced from bio-mass •Produced from syngas	•Produced from waste- and by-products

[1] GreenSynFuels - *Economical and Technological Statement regarding Integration and Storage of Renewable Energy in the Energy Sector by Production of Green Synthetic Fuels for Utilization in Fuel Cells, p.93, 2014*

Using green methanol has a lot of advantages compared to other types of fuels:

- Low to zero emissions – the use of renewable methanol from CO2 plant releases up to 90% less CO2 than the usage of a similar volume of energy from fossil fuels (Carbon Recycling international, 2016).
- Low production costs – its production it is cheaper than production of other products.
- Energy security – it is very flexible fuel, which can be produced from a broad range of products.

Methanol Cost Structure & Consumer Price

Methanol price at the pump is a result of the base production price, distribution & profits, CO2 tax, energy tax and Value Added Tax (V.A.T). All prices will be listed in €/L or €/MT. Distribution & profits, CO2 tax, energy tax and V.A.T. are listed according to Danish taxation rules.[2]

The Base Price is defined as the cost of methanol Free On Board (F.O.B) on a vessel, a train or truck(s). The company Methanex has posted prices for the European market since January 2002 (the so-called Methanex European Posted Contract Price (MEPCP)).[3]

Total Cost at pump

What is important is true measures of Consumer price – all based on a by/volume measure.

[2] GreenSynFuels (2011),*p.92*
[3] https://www.methanex.com/sites/default/files/methanol-price/Mx-Price-Sheet%20-%20May%2026%2C%202017.pdf

Methanol Price (Green Methanol)				
		Metric Ton		Liters
		1		1,250
Feedstock		1	€	500.00
		1	DKK	3,715.00
		Price per 1000 lts		Price per liter
Price	DKK	2,972	DKK	2.97
60% Methanol (vol)	DKK	1,783	DKK	1.78
40% Deionized Water (vol)	DKK	50	DKK	0.05
Distribution	DKK	500	DKK	0.50
Mixing Fuel Cost	DKK	160	DKK	0.16
Total Fuel Cost			DKK	2.49
Energy Tax			DKK	0.71
CO2 Tax			DKK	-
VAT			DKK	0.84
Final Price			DKK	4.04

* green methanol is exempt of CO2 tax

Methanol Price Methanex				
		Metric Ton		Liters
		1		1,250
Feedstock - Price from 01/10/17 to 31/12/17		1	€	330.00
		1	DKK	2,451.90
		Price per 1000 lts		Price per liter
Price	DKK	1,962	DKK	1.96
60% Methanol (vol)	DKK	1,177	DKK	1.18
40% Deionized Water (vol)	DKK	50	DKK	0.05
Distribution	DKK	500	DKK	0.50
Mixing Fuel Cost	DKK	160	DKK	0.16
Total Fuel Cost			DKK	1.89
Energy Tax			DKK	0.71
CO2 Tax			DKK	0.12
VAT			DKK	0.68
Final Price			DKK	3.40

Analysis of the value chain from producer to filling station

In the initial period (2012-2015) there will only be a need to purchase methanol in IBC containers, as the volumes are not high enough to make use of importing by ship. In the longer term – in the period of 2015-2025 – we will gradually be able to begin distributing in bulk (tankers), and by the end of the same period we will consider the possibility of importing by ship.

By purchasing in small volumes -> min. 5 IBC per purchase, immobilisation and price risks can be minimised.

The product is a hazard class II, which means we cannot store the IBCs at the stations without a special toxin permit and fire safety approval. The product is classified as toxic and extremely flammable (inhalation, skin contact and ingestion). If transported by road, it must be accompanied by a permit to carry dangerous goods, UN 3473. It is up to the local fire chief to decide how much we may have at the individual station (in IBCs).

Shipping import will require approved Hazard Class II tanks at Samtank's stations. If the current tank use is to change (petrol -> methanol), a new environmental impact assessment screening and study must be performed. The costs for this are an estimated DKK 200,000.

The min. tank capacity will be around 5,000 m3 for the best possible shipping rates. However, it will be suitable to have two smaller tanks available instead of one large one, as the tanks will need to be cleaned and maintained every five years, cf. applicable legislation. Furthermore, there is a risk of shutdown if unforeseen problems arise with one of the tanks.

We are working through OK's industry association, EOF, to challenge the Danish tax authority's position on levies on methanol used in transport.

WP3 - Specification of fuel, methanol and water quality measurements		
Lead	OK a.m.b.a.	
Description	The objective is to in detailfuel specifications. The specification will cover known aspects but also new aspects related to fuel cell operation handling and blending of bio methanol and other generic production processes. The specification will cover both engine specific details and fuel related details: • Gasoline Low/High Blends • Bio-diesel • Methanol water mix – fuel cells Clarify, describe and test the quality of base products and final blended product for HTPEM fuel cells.	
Link	WP8 – WP11	**Due**
Objects	• Fuel specifications • Reliable measuring results	

Fuel specifications

Gasoline Low/High Blends and Bio-Diesel

The results for comparison purposes of specification, will be included on Annex, since the scope and focus of this project and WP, is to clarify the standards for Methanol fuel and Water mix needed for the fuel blending used in the HT-PEM Fuel Cells.

Methanol

Scope: Methanol fuel specification, outlining the standards and specification of fuel from alternative suppliers to be used with the Reformed methanol fuel cell systems from SerEnergy A/S.

Fuel Composition

	Methanol	**Deionized Water**
Nominal	60% vol	40% vol
Minimum	58% vol	42% vol
Maximum	62% vol	38% vol

Deionized Water

The water in mix must have the following specifications:

Iron ppm	< 0,02
Chloride ppm	~0
Calcium oxide ppm	~0
Magnesium oxide ppm	~0
Evaporation residue ppm	<0,1
Conductivity µS/cm	<4
DHº	<0,1

The preferable process for obtaining deionized water is Reverse Osmosis over the Ion exchange systems as the above spec is hard to reach with the later mentioned system (parameters).

Evaporation residue

In RMFC-systems the methanol/water mix is passed through an evaporator, thus it is very important that the evaporation residue is minimal, otherwise the residue can potentially clog this component. Maximum 0,5 mg/L evaporation residue is acceptable. Serenergy must, for supplemental and continuously power supply, have an inline fuel filter that can clean from ~10 mg/L to the acceptable limit.

Methanol Grade and Particles

For use in Serenergy products, an industrial IMPCA methanol grade is acceptable. It is recommended that the supplier use particle filtration in the production process with a particle filter below 8µ.

Test of particle content, purity and storage

The purity and evaporation residue must be continuously verified, especially if the solution mix is stored over a period exceeding 2 months. A methodology FIFO (first in – first out) should be adopted to minimize the problem and the required staff must be trained in safety procedures to carry on this task and handle the dangerous goods. The solution mix should preferably be stored in Intermediate Bulk Containers (IBC), since the modular concept of the container allows flexibility in storage arrangements and ease of transportation if needed.

1000 lts IBC container

Storage concept for Methanol IBC containers

Reliable measuring results

Results

The WP has been delimited to Methanol/water mix relevant for Methanol Fuel cell applications and away from fuel blending with diesel/gasoline due to relevance looking forward.

The main quality parameter In terms of Fuel cell functionality is purity related to evaporation residue from Methanol and salts in water. The effect from the remains is that the fuel cell will evaporate and convert everything else and the remaining residue will eventually clog the system and cause a failure.

