mKETs-PL working document

Country report Sweden

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1. Policy perspective

1.1. Country specific innovation system with emphasis on KET

Sweden is amongst the most knowledge-intensive countries in the world. The country has a relatively strong position in most international comparisons of countries' innovation capacities and competitiveness. The EC Economic Analysis Unit (2012) shows that Sweden performs above EU average in almost all R&I dimensions (Innovation Union progress at country level, 2013). Sweden is ranked as the leading country of the EU's 27 member states on the Innovation Union Scoreboard 2011 (The Swedish Innovation Strategy, 2012).

Of all EU countries, Sweden invests most in R&D relative to its GDP. The total R&D expenditure in 2011 amounted to 3.37% of GDP, which is considered high compared to the EU average of 2.03. Venture capital investment and early stage funding as a share of GDP were both the highest among respectively the OECD and the EU Member States (Innovation Union progress at country level, 2013). **The volume of R&D investment however has decreased** somewhat over the last decade in contrast to many other countries (ERAWATCH COUNTRY REPORTS 2011, 2013). The large international concerns dominate the investments in R&D in Swedish industry (Ericsson, Volvo, Sandvik, Electrolux, Vattenfall, Atlas Copco, SKF, etc.). These multinationals have increased their investments in R&D (The Swedish Innovation Strategy, 2012). But while world competitors are also stepping up their R&D investments, **Sweden is losing ground due to an increasing delocalization of private R&D investment to firms outside the country**. The outflow of R&D business investment has exceeded the inflow since 2002 (Innovation Union progress at country level, 2013).

At the same time, SMEs are not growing fast. Although the survival rate (after two years) of new firms is relatively high, many innovative start-ups are bought up by larger often foreign firms (Innovation Union progress at country level, 2013). Sweden has a lower proportion of entrepreneurs than the EU average, according to data from Panteia/EIM, and **the proportion of SMEs in Sweden that conduct innovation work lags behind** that of other countries. The EC Economic Analysis Unit (2012) shows that the patenting activity of young firms in Sweden for example is clearly lower than that of young firms in the US and other Nordic countries. SMEs see lack of time and resources as the main obstacles for engaging in different forms of systematic innovation work, as shown by research from the OECD (The Swedish Innovation Strategy, 2012).

Just like its R&D intensity, the knowledge intensity[1] of Sweden is high as well. Sweden scores 64.6, compared the EU average of 48.74 (Innovation Union progress at country level, 2013). As of 2011 over 42 % of the Swedish work force was employed in "knowledge-intensive activities" and this sector has low unemployment rates (ERAWATCH Country Report 2011). Furthermore Sweden appears particularly strong in terms of human capital: proportion of graduates, proportion of population aged 30–34 with university education and the proportion of young people with high school education (The Swedish Innovation Strategy, 2012). However, **the number of students enrolling in science and engineering programmes, as well as the number of PhD graduates is decreasing** (ERAWATCH Country Report 2011).

The national innovation system is highly internationalized in terms of global research collaboration, global generation of innovation and global sourcing (The Swedish national innovation system, 2010). Today, exports represent half of Sweden's GDP. The open economy, political stability and the big investments made in education, ICT and R&D, have resulted in a strong position in different sectors (The Swedish Innovation Strategy, 2012), like healthcare, environment, energy, ICT, materials and security. All these areas are of relevance for KETs.

[1] Compositional structural change indicators measure changes in the actual sectorial composition of the economy in terms of production and employment, business research and development (R&D), high-tech exports and technological specialization and foreign direct investments. For more information see Innovation Union progress at country level (2013).

The main challenge, labelled as the Swedish Paradox (Edquist et al., 2008; Ejermo et al 2008; Kander and Ejermo, 2009) is to overcome **mismatch between innovation performance and growth**. Despite the R&D intensity, the contribution of high-tech and medium-tech products to the trade balance scores only 2.02, while the EU average score is 4.2 (Innovation Union progress at country level, 2013). The significant Swedish investment in R&D apparently does not result in corresponding and proportional economic growth.

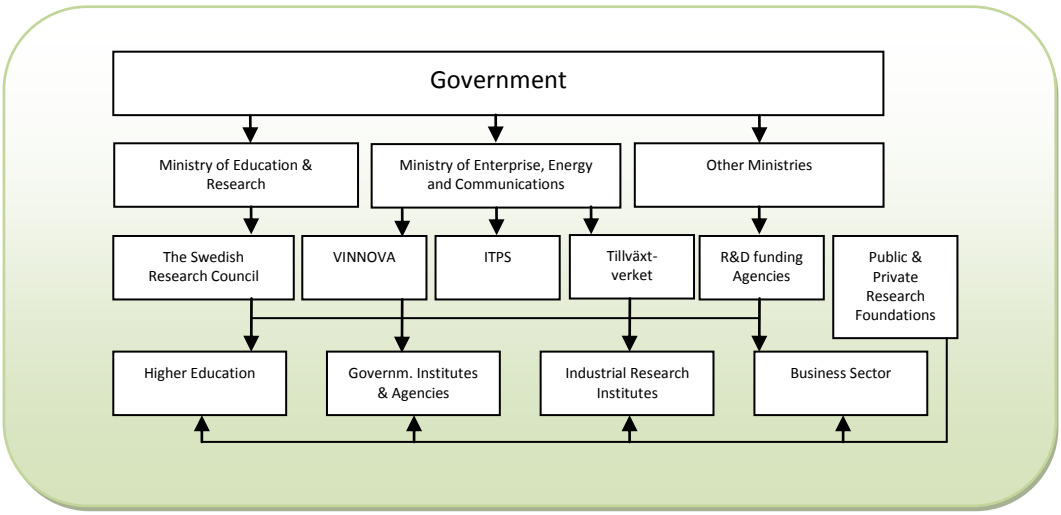
The ERAWATCH COUNTRY REPORTS (2013) gives an overview of the **challenges for Research & Innovation.** Of course, these challenges should be seen in some perspective, with reference to Sweden's strong position in the Innovation Union Competitiveness Report.

