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The contribution of research and knowledge accumulation in the development of the Norwegian battery electric vehicle market.

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Abstract

This paper investigates the role of research and knowledge building in developing the world's leading BEV market in Norway 1990-2020. Review of research articles/reports and other documents revealed that Politicians in the early years had little research-based knowledge to build decisions on. The Ministry of Transport therefore financed basic research to evaluate BEVs potential. Incentives suggested by lobbyist, were introduced at negligible cost to support testing/industrialization towards 2000 and 2010, without knowing their far-reaching future consequences. Norwegian industrialization failed by 2010. The policies started working after 2010 when OEM BEVs came. Researcher have after 2010 supported political decisions with market models and by analyzing user needs and policy effects. The early decisions should have been supported by research-based knowledge and regular policy reviews.

Keywords: Battery electric vehicles; Norwegian market; Knowledge development; Policies; ZEV targets

1. Overview and motivation

This paper investigates the role of scientific research and societal knowledge accumulation in developing the world's leading per capita BEV market in Norway. The story spans 32 years from the 1990 import of the first BEV to a 2020 market and fleet share of 54% and 12% respectively. The motivation for the study is that substantial BEV incentives have been introduced since the early 1990s, under great uncertainty and with far reaching future consequences. This gives rise to a question about what the politicians knew about BEVs when these incentives were introduced. The main research question of the paper is thus: How have politicians been supported and impacted by knowledge building research, studies and reports in the establishment of the policies that enabled the BEV market?

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2. Methodology and main contributions

The paper builds on a thorough review of over 250 research, government, civil services, consultants, NGO and industry articles, reports and other documents, supplemented by a systematic review of press articles using the Norwegian Retriever news archive services. The contribution to the public knowledge building was evaluated and compared to the policy and incentives and their motivation at different points in time. Many of the reviewed documents prior to 2000 are not publicly available and comes from the authors archive.

3. Results

3.1. Getting to know BEVs – The period 1990-1996

BEVs were at the outset in 1990 unknown to the vehicle sector, the general public, politicians and civil services. No one knew for instance how to register the first imported BEV in 1990. Figure 1 presents an overview of the period.

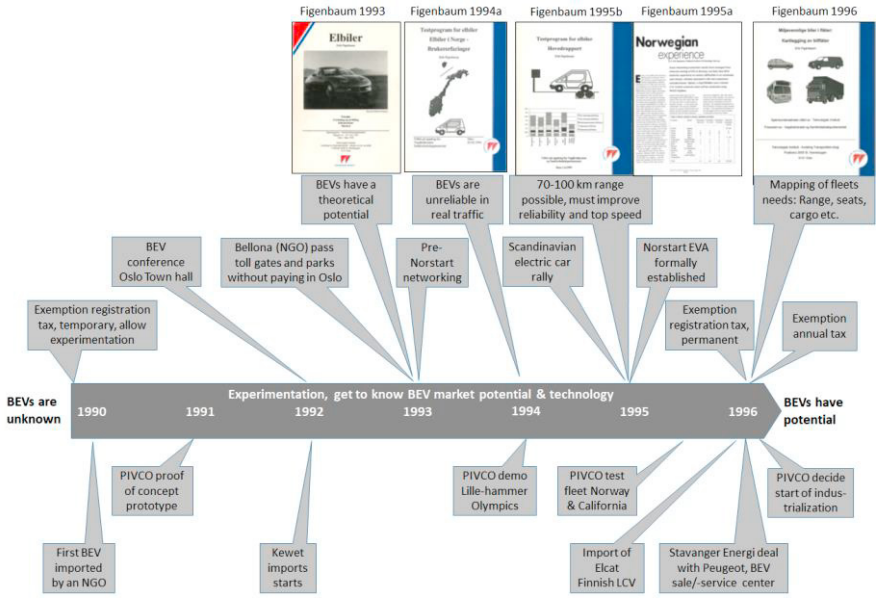

Fig. 1. Overview of the period 1990-1996.

