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# Value chain analysis of the Norwegian electric vehicles market – Think a first-mover

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## Introduction

Recently, Norway is described as “the leading country on electric vehicles (EVs)”<sup>1</sup>, in the highest number of EVs per citizens in the world. In April 2013, totally 11.474<sup>2</sup> EVs are registered. Actually an EV, Nissan Leaf, was the second most sold vehicle that month. The EV sale has doubled in last two years and has continued to grow in 2013. Seen against the current success, it is easy to forget the prehistories of EVs. Norway had early producers, already in 1990s, of the vehicles we know today as Think and Buddy. These EVs had a long and bumpy ride. This case study argues that the prehistories are important for the market we see today in Norway.

The case study is about the EV Think and how development of this vehicle contributed in creating an EV-market in Norway. Think was an EV pioneer, initiated and developed in Norway<sup>3</sup>. How was this possible? Norway has no automobile companies, an industry which is dominated by gigantic multinationals.

This case study shows how Think was developed by an entrepreneur who managed to combine technology from various companies. At this point of time, multinational companies had not yet showed any interests for EVs. Against this background, the lack of dominant automobile actors in Norway might have been even advantageous for Think. Still, the entrance of Ford Motor Company in 1999 enabled the mass production, and when Ford withdrew some years later the production stopped. National interest for EVs was re-awakened in 2006, when ownership of Think was back on Norwegian hands. However, market was now in change. Multinational automobile industry was also about showing interest for EVs and battery industry was growing. For the small and independent company of Think, the overall challenges of the financial crisis created severe problems in this market.

Although, the production has stopped, this case study argues that Think created an early awareness for EVs in Norway. Think created publicity and a general understanding of EVs, seeding the market for potential customers and suppliers. Moreover, the politicians were introduced at an early stage, for the need of cultivating a market for sustainable transport. This supports and might contribute to understand the processes of change emphasised in the literature on sustainable transition in transport (e.g. Hoogma et al. 2002; Geels et al. 2012).

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<sup>1</sup> e.g. BilNorge (2013); Norsk Elbilforening (2013c)

<sup>2</sup> In addition are 419 plug-in hybrids and 137 electric vans registered, Grønn Bil 2013

<sup>3</sup> Buddy was originally developed in Denmark.

Transitions are not only technical, but also social and political, happening through long-term and interlinked processes of change in niches, political regimes and macro level events.

This report is further structured in a presentation of the value chain characteristics of Think, mapping main production and RD&D activities. Then, key technologies are discussed.

Thereafter, market characteristics, geographical scope and institutional context are examined. This result in a discussion of path dependencies in the development of Think, and the impacts these paths had for the current EV market in Norway.

## **Methodology**

This case study is designed to contribute to theory development in the field of sustainable transport within the theoretical discussions of technological systems and sustainability transitions in the Nordic TOP NEST project. The case study follows the process tracing method of George and Bennett (2005) and analyses how the development of Think follows and contrasts with theoretical hypotheses of path dependency in the literature. The case study is a restudy of previous collected empirical data of Think. Data is collected from public available information on websites and newspaper articles, official documents, white papers research reports of Think and EVs in general and personal interviews<sup>4</sup>. In doing this restudy, the empirical material is updated and extended with the specific focus in the TOP NEST project, by collecting more public available information, research reports and a telephone interview with the previous managing director in Think Global AS.

## **1 Value chain characteristics**

The value chain characteristics of Think identify how the EV product flows through main activities (1.1), the main supporting activities in developing the product (1.2), the actors involved in each segment of the value chain (1.3), and the dominant value chain structure (1.4).

### **1.1 Main activities**

This section gives an overview of the main activities in the production of the vehicle Think (1.1.1), the battery technology (1.1.2), recharging (1.1.3), production of electricity (1.1.4), distribution and recharging points (1.1.5), and marketing and sales (1.1.6).

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<sup>4</sup> See Røste 2001, 2005 and 2009

### 1.1.1 Production of Think

The product of the EV Think has been developed and produced through five generations, see picture. The last two types, Think Classic and Think City, were put into production. The third generation, PIV3<sup>5</sup> called CityBee, is also found in the market, but was a prototype produced at the small scale of 120 vehicles.