Challenges for Research & Innovation

- Decreasing number of students enrolling for science and engineering programmes.
- Decreasing number of PhD graduates.
- Weak connections between academic research and industry.
- Role of the Swedish universities not entirely clear. HEI feel deregulated on the one hand, but at the same time micromanaged and monitored by the state.
- Decrease in private investment in R&D following from economic crises. Companies are facing increasing globalisation and competition, which may result in the larger transnational companies moving their R&D investments abroad.
- Traditionally low investments in R&D among SMEs.
- No formal or compulsory arena for co-ordination in the area of research and innovation policy and operations.
- A lack of comprehensive cooperation between relevant actors.

Source: ERAWATCH COUNTRY REPORTS (2013)

The most important **stakeholders involved** with these challenges, whether it be in defining R&D and innovation policies or in financing and performing the R&D, are represented in Graph 1 and some will be discussed hereafter.



Graph 1: Stakeholders in the Swedish research system
Source: The Swedish national innovation system, 2010, p. 24

The ministry responsible for the research policy is the **Ministry of Education and Research**. The **Ministry of Enterprise, Energy and Communication** has a complementary responsibility for innovation policy. These

Ministries are responsible for most of the public agencies and research councils that finance research in Sweden. The Swedish innovation policy went through a major reorganization in the year 2000. New agencies were created and some of the sectorial research funding agencies like NUTEK were reorganized. One of this new agencies is the Swedish Governmental Agency for Innovation Systems, VINNOVA (The Swedish national innovation system, 2010).

In Sweden, a total of nine **Government Agencies** fund R&D (Forskning.se, 2009):

1. FAS, Swedish Council for Working Life and Social Research
2. Formas, Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning
3. SIDA, Swedish International Development Cooperation Agency
4. Swedish Energy Agency
5. Environmental Protection Agency
6. Swedish National Space Board, SNSB
7. Swedish Radiation Safety Authority, SSM
8. Swedish Research Council
9. VINNOVA, Swedish Agency for Innovation Systems

In terms of funding, The Swedish Research Council and VINNOVA are most important. Listed in the Annexes of this country report, is an overview of the Swedish system of research funding.

The main agency supporting R&D (SEK 4,1 billion in 2009) is the **Swedish Research Council** (VR), funded by the Ministry of Education and Research. The main responsibilities of the Swedish Research Council include funding of research across fields of natural and social sciences, medicine and education (ERAWATCH, 2013).

The 200 employees of **VINNOVA** work on "promoting sustainable growth by improving the conditions for innovations, as well as funding needs-driven research" (VINNOVA, 2013). The agency promotes collaborations between different entities: companies, universities, research institutes and the public sector. VINNOVA's focus is on long term impact by problem solving research ("challenge driven innovation"). Annually, VINNOVA's investments are about SEK 2 billion, and since co-financing from actors must total at least the same amount, the funds have more than doubled (VINNOVA, 2013). VINNOVA was established in 2001.

In addition, several **research foundations** have been started with public funds, providing research funding in excess of SEK 1 billion annually (Forskning.se, 2009)**:**

1. Mistra, Foundation for Strategic Environmental Research
2. STINT, Swedish Foundation for International Cooperation in Research and Higher Education
3. Swedish Foundation for Health Care Sciences and Allergy Research
4. Swedish Foundation for Strategic Research, SSF
5. The Knowledge Foundation