Norway's high vehicle registration tax, partially based on vehicle value, and high production cost, made BEVs far too expensive. The Government exempted BEVs from the registration tax temporary to allow market experimentation in the National Budget for 1990. This shows that little was known about how BEVs would function in Norway. Soon after, the Danish Kewet mini-BEV, came on the market. The Ministry of Transport financed research on BEVs characteristics and potential documented in an article (Figenbaum 1995a) and a series of research reports (Figenbaum 1993, 1994, 1995b, 1996, a. o.), to establish basic national BEV knowledge. The research showed also a BEV potential (Figenbaum 1993), but the physical tests revealed quality issues and user complained about short winter ranges (Figenbaum 1994) and poor quality. Norwegian PIVCO Ni-Cd battery prototypes were showcased at the 1994 Lillehammer Olympic winter games and tested in Norwegian fleets and as station cars in California in 1995-1996 (Figenbaum 1997a, 1998a). They showed promise in the cold (Figenbaum 1997b) but needed a redesign to improve quality. "Norstart – Norwegian EV Association" (EVA) was established as a stakeholder interaction arena promoting BEVs, production of BEVs and working for more incentives. Press articles, conferences and rally events were other sources of information. The Parliament exempted BEVs from the annual tax from 1996 to continue the market experiments. An NGO in Oslo driving a BEV, refused to pay for parking and road tolls. They wanted an exemption for BEVs. The press coverage was large, and Oslo Municipality gave in late 1995. The Parliament amended the road toll and parking regulations accordingly and these incentives were introduced in 1997 and 1999. PIVCO industrialized

a BEV from late 1996, aided by automotive expertise from Lotus Engineering (UK) and experienced OEM suppliers (Figenbaum 1998a), and financed by research grants and investors. The outcome from this period was that BEVs could have a market potential, but it was by no means certain that it could be realized due to the technology limitations, and improvements were certainly needed, especially on quality.

3.2. Industry Development Part 1 – The period 1997-2002

BEVs potential grew with PIVCOs industrialization plans for BEV production, albeit with some scepticism among the civil services. PIVCO, which had been renamed THINK, went bankrupt at the end of 1998 as financial resources had been exhausted in the attempt to establish the production of a new model (Figenbaum 1998b). Critics thought that BEVs were doomed, that BEV production was not for Norway, but were silenced when Ford bought THINK in early 1999 (Hoogma et al. 2002) to get BEVs to meet California's ZEV mandate. The timeline is shown in figure 2.

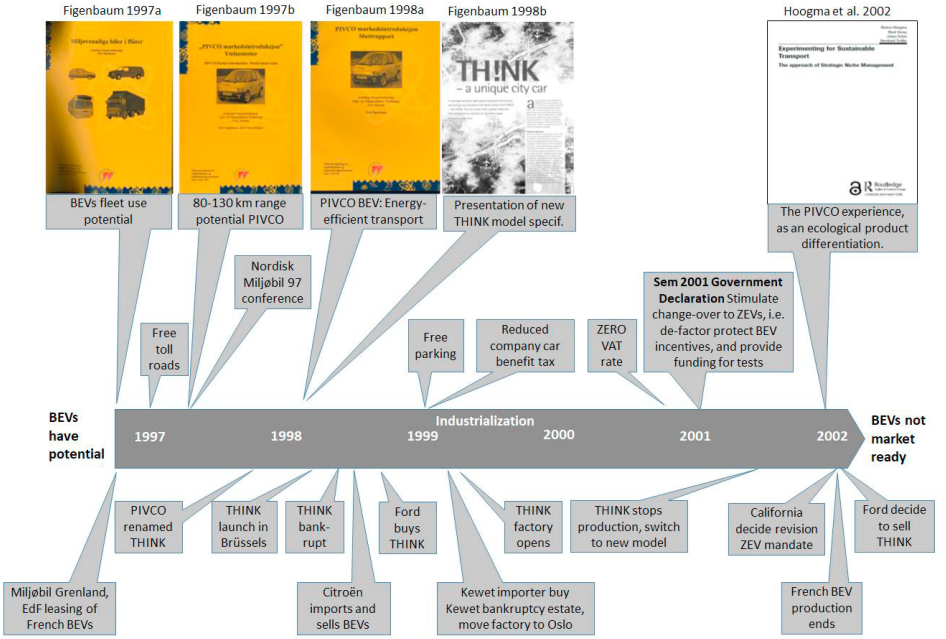

Fig. 2. Overview of the period 1997-2002.

