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Norway's electric vehicle deployment success. A historical review including plans for fast charging stations covering all of the country - by 2015.

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Abstract

The history of electric vehicle dissemination in Norway is a successful one. Its 5 million inhabitants are already one of the biggest electric vehicle user nations in the world. The number of vehicles recently passed 12.000. It is expected that a total of 20.000 to 40.000 electric vehicles will be on the road in Norway in 2015 and 60.000 to 80.000 in 2020. Many of them will establish a clear link with the buildings where they are parked and renewable energy powered Zero Energy Buildings and Plus Energy Buildings can become a partner. Mutual benefits can develop between the transportation and the building sector.

History is a useful tool to, in the aftermath, study how success was achieved, what worked well and what did not. This paper offers a historical review, studies the obstacles that have been overcome and points at a way forward, a way other nations pursuing the same track possibly can learn from.

It also points at interesting new possibilities arising with cheap renewable fuels like solar energy being on the verge of becoming globally competitive.

Keywords: electric bus, solar, charging stations.

1 Introduction

The recent flight of the Swiss "Solar Impulse", the attempt at flying at night has succeeded and the next step is a round the world flight in 2015 (1). At the end of 2011, globally at least 110 established electric or hybrid vehicle types were under development towards series or mass production, demonstrating the huge technical drives to go electric.

Over the next decades one can expect a massive shift from vehicles with combustion engine to hybrids and electric ones. This shift will not only happen with cars, but with buses, offering an alternative to city rail/trams, boats and planes.

In many cities electric minibuses were tested out with good results decades ago. In Stavanger, Norway a 16 seat and 18 standing passengers minibus, half seated and half standing worked well as early as 1994 (2). Three sets of exchangeable batteries were used. This was the first electric bus in regular traffic in Scandinavia. The Neoplan/Varta operated by SOT and the local electricity utility Lyse that was owned by the municipalities in the area. The bus was very popular and worked well (fig1).

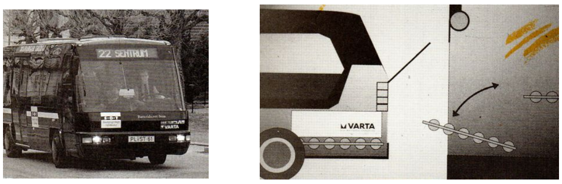


Fig 1. Electric bus Neoplan/Varta, tested in Stavanger and working well in 1994. Exchangeable batteries.

It is still a mystery why its use was terminated but Lyse and its board of politicians decided to play down their activity in the field and instead go for natural gas as fuel for cars and buses. A complete natural gas infrastructure was established in the Stavanger region from 2000 to 2013. A pioneering electric car partner, the electric utility Lyse, was hence lost to fossil fuels. Norway with its 5 million inhabitants is already one of the biggest electric vehicle user in the world. The number of vehicles recently passed 12.000. The sale of electric vehicles lately represented 1,5 – 2,0 per cent of total car sales a year in Norway. In 2012 over 2000 new electric vehicles entered the market. This is a result of strong government incentives fought in place by individuals and environmental organisations way back since the late 1980ies. The incentives include no VAT and reduced road tax when buying an electric car, free city parking and charging, free toll road passing and permission to drive in public-transport lanes.
It is expected that a total of 20.000 to 40.000 electric vehicles will be on the road in Norway in 2015 and 60.000 to 80.000 in 2020 (fig2).

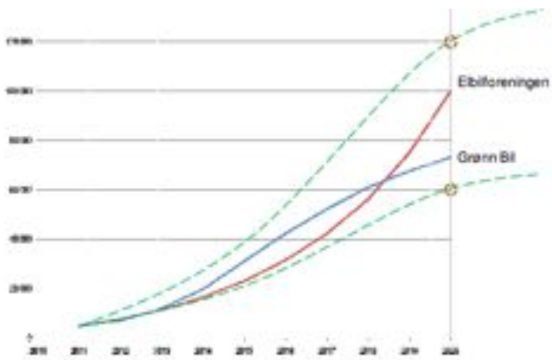


Fig. 2. Cumulative prognosis of nos of electric vehicles in Norway 2011 – 2020.