IMPCA – Industrial grade Methanol

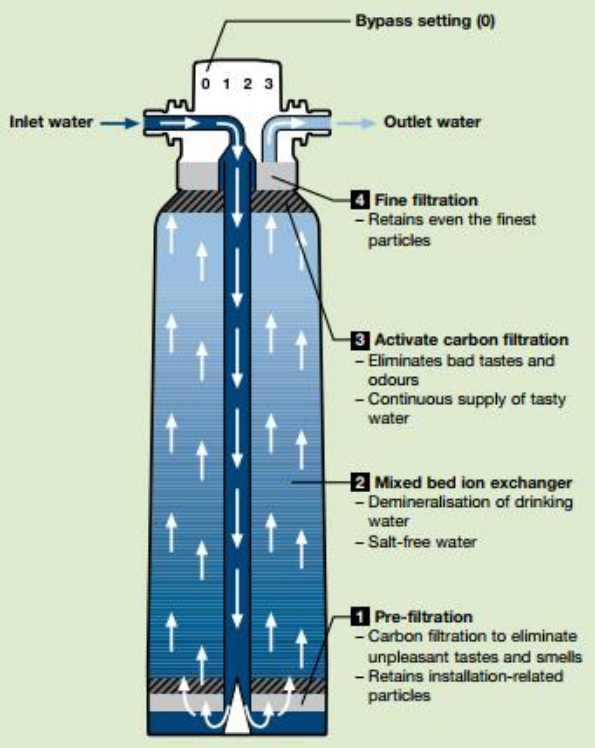
It is clear to ensure a worldwide adoption of the Methanol concept that Industrial grade methanol should be implemented and not special grades such as medial or direct sourced where the methanol supplier has dedicated transportation and storage from production to point of distribution. The IMPCA standard for methanol has been adopted and major Methanol suppliers adheres to this.

Control of fuel quality

A control method to verify fuel quality has been developed and can be done batch wise from various suppliers. This gives a good number for evaporation residue and can be used to do batch quality check, However, it has been observed that suppliers can have varying quality within the IMPCA quality metrics but outside the developed Methanol/water spec.

Filtering

To ensure a fuel quality that is acceptable according to the developed spec an “in-line” point of distribution filtering is needed. Several options were surveyed and a water purification concept was adopted as this removes Salts from water and impurities from the Methanol at the same time and can be flexible in both premixed delivery or onsite blending.



Inner Structure of the BWT Bestdermin filter cartridge

BWT Bestdermin cartridge

The water filter can be installed with a conductivity measurement which will give a measure on both impurities’ in water and Methanol – Several tests has been performed and the filter can remove ~90% of the impurities’ while enabling an online and continues measurement of fuel quality.

Fuel Mix

Reformed Methanol Fuel Cell (RMFC) systems can preferably use a pre-mix of 60 % methanol and 40 % de-mineralized and de-ionized water (on a volume basis). This mixture is advantageous as an energy-carrier compared to pure methanol for four reasons:

1. This fuel is safer from a fire perspective than pure methanol
2. This fuel is cheaper to transport as a result of the lower flammability (20% per l, but also 38% less energy per liter.)
3. No water-condenser is needed (cost, weight, efficiency).
4. 1 bipolar-plate per cell instead of 2 at a lower cost per kW is possible.

When methanol and water are mixed the molecules mix and the blend becomes denser. The relation between the original volume of methanol and water before mixing and the finale volume is seen in Figure 42. The original volume of water does not appear, but it is 100 minus the original volume of methanol before mixing. This means that one can actually carry almost 4 % more energy in one liter of 60/40 methanol than one should think.[4]

MSDS – Safety Datasheet download:

http://serenergy.com/wp-content/uploads/2014/06/Methanol-60-MSDS-US.pdf

Conclusion

The WP is completed and detailed specifications on Methanol fuel quality and simple feasible ways of cleaning the Methanol/Water mix. Furthermore, a simple resistance measurement as known from water purification can be implemented to ensure fuel quality. Special attention was given to mention inputs over fuel stock management and routine testing of the stock, to ensure the continuous availability of the fuel.

[4] GreenSynFuels (2011),*p.73*

WP4 – Specification of Refueling station concept (Lead:HA)		
Start **End**	M4 M6	
Description	The objective is to specify and develop a suitable concept for various applications, both retrofit on existing infrastructure and as a rapid deployment solution to supplement demonstrations or fleets. The goal is to ensure a design that is cost-effective and suitable to for a gradual implementation of methanol into the transportation sector. The work includes: • Fulfillment of current standard regulations • Homologation with future regulations • Design based principles including safety mechanisms. • Evaluation of the design according to export conditions The output will be a clear understanding of the work in development work packages.	
Link	WP7 – WP8 –WP9	**Due**
Objects	• Design specification • Conceptual design	

Methanol dispenser specifications:

- Complying with MID Measurement Instrument Directive, ”Sikkerhedsstyrelsens bekendtgørelse af nr. 436 af 16. maj 2006” according to EU directive nr. 2004/22/EF.
- Comply with applicable rules of ”Tankstationsbekendtgørelsen”.
- Fulfill the rules for flammable liquids.
- Fulfill the rules for toxic liquids, the user must not get in contact with the liquid or vaporized methanol.
- Hydraulic parts may not pollute the product(s) wetted parts must be stainless steel or plastic that is resistant to methanol.
- Should be working in the OK concept as a system dispenser using IFSF standard protocol.
- Should be working as a stand alone dispenser without network connection.
- Fuelling of a wrong product must be avoided (special nozzle design), that can only fit to a methanol tank.
- Only one type of dispenser type should be used, regardless if the methanol and water supply is mixed or separated.
- The dispenser cabinet design is according to OK general design rules.

WP5 – Development of retrofit concept (Lead:HA)		
Start **End**	M4 M12	
Description	The goal is to design, develop and test a retrofit solution that enables refueling station operators to retrofit an existing tank and pump to work with methanol-water mix for fuel cells. The retrofit concept is expected to entail an upgrade of underground tanks with a plastic membrane and replacement of non-resistant components with other materials. Furthermore, the design of a simple delivery system that complies with relevant cars and that does not allow refueling of any wrong fuel type or mix. The retrofit concept will be aligned based on different setups in the market for stations in general with special focus on the project partner setup. The scope is to reduce infrastructure costs, deployment speed and resource demand. The retrofit concept will have a significant impact on the overall operator business case when exploring alternative fuels and their feasibility.	
Link	WP6-WP7-WP8	**Due**
Objects	• Design/rebuild concept • Functional diagram • Cost analysis • Prototype • Insitu Test program	

Concept

The concept for installing a methanol dispenser that can dispense a methanol and water mix is the following:

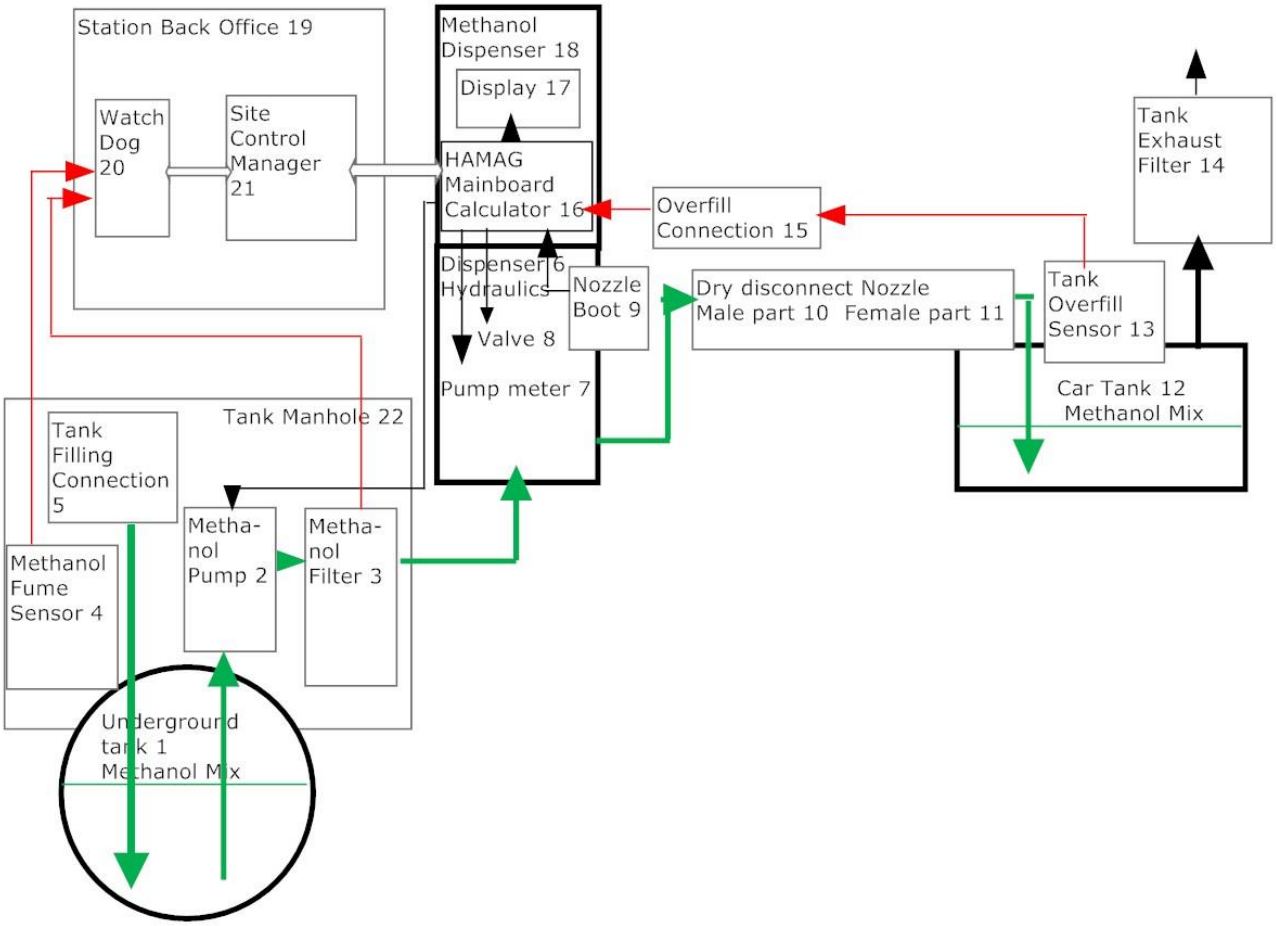
- Updating an existing underground tank chamber with a methanol resistent membrane/or new tank. (OK)
- Replacing the suction line with a methanol resistant piping (stainless steel/ methanol resistant plastic). (OK)
- Replacing an existing MPD-dispenser with the methanol dispenser.
- All electrical supplies are established and can be reused.
- Test a prototype

Functional Diagram

Below figure shows a functional diagram of the concept.

- Underground tank 1with manhole 22
- Due to problems with specifying a suction pump 2 for the dispenser a solution with an external Ex-pump mounted directly in the tank manhole was the most economical solution.
- The quality of the methanol/water mix is controlled by a conductivity measurement after the filter 3 that removes impurities from the methanol/water mix. Signal from the conductivity measurement on the filter 2 is sent to the Watch Dog 20 that stops delivery in case of pure product quality and passes the alarm through to Site Control Manager 21 an from here forwarded to the OK company head office.

- Besides 2 pcs. Methanol Fume Sensors 4, only one shown in the functional diagram, one in the Tank Manhole 22 and the other one in the system water drain, close down the station in the event of methanol gas evaporation.
- A stainless steel pipe connects the filter with the Dispenser Hydraulics 6 .
- To start a fueling the dispenser need the following conditions to be fulfilled:
    - A payment card is accepted by the mainboard 16
    - The Dry Disconnect Nozzle 10 is taken from the Nozzle Boot 9 and connected to the car refueling connection 11 by opening the dry disconnect coupling turning the nozzle 90°.
    - The cable for the car Tank Overfill Sensor 13 is connected to the Overfill Connection 15 and if there is free space in the Car Tank 12 the "OK" signal is passed on to the Mainboard 16.
    - The Mainboard 16 gives a start signal to the pump
    - The outlet Valve 8 opens for fuelling.



- The Pump 2 forces the fluid through Filter 3, Pump meter 7, Valve 8, Delivery hose, DDC nozzle 10 and DDC coupling 11 to the Car Tank 12.
- The filling of the Car Tank 12 is only possible if the repressed gases in tank get out. To make this happen the fumes are forced through a Gas Exhaust Filter 14 that removes evaporated methanol fumes from outflowing gases. Se car filling concept below.
- The fueling stops if:

  - The Car Tank 12 is full and the Tank Overfill Sensor 13 gives a “full” signal to the Mainboard 16.
  - The DDC Nozzle 10 is closed and removed from car tank DDC connection 11and placed in the Nozzle Boot 9. The Nozzle Boot 9 switch give signal to Mainboard 16 to close delivery Valve 8 and to stop the Pump 2.
  - In the event of not receiving pulses from the Pump Meter 7 the Mainboard 16 stops automatically the fueling in progress with a time out.
- During the fueling the Mainboard calculates the delivery and price and shows the actual fueling in the Display 17
- Fueling data are sent to the Site Manager and forwarded to OK head office.

DDC Nozzle design

The nozzle is designed as a spill free stainless steel nozzle with a dry disconnect coupling (DDC) to comply with the toxic and environmental rules for methanol. The DDC-coupling is made of two parts, one part on the nozzle as showed below and the other part mounted to the car tank filling tube. Both parts, the nozzle and the car connection part are normally closed and only opens when joined together and turned 90°.

Car filling concept/ Tank Exhaust Filter

In contradiction to a normal gasoline nozzle under delivery, this nozzle does not allow repressed gases in the car tank to be sucked back to the tank. Instead, the car has a gas exhaust filter that collect the evaporated methanol. An automatic nozzle stopps the delivery, when the liquid reaches a little sensing tube at the end of the nozzle filling pipe. This is not possible with the DDC-nozzle. To avoid overfilling the car tank the tank is equipped with an optoelectrical overfill sensor. Through a cable the sensor is connected to the dispenser. If the car tank is full the dispenser instant stops the delivery by closing the dispenser delivery valve.

In Situ Test Program

A methanol dispenser is manufactured for use on station “Skalborg” se WP8.

Cost Analasys

In comparison to a fossile fuel multipump dispenser the estimated price for a Methanol Water Mix dispenser is 2 to 2½ times higher. Not included in this estimation is the forecourt and tank rebuild/replacement and other additional work like piping.