The Government introduced more incentives when Fords CEO, the Norwegian King and the Prime minister opened the THINK factory in Nov. 1999. THINK decisions were from then on taken by Ford in Michigan. Ford had a long-term perspective and wanted a strong home market for THINK were early technical problems could be solved. Ford preferred national fleet adoption targets as in the US, that were more predictable than tax incentives. The Norwegian way was however to have general incentives applicable to all BEV buyers, whether public or private fleets or consumers. The 1999-2000 THINK BEV became too expensive and found few customers. The EVA managed to lobby for a zero rate VAT for BEVs, that reduced prices overnight by 20% from 2001. BEVs became marginally competitive. The interest in research and testing in Norway ended as THINK through Ford now had all resources in-house. Other parts of the BEV ecosystem thus got less resources and politicians became increasingly dependent on Ford to develop the market in Norway. When California pulled the plug on the BEV part of the ZEV mandate in 2002, it sent a signal that "BEVs are not ready for the market". Ford sold THINK as it had no longer a need for BEVs to sell in California, and both THINK and Ford had various problems at the time. The 2001 Government declaration contained a paragraph supporting BEVs, so the politicians kept the incentives in place. THINK employees and other actors still believed in BEVs, but politicians looked to other options such as hydrogen.

3.3. Global and National Downfall – The period 2003-2006

The general public feeling was now that BEVs were not market ready. It did not help that the new THINK owner never got the production restarted. THINK became a prototype workshop. OEMs and politicians turned to hydrogen

and biofuels. BEVs prospects seemed dim, but incentives remained, protected by the 2001 Government declaration. Small entrepreneurs discovered that these incentives combined with a collapse of the BEV interest globally made it possible to buy cheap second hand French BEVs and sell them profitably to users of bus lanes that were opened to BEVs from 2003-2005. Norwegian investors bought Kewet and started production in Norway from 2005. A small market for BEVs continued and the fleet doubled between 2002 and 2006 while most other countries experienced a reduction. Very little research was done in this period. A Ministry of Finance vehicle taxes report saw practical problems with BEV exemptions (MoF 2003). The health impact was estimated (Selvig et al. 2003), and THINKs potential assessed (Bech 2004). A BEV city user survey was carried out (ECON 2006), finding that user incentives were essential. Press activity was large due to the THINK sale, second-hand imports and the bus lane access. The EVA transitioned from an industry cluster towards becoming a consumer organization with about 400 members in 2005. The 2006 Low Emission Commission (LEC 2006) official Norwegian report (NOU) on how to get to the low emission society by 2050, found that ZEVs, low emission vehicles and biofuels were essential transport sector contribution. The 2005 Government declaration stated to use the taxation system to stimulate sales of environment friendly vehicles. Hydrogen proponents lobbied to get the same incentives for hydrogen as for BEVs, thus simultaneously fighting to keep the BEV incentives. Politicians thus saw mixed messages and sat still in the boat.

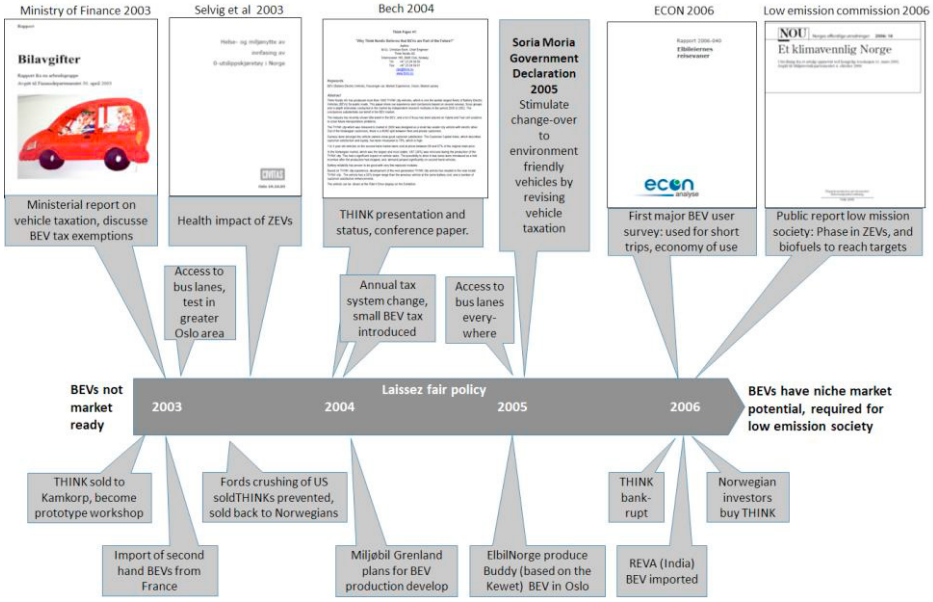

Fig. 3. Overview of the period 2003-2006.