Four main obstacles have been experienced, they are all about to be overcome and as a result we can expect a faster growth in electric propulsion.

2 Obstacle one: Biased government backing

Although there were some electric trucks in Norway used by the electric utilities among those Lyse as early as hundred years ago, the first electric vehicle in our time was imported to Norway from Switzerland in 1989. After having spent several years visiting the Tour the Sol solar electric car races established in Switzerland by Urs Muntwyler, I was inspired to bring attention to a field totally neglected in oil and natural gas exporting Norway. In an alliance with Morten Harket and Magne Furuholmen of A-ha and Bellona, the environmental organisation, I really had to step outside my normally academic approach. We imported a Larel to Norway. It was an Italian Fiat Panda redone for electric propulsion in Switzerland (fig3).

Fig 3. A historic picture of the individuals that initiated the first import of an electric vehicle to Norway in 1989. This act opened up a the path for the success electric vehicles are in Norway today. From left; Morten Harket (a-ha), Harald N. Røstvik (Author, Professor, Architect), Frederic Hauge (Bellona) and Magne Furuholmen (a-ha)

The authorities resisted our requests for the introduction of incentives, so several campaigns were necessary. Through a high media profile made possible by the people involved and their celebrity status, we were ensured wide coverage of our use of the car to embarrass the authorities. We were driving through toll stations and onto tollroads refusing to pay, parking illegally and refusing to pay fines. Finally the car was toed in by the authorities and put on an auction by them to cover the fines piled up. The media coverage of the auction was tremendous.

Through such and similar actions, our demands were finally met after years of fighting. We had paved the way for the exquisite incentives introduced in 1995 and 1996 and still in place in Norway. They have since been the main "drivers" of the electric vehicle interest in Norway. According to governmental signals they will remain in place till at least 2017.

But during the years to follow, the centre stage was from taken by the heavily state subsidised Pivco – City Bee, the electric vehicle project, founded in 1991 and later renamed Think. It came to dominate the sector with all its ideas and dreamlike approach to the dissemination of vehicles. It became clear that they could not deliver as promises were followed by promises. The heavy backers did however not back down and Think was saved from bankruptcies several times by its friends in and out of government. State owned companies bought their overpriced cars in spite of them breaking down repeatedly and the lack of service personnel outside Oslo led to frustration and despair among its users. Think muddled on, in spite of more and more money being poured into the company without much progress, it continued expressing higher and higher hopes for the future. It was a constructed fairytale.

The only other manufacturer in Norway was former Danish Kewet that was taken over by a Norwegian company in Oslo and renamed Buddy. It was a low key, inexpensive, simple and well working city car that developed its limited production over time and without the necessary massive financial support of the state and state-owned backers.

It has proven hard for others to gain support for alternative solutions to the Think fairytale. I was involved for years with a design and prototype testing of The Butterfly, a solar electric three wheeler for taxi and similar traffic in congested city centres in the third world, developed with Peter Opsvik the internationally recognized Norwegian industrial designer responsible for the designs of Tripp Trapp and other chairs. However, we received very little backing. Innovasjon Norge, a state financed body that is supposed to fund innovation broadly had backed Think in a big way. My final contact with them while Think was still alive but showing sign of weakness, ended with the following message from them: We have put so much money into Think that we do not want to create a competitor while Think is on the road.

2.1 Lessons learnt

In the aftermath of the final Think collapse in 2011 there seem to be agreement that too much focus on and funding of Think, deprived other actors of similar possibilities. It is still a mystery how the Antitrust Act regulating unfair competition resulting from heavy subsidies to one player only, was omitted. Think became dominating and stole all the attention and most of the Norwegian funding available in the sector, in spite of the company filing for bankruptcy four times in only 20 years. Norway seemed blinded by the Think fairytale. The impression was wrongly created that no one else worked seriously on the issue apart from one, Think, could deliver. Today the commercial Norwegian market is dominated by several manufacturers, all foreign with Mitsubishi (MiEV) dominating and with Tesla as a strong runner up while Buddy is still produced in small numbers only. Think is finally completely dead and not at all kicking.

The singular one eyed state support for one company only is a lesson learnt of how not to handle technological innovation. The moment such a company break down there are no one else to replace its activity. Norway did with open eyes put only one egg in the basket, other nations had several and have succeeded to create industrial products and also to produce electric cars that work well.