Picture 1.1 Five generations of Think, source: Grønn Bil 2013



Think Classic was the fourth generation, developed by the Norwegian company PIVCO AS, Personal Independent Vehicle Company. The company presented the ready and type-approved EV at an international automotive exhibition in Brussels in October 1998. The company was at this point bankrupt from the development process since this was the only portfolio of the company. Development processes have high costs and no income. Some of the owners managed to establish PIVCO Industries AS to secure the rights of the bankrupt estate. Shortly later they found the interest they had been searching for in the automotive industry and sold the main shareholder position to Ford Motor Company.

Ford put Think into production in November 1999, at the factory at Bjørkelangen in the region of Akershus, just outside Oslo. Ford named their operational company TH!NK Nordic

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<sup>5</sup> Personal Independent Vehicle number 3

AS, and produced 1200 Think Classic before the production stopped in 2002. Ford withdrew and sold the company rights to the Swiss company KamKorp Microelectronic.

*Picture 1.2 Think City, source: Teknisk Ukeblad*



In 2006 the ownership of Think was back in Norway, by a group of investors. The new company, Think Global AS developed a fifth prototype, PIV5. This model is referred to as Think City in this study and the fourth generation as Think Classic to prevent confusion. In 2008, about 100 Think Cities were produced in the factory at Bjørkelangen. However, the production stopped due to financial distress. Think and the rest of the Norwegian EV industry had severe challenges in financing the production during the financial crisis. In the end of 2009, the production started up again, now having been moved to Valmet Automotive in Uusikaupunki in Finland. Think Global also opened a factory in Elkhart Indiana, producing vehicles for the US market.

In March 2011, the production of Think Classic was closed down. Electric Mobility Solutions AS bought the shares, and announced that the production will start up again, but nothing has happened two years later.

### **1.1.2 Battery technology**

Think has used various types of batteries and is developed to be flexible on batteries to be able to use the latest technology.

Think Classic has 19 SAFT Nickel Cadmium (NICd) batteries connected in series. Think City has also NICd batteries, ZEBRA batteries from Mes-Dea, whereas the models produced in US have Lithium-ion batteries from EnerDel.

### **1.1.3 Recharging**

Think was originally produced to be charged at normal sockets with 230 volt, 10 and 16 ampere. Fast recharging was no topic in the development of Think. In the end of the 1990s EVs were still rare niche products and the battery technology was little developed. Think was also initially designed to be a city vehicle with short driving range. Normal recharge needs about 6-8 hours to be fully recharged in the ZEBRA and the Li-ion battery pack.

### **1.1.4 Electricity**

The sustainability of EVs has been questioned, given the dominant technology of fossil fuel in the electricity production worldwide. In Norway, on the other hand, electricity production is highly renewable. Over 99 per cent of the electricity produced in mainland Norway is covered by hydropower plants<sup>6</sup>. Hence, driving an EV in Norway is highly sustainable.

### **1.1.5 Distribution and recharging points**

The energy distribution company Oslo Energy was involved in the development of Think. At that time, they were local distributor of energy in Oslo, wholly owned by the municipality of Oslo. The energy distributor company participated as developmental partner in a European RD&D-project for distribution to EVs, see 1.2.2. The collaboration continued in a market research project with Statoil. Oslo Energy did here build 15 recharging points and Statoil had PIV3s for hiring.

### **1.1.6 Market and sales**

In today's Norwegian market around 1000 Think's are registered. About one half of these are the fifth generation produced by Think Global in 2008-2011, and the other 500 are the classic model produced by Ford in 1999-2003.

Think Global AS was also working on developing another model, Think Ox. This model was not put into production. The concept was a four-door family model which was bigger than Think City.

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<sup>6</sup> <http://www.world-nuclear.org/info/Energy-and-Environment/Renewable-Energy-and-Electricity/>

## **1.2 Main supporting activities**

The innovation process of Think reveals many supporting activities. The development was directly supported by: RD&D and collaboration with companies (1.2.1) and public RD&D and funding from public agencies (1.2.2). The development was also evolving out of the activities in the involved companies, key technologies, market characteristics and institutional context as discussed in the next sections.

### **1.2.1 RD&D in companies**

Originally, the idea of Think was initiated by the manager of a factory which produced products in thermoplastic, Bakelittfabrikken AS. The idea was to create a lightweight vehicle that did not need much energy to drive around. The initial idea was to combine thermoplastic as one core component with the other main component: the frame in aluminium. The frame was created for Think by Hydro Automotive Structures.

The prototypes were built by local car enthusiasts, although some European companies were involved in developing the second prototype in 1994. These companies were participating research in an EUREKA research project<sup>7</sup> and were an Austrian company with competence on vehicle engineering and a Swiss research institution on safety and crash tests.