3.4. Industrial Development Part 2 – The period 2007-2010

The knowledge of BEVs potential was still limited at the start of period. The Ministry of Finance did not bother to look at BEVs in discussing the future of the vehicle taxation system (MoF 2007). BEVs were seen as special purpose vehicles for commuting in bus lanes and to save toll road expenses. Climate policy and issues were high on the agenda globally and in Norway. It was a good time to re-establish BEV production at THINK, owned by Norwegian investors from late 2006. The plan was to produce the model developed earlier under Ford. International investors joined in 2008 after the vehicle had been launched at the International Autoshow in Geneva, and deliveries had started. Reduced ferry rates for BEV owners were introduced to aid this industrialization but also treat ferries equal to toll roads. THINK had funding problems during the 2009-2010 global financial crisis, and production was moved to Valmet in Finland. By the end of 2010 it was over. THINK went bankrupt. A fate also suffered by the Buddy producer that also had developed a new model for 2009. This shows that politicians succeeded in building an incentive package that supported BEVs, but it was not specific enough to support industrialization in Norway. It was also a timing issue. BEVs might not have succeeded anyway due to high user barriers related to short range, long charge time without fast charging, small vehicle sizes and the high cost of the Li-Ion batteries. Earlier BEVs had stumbled upon even larger

barriers. THINK thus lost the opportunity to profit from the later cost reductions of Li-Ion batteries. Soon new insights and additional perspectives were gained from consultant reports, public sector documents and more and broader research on BEV user needs. Systematic knowledge review within Klimakur2020 project and its 2010 report (Klimakur 2020), and stakeholder viewpoints from the Electrification Group (2009), put BEVs high on the political agenda. With THINKs rebirth and the Buddy redesign, the BEV potential among multi-vehicle owners and fleets seemed to be higher than before. User needs were surveyed (Asplan 2009, Mathisen et al. 2010) and the economy of use calculated (Jørgensen et al. 2010), finding 200 km to be the critical range. Pöyry (2010) saw BEVs as a new paradigm. The Green highway project (2009) made an overview of available BEVs.

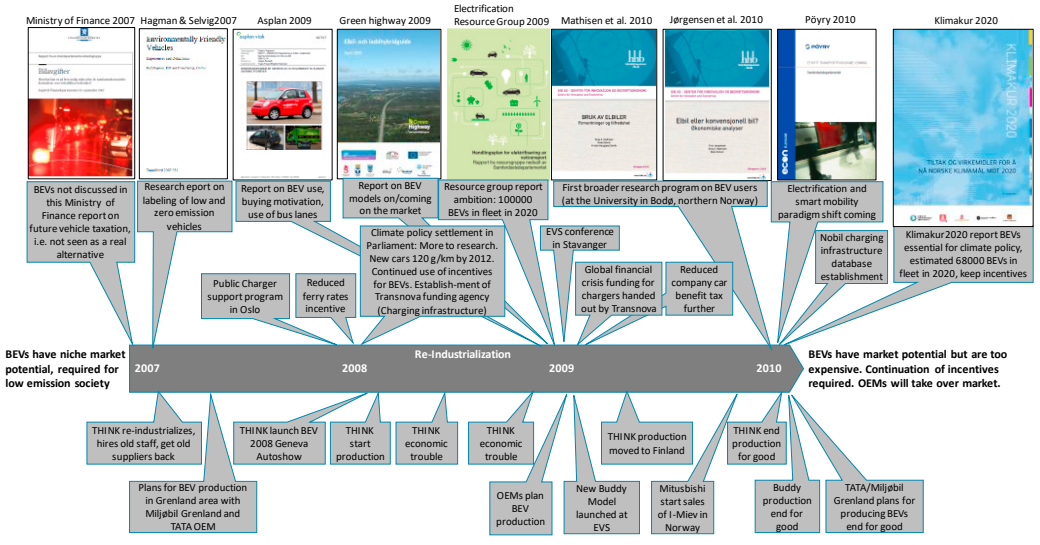

Fig. 4. Overview of the period 2007-2010.