Think thought they could make it because they had strong public backers. Nowadays we see similar company breakdowns:
With companies like Fisker, the electric sport car manufacturer, it was evident until the last moment that even their backers thought they had a winner until the last moment. Similar experiences are found with Better Place, the battery station company that in spite of fast improvements in battery technology insisted that battery packs would remain poor for so long that the entire pack would have to be shifted regularly at a station instead of just fast charging it when the car was parked almost anywhere. The Better Place system

required the building of brand new stations all over its markets at a high cost. The bankruptcy spring 2013 showed that even their strong global backers too found it hard to pick a winner.

What Better Place tried to do was to ignore the development in battery technology having taken place since the testing out of electric buses with three sets of exchangeable Varta battery packs way back in 1994. Batteries have improved over the last 20 years, not least thanks to the millions of packs working well in Toyota hybrids, other cars and computers all over the world. Such an impressive development cannot be ignored. Better Place did so and paid the price.

3 Obstacle two: Charging stations

Norway is practically fully electrified as a result of all the huge hydro power production. Electricity is even used for heating of buildings. There are sockets all over the place and even on the exterior of houses for lights and garden equipment like lawn moaners. Adjusting this slightly to be able to power electric vehicles is easy. But this does only count regarding detached housing.

In addition, 25% of all households in Norway are housing co-ownerships. There, establishing electric sockets and parking is a little more tricky. This challenge is now being approached.

An online system showing maps of charging station location is established and used as any GPS in the vehicles.

Electric vehicles need for charging station infrastructure has long been known and a number of normal (slow) charging stations have been established. Simultaneously, since a number of car types with longer driving ranges from 120 to 150 km has recently been made commercially available at reasonable prices and the need for fast charging stations is growing.

Transnova, the national governmental body that promotes and funds such developments are supporting the deployment of charging stations, both slow-, semi- and fast- and it is happening systematically and quickly. Incentives for electric vehicles are kept and we even see a move towards testing out larger electric sea going vessels and a clear link between the transportation sector and the buildings sector mainly housing is evident. The wider concept of urbanism is hence brought into the debate and planners and architects are now engaging themselves in ensuring proper infrastructure for cleaner transportation when new city areas are built and older refurbished.

Transnova wanted to see developed a reasonable network of charging points at distances relevant to the car users. Typical charging points have been city centres, supermarkets, petrol stations and cafes along the main roads. Late in 2011 it launched a competition to design a set of strategies and criteria for deployment of fast charging stations in Norway, making it possible to drive anywhere in the country with modern electric vehicles.

Sivilarkitekt Harald N. Røstvik AS and Poyry Management Consulting (Norway) AS won the tender competition. The analysis and research work resulted in a set of criteria for placement of charging stations, a cost calculation and a set of alternative finance models to stimulate quick establishment of the necessary fast charging infrastructure.

The conclusions of the work were that the cost of establishing the charging infrastructure is surprisingly low.

To cover the majority of the routes in Norway with charging infrastructure that would allow a complete travel through all of Norway appeared to be realistic. in addition to the stations already in place, only 200 fast charging stations seemed necessary. The cost of such infrastructure development for Transnova is only 5 million Euro. The cost is based on an assumption that Transnova subsidises the investment by 50 percent. The standard necessary will be based on both the ChaDeMO and future standards now discussed among the European car manufacturers. A follow up to the project is underway and to be completed ultimo 2013.

Maps that show the existing and future charging points are developed and deployment is already taking place based on this plan (fig4).

Fig. 4. Fast charging stations established or planned.

In this initial phase some extremely cold areas (down to minus 30C) are excluded from the plan to avoid the most challenging mountain stretches that are anyway occasionally closed due to snow and harsh winter conditions during winter. Areas are:

-Inland North of Lillehammer.
-Inland North Norway.
-Inland mountains in South Norway (Geilo).
-Inland West Coast Norway (counties Sogn og Fjordane and Møre og Romsdal)

The question then raised was to develop alternative business models for deployment.
How can one establish a well functioning market for fast charging, where state subsidies gradually become obsolete? Until now Transnova subsidies have been a condition of the success. The study uncovered which key actors have interest in fast charging and how a well functioning business model could look.