Professional vehicle engineering competence was searched for, when it was decided to develop the idea into a commercial product, after successfully demonstrating PIV3. PIVCO made a contract with the British sport-car and engineering company Lotus. The contact lasted for almost two years, with stays studying how Lotus was working and with experts from Lotus placed at Bjørkelangen to develop the production.

Ford Motor Company entered PIVCO Industrier AS with their massive automotive competence in end of 1999. Think Classic was at that time a ready-made and type-approved EV and Ford had automotive competence needed to put Think into mass production. Ford also had capital from their massive production portfolio. Besides, Ford branded Think in a wider green initiative, the enterprise Think Mobility, also developing two electric bicycles and a low-speed resort vehicle. Ford closed the electric mobility RD&D in 2002.

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<sup>7</sup> <http://www.eurekanetwork.org>

Think Global AS rebuilt the small and independent company in 2006, with expertise from the international automotive industry. Many of the early local car enthusiasts and engineers who had developed Think were brought back. The leader team was strengthened with expertise from the global automobile industry, and many new factory workers came from the closed Saab-production in Sweden. In addition, a contract was made with Porsche Consulting to professionalize and make the production line more efficient.

Think Global had several attempts at developing the battery technology. First in collaboration with Tesla Motors in 2007, but when the transaction did not give results new suppliers had to be found. A123Systems was involved and when production was moved to Valmet in Finland, EnerDel was also involved.

### **1.2.2 Public RD&D and funding to Think**

Public RD&D funding was critical in developing Think Classic. All four prototypes received substantial support from the public research agency and the industrial research agency.

The public research agency NTNF<sup>8</sup> was involved from the beginning, supporting the feasibility study in 1991, of whether the technology concept was feasible in combining the two critical materials: thermoplastic and aluminium. NTNF did also support the first prototype, a physical test combining the materials and not a drivable model. The Ministry of Transport and the Ministry of Petroleum and Energy did also contribute with financial support to PIV1.

The European research programme EUREKA contributed also with support resulting in PIV2 in 1994, as mentioned in 1.2.1. EUREKA was financed by public support from the industrial research agency, Industrifondet<sup>9</sup>. Funding was handled through the public measure: “Public RD&D-contract”, a support scheme to company based development relevant for and in financial collaboration with a public organisation. Oslo Energy was the public organisation, at that time the municipal energy distributor company in Oslo.

The next two models, PIV3 and PIV4, were heavily funded by support from the Norwegian Industrial and Regional Development Fund (SND) from 1995 till 1998. The agency contributed with risk capital, development grants and loans. Support was also granted through

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<sup>8</sup> Norwegian Research Council for Scientific and Industrial Research, prior agency structure of todays Research Council of Norway

<sup>9</sup> Prior agency structure of todays Innovation Norway



an additional public RD&D contract with Norwegian Pollution Control Authority, and in an arrangement for the factory facilities at Bjørkelangen. The public support from SND stopped when Think was type-approved, regarding the development process as finalised.

Think Global did not receive any public RD&D support to develop the fifth generation, Think City. However, the company did receive support from the Research Council to participate in two projects on the shortcomings of batteries for EVs, on Zero Emission Mobility. Think Global o received a risk loan from the public investment company Investinor in 2009,

### **1.3 Companies involved in each segment of the value chain**

Many companies have been involved in developing and producing Think. This section gives an overview of producing companies of Think (1.3.1), main collaborators (1.3.2), and main supporters (1.3.3) in the value chain.

#### **1.3.1 Think**

Think has been produced in various owner constructions: PIVCO AS, Pivco Industrier AS, Think Nordic AS and Think Global AS. Think has also had other owners, but these have not contributed with any produced vehicles.

##### **PIVCO AS**

PIVCO AS developed the early prototypes resulting in the model Think Classic. PIVCO was initially an individual enterprise established in November 1990. The entrepreneur recruited local car enthusiasts and engineers to develop his<sup>10</sup> idea.

##### **Pivco Industries AS**

This was a private company established by some of the former owners and workers in PIVCO in November 1998. The company was established to protect the production rights of Think from the bankrupt estate when searching for new owners.

##### **Think Nordic AS**

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<sup>10</sup> Actually his father's idea.

Ford established the operational company Think Nordic AS in 1999 together with the Norwegian owners from PIVCO Industries AS. Around 55 persons worked in the production of Think at Bjørkelangen.