3.5. Market roll out – The period 2011-2015

OEMs and the traditional vehicle importers and dealers took over the market from 2011, using their distribution channels, and networks with politicians, to establish the world's leading BEV market. For politicians BEVs was a climate policy measure that worked, and incentives remained in place in spite of an increasing tax income loss. An increasing number of models became available as OEMs gradually adapted to EU's new vehicle CO2-requirements for 2020. Politicians were increasingly in a crossfire between actors wanting incentives and those that opposed them, mainly economists supporting technology neutral policies. Researchers provided much broader perspectives and knowledge than before. Research focused more on how policy targets could be met and understanding user needs and behaviour. Econometric models of the market could be established and calibrated with real market data. Figenbaum and Kolbenstvedt (2013) summed up the current status of BEVs in Norway. The Governments 2012 Climate Policy Report to the Parliament used data from Klimakur. It was the basis for the 2012 Climate Policy Settlement, targeting 85 g CO2/km by 2020 from the average new vehicle, which required selling a share of ZEVs or PHEVs (Figenbaum et al. 2013). The BEV incentives should remain in place at least until 50000 BEVs had been sold or through 2015. The new 2013 Government decided to keep the incentives in place through 2017 regardless of sales, acknowledging the need for stable policies as was found by Figenbaum and Kolbenstvedt (2015) to be essential. More market knowledge became available (Figenbaum et al. 2015) with different approaches (Ryghaug and Toftaker 2014), pointing at pitfalls (Holtsmark and Skonhoft 2014, Klöckner et al. 2013, Aasness and Odeck 2014). Laurikko et al. (2013) found in tests an up to 50% winter range loss, but users nevertheless coped well with these BEVs (Figenbaum et al. 2014) owned by multi-vehicle households using them locally and charging at home.

The Compett project listed in 2015 up 10 success factors in developing the BEV market (Compett 2015):

1. Society can reduce range issues and other barriers with flexible policies and incentives:
2. Electric vehicles can cover a large share of transportation needs.

3. Multi-vehicle households and fleets are in the best position to adopt electric vehicles.
4. BEV owners mainly charge vehicles at home in private parking places and some at work.
5. Smart policies and incentives can reduce the burden on public budgets.
6. Raising awareness and schemes to allow testing are important in the early phase.
7. User incentives, i.e. bus lane access, can be effective even without purchase incentives.
8. Incentives work most effectively when BEVs are available from different manufacturers.
9. Policies should be carefully planned and implemented as a stable national framework.
10. Potential new consumers need more information about what BEVs can and cannot do.