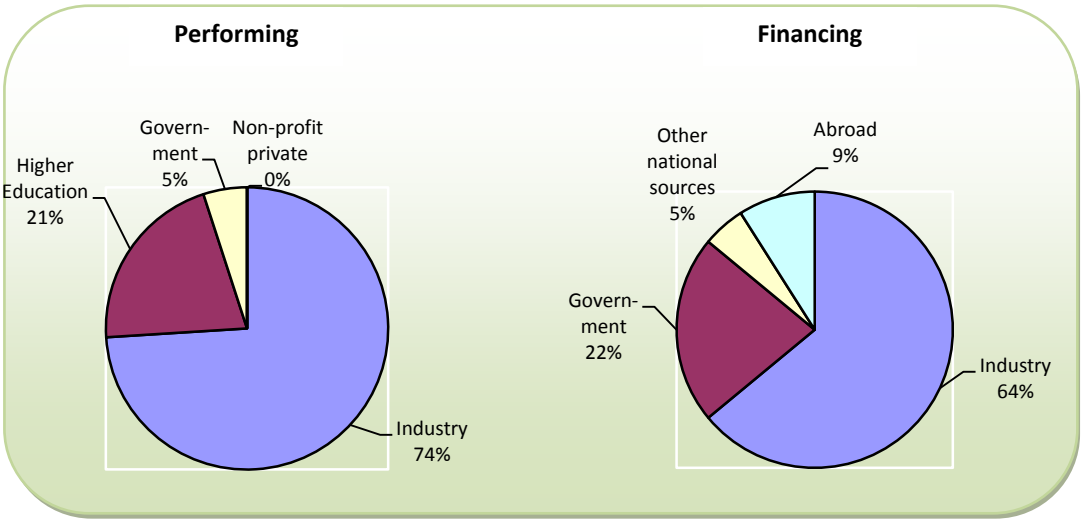
Local government bodies including city and municipality board are active in supporting local initiatives. In addition, these government (local and nation-wide) agencies work in collaboration and cooperation with private companies in various technological fields including nanotechnology and biotechnology in the creation of research and testing facilities.

The **industrial research institutes** focus on applied research. They are jointly funded by the government and the industry. These institutes (often called IRECO institutes) however, in contrast to some other countries, play a minor role in the Swedish innovation system, with even decreasing budgets over time (The Swedish national innovation system, 2010).

By far the greatest share of publicly funded research in Sweden is conducted in **HEIs**. Sweden has 14 universities and 25 other HEIs. The university sector is dominated by approximately 10 universities which are responsible for almost all R&D performance in the country. The most important ones are (The Swedish national innovation system, 2010):

1. The Karolinska Institute
2. Chalmers University of Technology
3. Uppsala University
4. Lund University
5. Gothenborg University
6. The Royal Institute of Technology (KTH)
7. Stockholm University
8. Linköping University
9. Luleå University

As for financing and performing R&D, **the industry** is, by far, the main stakeholder. Graph 2 shows that the industry is responsible for the vast majority of Sweden's R&D performance and funding. In relation to its economies size, Sweden has a broad industrial structure with some important multinationals, like Ericsson (ICT), AstraZeneca (Pharmaceuticals), Volvo, Scania and Autoliv (Automotive), Industrial machinery (ABB), Packing (Tetrapack), Household appliances (Electrolux) (The Swedish national innovation system, 2010). It is no surprise that these companies are all involved in KETs.



Graph 2: R&D expenditure; Performing and Financing (based on OECD 2010)
Source: The Swedish national innovation system, 2010, p. 15

Private non-profit organisations collectively contribute SEK 2.3 billion to Swedish research (see Annexes).

Venture capital firms across the country are playing a role in supporting innovation with a more narrowed focus on SMEs as many larger companies have in-house innovation R&D areas.

1.2. *Organisation of mKETs policy*

In the past three years the research and innovation policy in Sweden did not change much. It can be conceived of as part of a fairly strategic, coherent and integrated policy framework, oriented towards addressing major societal challenges which also reflect EU priorities. The general perception among both policy makers and the general public is that R&D is of great importance for Sweden to stay or become more competitive, and therefore it will most likely continue to be prioritised in terms of policy mixes (ERAWATCH, 2013).

An important requirement for Sweden's ability to successfully contribute to addressing the challenges listed on page 5 of this report, is leading research and innovation in key enabling technologies. Sweden therefor takes the following policy measures (ERAWATCH, 2013):

- **assuring the quality of education**
- **launching strategic research areas**
- **building and maintaining a research infrastructure**
- **launching public-industry joint funding of research, innovation and development**
- **establishing public private partnership (PPP) programmes that target the knowledge demand from both universities and industry**
- **establishing innovation offices at universities.**

Specific measurements to assuring the quality of education are organizing a post-doctoral employment scheme, investing in the quality of mathematics, engineering and science in primary and secondary school and developing a quality assurance system for evaluating research at universities. Recently, the Swedish HEIs have a new legislation which allows for far reaching university autonomy to increase the quality. Tax deductions for foreign experts is a measure to stimulate in-coming mobility and utilisation of foreign knowledge (ERAWATCH, 2013).

The strategic research areas the government has launched, also address KETs: Energy, Sustainable exploitation of natural resources, Effects on natural resources, ecosystems and biological diversity, Climate models, Sea environmental research, Cancer, Diabetes, Epidemiology, Molecular biology, Neuroscience, Stem cells and regenerative medicine, Health, Nanoscience and nanotechnology, E-science, Material science, incl. functional materials, IT and mobile communication, Production technology, Transport research, Security and crisis management, Politically important geographical regions (ERAWATCH, 2013). The four societal challenges that have been identified by VINNOVA are: Information Society 3.0, Sustainable Attractive Cities, Future Healthcare and Competitive Production. They correspond to the priority research areas of the Vinn Excellence Centers (Telecommunications & Innovative Services, Modern Working Life & Sustainable Transport, Biotechnology & Better Health and New Materials & Production Methods (VINNOVA, 2013).