The study concluded that the possibility for a fast charging business model to be established and become successful is realistic. A key element in this is the establishment of a well functioning, reasonably priced subscription system.

During this phase it is crucial to strike a balance between experimenting and fragmenting. It is too early to get locked into one permanent model. Simultaneously, a fragmented system with incompatible local monopolies will be negative for the market development.

There are three particular technologies that stand out as well suited in a future business model:

- The use of a centralised invoicing/payment system.
- Active use of mobile phone apps for payment.
- Direct communication between the vehicle and the fast charging station.

3.1 Lessons learnt

The strategy plan concluded that a complete deployment of the necessary 200 stations by 2015 is realistic, given the current annual subsidies established by Transnova. It recommends starting deploying stations at the central areas around the capital Oslo, the South coast from Oslo to Stavanger and from Oslo up North to Trondheim.

The result of the last deployment subsidy application round was presented in February 2013. 31 new stations were offered support. There are currently 60 fast chargers established in Norway at 55 stations. Another 68 chargers are planned at 54 stations. In total there are hence 128 chargers established soon at 109 stations (fig5).

Oversikt eksisterende og planlagte hurtigladere, inkludert semihurtig				
Fylkesnavn	Idag	Planlagt	Totalt	Andel
Akershus	10	8	18	14%
Buskerud	8	9	17	13%
Østfold	6	9	15	12%
Hordaland	9	4	13	10%
Rogaland	6	4	10	8%
Oppland	2	7	9	7%
Vestfold	0	7	7	5%
Sør-Trøndelag	5	2	7	5%
Oslo	3	3	6	5%
Nord-Trøndelag	3	2	5	4%
Aust-Agder	1	3	4	3%
Hedmark	2	2	4	3%
Møre og Romsdal	1	3	4	3%
Vest-Agder	2	1	3	2%
Nordland	1	1	2	2%
Telemark	0	2	2	2%
Troms	0	1	1	1%
Sogn og fjordane	1	0	1	1%
TOTALT	60	68	128	100%
Kilde: Norsk Elbilforening – elbil.no				

Fig 5. Fast chargers deployed by location (first figure column), planned (second figure column), total and finally percentage of total.

The goal of establishing 200 fast charging stations by 2015 is within reach.

4 Obstacle three: The fuel

Electricity is just an energy carrier. Electricity has to be produced. From an environmental point of view, production from a renewable source is preferable to that of a fossil one. The ultimate solution will naturally be a world fuelled by renewable energy from solar and wind and other relatively clean sources, as we adapt cities for climate change (3).

In Norway, most of the electricity is produced from hydropower, a renewable source. Norway's annual production of hydropower is 130-140 TWh representing 98% of electricity used in Norway and half of its land based energy (heat plus electricity).

Since the development of solar and wind power continues, as climate change discussions have an impact we should see a shift from dirty fuels to cleaner fuels. In due time powering the electric vehicle fleet will be done by clean renewable energy. Norway is connected with cables transporting power to/from the European continent and to/from Sweden and the UK. Over the 10-15 last years Norway has had a net export surplus of hydropower.

As a comparison Germany's solar PV production in 2011 was 18 TWh. Germany and Italy represented almost 70% of the installed solar PV capacity in Europe that year.

On April 24, 2013 a record 23,6 GW solar PV was produced in Germany and a few days earlier, on April 18, the sum of solar PV and wind production in Germany reached 36.6 GW. For the first time on a weekday at midday those two energy sources alone delivered more than 50% of the total powert need in Germany. It does not stop there. The capacity of solar PV alone will probably increase to 36 GW in 2016 and 43 GW in 2020.

The cost of solar PV has fallen by 80-90 % from 2006 to 2013. In the period 2007 – 2012 the global solar PV market has increased by 70% in spite of the financial crisis. It will not stop there. Considerable efficiency increases from today's 15-17% is possible. McKinsey has concluded that they expect solar energy from large grid connected installations to cost below 8 Eurocent (0,6 NOK) per kWh by 2015. This is less than 35% of the cost of power from diesel aggregates that we still see in many developing countries and the costs will continue to fall. Expected fall from now till 2020 is another 70 %. It will not be necessary to subsidise solar much longer, like fossil fuels still are subsidised, to make it competitive in the near future.