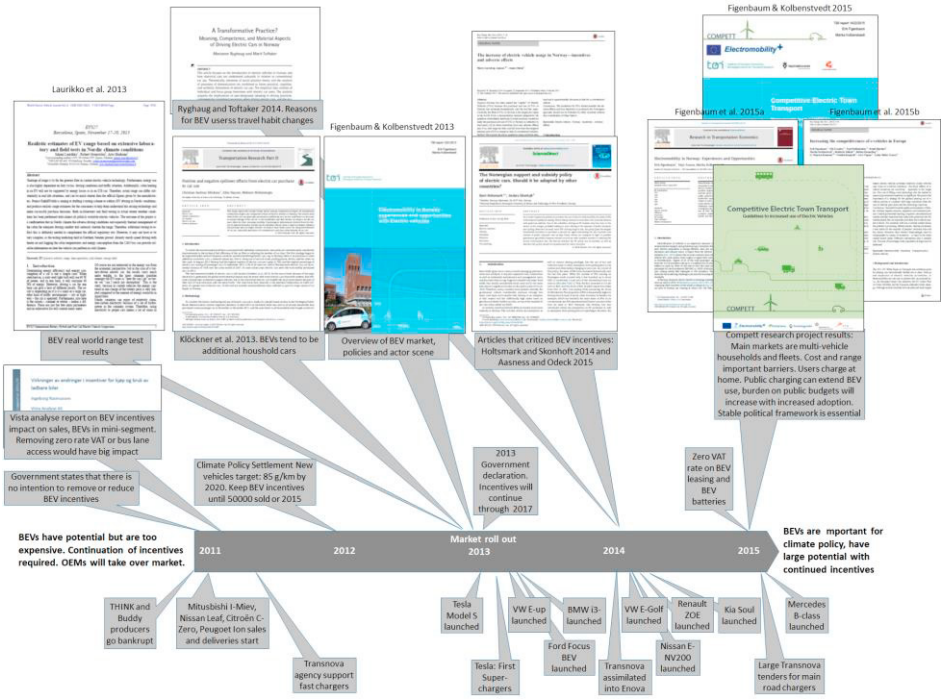

Fig. 5. Overview of the period 2011-2015.

3.6. Mass market deployment and plan for 2025 ZEV only market – The period 2016-2020

In this phase the research and knowledge development focused on understanding the market (Figenbaum 2017) and its users (Figenbaum and Kolbenstvedt 2016, Figenbaum and Nordbakke 2019) and modelling future prospects, as this was most important for politicians. The research became international oriented and was also done by foreign researchers interested in the reasons for the high market shares. Most topics were covered so politicians had a much broader knowledge pool to make decisions about BEV incentives and policies. The market shares increased rapidly when old incentives remained and some new were added and longer range BEVs became available in all sizes and segments. The target of only selling ZEVs from 2025 that was introduced as part of the 2017 National Transportation Plan, protected incentives from rapid downscaling as it is unattainable without significant BEV incentives. The market development was sustained with a wide selection of BEVs that OEMs developed to be able to reach EUs new vehicle CO2 legislation for 2025 and 2030. Figenbaum (2017) summed up the 1990-2016 period and Klimakur 2030 (2020) laid the ground for future policies, as the Klimakur2020 (2010) did a decade earlier.

3.7. Financing the BEV policy

Norway has from 1990 funded overspending with economic surplus from the oil and gas sector as seen in figure 7. The tax income loss from BEV incentives, not counting the road tolls and parking fee exemptions, was very small up to 2010, and largely unknown to politicians. It was not until the 2011 National Budget that the Government reported

the complete tax income loss in the budget documents. The loss has been dwarfed by the amount of oil and gas money. Politicians has thus had the ability to offer BEV incentives without sacrificing other policy goals.