Especially the last 5 years, several initiatives were taken to build and maintain a solid research infrastructure. There is an increased focus on providing funding, better access to seed funding and venture capital, as well as increased access to research and testing facilities across technological fields. This will expand off of the current success with RISE, Research Institutes of Sweden, which focuses on linking research and technology across academia, enterprises, and society to connect the market and people to the academic research in innovation. Furthermore, some measures have been taken to make it easier and less costly for firms to protect their inventions, e.g. in relation to patents applied for through the European Patent Office (ERAWATCH, 2013).

To help restore the imbalances between knowledge creation and value creation, and to increase private R&D investment, the government has proposed a number of policy changes. The government wants to stimulate public-industry joint funding of research, innovation and development and has limited many traditional research grants. Its spending on VINNOVA has increased, in order to better bridge the academic and industrial spheres. In their mix of support measures, VINNOVA targets individual researchers and small firms as well as institutional grants to large consortia, established R&D companies or universities as a whole. The funding is primarily distributed in the form of project grants. Usually VINNOVA demands co-funding from the private sector at least 50%. In 2010 the average level of co-founding amounted to 57% (ERAWATCH, 2013).

To target the knowledge demand from both universities and industry the government stimulates the establishment of public private partnership (PPP) programmes. About half of VINNOVA's total funding is spent on different types of PPP-collaborations aimed at achieving innovation (ERAWATCH, 2013). One of the most successful programmes VINNOVA has implemented is called **VINNVÄXT**. This programme has a wide reach and broad qualifications. The programme is a competition for long-term funding (up to 10 years) which aims to reach different sectors in fostering innovation. This includes the KET's, but is not limited to this sector as the primary goal is to increase the overall competitiveness of Sweden on various innovation levels. For more information on VINNÄXT, see paragraph 1.3 and http://www.vinnova.se/en/Our-activities/Individuals-and-Innovation-Milieus/VINNVAXT/.

To provide another forum for collaboration between the private and public sectors, universities and colleges, research institutes and other organisations that conduct research, VINNOVA sets up **VINN Excellence Centers** (see: http://www.vinnova.se/en/Our-activities/Individuals-and-Innovation-Milieus/VINN-Excellence-Center/). The Centres deal with both basic and applied research and they work to ensure that new knowledge and new technological developments lead to new products, processes and services. In the next paragraph more details on these PPP programmes will be given. For more information on VINN Excellence Centers, see paragraph 1.3 and http://www.vinnova.se/en/Our-activities/Individuals-and-Innovation-Milieus/VINN-Excellence-Center/.

VINNOVA, on assignment by the Ministry of Education, proposed a division of a total of € 500k per year during the years 2010-2011 to universities, which were given the opportunity to establish innovation offices. A total of eight innovation offices were established in Sweden. Moreover, a new IPR system is introduced in which university staff is obliged to report to the employer any outcome of their research that potentially could lead to commercialisation (ERAWATCH, 2013).

All together these policy measures should not only foster the growth in new research, but also take the next step in encouraging a market directed focus to further technological advancements. An interesting observation is that innovation with respect to KETs is included, but **the scope of the policy framework is much broader than KETs**. **Biotechnology has much interest in Sweden**. It was ranked amongst the top five in Europe in 2000 (Industrial Biotechnology in Sweden, 2009) and VINNOVA defined biotechnology as one of the priority growth areas. Nanotechnology, on the other hand, has a weaker position. The VINNOVA analysis "Nanotechnology in Sweden" (2008) points out that **the nanoscientific knowledgebase is strong, but there is a lack of national political interests**. Other weaknesses in the system are uncertainties in the market (the market potential has not been clarified and there are too few concrete applications of nanotechnology), that result in muted enthusiasm from industry and insufficient capital. Coordination and collaboration between academia (also in between different groups of research actors) and industry is needed. **The situation of microelectronics is unbalanced**, according to an International Evaluation of Swedish Research in Microelectronics (2008). The research is funded by all three agencies: VR, VINNOVA and SSF. The Panel recommends "joint or coordinated calls for the three funding agencies" and "the calls should cover the full spectrum of microelectronics studies from materials, components and circuits to simulations and software research". **Specific policy measures fostering innovation structures that involve two or more of the KETs are not easy to find, although some of the VINN Excellence Centers deal with multi-KETs** (see the next paragraph).

1.3. *Main policies for Pilot lines*

Sweden's regional innovation environments should have international appeal (The Swedish Innovation Strategy). To strengthen the regional appeal and take advantage of unique national and regional opportunities, VINNOVA has implemented the **VINNVÄXT** programme. This programme is stimulates the creating of pilot lines. According to international evaluators, the initiatives of this programme develop well or very well. "The latest follow-up data from reveal that more than 1000 for-profit companies are involved in the project, with 55 new products, 122 new prototypes, 47 new processes and contribution to 33 patents reported. The follow-up also shows that the initiatives helped to 24 companies make start-ups or expansion investments." (p.14, ERAWATCH, 2013). The current initiatives are (VINNOVA, 2013):

- Fiber Optic Valley (Information and Communications Technology)
- Framtidens Bioraffinaderi (CleanTech)
- GöteborgBIO (Biotechnology)
- Hälsans Nya Verktyg (Services)
- Innovation i Gränsland (Biotechnology)
- Peak Innovation (Services)
- ProcessIT Innovations (Services, Product Realisation, CleanTech)
- Robotdalen (Product Realisation)
- Smart Textiles (Services)
- Triple Steelix (Product Realisation)
- Uppsala Bio (Biotechnology)