Conclusion

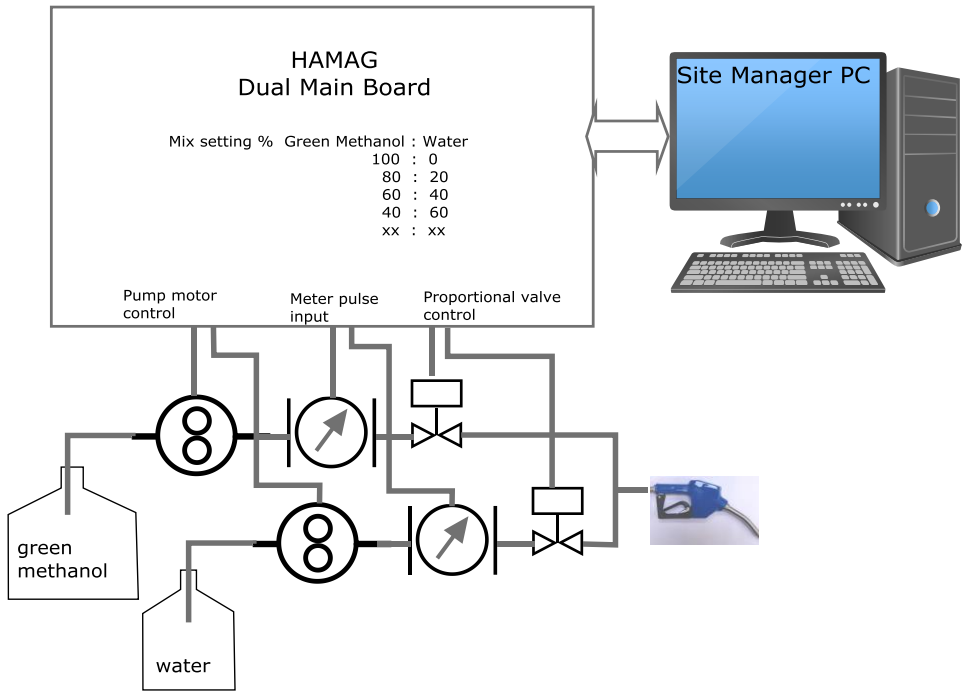
A Methanol dispenser has been produced and put into service at OK station “Skalborg”. An approved MID version of the mainboard is now available for further dispenser productions.

WP6 – Development of mixing unit (Lead: HA)		
Start **End**	M6 M18	
Description	The work package will entail the development of a mixing unit enabling raw methanol to be mixed with water onsite. The concept will enable several products and or variants to be made in the same system. A water purification system will be designed to ensure onsite tap water can meet purification specifications. This will reduce the distribution of methanol mix with 40% and increase the flexibility for deployment. The mixing unit development will explore several concepts to meet various station configurations and operators demands. Furthermore, focus will be on to onsite monitoring of fuel quality and mixing resolution. The mixing unit will be a part of both the rapid deployment solution and the retrofit concept.	
Link	WP 6- WP7 – WP9	**Due**
Objects	• Design of Fuel mixing unit • Prototype • In situ testing	

Design of Fuel mixing unit

The main part of the mixing unit is a software based digital regulation system in the HAMAG MID mainboard. Se MID system enclosure description. Based on earlier experience with mixing units for diesel and biodiesel, development of a mixing unit for methanol/water mix is completed.

Block diagram of the implemented mixing system:



Water Purification system

Several proposals for the for the water purification system has been discussed, but not installed in the test site at Skalborg, due to problems with the coating of the underground tank. This is the reason why the tank can't be filled with clean methanol.

In situ testing

The mixing unit is testet as a part of the MID approval. The meters have a max, deviation of ±0,5% in a measuring range of 10% to 100% flow. The digital regulations systems of the Dual Mainboard that controls the proportional valves easily can obtain a mixing fuel composition according to the mixing demands for the fuel cells shown in the table below.

Fuel Composition

	Methanol	Deionized Water
Nominal	60% vol	40% vol
Min	58% vol	42% vol
Max	62% vol	38% vol

Conclusion

Development of an MID approved methanol dispenser with a methanol/water mixing unit is accomplished.

WP7 – Development of rapid deployment solution (Lead:HA)		
Start **End**	M6 M18	
Description	The focus is to develop and test a rapid deployment solution as a container configuration facilitating a simple, flexible and fast way of meeting demand for a fueling solution. The development will entail a generic platform suiting several different applications with limited adaption, among others are vehicle demonstration, auxiliary vehicles and material handling. The rapid deployment solution entails in addition to the physical frame; • Fuel container • Monitoring system • Delivery system • Mixing unit • Water purification unit The unit will be specified for above ground installation and have an integrated monitoring system to ensure a service and logistic strategy suited to relevant demand. The system will be designed to meet current and future legislative demands.	
Link	WP4 – WP6	**Due**
Objects	• Design of rapid deployment solution • Prototype • Test	

Design of rapid deployment solution

As shown in the photo below a rapid deployment system with a capacity of fueling 10 to 100 cars a day could be a container solution with an integrated booth for the methanol dispenser. Unfortunately, above ground storage tanks for clean methanol must have an inert gas topping to avoid evaporation of methanol. Typical this is implemented with Nitrogen, called nitrogen blanketing (se enclosure) and needs a high pressure container tank. Another method is to cool down the methanol or to mix with water, where the last suggestion is the most obvious one.

For rapid deployment systems we suggest to use premixed methanol/water 60:40. A 20 ft. high cube tank container can contain approximately 20.000 l methanol/water mix. Therefore, the mixing- and water purification unit are not necessary in this solution. Filter, monitoring system, leak detection, level control and overfilling protection are typical placed in a small technical office at the end of the container.

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Conclusion

With the exception of the costs for preparing the site where to place the rapid deployment system, the price for a 20 feet container with a Methanol Water Mix dispenser is estimated to be 1.3 times higher than a corresponding diesel container station.

WP8 – Deployment of refuelling solutions		
Lead	OK a.m.b.a.	
Description	The main goal is to deploy refueling solutions in actual operation to support related activities and demonstration. The scope is 1-3 stations or locations to ensure suitable room for test in both configurations and with a possibility to cater for relevant requirements arising from other demonstration projects. Find suitable locations for methanol filling stations Get approvals from authorities (police, fire-brigade-chief, municipality etc.) Rating of locations according to infrastructure and a number of technical factors such as available space for vehicle maneuvering etc.	
Link	WP7 – WP9	**Due**
Objects	• Suitable locations • Complete drawings of filling stations with layout of tank areas and vehicle turn-around radius.	

The methanol fuelling station is to be constructed in accordance with applicable legislation for petrol installations and carried out in accordance with Danish directives applying to oil tanks and the requirements laid down in Statutory Order no. 555 on the prevention of soil and groundwater contamination from service stations.

Description of the methanol fuelling concept:

Compared to petrol fuelling stands, the following adaptations are required for methanol stands. In order to be able to handle the product, any parts that come into contact with the liquid must be made of steel, plastic and rubber.

- The methanol tank at the station is constructed from a special coated black steel with vacuum leakage monitoring, a level meter and overfill protection.
- The pump used to deliver the methanol is not located in the stand, but in the tank. The pump and pressurised pipes are submerged in the tank, and the electric motor is located in the tank well with a drive shaft down to the pump. Approved pump and sealed connection in the tank cover.
- Pressurised pipe from tank to stand with leakage monitoring.
- Stainless steel flow meter and pulse generator mounted in the stand.
- Stainless steel magnetic valve, used for starting and stopping, mounted in the stand.
- A chemically treated rubber hose that is resistant to methanol is used as the delivery hose.
- The fuelling gun is made of stainless steel, and it is fitted with a stainless steel dry connection to the vehicle to be fuelled, which has a corresponding dry connection piece. This ensures that other vehicles cannot be filled with methanol and that the pistol cannot be inserted into other tanks.
- The vehicle's tank is also fitted with an electric overfill protection device. A plug on the vehicle connects with a cable to the stand while fuelling. If the stand does not receive a signal from a connected vehicle, the fuelling procedure cannot begin. A signal is sent to the stand when the vehicle's tank is full. As soon as the vehicle's overfill protection is activated, the magnetic valve closes to stop the fuelling and the pump is stopped.