### **Think Global AS**

The private limited company Think Global AS bought the production rights of the bankrupt estate of KamKorp in 2006. Think Global was established by a group of Norwegian investors, leaded by Inspire AS, two of the founders of the solar cell company REC and other distinguished business leaders. Around 200 were recruited to work at the factory at Bjørkelangen.

## **1.3.2 Collaborators and suppliers**

Think has been developed in collaboration with many companies, as indicated in section 1.2.1. Actually, the number of suppliers is around 120. This section does not give an overview of all these suppliers, but focuses on main collaborators and suppliers.

### **Bakelittfabrikken AS**

The entrepreneur of PIVCO was manager at the factory Bakelittfabrikken AS, where the whole thing initially started. Bakelittfabrikken AS<sup>11</sup> has produced products in thermoplastic since the foundation in 1946, e.g. row boat<sup>12</sup> and ammunition. The idea of Think was to use this hard plastic material in a new product in the body of the vehicle.

### **Hydro Automotive Structures**

Hydro Automotive Structures<sup>13</sup> was invited in from the start, and created the aluminium frame for Think. Hydro produces aluminium profiles to the global automotive industry. The largest operation is located at Raufoss in Eastern Norway and has about 1.200 employees.

### **Ford Motor Company**

Ford Motor Company was *the* rescuer of Think in 1999, with their entrance as main shareholder it was feasible to put Think into production, see section 1.2.1. However, when Ford withdrew in 2003, the production stopped. Ford announced that they would concentrate

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<sup>11</sup> The factory is now Nammo Bakelittfabrikken AS, a part of the Nammo Group

<sup>12</sup> The row boat Pioneer was a popular product in Norway in the 1980s

<sup>13</sup> Benteler Group bought the company in 2010

their effort on fuel cells. Ford is among the largest automakers in the world with around 166.000 employees working in offices and plants all over the world.

### **InSpire Invest AS**

InSpire Invest AS was the leading investor in the new company Think Global AS and the chairman was the managing director in the start-up. InSpire Invest is an advisory group specialized in sustainable development, social and governance issues. The group includes five people, located in Oslo and London. After closing down the production, the company has continued the research projects on overcoming the barriers of EV batteries, in the ZEM-alliance (Zero Emission Mobility).

### **Tesla Motors**

Tesla Motors was to develop a special battery pack for Think based on their competence on Lithium-ion batteries. Tesla Motors is an EV company located in Palo Alto, California with around 2.000 employees, which also has engineering services for other EV companies. Tesla was founded in 2003 and introduced the sport car inspired model Tesla Roadster in 2008.

### **Valmet Automotive**

The production of Think City was moved to Valmet Automotive in Uusikaupunki, Finland in 2009. Valmet Automotive is a vehicle engineering and manufacturing service provider for the automotive industry. Valmet was founded in 1968 for producing the Swedish Saab to the Finnish market. Valmet got new owners and went through a heavy renewing strategy in 2010. The company now employs 1.700 in Finland, Sweden, Germany, Poland and China.

## **1.3.3 Investors and Supporters**

Financial investors were important since Think was developed in a small independent company with no income from other products during the development process.

In the early phase, the Norwegian oil company Statoil was central and the two big state companies of post and telecommunication were important sponsors. The development was also financed by other large private companies in the insurance business, tobacco industry and food industry.

No automotive industry companies were involved. The industry was interested, but PIVCO AS was told to come back when they had developed their idea. Besides, none of the supporting companies had a particular sustainable development profile. This changed under Think Global.

Think Global was founded by several sustainable oriented actors. InSpire Invest is already mentioned and the founders of the solar cell company REC, who were initiators of the reintroduction of Think. The investor group also involved a hotel-owner, a retailer and a food industry owner. Think Global managed to attract support from the automotive and the EV industry, e.g. Porche Consulting, Valmet Automotive, Tesla Motors, A123 and EnerDel.

#### **1.4 Modular value chain structure**

The modular value chain structure appears to be the dominant structure for how Think was developed and produced. Think was developed out of competence, collaboration and financial support from many companies, collaborators and suppliers, and investors and suppliers.

## **2 Technology characteristics**

Think had from the very start the strategy of networking and buying best available technology from various suppliers. Additional strategy was keeping the vehicle simple and lightweight. Think is built of considerably fewer automotive parts than ordinary vehicles, only around 600 compared to the usual of 5000 parts.