To provide another forum for collaboration between the private and public sectors, universities and colleges, research institutes and other organisations that conduct research, VINNOVA sets up **VINN Excellence Centers** (see: http://www.vinnova.se/en/Our-activities/Individuals-and-Innovation-Milieus/VINN-Excellence-Center/). The Centres deal with both basic and applied research and they work to ensure that new knowledge and new technological developments lead to new products, processes and services. VINNOVA's ambition is to establish 25 different VINN Excellence Centers that will be funded for a period of 10 years. Today VINNOVA is funding 18 VINN Excellence Centers. While some of the VINN Excellence Centers deal with a single KET, other involve multi-KETs. Some good examples of multi-KETs centres are:

- BiMaC Innovation, the Royal institute of technology Category: Materials, CleanTech
- BIOMATCELL - Biomaterials and Cell Therapy, Göteborg university Category: Biotechnology, Materials
- Chase - Chalmers Antenna Systems Excellence center, Chalmers Category: Information and Communications Technology, CleanTech
- FunMat - Functional Nanoscale Materials, Linköping university Category: Materials
- HERO-M - Hierarchic Engineering of Industrial Materials, the Royal Institute of Technology Category: Materials
- iPack Center - Ubiquitous Intelligence in Paper and Packaging, the Royal Institute of Technology Category: Information and Communications Technology, Biotechnology, CleanTech

The VINN Excellence Centers are not the only of its kind in Sweden. The industrial biotechnology field has its own such establishment in Piteå, the Solander Science Park. This park receives its funding largely from local administration including the Norrbotten County Council, Piteå municipality, and the Norrbotten County Administrative Board as well as EU funding. The approach is multidisciplinary and research projects in areas such as raw material characterization and supply, thermochemical and biochemical conversion of biomass, process integration and energy-economic system analysis are suggested.

2. Business perspective

2.1. Implementation of multi-KETs pilot lines

The main players in charge of pilot lines in Sweden are in ICT, raw materials, pulp and paper and energy (sustainable fuels such as gas, liquids, and bio based masses). Mainly Swedish **industry and RTOs** are very active whereas universities are often part of consortia without taken a lead role in the investments.

In Swedish industry one can distinguish between different types of pilot lines. **A first type of pilot lines are abundant small-scale demonstrations of the production processes**, for example for casting components. **A second type of pilot lines are small production plants** that run continuously to demonstrate the process and where complete technology is delivered, for example gasification plants.

New technology means **risk**. In case of combining different key enabling technologies in the context of pilot lines this is certainly a key rule. As such the investment in pilot lines is a very risky business for research institutes and due to this risky nature failures can be expected. Failures could originate from the wrong judgement of the **payback period**. More generally and dramatically, funding could dry up as was the case in some Swedish gasification plant projects. In addition making right decisions requires that similar activities in one (or even several countries) are coordinated. In the case of Sweden **coordination** between different universities and research institutes seems to be important here. Finally the **timing** of the pilot plant investment is crucial. Major breakthroughs in technology (invention, publication) may take 15 years before they reach commercial production. Although industry may be interested in stepping into a multi-KETs pilot line consortium they may not be ready yet, as they want to observe and understand when it is the right time to step in. The key question is if there is a real interest. This holds especially for larger investments such as investments in bigger pilot lines. But even if there is real interest things can still go wrong mainly because:

- Funding can be reduced during the negotiations
- It is not clear which partners take the assets into their books and how they are valuated
- Project set-up is too complex (who owns the technology and how to share IPR often is a big challenge)
- Operational costs are discarded

A pilot line requires to serve several clients and not to be dependent on one client. Such a set-up will enable paying back the investment. However, working with several clients implies that the pilot plant operator has to be extremely good in **handling secrecy**. There seems to be even a trend that higher secrecy is needed. The multi-client system means that one needs multiple clients from an ecosystem but it also implies one cannot address all players. Indeed, sometimes one has to decline clients because the key clients would otherwise be lost due to reasons of secrecy and **trust**. Conflicts here are rare but they do occur. Pilot lines also need **international clients**. International leading competence naturally attracts international clients. Companies shop around for pilot lines. Some Swedish players have subsidiaries abroad as they see it as an important asset. Via **foreign subsidiaries** Swedish clients may have better access to customers and suppliers (value chain concept). Typically one builds pilot line consortia first on a European scale and then adds some good players from Brazil, India or other markets. From Swedish perspective often Europe is informally seen as the home market or focus.

Often a pilot line is financed only by private players. It is important to underline that **most pilot plants are not built from scratch but investments are upgraded and adapted to new technology**. Typically over time a player can have invested tens of millions EURO in different pilot lines that each cost a few million EURO.

As a rule, pilot lines are set up by customers with fairly large R&D budgets. All these operations are market driven. But sometimes pilot lines are financed by research institutes themselves. While the RTO charge costs for the services related to the experiments they usually pay the amortizations and the operating costs themselves.