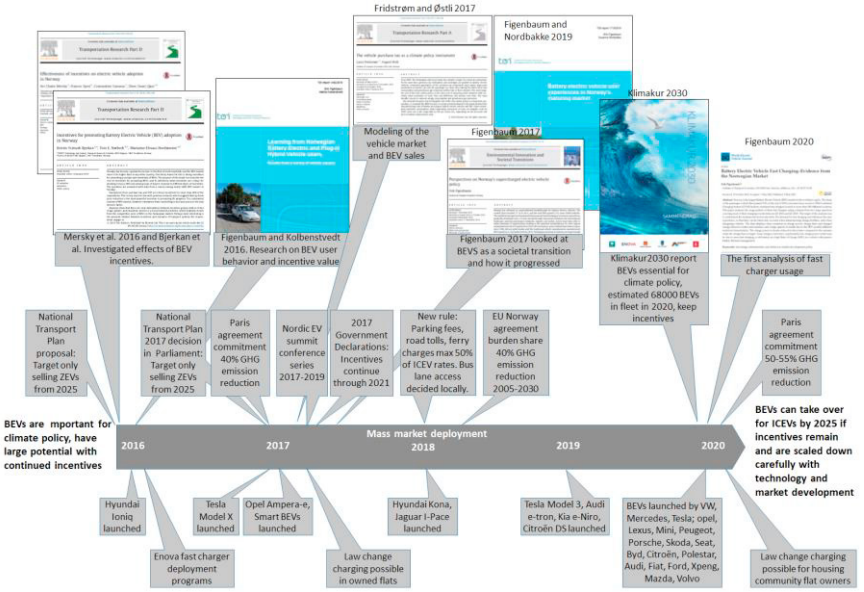

Fig. 6. Overview of the period 2016-2020

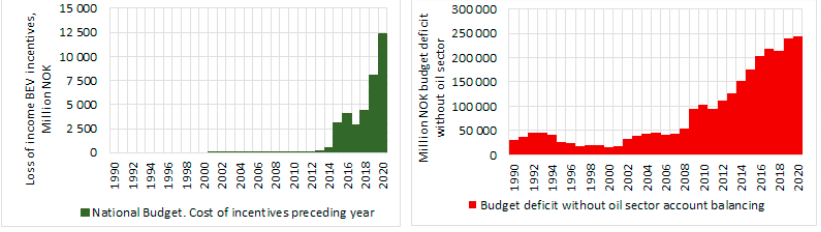

Fig. 7. National budget, cost of BEV incentives preceding year, and budget deficit without the oil and gas sector

4. Conclusion and future works

Politicians had in the early years little information to build decisions about BEV policies on and financed research to investigate BEVs potential. Incentives suggested by lobbyist, were introduced at little cost to support testing and industrialization. They went under the radar, until Norwegian BEV industrialization had failed, and started working when OEM BEVs became available. From then on researchers supported decisions by analyzing user behavior and modeling the future market. The research shows that policy decisions with low immediate impact can have large future consequences. Politicians should ensure that knowledge is available and that proper processes are followed. Policies should be reviewed regularly. New insights can be gained by comparing Norway with other countries.

Acknowledgements

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References

Asplan Viak 2009. Spørreundersøkelse om bruk av og holdinger til elbiler i norske storbyer. Asplan Viak NOTAT, 2009-12-14.

Aasness, M. A., Odeck, J. The increase of electric vehicle usage in Norway – incentives and adverse effects. Eur. Transp. Res. Rev. (2015) 7: 34.

Bech C. 2004. Why Think Nordic believes that BEVs are part of the future? Think Nordic 2004. Presented at the 2004 European El-Drive Transportation Conference & Exhibition on Urban Sustainable Mobility is possible now.

Compett 2015- Handbook of Electromobility. Overall Compett Era-net Electromobility+ project results 2015.

ECON 2006. Elbileiernes reisevaner. ECON Analyse. Rapport 2006-040.

Electrification Group 2009. Handlingsplan for elektrifisering av veitransport. Rapport fra ressursgruppe nedsatt av Samferdselsdepartementet.

Figenbaum E. 2020. Battery Electric Vehicle Fast Charging–Evidence from the Norwegian Market. World Electric Vehicle Journ. 2020, 11(2), 38

Figenbaum, E. (2017). Perspectives on Norway's supercharged electric vehicle policy. Environmental Innovation and Societal Transitions, Volume 25 December 2017, Pages 14-34.

Figenbaum, E., Kolbenstvedt, M. 2016. Learning from Norwegian Battery Electric and Plug-in Hybrid Vehicle users. Results from a survey of vehicle owners. TØI-rapport 1492/2016. Oslo: Transportøkonomisk institutt.

Figenbaum E., Assum T., Kolbenstvedt M. (2015). Electromobility in Norway - experiences and opportunities. Research in Transportation Economics, Volume 50, August 2015, Pages 29-38.

Figenbaum, E., Kolbenstvedt, M. 2015. Competitive Electric Town Transport. Main results from COMPETT. TØI-rapport 1422/2015.

Figenbaum, E., Kolbenstvedt, M. 2013. Electromobility in Norway – experiences and opportunities with Electric vehicles, TØI rapport 1281/2013.

Figenbaum, E., Eskeland, G. S., Leonardsen, J. A. & Hagman, R. 2013, 85 g CO2 per km i 2020 - Er det mulig? TØI-rapport 1264/2013.

Figenbaum, E. 1998a. TH!NK, a Unique Citycar. Electric & Hybrid Vehicle Technology 98. UK & International Press 1998.

Figenbaum, E. 1998b. PIVCO markedsintroduksjon – Sluttrapport. Report. Teknologisk Institutt 1998.

Figenbaum, E.1997a. Miljøvennlige biler i flåter – Hovedrapport. Report. Teknologisk Institutt 1997.

Figenbaum, E.1997b. PIVCO markedsintroduksjon – Ytelsestester. Report. Teknologisk Institutt 1997.

Figenbaum, E.1996. Miljøvennlige biler i flåter – Kartlegging av bilflåter. Report. Teknologisk Institutt 1996.