These positive prospects have encouraged some of the most powerful companies and countries in the world to enter the solar PV market with their products. Among them are China and Saudi Arabia (4).

4.1 Lessons learnt

If all the vehicles (not trucks and buses) in Norway were electric, this would only require approximately 5 TWh or less than 4 % of the Norwegian production of 130-140 TWh that varies from year to year depending on how much it rains. Electrifying the Norwegian vehicle fleet is hence possible and without developing much new electricity production. Instead upgrading of the existing system will lead to a gain many times the 5 TWhs.

5 Obstacle four: Merging vehicles and buildings

Electrifying the transportation sector will have huge impacts on charging/tank filling and driving patterns as well as a positive impact on noise and air pollution in cities. Simultaneously the emerging of Zero Energy Buildings Buildings (ZEBs) and Plus Energy Buildings (PEBs) that can be charging electric vehicles through their renewable energy systems are being developed. The two fields can possibly play "charge and discharge me" together, in a way that strengthens both.

While the scientific development in these fields takes place at great speed, the public is asking themselves about its status in a jungle of information flowing scattered through the media without any coherent explaining that can put each little drop of information into the whole picture, trying to respond to questions like: What can solar do in a city? What can electric vehicles do? How can we charge them, where and with what kind of energy? Where will the energy systems be positioned? On buildings? It seems necessary to recap some historic facts:

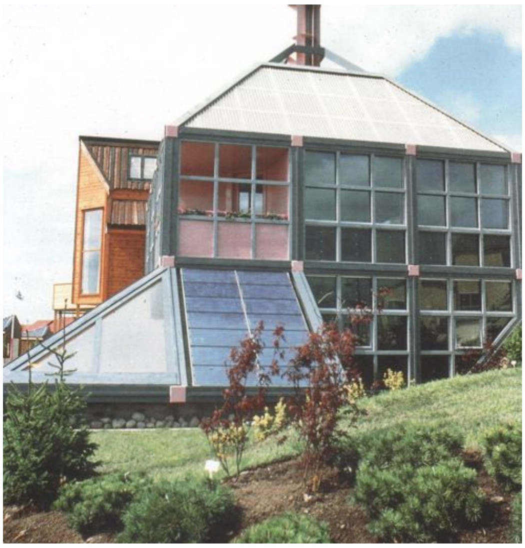
Germany introduced its solar PV grid "feed-in-tariff" incentives twenty years ago. A range of countries all over the world have later implemented similar incentives that have helped make solar PV grow. In Germany the volume of solar sales have grown on average 70% a year over the last 20 years (5). In 2012 solar PV represented 3-4% of the German electric power supply system. In the summer solar PV delivers over 20% of the power need in Germany around lunchtime. During 2012 it is expected that solar PV frequently will deliver 40% of Germany's electric power need if the best hours are selected. Germany used to have a large mid-day power deficit. As a result of the new power from solar PV, prices of mid-day electricity have fallen sharply and incentives have resulted in a 75% fall in the cost of electricity from solar PV.

It is a combination of technological progress and fierce Chinese competition that are pushing prices down. The Norwegian solar PV manufacturer REC claims to have reduced prices of solar modules by 80 percent during the last five years due to large scale manufacturing (10).

In 2000 there were 700 million combustion engine vehicles in the world. At the pace things are going, by 2050, the number could be 3 billion, placing a heavy burden on cities.

In UK during the mid 1980ies, energy efficiency was becoming a hot topic but very few architects were engaged and hardly any were interested in buildings demonstrating energy autonomy. There was the Centre for Alternative Technology at Machynlleth in Wales that started in 1973. In 1975 Brenda and Robert Vale, England wrote the famous book "The Autonomous House" (6).

In Norway, Europe's first attempt at making an energy efficient renewable energy based modern low cost autonomous house was initiated in 1985 and the result "Chanelle", used a combination of energy sources: Air based solar walls and roofs of 56m^{2}coupled with a 92% efficient log fire, the Swedish type kakkelugn (7). The heat from the two sources was stored in a 1 000 litre water tank catching the high temperature energy from the hot air as it passed an air/water heat exchanger. Electricity was generated from a 1 kWp vertical axis windmill and a 2 kWp solar PV system covering 12m^2, both coupled with a 50kWh battery bank as this was before the days of the grid connection (fig6).