Pilot lines do not only involve an initial big investment. **The operational costs of bigger pilot lines should never be underestimated**. This is an important issue and can be a key factor that leads to failure. Operators need salaries. In addition the pilot does not generate profits during the development stage and this can take a long time (easily 5 years). Also in Sweden there are multiple examples of pilots that failed because of the accumulation of operational costs. It is up to the tech providers to decide how much money to poor in the pilot project.

SMEs or smaller players often do not get involved with pilot line activities for several reasons:

- Smaller players do not have the financial means to invest in expensive pilot lines and to cover the high costs to use pilot lines. Experiments can become actually very costly.
- For smaller players applications for public money for pilot line investments and use may be cumbersome as they have less R&D resources to inform themselves and smaller technology/ engineering networks.
- In the context of a pilot line smaller players can often not deliver the incoming parts and the final parts in the production process and therefore they want someone that can take care of the whole process.

Because of the above challenges to attract SMEs, public pilot lines mainly attract large companies as pilot experiments are part of their R&D efforts. Sometimes, special mechanisms are set up. As an illustration the rule in research institutes in the Swedish ICT sector is that they own the IPRs on material, components and processes. The reason is that this prevents monopolies from private players enabling smaller players to have access to the very expensive pilot plants while paying licencing fees.

Cooperating in pilot lines involves big challenges. To start with, it is important to form strong, multidisciplinary consortia. Pilot lines can be unique because of the mixture of technologies and disciplines. One should find out what interested companies would best fit the pilot line goals, and support the investment. All partners participating in the pilot line consortium should contribute value. In Sweden pilot lines are run by institutions and companies. It is harder to get universities on board, since universities do not want to use their own funding for pilot lines.

Often the biggest challenge is to agree upon IPR. It is recommended to start discussing roles and IPR openly at an early stage. Pilot lines you don't cover IPR by patents. Processes can usually not be covered by patents, only products. The way things are protected is via secrecy. If one wants to file patents one has to disclose processes (risky strategy) and patent in a quiet broad range. The risk is that the office can narrow down the range or give you a patent outside the range. Products are easier to protect. A general rule is that the customers that pay the experiments want to be able to patent using the results. However, research institute has the right to use the results for future research, not for commercial purposes. Last but not least, it is key that the research institute should not be competitive with its clients.

Regulation is an important driver for creating new demand. This mechanism is for example illustrated by the growing market potential for solid biofuels to be used in fire power plants as to reduce greenhouse gases. In the world there are currently about 70 projects running from laboratory pilot lines to demo plants.

2.2. Evaluation of KET policies/KET innovation eco-System

In Sweden there are many research institutes and universities (see paragraph 1.1). Coordination of all these players is sometimes challenging especially in the context of setting up pilot line activities.

Swedish pilot line owners and operators have used the following support instruments:

- Instruments from VINNOVA
  - Company friendly when it comes to IPR
  - No equipment (only exceptionally)
  - VINNOVA has been discussing innovation cheques for SMEs so they can pay the use of pilot lines. This may however constitute dishonest competition based on firm size.

- Energy agency (Energimyndigheten: http://www.energimyndigheten.se/en/):
  - Key in pilot investments that relate to energy
  - Larger projects: gasification, bio-waste, combined heat and power plant
  - Equipment
  - Public funding 30% to 50% of the total investment
- Swedish government scientific council
- Wallenberg Foundation: http://www.wallenberg.com/
- Industry

The current Swedish policy directions may include some risks:

- Attention should not only be paid to electronics and bio applications, but also to big challenges (reduction of carbon) and design solutions, construction materials as to improve their properties.
- VINNOVA currently encourages taking knowledge from different areas, but one should not forget to creating new knowledge, especially in the long term.
- It takes lots of time and energy and paperwork to apply for funding for pilot plants. EU projects are complicated to handle and require often players from several countries. Piloting involved a lot of daily work to demonstrate and learn technology. Focus should also be on how to publish the results. Official support should not only focus on the big investments.

3. Conclusions

3.1. Summary of policy perspective

Sweden is amongst the most knowledge-intensive countries in the world, but the country struggles with a mismatch between innovation performance and growth. Policy makers therefor not only focus on the quality of education and research, but also on the commercialisation. This is done for example by establishing public private partnership (PPP) programmes that target the knowledge demand from both universities and industry.

Although the scope of the policy framework is much broader than KETs, they could be addressed by existing measures. The VINNVÄXT programme for example stimulates the creating of pilot lines. Another successful example of bridging the valley of death, by ensuring new knowledge and new technological developments lead to new products, processes and services, are the 18 VINN Excellence Centers. Not all of these centers involve KETs, but some even involve multi-KETs.

3.2. Summary of business perspective

The multi-KETs dimension is not stressed too often by pilot line owners. Most Swedish players still talk about pilot lines in general. In Sweden pilot lines are run by research institutes and large companies. In general, universities do not want to use their own funding for pilot lines and it is very challenging to get SMEs aboard of pilot lines. The main challenges in pilot projects are the right to exploit results of joint and publicly funded projects, the ownership of the assets and the high operational costs.