Figenbaum, E. 1995a. Norwegian Experience. Electric & Hybrid Vehicle Technology 95. UK & International Press 1995.

Figenbaum, E. 1995b. Testprogram for elbiler – Hovedrapport. Report. Teknologisk Institutt 1995.

Figenbaum, E. 1994. Testprogram for elbiler – Elbiler i Norge – Brukererfaringer. Report. Teknologisk Institutt 1994.

Figenbaum, E. 1993. Elbiler – Statusrapport. Report. Teknologisk Institutt 1993.

Green Highway 2009. Elbil- och Laddhybridguide. April 2009. Green Highway Interreg. project.

Hagman, R., Selvig, E. 2007. Environmentally Friendly Vehicles. Experiences and Definitions. TemaNord 2007:531. Nordic Council of Ministers.

Holtsmark, B., Skonhoft, A. 2014. The Norwegian support and subsidy policy of electric cars. Should it be adopted by other countries? Environmental Science & Policy 42 (2014) 160-168.

Hoogma, R., Kemp, R. Schot, J., Truffer, B. Experimenting for Sustainable Transport. The approach of Strategic Niche Management. Chapter 4: Experiments in Electrifying Mobility, The PIVCO experience: ecological product differentiation. Routledge 2002. ISBN 978-0-415-27116-5.

Jørgensen, F., Mathisen, T. A., Solvoll, G. 2010. Elbil eller konvensjonell bil? Økonomiske analyser. SIB rapport nr. 2/2010. Handelshøyskolen i Bodø, Senter for innovasjon og bedriftsøkonomi.

Klimakur2030. 2020. Klimakur 2030. Tiltak og virkemidler mot 2030. M-1625/2020. Utarbeidet av: Miljødirektoratet, Enova, Statens vegvesen, Kystverket, Landbruksdirektoratet, NVE. Utgitt av: Miljødirektoratet 2020. www.klimakur2030.no.

Klimakur2020. 2010. Sektoranalyse for transport, Klimakur 2020 - Tiltak og virkemidler for å nå norske klimamål mot 2020, Statens vegvesen, Avinor, Jernbaneverket, Sjøfartsdirektoratet, Kystverket, Klima- og forurensningsdirektoratet. 17. mars 2010.

Klöckner, C. A., Nayum, A., Mehmetoglu, M. 2013. Positive and negative spillover effects from electric car purchase to car use. Transportation Research Part D21(2013)32–38. https://www.sciencedirect.com/science/article/pii/S1361920913000278?via%3Dihub

Laurikko, J., Granström, R., Haakana, A. 2013. Realistic estimates of EV range based on extensive laboratory and field tests in Nordic climate conditions. EVS27. Barcelona, Spania, November 17-20, 2013 World Electric Vehicle Journal Vol. 6 - ISSN 2032-6653 - ©. 2013 WEVA

LEC 2006. Low emission committee. Et klimavennlig Norge (Norwegian). Official Norwegian Report (NOU).

Mathisen, T. A., Solvoll, G., Smith, K. H. 2010. Bruk av elbiler. Forventninger og tilfredshet. SIB rapport nr. 6/2010. Handelshøyskolen i Bodø.

MOF 2003. Ministry of Finance. Bilavgifter. Rapport fra en arbeidsgruppe. Avgitt til Finansdepartementet 30. april 2003.

MOF 2007. Ministry of Finance. Bilavgifter. Rapport fra en interdepartemental arbeidsgruppe. Hvordan kan en på best mulig måte prise de samfunnsøkonomiske kostnadene som veitrafikken forårsaker. Avgitt til Finansdepartementet 20. september 2007.

Pöyry 2010a. Et nytt transportparadigme i emning. Econ Pöyry Report R-2010-095. Econ Pöyry /Ministry of Transport (Norway).

Ryghaug, M. & Toftaker, M. (2014). A Transformative Practice? Meaning, Competence, and Material Aspects of Driving Electric Cars in Norway. Nature and Culture 9(2), Summer 2014: 146–163. doi:10.3167/nc.2014.090203

Selvig, E., Stølan, A., Flugsrud, K. 2003. Helse- og miljønytte av innfasing av 0-utslippskjøretøy i Norge. Civitas, Oslo 19.10.03.