### **2.1 Thermoplastic technology**

The idea of Think started in the excellence of the thermoplastic technology. The idea was to use this technology in developing the new product of the vehicle body. The idea was a lightweight construction together with the frame in aluminium to overcome one of the main challenges for EVs: the weight. This in contrast to the EVs on the market which mostly were rebuilt traditional cars. These were heavy and required much battery capacity.

The plastic material also has other advantages. Most importantly, it is coloured during moulding process and does not need painting, and it does not become rusty and easily dented. Hence, the body was produced and created to be a sustainable product.

## 2.2 Battery technology

Most models of Think sold in Norway have ZEBRA Sodium battery, a battery pack of 19 NiCd water cooled batteries. ZEBRA<sup>14</sup> represents well known battery technology, developed already in 1970s and 1980s. Technology is well tested, and turns out robust and inexpensive.

Think City manufactured in Elkhart has Lithium-ion batteries from the local battery producer EnerDel. EnerDel was one of the main investors in Think Global AS in 2009, with the battery supply contract.

Many battery producers were involved in developing Think City. First, Tesla Motors which was to develop a special battery pack suited for Think, based on their competence on Lithium-ion batteries. However, the contract was terminated after about one year because of serious delays. Two other battery producers were now involved: A123 and EnerDel, which contributed with their existing lithium-ion batteries for transportation.

Lithium-ion batteries are thought to represent the “new” battery technology, and are found in most EVs released in the market today. The battery type is common to types we know from consumer electrics as cell phones and computers, and has the advantage of storing energy in the battery. Although the main challenge is still in the capacity these batteries are thought to handle fast recharging better. However, the Li-ion batteries in Think City models have also been doubted to handle the intensity. Yet, Think City models are rebuilt and have used the facilities of fast recharging.

The two various battery types have their enthusiasts<sup>15</sup>. ZEBRA has slightly longer driving distance, about 180 km compared to 160 km for Lithium-ion batteries. The battery is also thought to last longer before capacity is reduced and have to be replaced by a new battery pack. The lifetime of batteries is still a major problem, as in battery products in general. However, as pointed at, the use of fast recharging might here be a related factor. Lithium-ion batteries are also thought to have challenges in cold winter weather. The battery not only last shorter due to the energy used, but cannot be recharged if the temperature is too low. This might be a local problem for EV drivers in the coldest part of Norway.

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<sup>14</sup> Zero Emissions Batteries Research Activity

<sup>15</sup> Norsk Elbilforening 2013; Think City 2013

### 3 Market Characteristics

In Norway, the EV market has had an impressive growth. In April 2013, the EV Nissan Leaf was actually the second most sold vehicle in Norway, and totally 11.474 EVs were registered in April 2013<sup>16</sup>. The market has developed from being a niche to mass market. The early market was dominated by small city vehicles, as Buddy, Reva and Think driven by EV enthusiasts. No global automotive companies produced EVs. During the last couples of years, though, many new EVs have been introduced on the Norwegian market, many from the established automotive companies.

Although the market has grown, EVs are still only amounting to 0.33 per cent of the total fleet of passenger cars, which is listed to 2.4 million passenger cars in Norway in 2012<sup>17</sup>. However, the annual growth rate for the number of registered EVs has increased from just 105 per cent in 2009 to 204 per cent in 2012, which means that in 2012 the number of registered EVs more than doubled. The interest organisation for EVs in Norway indicates a prognosis of 6-6.500 new EVs registered in 2013<sup>18</sup>. Figure 3.1 shows the development from 2008 to 2012.

Figure 3.1 Electrical passenger cars and vans registered in Norway, 2008-2012 (Source: SSB)