Underground methanol tank

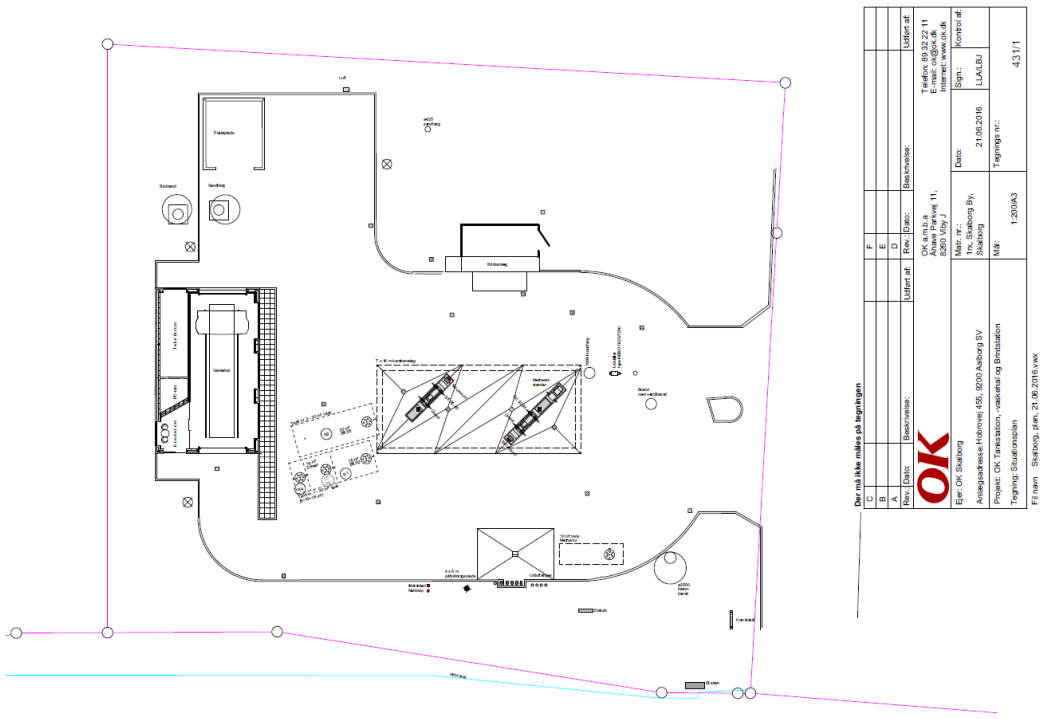
The fuel stand is supplied by an underground methanol tank that has a double wall with built-in monitoring of the cavity. The pipework is also double-walled, and each pipe cavity is also monitored. Electronic direction calculations are logged, along with a level meter and overfill protection based on the same principles that are used in traditional petrol stations.

A fire safety permit was obtained from Aalborg Emergency Management Centre, and a permit was applied for from the Danish Environmental Protection Agency for the wholesale distribution of methanol from the filling station. And now, Europe's first methanol station is set to open. The consortium Green Methanol Infrastructure, a partnership between the Danish companies OK, Hamag and Serenergy, will open the first methanol station in Europe on 26 August 2015. The fuelling station, which is located on Hobrovej in Aalborg, Denmark, is to be inaugurated as part of an innovation project under the Danish Energy Agency. The purpose is to make use of existing infrastructure for the distribution and filling of sustainable, liquid transport fuel, such as methanol.

Suitable locations

The methanol fuelling station is located at the OK plant in Skalborg, Denmark, which is an OK multi-fuel plant that, in addition to offering petrol, diesel and a Nordic Swan Ecolabel-certified washing pit, also contains a hydrogen fuelling station. The location is ideal as it is close to Serenergy's headquarters, which can use the methanol fuelling station in its testing. Furthermore, Aalborg Municipality has shown a great deal of interest in our project, and is a municipality that sees the potential in methanol-powered cars as a serious alternative.

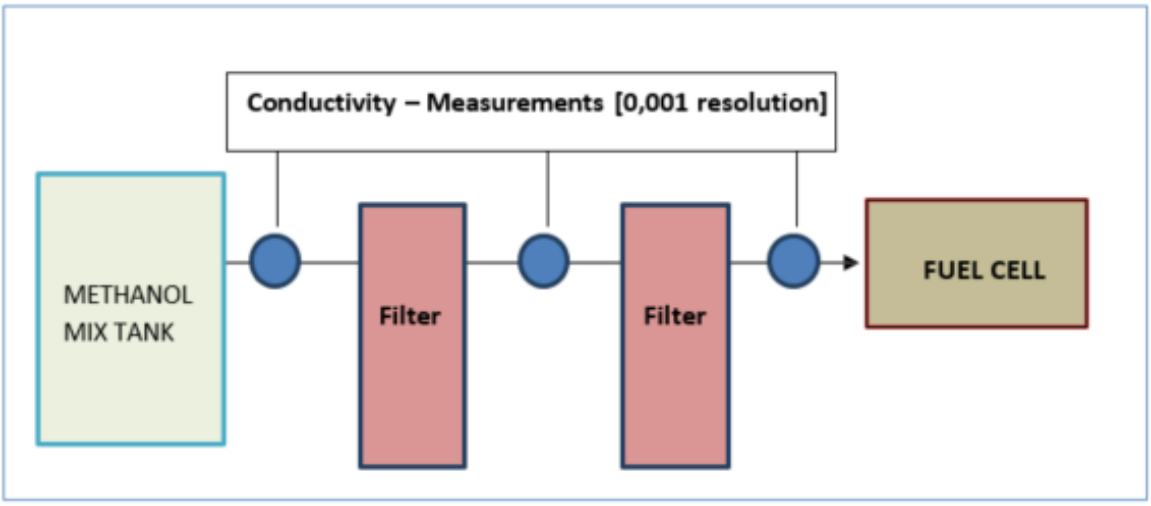
Complete drawing of filling station with layout of tank areas and vehicle turn-around radius.



WP9 – Test of Methanol mix in fuel cell solution		
Lead	Serenergy A/S	
Description	The main goal is to test how bio-methanol works in the HTPEM – Low temperature steam reformer configuration designed and manufactured by SerEnergy. Especially the effects of long term operation are in focus to identify any effect of impurities and/or quality in general. Benchmark control group tests with conventional methanol will be evaluated against the results and several filter solutions directly in the fuel cell system will be tested.	
Link	WP5 – WP12	**Due**
Objects	• Test configuration • Test report	

Test configuration

A basic test configuration has been developed with a lab-based filtering system and high-resolution resistance measurement of water/methanol mix.



Theoretical representation of the test configuration

The fuel will be processed by an inline filtering setup and the fuel cell will be tested in continuous operations and cyclic mode (start/stop) and all metrics on the systems logged for comparison.

External Methanol Fuel Mix tank

Test Configuration setup on the laboratory

Bio Methanol and Bio-Methanol mix test

A sample of Bio – Methanol obtained from BioMCM was tested using the configuration test setup reported.