3.3. Recommendations to support pilot lines

Our recommendations for support are mainly about are the coordination and composition of the pilot lines. Coordination and focus in the area of research and innovation policy and operations can be improved to stimulate the success of multi-KETs pilot lines. There is no formal or compulsory arena for coordination, and the lack of comprehensive co-operation between relevant actors at this level is a recognised weakness of the system (ERAWATCH, 2013). Biotechnology has much interest in Sweden (Industrial biotechnology in Sweden , 2009), but the nanotechnology lacks national political interests (Nanotechnology in Sweden, 2008) and the situation of microelectronics is unbalanced because the research is funded by three different agencies (Swedish Research in Microelectronics, 2008).

Daily coordination of pilot lines is critical for its success. This should not only involve the daily work to demonstrate and learn from technology, but much attention should also be given to handling secrecy, building trust and well-considered arrangements on forehand on rights to publish and own the results. Participants should view the chosen IPR regime as fair and workable, respecting background knowledge and providing fair access to foreground knowledge (Long Term Industrial Impacts of the Swedish Competence Centres, 2013).

Imbalance of power between participants should be avoided, because it hampers spill over and encourages abusive relationships between the large and small firms. Preferably, the composition of a pilot line is a mixture of inventors, entrepreneurs and capital. Inventing alone is not enough; a multi-client concept is needed as to be able to pay back the investment. Pilot lines also need international clients; international leading competence naturally attracts international clients. Even more important however, is that pilot lines allow small players to access the market with their solutions. In the mid-term this can have a positive effect on the market concentration and it can actually boost competition and drive prices down. The large international concerns that dominate the investments in R&D in Swedish industry, are increasingly investing in other countries. SMEs create new demand or transfer knowledge to existing companies. It is therefore very important to build an ecosystem which also includes small young companies around the pilot line activities.

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4.1. Literature

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- http://www.vinnova.se/en/

4.2. Interviews

- Peter Björklund (Manager Technology, Metso Power AB, Sweden; telephone interview, 30.05.2013)
- Leif Ljungqvist (ACREO, telephone interview, 10.06.2013)
- Margareta Lundberg (R&D Manager, Service, Technology, Metso Power AB, Sweden, telephone interview, 03.06.2013)
- Staffan Söderberg (CEO, Swerea KIMAB; telephone interview, 31.5.2013)(SWEREA KIMAB focuses on materials and product development: metals and corrosion; funding: 55% industries, 45% Swedish State)

Other key persons discussed with by phone or emailing:

- Peter Eriksson (VINNOVA – Swedish Governmental Agency for Innovation Systems)
- Mats Robertsson (VINNOVA – Swedish Governmental Agency for Innovation Systems)
- Christine Wallgren (VINNOVA – Swedish Governmental Agency for Innovation Systems)
- Olof Sandberg (RISE Research Institutes of Sweden)
- Daniel Söderberg (INVENTIA)

5. Annexes

GOVERNMENT AGENCIES FUNDING R&D	PUBLIC FOUNDATIONS	PRIVATE FOUNDATIONS AND FUND-RAISING ORGANISATIONS
FAS, Swedish Council for Working Life and Social Research *SEK 405 million* Research concerning the labour market, labour organisations, public health, work and health, welfare, and social insurance, social services, and social relations.	**Mistra, Foundation for Strategic Environmental Research** *SEK 200 million* Research concerning a good living environment and sustainable development.	**Swedish Cancer Society** *SEK 371 million* Basic, clinical, and epidemiological cancer research and demonstration projects in health care.
Formas, Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning *SEK 840 million* Prominent research that contributes to sustainable development relating to the environment, agricultural sciences, and spatial and community planning.	**STINT, Swedish Foundation for International Cooperation in Research and Higher Education** *SEK 65 million* International cooperation in research and higher education.	**Swedish Childhood Cancer Foundation** *SEK 111 million* Research to prevent and combat cancer in children.
SIDA, Swedish International Development Cooperation Agency *SEK 1,05 billion* International research grants for developmental work and Swedish research concerning developmental collaboration.	**Swedish Foundation for Health Care Sciences and Allergy Research** *SEK 60 million* Research concerning health sciences, allergy, and other hypersensitivity.	**Swedish Heart-Lung Foundation** *SEK 150 million* Medical research concerning the heart, lungs, and circulatory system.
Swedish Energy Agency *SEK 1,13 billion* Research creating conditions for an ecologically and economically sustainable energy system.	**Swedish Foundation for Strategic Research, SSF** *SEK 508 million* Research in natural sciences, engineering, and medicine.	**Knut and Alice Wallenberg Foundation** *SEK 1,02 billion* Support for basic research in the natural, technological, and biomedical sciences, and for expensive scientific equipment.
Environmental Protection Agency *SEK 100 million* Supports interdisciplinary research on environmental protection and nature conservation.	**The Knowledge Foundation** *SEK 200 million* Advancement of knowledge and expertise among the business community, higher education institutions, and research institutes.	**Riksbankens Jubileumsfond,RJ** *SEK 350 million* Financing of research in humanities and social sciences.
Swedish National Space Board, SNSB *SEK 60 million, national programme* *SEK 120 million, Swedish contribution to ESA's scientific programme (European Space Agency)* Research, development and other activities relating to Swedish space and remote sensing activities.		
Swedish Radiation Safety Authority, SSM *SEK 90 million* Research on radiation protection and nuclear safety.		
Swedish Research Council *SEK 4,1 billion* Funding of basic research of the highest scientific quality in all fields of science.		
VINNOVA, Swedish Agency for Innovation Systems *SEK 2,15 billion* Development of efficient innovation systems and funding of needs-driven research.		