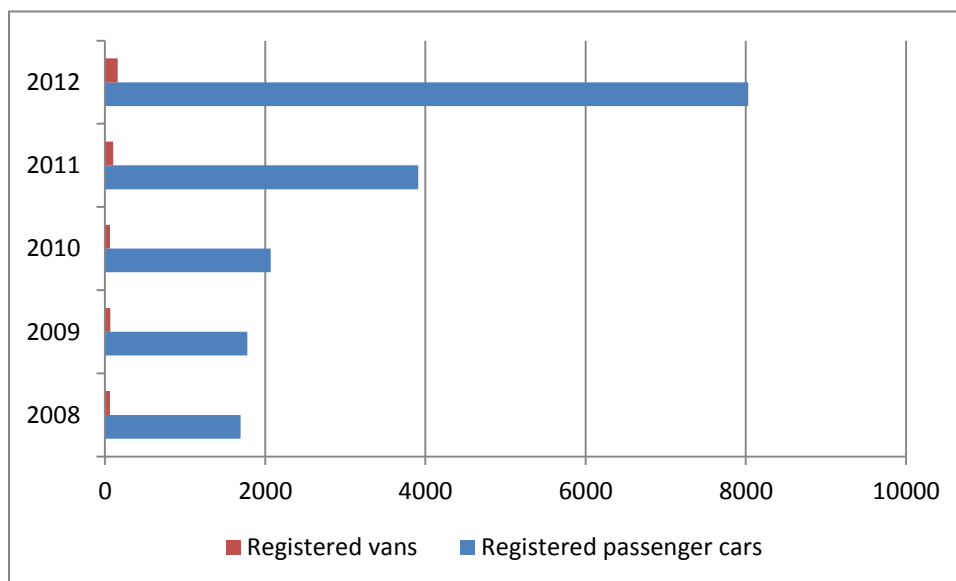


Table 3.1 demonstrates that EVs are concentrated in the metropolitan area of Oslo and Akershus, although private EVs are registered in all counties in Norway. In 2012, about 50 per cent of the EVs were registered in Oslo and Akershus. On the other hand, the annual growth rate in 2012 is higher in some of the other counties, especially in Hordaland, Rogland and Sør-Trøndelag.

<sup>16</sup> Opplysningsrådet for veitrafikk (2013)

<sup>17</sup> Data from the Statistical Bureau from 2012: 8031 passenger cars and 159 vans registered.

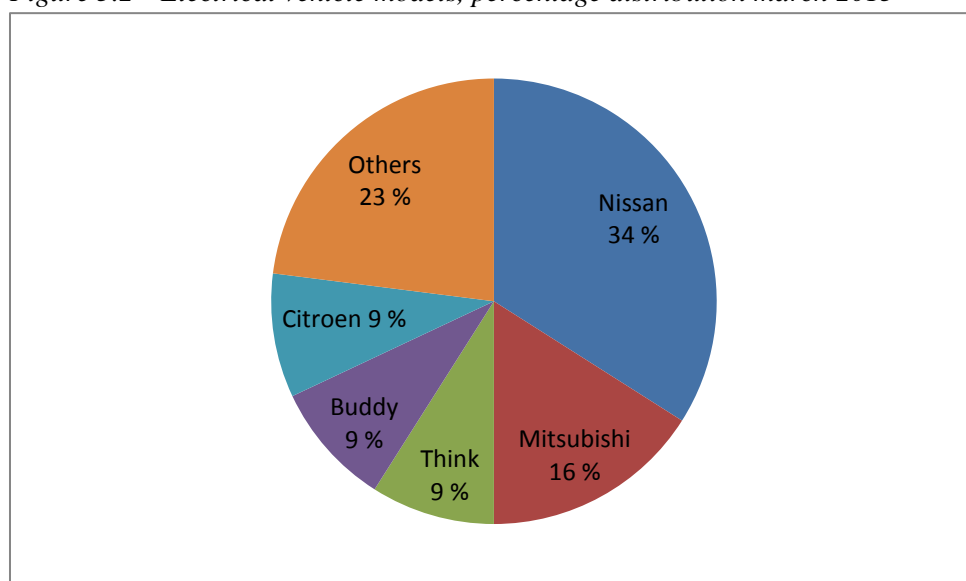
<sup>18</sup> Norsk Elbilforening (2013)

Table 3.1 Number of private EVs registered in 2008-2012, in the Norwegian counties (Source: SSB)

County	2008	2009	2010	2011	2012
Akershus	702	698	805	1358	2415
Oslo	311	361	437	752	1526
Hordaland	252	251	229	417	969
Rogaland	86	86	94	279	668
Sør-Trøndelag	66	73	103	224	608
Buskerud	114	105	117	224	459
Møre og Romsdal	22	21	33	96	271
Vest-Agder	43	54	63	109	216
Vestfold	27	25	34	86	191
Østfold	17	16	17	67	146
Nordland	1	3	7	49	99
Aust-Agder	15	17	18	39	94
Nord-Trøndelag	5	7	10	26	73
Troms Romsa	1	13	29	47	65
Telemark	13	12	15	29	46
Oppland	4	6	7	16	37
Hedmark	5	8	9	14	35
Sogn og Fjordane	5	5	6	9	25
Finmark	1	1	2	8	18

Although, Nissan Leaf makes a total of 74 per cent of the total sale of EVs so far in 2013, the market has many various models. Figure 3.2 shows the distribution for march 2013.