Test ID	P129

Test conducted by	INA
Conclusion written by	INA

Start date	01-06-2015
End date	21-07-2015

Test objective	To test the residue contents of pure bio methanol and bio-methanol mix (60/40) from BioMCN
Test description	5 L evaporated
Conclusion	Both samples meet the stated requirements for use

Pure Bio Methanol	
Beaker before	87.8560 gr.
Beaker after	87,8955 gr.
Residue	0.0395 gr.
	39.5 mg.
Residue per volume	7.9 mg/l

Bio Methanol Mix	
Beaker before	87.6017 gr.
Beaker after	87,6236 gr.
Residue	0.0219 gr.
	21.9 mg.
Residue per volume	4.38 mg/l

Conclusion:

The resulting tests of the Bio Methanol analysis from BioMCM shows that this particular supplier fuel is suited for the intended purpose. The outcome of the test reveals that the parameters are in line with the requirements stated by Serenergy for the use in HT-PEM Fuel Cells.

WP10 – Test and demonstration of refuelling station concepts		
Lead	OK a.m.b.a.	
Description	The main objective is to demonstrate and test the refuelling solutions and underlying concepts in refuelling stations on 1-3 locations in the eastern part of Jutland. Further, the purpose of developing and installing 1-3 methanol filling stations is to combine the concept with other Danish demonstration projects, which aim to develop vehicles with built-in methanol-driven fuel cells. Another objective is to allow for regular cars with combustion engines running on methanol blends to use the methanol filling stations.. The demonstration will be controlled based on the fuel and its usage and will act as a proof of concepts. The main goal is to demonstrate the feasibility and verify the measurements used and calculated in the analysis section of the project and to create public awareness of the solution.	
Link	WP10 – WP11 - WP13	**Due**
Objects	• Test report • Demonstration evaluation	

Methanol Mix Pumping Station

A test refuelling station at OK Skalborg, in Aalborg, close to company Serenergy, that has access to a test car, was inaugurated in August 2015. To start with, the tank was filled with a 60/40% methanol-water premix. The need to control the methanol quality before it is dispensed into the vehicle is necessary. The quality is checked with a conductivity measurement after the filter. A filter with the necessary volume flow is placed in the tank manhole, because it is too big to be in the dispenser. To avoid having the filter in the suction line, the dispenser pump is placed in the tank.

- A stainless-steel underground tank was build and fitted.
- Dispenser pump is placed in the underground tank
- Filter and conductivity meter in the manhole
- The fuel line from tank to dispenser is a pressure line (max. 2,5 bar)
- The dispenser is a one-sided prototype dispenser with the necessary approvals for use in public areas.

Skalborg Methanol Mix Refuelling Station

The initial test went without any major surprises, demonstrating the reliability and potential of the retrofitting solution. The installation period and the whole process obeyed to a rigorous Project Management Program, to assess all the stages and document the process, so upon ramp-up of the manufacturing process of vehicles and deployment of refuelling units across Denmark, both sides of the Project can in fact happen and be delivered simultaneously.

Vehicles

The following sections are focused on reporting about the vehicle part of WP10. The vehicles themselves and their creation are not part of GMI, but a prerequisite for carrying out a true pro and concept.

- Status MECC (project already concluded):

The MECC project aimed at producing Methanol fuel cell cars has had a substantial number of initial complications. In addition to Ecomove as a project partner midway in the project, stopped making electric cars, Ecomove has now also chosen to step out of the project very late in the phase and effectively leaves 90% of the task unresolved.

At this stage, SerEnergy has taken over the task and was responsible for implementing 2-Fiat500 fuel cells as well as certification and testing of the same. There is no doubt that the task is great, but SerEnergy has hired extra resources as there is full focus on executing the project.

As part of MECC, the cars must be tested first internally at SerEnergy and later through 10 weeks by professional users.

Once the cars are certified, there will initially be an 8 to 10-week period of internal tests and adjustments followed by a 10-week test by selected partners.

In both test periods, there will be a general focus on the functionality, operation and stability of the vehicle, specifically at the service station and the tank and vehicle interface, there will be focus on safety, functionality and the very low-tech user-friendliness.

Inauguration and refuelling test of the Fiat 500 FCV

Demonstration Evaluation

The evaluation period allowed to troubleshoot and correct some initial development glitches. Due to high-level of systems integration aboard of the Fiat 500 FCV, vibrations, start & stop and the initial positioning of components were the key reasons for the 8 to 10-week test period.

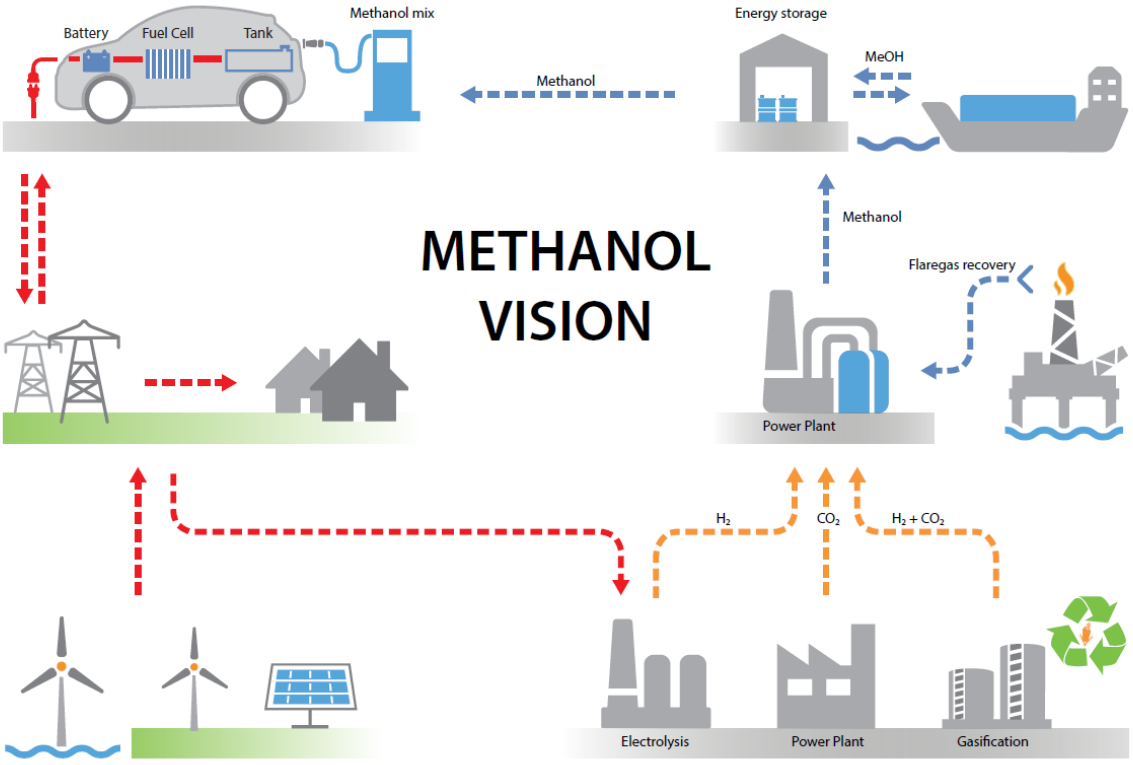
Due to the similarities of the refuelling process, it took just a few minutes to explain the nozzle connectivity process and from the second refill, all the drivers felt no difference. In addition to this, all operational aspects of the petrol station, such as maintenance of systems, refuelling of the tanks with the Methanol Mix and security procedures were all implemented and subject to training certification for safe use and handling of hazardous materials.

On a later stage, Serenergy, continuing with the development of the Methanol Fuel Cell Mobility program, developed the Serenus eV-200 EV ReX. This vehicle was also tested in Aalborg and the refuelling process was also performed in Skalborg OK petrol station, to validate the new developed solution and add a new member to the Methanol FCV, following the key guidelines of the GMI project.