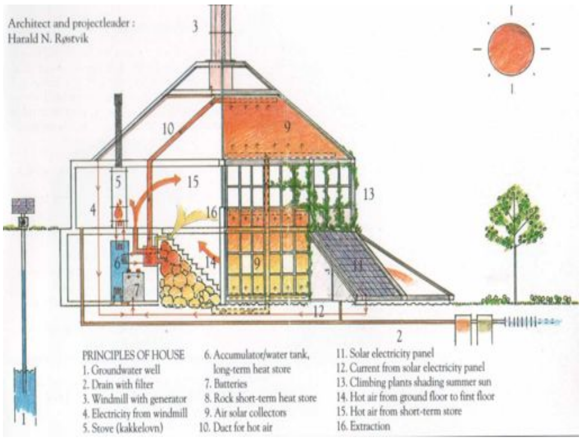


Fig 6. Chanelle designed in 1985. Built 1988.
Architect: The author.

The idea of the house was also to see the transport sector together with built form in that electric slow charging facility for an electric vehicle was introduced. In a video[i] this holistic view approach was demonstrated and for the first time tried out (8). When the house was finished there was not one single electric vehicle in Norway. The test vehicle for the house an in Switzerland electrified Fiat Larag had to be imported with help of the architect, Bellona, the environmental organisation and Morten Harket, the lead singer of a-ha. The total costs of the innovative research, planning and construction was less than 200 000 Euros for the house of 121m^2, hereof building cost was 95 000 Euros the site cost was 65 000 Euros and the remaining 40 000 was energy research, planning and coordination. The house saved 2 000 Euros in energy costs every year.

In Germany, four years later, in 1992, the Germans started working on solar feed in tariffs and hydrogen based solutions also picked up. In Freiburg a huge team of energy consultants Fraunhofer ISE and German architects Planerwerkstatt Hølken Berghoff, did an energy self-sufficient solar house (9). Hydrogen was the energy carrier, powered by a 4 kWp solar photovoltaic array. A fuel cell was a key component and the battery pack of 19 kWh.
The total cost of the innovative research, planning and construction was in the region of 1, 5 – 2,0 million Euros, tenfold that of "Chanelle". But was this a design/cost approach relevant to mass housing?

In UK, during 1995 architect and professor Susan Roaf at Oxford Brookes had her Oxford Ecohouse completed. It was a 270m^2 house. It maximised energy efficiency getting its power from the first photovoltaic cell roof installed in Britain. Its capacity was 4kWp. A wood stove, a solar heating system of 5m^2 hot water panels were other components, a financially sound attempt at making autonomous housing realistic and inexpensive.

In Germany again, almost two decades later, Germany having become the solar hub of Europe as a result of the authorities' strong solar PV "feed in tariff".
The latest design for an autonomous house, the widely published 147 m^2 plus-house in Berlin designed by engineer and professor Werner Sobak, Stuttgart was put up temporarily, at 2,2 million Euros. The design points at the relationship between the transportation sector and housing by having a building integrated carport with induction charging. It is an expensive and technology-demanding solution. Why a normal slow charging cable is not chosen when the car is parked at home for hours at night is probably a relevant question. The design's close tie with the private vehicle carport eliminates sparking people's imaginations as to life style change like mode shift towards electric bikes.

Discussion on relevance of housing and electric cars emerged. The Berlin house being covered with an envelope integrated solar PV system that produces electricity. There are 73m^2 on the South façade and 98m^2 on the roof, all in all 171m^2 solar PV. If we assume some of the orientation is not ideal, it takes 7m^2 per installed kW of PV, there is then 25 kW installed peak effect. The best orientation solar system would produce approximately 1000 kWh/kW installed effect/year.

Again, due to a not ideal orientation the Berlin house according to the project description will offer only 16 625 kWh per year or 665kWh/kW (10). Based on this one can calculate how much energy the system will deliver on average per day. It is 45 kWh. According to the project report "the electric vehicle can be charged at night via a buffer battery with capacity 40 kWh." The total solar electricity produced, 16 600 kWh, is according to the project report enough to run the electric vehicle alone 30 000 km. This seems based on an assumption that it takes 0,55 kWh/km.