Figure 3.2 Electrical vehicle models, percentage distribution march 2013<sup>19</sup>



<sup>19</sup> Grønn Bil (2013)

## **4 Geographical Scope**

The development of Think in Norway has been located in the municipality of Aurskog-Høland in the county of Akershus. The geographical site was chosen because it was here it all started, in the factory Bakelittfabrikken AS managed by the entrepreneur. The entrepreneur and the management group had headquarters in Oslo.

Later a factory was facilitated for producing Think Classic at Bjørkelangen. As mentioned in section 1.2.2 SND did contribute to arrange the factory facilities at Bjørkelangen. This was done in a local initiative to offer PIVCO good production conditions. The initiative was led by the major in the municipality of Aurskog-Høland, and other contributors were also locally oriented in scope: the regional county administration, local banks, an energy distributor and some local companies.

Think Global AS reopened the factory at Bjørkelangen which had been closed down by the previous owner. The head quarter was placed at Fornebu in Oslo. Think Global managed in this way also to bring back much of the local enthusiasm and competence from the early phase. When Think Global AS had to close down in 2011 some of the workers were offered to move with the new owners to Germany, but only a few went and returned shortly to Bjørkelangen.

## **5 Institutional Context**

In Norway EV buyers are given many economic advantages and benefits provided by law. EVs are for example exempted from purchase tax, which is extremely expensive for other cars, from the 25 per cent VAT of new vehicles, and from charges in toll roads. EV users are also given other benefits, of for example, free access to drive in bus lanes, which might be an attractive choice for travellers in crowded metropolitan areas. Table 5.1 lists public benefits for EVs in Norway, and when these were introduced.



Table 5.1 Public benefits for EVs in Norway<sup>20</sup>

Measure	Introduction
Free municipal parking	1993
Toll roads, no charges	1996
Annual road tax reduced	1996
VAT exemption	2001
Purchase tax exemption	2001
Access to bus lanes in test areas	2003
Company car reduced tax	2004
Access to bus lanes, permanent	2008
Free ferries	2008
Mileage rate, extra supplement in the state regulative	2008
Recharging, free public	2009

In the early phase, when Think was merely an idea, no political actors pushed for EVs in Norway. EVs were not yet on the public agenda. With the development of Think at Bjørkelangen, PIVCO AS managed to bring EVs on the agenda in Norway. Think was mentioned in debates in the Parliament and local and regional politicians pronounced needs for EVs.

Lately many actors have raised interest for enhancing the use of EVs in Norway, as for example Transnova and Grønn Bil, which both were established in 2009. Transnova was established by the Ministry of Transport to reduce emissions from transport, and Grønn Bil originated as a part of the action plan for EVs<sup>21</sup>.

## 6 Path Dependencies

This case study describes how Think is developed out of knowledge in various companies, mapped in the main production activities in section 1.1, supporting activities in 1.2 and companies involved in the value chain in 1.3. The mapping shows how Think was developed out of competence, collaboration and financial support from many companies, collaborators and suppliers, and investors and supporters. In that sense, Think follows in many ways the path in conventional automobile industry, not only explained by localization but in nested industry, in local, regional, national and global value chains (Sturgeon 2008).

<sup>20</sup> ZERO (2010), Norsk Elbilforening (2013b), Lovdata

<sup>21</sup> <http://www.gronnbil.no/om-groenn-bil/hovedprosjektet-groenn-bil-article19-140.html>, <http://www.transnova.no/om>, "Handlingsplan for elektrifisering av veitransport"

Think was possible to develop because PIVCO AS identified possibilities and managed to combine and integrate these in the innovation process (Røste 2001; Røste and Hernes 2005). Although, Norway has no automobile companies, many manufacturers are leading suppliers to international automobile industry. One of these companies, Hydro Automotive Structures was involved in developing Think from the beginning. Hydro found the technology concept interesting, combining thermoplastic and aluminium. The other core technology was already accessible, in the thermoplastic technology at Bakelittfabrikken. It was here the idea of Think started, with the manager at Bakelittfabrikken. He got the idea of using thermoplastic technology to mould the body of EVs. This would result in a new product portfolio for the factory, and a radical new product of body of vehicle in thermoplastic material. The product was new in its qualities of being lightweight, coloured in the moulding process, from being rusty and easily dented, see section 1.2 and 2.1.