WP11 – Strategy and roadmap development		
Lead	Serenergy A/S	
Description	The goal is to develop an overall Danish strategy for implementation of methanol in the transportation infrastructure, the strategy and accompanying roadmap will include a set of goals, activities and tools that will enable the future development. A main objective is to ensure the strategy is based on sound analysis from the project enabling a focus on the area where the effect and cost-effectiveness is highest. The formulation of the strategy should be seen as the main recommendations from the project conclusion and will be a part of the dissemination to stakeholders.	
Link	WP4 – WP5	**Due**
Objects	• Methanol strategy • Methanol roadmap	

Methanol Strategy

The Methanol 2020 Vision is a Mission & Vision Statement that embodies the whole project and guides all envolved partners in the GMI project.



Methanol LCA – 2020 Vision

It is the expression of a broader, global vision of the Methanol Lifecycle and the whole value chain associated along the process.

The Methanol Strategy comprises 2 steps:

1. Methanol strategy for Mobility Solutions – Methanol Fuel Cell Vehicles and ReX
2. Methanol Roadmap for development and deployment of more Methanol Mix Fuel Stations across Denmark and Europe.

For the Mobility Projects, a 3 key-point strategy was design to ensure that the usage of the vehicle is cost effective and the technology has a maximum positive effect over the utilization and environmental outcome:

- The vehicle must have a daily usage period of over 8 hours
- It must have a low power usage to allow the range extender to fill the gap and provide the extra needed power.
- Heavy duty vehicle, to accommodate the batteries and methanol fuel cell. As in a last mile service provider, the vehicle will reduce emissions on city centers, the extra cargo space will make it cost effective and the reduced service required adds to the competitive ROI. This same operational paradigm is applied to Light Commercial vehicles (LCV), Buses and Large Trucks.

As showcased already, the Fiat 500 FCV and the Serenus Ev-200 EV ReX vehicles are the current developed vehicles that already are proving their value on the roads.

- JustEat, the food delivery service, uses the Fiat 500 FCV currently for deliveries in Aalborg. It allowed to further integrate new components and solutions, that were the technological base for the Serenus vehicle.
- The Serenus Ev-200 EV ReX is currently used as a service vehicle for Serenergy and has been showcased across multiple events and awareness initiatives, to promote both the developed technology, but also the GMI initiative that will sustain the growth and build/deployment of new units on the roads.

Serenus Vehicle exhibited in the H2FC 2017 at the Hannover Messe

Methanol Roadmap

The commercial strategy is a rough outline on how the process and its elements will reach a commercial success. There is no question that the winner in alternative transportation has not been determined yet – but within liquid fuels this is a track to explore. The development and demonstration is a first step to gain knowledge and experience and the below is a rough outline of the strategic potential for the project.

Timeline

The timeline for the commercial rollout is delimited to the immediate targets:

Development - 2013/2014

- Detail planning and development
- Worldwide promotion and planning

Demonstration - 2014/2015

- 1-10 stations (expected)
- Worldwide similar numbers

Niche markets - 2016 – 2020

- 10-100 stations (ramp-up stage)
- Worldwide similar numbers

Danish minimum infrastructure - 2020 – 2030

- 100-350 stations

The stages offer a timeline when the concept will be ready for market introduction, the penetration will be based on competitiveness and overall macro development is energy policies and other alternative tracks. The distribution of fuel, vehicles and refilling stations will follow the established channels by the partners to diminish any barriers related to this aspect. Methanol ready combustion vehicles will be services and delivered through normal distribution chains, however here a firm strategy for cooperation between refilling station and operator is needed. Here OK will take an active role thereby offering a unique opportunity to expand within the energy supply business. Beyond the Danish market where OK is primarily active HAMAG will export the concepts through existing relationships in Europe. In addition to this growth markets like china where Methanol is used today as a transportation fuel there will be an opportunity to enter a massive market. Details for this will be developed in the project.

WP12 – Dissemination and communication		
Lead	OK a.m.b.a.	
Description	A well-organized communication campaign is vital to the success of the project with regard to reaching the relevant customer segments, ensuring political support and building confidence in the new technology. In order to keep all relevant stakeholders well-informed about the new potential alternatives to fossil fuels in transportation, the feasibility of the methanol filling stations, project milestones and general public opinion etc., a series of communicative actions must be taken by e.g. building a website, writing press releases, organizing press conferences and seminars etc.	
Link	All WP – WP1	**Due**
Objects	• Seminar on project • Building, administrating and updating a project website during the entire period including Web page with results, Press releases • Organizing 2-3 press conferences /seminars/stakeholder events • Organizing events for potential users of the methanol filling station, e.g. OK's co-owners and other relevant stakeholders. • Organizing seminars for stakeholders and students	

GMI website

In connection with the commencement of the project, the partners have launched the website greenmethanol.dk, in which the visions, perspectives and results of the project are regularly communicated. The website has been online for the duration of the project's lifetime.

Press conferences/seminars/stakeholder events

Local, regional and national Danish media outlets as well as relevant industry outlets have been kept regularly updated on the project's latest developments – in connection with the presentation of the methanol filling station at the 2014 and 2015 Hannover Messe, at the inauguration of the methanol fuelling station in Aalborg, and elsewhere.

The station opened on Wednesday 26 August, and the inauguration also included a demonstration of ground-breaking technology in the form of methanol-powered vehicles with built-in fuel cells. At the same event, interested audience members and the press were invited to learn about green methanol and transport, as well as to gain insight into the technology behind it all. The focus was on both the methanol-powered vehicles and the methanol fuelling station.

The day's programme:

11.30-12.00: Welcome and inauguration of the methanol fuelling station

from Aalborg's Mayor, Thomas Kastrup Larsen.

- Jørgen Wisborg, CEO of OK a.m.b.a: Driving green needs to be easy!
- Anders Korsgaard, CEO of Serenergy: Driving green needs to make sense!
- Demonstration of the methanol-powered electric cars and other methanol-powered vehicles with built-in fuel cells.

12.30-16.00: Reception, press conference and seminar with Serenergy.

Welcome and company tour of Serenergy

Presentation of Danish and international stakeholders from the methanol industry

(presentations by Serenergy will be held in English)

- Mads Friis Jensen, Commercial Director of Serenergy: Development of methanol-powered fuel cells for transport.
- Eelco Dekker, Chief European Representative, Methanol Institute: Methanol today: the current market and the future.
- Lars Fredrik Berg, Project Manager, Fraunhofer Innovation Cluster "REM 2030": Development of methanol-powered fuel cell cars – the logic behind the decision to use hybridisation and a methanol range-extender.
- Bo Gleerup, CEO, Nordic Green: The production of green methanol.
- Rikard Gebart, professor at the Institute of Energy Engineering, Luleå Technical University: Green methanol from Swedish forestry.

Press coverage

We sent out a number of stories to the press in subsequent years that have generated a reasonable amount of publicity. The headlines and links to articles from the past years can be found below.

You'll soon be able to fill up on methanol in Aalborg

An OK filling station in Aalborg will be the first to offer methanol to Danes.

At the official opening, Serenergy will present a Fiat 500 that can travel 800 kilometres on a full tank.

READ MORE ABOUT THE OPENING OF THE METHANOL FILLING STATION HERE

Aalborg gets Europe's first methanol fuelling station

Methanol is a potential long-term replacement for fossil fuels – both because it is environmentally friendly, as it can be produced from almost any type of biomass, and because it is a liquid fuel that can be processed in existing distribution systems.