If we instead assume a 15 000 km annual drive, then half of the produced solar electricity will be needed to power the electric vehicle, or 8 300 kWh from an 85m^2 solar PV array. This is hardly any progress since the Chanelle house in Norway in 1988 demonstrated the same possibility 25 years ago.

In Norway the total number of motor vehicles are now 2, 3 million. The number of electric vehicles are 5 000 or 0,2% only, still saving 150 000 tons CO2 over the vehicles' lifespan in an economy basing all its electricity production on hydropower (11). But something is about to change. In some regions of the country electric vehicles are the best sellers. The excellent Norwegian incentives like driving in public bus lanes, free parking with free electricity at selected spots and waiving of all sales taxes and VAT on electric vehicles have made them popular, now that they can run up to 170 km per charge on relatively flat roads and on summer conditions temperature wise. The numbers of vehicles are hence set to explode and even if the incentives might be slightly adjusted studies show it will not have a damaging effect on their popularity.

5.1 Lessons learnt

To find the link between on-housing solar PV and the electric vehicle realistic, many things must happen:

- Solar PV systems must half the prices. This is possible in five to ten years.
- Efficiency per area must be increased by 30%. This is possible.

- Electric vehicles must become lighter and less power demanding. A 30% reduction is possible.
- Driving distances for private cars must be reduced. A halving is possible through mode shift.

If the three improvements are successfully introduced, the needed solar array area will be reduced from 85m^2 to a mere 21m^2. If so, solar can be architecturally integrated. If not, solar PV will have to spill into the landscape and become sculptural. This is a possible approach in dense neighbourhoods (12).

The EU will from end 2020 through its Building Directive Article 9, demand that all new buildings be close to ZEB. Will the the extremely expensive examples have a replication value at all?
A recent study at University of California, Berkeley approached the climate change challenge posed by the UN climate change panel, the IPCC based on a wish to limiting the global temperature rise to two degrees C towards 2050. To achieve this would mean an 80% reduction in CO_2 emissions. They asked: Is this possible and what does it take for the transport sector to achieve its share? As vehicle emissions have fallen from 2-300 gram CO_2/km to under 100 and with the best hybrids under 40, fast improvements are happening. In order to reach the emission targets of the IPCC, the transportation sector must see the following combinations:

- Electric vehicles have to run on renewable, almost CO_2 free power.
- Second generation bio fuel vehicles with energy need below 0,08 litres per 10km must be made available. Today 0,30 is possible.
- Petrol- and diesel vehicles have to do with less than 0,02 litres per 10 km.

An energy need of 0,02 litres per 10 km equals 6 gram CO_2 per kilometre. Today's average under 100 grams is not so impressive then, if seen in this context. Researchers have expressed that such figures are beyond even the most optimistic technology scenarios for 2050 (13).
New technology for the existing combustion engine is hence not enough to respond to and fulfil the need to curb climate change within the 2 degrees C limit. It also means that autonomous family housing either in the expensive or the cheap end of the scale is not enough. Attitudes must change. Mode shift in the transport sector is absolutely necessary and we must live denser and more energy efficient in the cities to reach the goals of IPCC. But if we do and if population growth is limited to 9 billion from today's 7 billion, it can be done.

6 Conclusions

The major obstacles to the dissemination of all kinds of vehicles using electric propulsion seems to be on the verge of being removed in Norway. The lessons learnt are those of avoiding one sided biased support of either one technology only or one manufacturer, believing in a more lush technology development and making the most of economic and other incentives during a limited but predictable time span only. Today the situation is hopeful mainly due to a range of options as to charging often in combination (fast, medio, slow), a range of vehicles available at moderate and competitive prices and a strong network of serious service providers since most vehicles are manufactured by the major car manufacturers in the world. The age of the small garage industry seems to be over. A range of new options appear. The urban issue linking electric propulsion to Zero Energy Buildings and Plus Energy Buildings are offering interesting new links between powering the vehicle and producing renewable energy on homes and offices and vise versa. It is the urban challenge that is the problem and herein also hides the solutions.

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