Scholarly literature on sustainable transition in transport (e.g. Schot et al. 1994; Orsato et al. 2012; Geels et al. 2012) emphasises the strong technological regimes in gigantic automobile multinationals as the worst challenge for EVs. Moreover, this literature has also studied an early phase in developing Think, and describes the experimental project of PIVCO as successful partly because of the lack of industry (Schwartz 2002; Hoogma et. al 2002). PIVCO did not have to fight against dominant technological trajectories of automobile production in Norway.

However, although PIVCO managed to create Think detached from established automotive companies, the independent position was also a main challenge (Røste 2001; Røste and Hernes 2005). Initially, an embedded disbelief for car production in Norway was troublesome. Disbelief was rooted in previous failed attempts to develop autos in Norway, especially Troll in 1950s. Scepticism did not reflect on why Troll failed and why it was thought to happen again<sup>22</sup>. Disbelief in developing an EV in Norway in 1990s was noticeable in for example newspapers, automobile and financial press, and in unwillingness from public RD&D agencies to support Think. The fear of failure might have withdrawn potential collaborators, suppliers and financial investors to participate in developing Think.

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<sup>22</sup> Troll is also a story of an enthusiastic entrepreneur who managed to build five models together with international collaborators, but stopped because of rigid bureaucratic restrictions on production and market sale of cars in Norway and in deficient public support in building national automobile industry, e.g. <http://www.nrk.no/programmer/tv/autofil/1.4799998>

PIVCO worked carefully to change the societal understanding of vehicle production in Norway. PIVCO also suffered from another related challenge, the international disbelief of EVs. Market potential for EVs was harshly doubted, based on the limited driving range, in imperfect battery technology and frequent need of recharging batteries.

On the other hand, lack of an international EV-market was also an advantage for Think. PIVCO could experiment and create a niche market and thereafter increasing production little by little. PIVCO's strategy was to market their product as something else than a traditional car. PIV was not a car, but a city-vehicle. PIV was a personal independent vehicle suited for individual transportation in cities and densely populated areas. The vehicle was small, fitted for driving and parking in crowded areas. It was also environmental friendly, in not giving off any emissions. PIV was also nearly soundless.

This new type of vehicle, a city-vehicle and a sustainable individual transport, was important for the received public RD&D support, see 1.2.2. Not a car, but a new mean of transport. Moreover, location was crucial in this early phase. Early public benefits, see section 5, was decided to enhance EV-market in Norway. Think had a pioneering position at this point and was also a part of political decision-making processes (Røste 2001; Røste 2009). Political processes were driven by interest for EVs, but also for creating regional industry and jobs, and radical new industry in Norway.

Hence, Think had an important role as first-mover in building the new market for EVs in Norway. The development of Think implied in many ways a making of new technological paths in the existing transport regime, or creating a new technological regime of EVs. As the case study shows, these new technological paths were not created during the night, but were a social evolutionary process created in interaction with many actors and events involved in the innovation process of Think. In creating societal and technological understanding and political interests in EVs, Think paved the path for the current generation of EVs. The public benefits have created an EV-market, which made Nissan Leaf and Tesla affordable for the Norwegian vehicle mass market.

However, for the small independent companies of Think it was challenging. Compared to gigantic international automotive companies they had little equity capital. PIVCO AS and Think Global AS had no other production portfolios to finance the experimentation and development of the models. Moreover, these small and independent companies did not get same arrangements as the established automobile industry. Contrasting to the good deals of

delays for established industry that do not have to pay for parts before products have been sold, suppliers demanded payment in advance from Think Global AS. Transactions also showed how contracts with the small company were put aside when leading multinationals required services from vehicle engineering companies. The small and independent company appeared even smaller when gigantic industry enters into the new market of EVs.

## **7 Conclusion**

This case study shows how Think was developed outside traditional automotive industry, and how Think had an important role as first-mover in building a market for electric vehicles in Norway. Lack of market was at some extent an advantage for Think, making creation of a niche possible and thereafter increasing the production little by little. Creating public benefits for EVs in Norway has been important, but also in the social understanding of EVs. Think has created a special focus in Norway, in market and among politicians. Belief of EVs as a possible means of transport has been brought forward and institutionalised by the many public benefits for EVs in Norway.

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