READ MORE ABOUT EUROPE'S FIRST METHANOL FUELLING STATION IN AALBORG HERE

Petrol company will sell methanol and increase the travel range of electric cars to 800 km

OK wants to convert several of the company's filling stations to biomethanol, so that the travel range of electric cars can be extended to 800 km, with the help of fuel cells.

READ MORE ABOUT BIOMETHANOL FILLING STATIONS HERE

Methanol soon to be used in electric cars

With a new project, three Danish companies hope to demonstrate how the travel range of electric cars can be increased by fitting them with a methanol fuel cell. In principle, such cells can be installed in all electric cars.

READ MORE ABOUT METHANOL IN ELECTRIC CARS HERE

Hamag builds methanol fuelling station

As a result of a EUDP-supported project, the three companies Hamag, SerEnergy and OK can now present the first prototype of a new methanol fuel stand at the Hannover Messe, to be held 13-17 April.

READ MORE ABOUT THE NEW METHANOL FUELLING STANDS HERE

SerEnergy extends the travel range of the electric car with new technology

The drawback of battery technology is the fact that you can only drive relatively short distances in an electric car between charges, says Mads Friis Jensen, Commercial Group Manager of SerEnergy.

READ MORE ABOUT THE EXPANSION OF THE ELECTRIC CAR'S TRAVEL RANGE WITH NEW TECHNOLOGY HERE

Methanol can help electric cars get moving

The drawback of battery technology is the fact that you can only drive relatively short distances in an electric between charges. But by installing a fuel cell that can produce electricity for the battery, we can solve this problem. The fuel cell is powered by a mixture of methanol and water. It can be filled up from a fuel stand, just as we already do with petrol and diesel, explains Mads Friis Jensen, Commercial Group Manager of Serenergy, to finans.dk.

READ MORE ABOUT HOW METHANOL CAN HELP ELECTRIC CARS HERE

From petrol station to fuelling station

New energy types are on the way to the transport sector. Wherein lie the practical challenges for the distributors of energy to consumers? Anders Knudsen from OK and Michael Norden from Uno-X provide their best bets.

READ MORE ABOUT THE CONVERSION FROM PETROL STATION TO FUELLING STATION HERE

Online

Website

We regularly update our website, greenmethanol.dk, where we present our project and communicate our message. The website is currently being extensively updated with new photos, editing of existing text and the addition of new content. The site is available in Danish, English and German.

LinkedIn

We have created a LinkedIn profile in order to communicate the project's messages to professionals who may be interested.

GMI's LinkedIn profile should be seen as a shared project profile in which OK, Serenergy and Hamag can all contribute content and themes within a relevant agenda, with a focus on methanol and the transport sector. GMI's LinkedIn profile is intended to promote awareness of the GMI project rather than promote the contributing companies as its first priority.

- Why LinkedIn?

The GMI project appeals first and foremost to a professional network, and LinkedIn is therefore a good platform on which to promote the project in a B2B universe. Companies included in the consortium work primarily on a B2B basis, though OK is both B2B and B2C. LinkedIn is also a good platform on which to assemble GMI's professional network.

On LinkedIn, GMI has the ability to interact with interested parties in their everyday lives. Because GMI runs on a project basis, this also means that the product still needs to be commercialised. Initially, it is thus a matter of getting in touch with interested parties on LinkedIn. LinkedIn must therefore be seen as the ideal social media platform on which to reach the professional crowd of interested parties to which the project is geared.

Participation in Hannover Messe

In connection with the 2014 and 2015 Hannover Messe, the GMI project participated with MECC and presented the prototype of our methanol fuelling station, as well as the MECC project's newly purchased and refitted Fiat 500.

For the occasion we produced a brochure and a demonstration video in which we created a temporary installation of the methanol fuel stand at an OK station in Horsens, Denmark. We filmed the station and supplemented the footage with a living graphic illustration, which showed how the fuelling concept will work in practice.

Conclusion

The project's communication initiatives are going according to plan, in pace with the development and the results of the project.

A main platform of communication and dissemination will be a central website with access to results and information about the project and the methanol concept in general.

During the project period workshops will be held as a way of convening product stewardship for the methanol refueling concept and participation in the national and international debate on alternative drivetrains and fuels. The political level will also be engaged to ensure knowledge is directed to decision makers within the area.

Scientific results from the project will be sought presented at international conferences and published in journals. Furthermore the output will be included in larger drivetrain and energy plan work on a European and international level.

The demonstration of the refilling stations will be conducted in close collaboration with the related projects, primarily Modular Energy Carrier Concept – but also other upcoming Methanol demonstration projects.

6. Utilization of project results

OK a.m.b.a. (OK):

OK will use the project's results to enable a quick estimate of the practical costs of establishing a methanol fuelling station and developing the multi-fuel concept. Going forward, OK will place the establishment of the electric charging stands and hydrogen fuelling station on equal footing with methanol fuelling stations.

OK's focus has been to clarify the final challenges of storing methanol at the methanol fuelling station. OK will subsequently stand by and await the demand for methanol-fuelled vehicles.

HAMAG A/S:

HAMAG A/S has developed a basic koncept for the production of MID approved Methanol, Methanol Water Mix dispensers. These products will be launched on our website www.hamag.dk. Besides we can convert our expirience to the production of other dispensers for distribution and sale of water based fluids like fertilizers, adblue and deionised water.

Still there are obvious topics for further development of the filling koncept, to find a better solution regarding a spillfree filling nozzle that can take the back the methanol gases from the vehicle tank to the delivery tank.

Serenergy:

The results of this important project will be used to sustain and further develop Serenergy´s vision of a full Methanol Fuel Economy in the near future. Current efforts in new R&D projects, OEM Partnerships and Field trials have the GMI project as basis, since fuel supply is fulcral to meet the demand generated by the adoption in larger numbers of the HT-PEM Methanol Fuel Cell.

A Fuel-Cube turnkey solution for clients is currently in advanced stage of trial, 6 serenus eV-200 EV ReX vehicles were developed and are currently circulating on Danish and german roads and the Fuel Cell EV ReX Bus project is also on track, being expected to start the road trials in Aalborg during 2018.

All effords are now towards the promotion of the technology and demonstrating the feasibility and economic advantages of reconverting Petrol/Diesel pumping units into Methanol Mix, assuring that the forecasted infrastructure roadmap meets the stated goals within a reasonable timeframe.

7. Project conclusion and perspective

The Methanol roadmap was designed to englobe all the delivered items of this project, allowing for the market forces to adjust and pull the solution towards a greater market presence in the present/near future.

One of the key advantages of the Methanol Pathway, is the retrofitting of current refueling units, undercutting expensive investments in other dedicated infrastructures, such as Hydrogen, that at present market prices, can only deliver a fraction of the needed demand and are not possible to be further escalated once deployed, without huge investment costs just to double supply capacity.

The Methanol Supply Chain is well known and the costs associated to obtain Green Methanol, perform the fuel mix and distribution are, from the operational point of view, similar to Fossil Fuels, but at a cost level, much lower.

The installation of Methanol Mix fuel stations will allow market operators to gradually convert their units from Fossil Fuels to Methanol Mix, winning an edge over potential competitors by embracing the change first. The shared use of installations, will allow consumers and businesses to gain higher awareness of the transition efforts towards a more sustainable future. Using both side-by-side, and providing demonstration initiatives, can accelerate the transition further.

In areas where retrofitting is not possible, the installation of new Methanol Mix pumps can be performed at a competitive price, adding flexibility and options to the clients, contributing for the expansion of the network and the normalization of operations using HT-PEM Methanol Fuel Cells.