Graph 3: The Swedish system of Research Funding (budgets of 2009)
Source: Swedish Research, Main financing bodies, p. 2

Pilot lines in this country

Pulp and paper

- FEX Papermaking Pilot Plant, Stockholm, info & contact: http://www.innventia.com/en/Our-Ways-of-Working/Demonstration-and-pilot/FEX/
- Nanocellulose pilot plan production, Stockholm, info & contact: http://www.innventia.com/en/Our-Ways-of-Working/Demonstration-and-pilot/Pilot-plant-for-nanocellulose/

Energy

- Gasification pilot plant:
  - Testing of boiler activities at University for last 15 years (production of heat)
  - Few years ago new project started with:
    - Municipal energy company "Gotheborg Energi"
    - Chalmers University
    - Metso Power: originally Metso Power was the supplier of the plant and its components. Metso did not deliver the technology as it was created earlier by another player
    - Company (from university) that owns the boiler unit.
  - Different partners with different complementary interests
  - Only after Metso Power became part of a research consortium when it accepted an offer to join as a research cooperation partner.

- Torrefaction plant (not realized):
  - Plant where roasting technology is applied to wood based mass as to increase energy density. End product is biocoal brickets.
  - The partners involved were: (1) Municipal power companies, (2) University company, (3) Metso (came in latest).
  - Total investment of 15 Million Euro (Typical cost of a torrefaction pilot plant)
  - Public funding (30% to 50%) of Energimyndigheten (http://www.energimyndigheten.se/en/): 5 million public funding was accredited.
  - Capacity of a small factory: 30.000 Tons per year (industrial development plant)

I.T.

Acreo testbeds: https://www.acreo.se/labs-and-testbeds, e.g.:

Acreo National Test bed, broadband technology, test of services and equipment, Stockholm, info & contact: https://www.acreo.se/groups/acreo-national-testbed

Acreo Fiberlab, manufacturing of advanced optical fibers and preforms, Hudiksvall, info & contact: https://www.acreo.se/groups/fiberlab

Printed Electronics Arena, pilot plant/demo of printed electronics, Norrköping, info: http://www.printedelectronicsarena.com/ contact: http://www.printedelectronicsarena.com/om-pea/medarbetare.aspx

Acreo has activities in 5 pilot lines:

1. IBP: Integrated printed bio-sensor platform. Electronics: printed manufacturing of electronics from organic materials.
   - Ownership of Acreo and Linköping University
   - Development of projects from universities and industry
   - Customers from Europe, USA and Asia. For example from pulp and paper industry.
   - Production of components for example for companies that want to integrate transistors.

- Development of processes that address the system level.
- 3 to 7 million Euro investments over last 10 years
- team of roughly 10 people to develop products
- role to role fashion of printed electronics
- Technologies used: printing processes

More info: One exciting innovation this year is a fully integrated disposable biosensor platform, developed by Acreo Swedish ICT together with Linköping University. It is a unique biosensor concept presenting a new paradigm in inexpensive bio-sensing devices, perhaps making such sensors as common as the RFID tag in the near future. The integrated biosensor is an entire system including power source, sensor and display all printed on a sheet of flexible plastic or paper integrated with conventional readout electronics. The future vision is to replace the conventional electronics with a low-cost chip mounted on the flexible substrate. The main application focus lies within PoC such as: home monitoring and diagnosis of kidney disease, cardiac monitoring, sports medicine, stress measurement – and many others. Other possible applications are agriculture and food safety.

2. Two different nano electronics pilot lines
    - Clean-room with complete process lines for the production of sensors
        - Facilities for SME's
        - Cooperation with IR-NOVA (http://www.ir-nova.se/) and Ascatron (Acreo spin-off for fabrication of silicon carbide semiconductors (SIC) electronics)
        - Target customers are suppliers of power devices and modules to the power electronic industry (power electronics)
        - Process equipment

More info on SIC electronics: The usage of SiC electronics is increasing the efficiency in power electronics which minimizes electricity conversion losses. The implementation of SiC semiconductors also enables very compact and light power systems. In addition SiC semiconductors can be used for high temperature electronics and sensors, which will enable new applications beyond the possibilities of traditional semiconductor devices.

3. Fiber-production
    - Process industry / medical devices
    - Fibretronics: type of fibre on world market
    - Volume orders in fibre production

4. PLAN for a new pilot line for SIC components: upgrade to 6 inch pilot line from a 2 inch pilot line.
    - Demand for components with higher energy efficiency
    - Sweden has been successful in developing new materials already for 25 years
    - Regulation drives demand and demand regulation
    - Electrical vehicles
    - Acreo has a good position here

Raw materials

Blast furnace for iron production: Big pilot owned by LKAB and operated by Swerea Kimab. Unique in the world. Pilot attracts European and International producers of steel. Japanese clients come to obtain solutions for reduced carbon emission. Runs experiments of three weeks and runs several days without breaks.

KIMAB Gothenburg IPS (Check details from interview): to develop production techniques for new materials. Swerea has several pilot lines (check them online)

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