mKETs-Pilot lines project
The goal of the mKETs-PL project is to prepare and foster
a common understanding and consensus for future actions
in Europe focusing on multi-KETs pilot lines

mKETs-PL working document

Country report Japan

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Content

1. Policy perspective

1.1. Country specific innovation system with emphasis on KET

The following chapter introduces the current innovation system in Japan with a focus on KETs. The main drivers and tools regarding innovation policy are identified and prevalent trends are outlined.

The Japanese innovation system can be subdivided into four parts, the political system and administration, the intermediaries, the industrial system and the research and educational system. These systems work hand in hand on policymaking. The political system and administration (Figure 1) is led by the prime minister and the cabinet office. Ministries that play an essential role in innovation policy are the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Economy, Trade and Industry (METI) and the Ministry of International Affairs and Communication (MIC). Hierarchically below these ministries are the intermediaries. These function as a bridge between the two other parts of the system, the industrial system and the research and educational system. Some major organizations which are part of the intermediaries are the New Energy and Industrial Technology Development Organization (NEDO), the Japanese Science and Technology Agency (JST) and the National Institute of Science and Technology Policy (NISTEP). (Woolgar 2011)

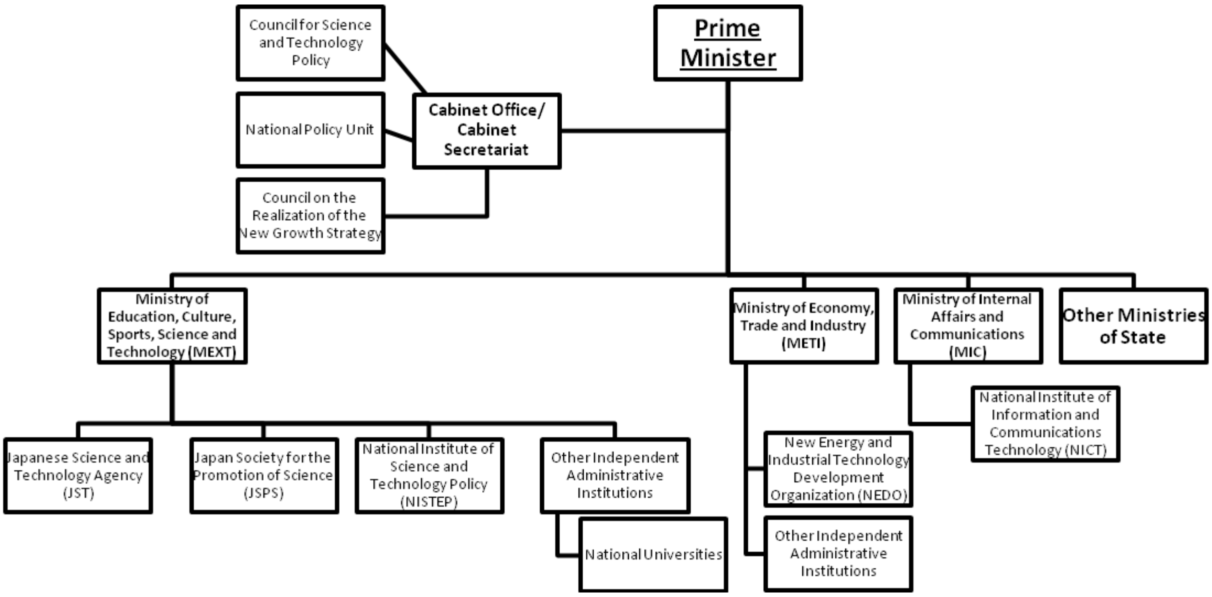

Figure 1: Organigram of the Japanese innovation system. Adapted from (Woolgar 2011).

The main goal of these institutions is to help strengthen Japans economy, especially in fields of science and technology. Mainly, R&D in Japan takes place in high-technology and medium high-technology areas. The public initiatives aim to tackle global social issues (comparable with EU societal challenges) related to life innovation, green innovation and energy efficient technologies in general. To the best of our knowledge, there is no awareness of KETs as a concept; however, several KETs technologies are explicitly highlighted as **key industrial technology fields** in the Japanese innovation system: nanotechnology, micro- and nano-electronics, photonics (especially LED and PV), advanced materials and manufacturing are the KETs that are pushed most in Japan. Biotechnology is also more and more supported. (Larsen et al. 2011; NEDO 2012a) Many research measures have been taken by the government which lay their emphasis on these technologies. Some main plans are for example to reduce corporate tax rates to attract more overseas R&D, (METI 2010b) to set a higher budget for R&D and to combine the R&D funding and time-period to enable a seamless pursuit of medium- to long-term R&D. (Woolgar 2011) In order to achieve demand-side innovation, a platform for dialogue has been established. Here industrial companies can state what they need and research centres can display what is being researched and developed at the moment. This way, innovations can be commercialized more quickly and

effectively. (Woolgar 2011) Concerning the industry, the government has said to lessen the burdens on domestic industry. The Industrial Structure Vision (METI 2010b) lists greater endeavours towards international standards as a future aim and also displays a strategy for commerce. The overall goal, however, is to bridge the gap between academia and industry, so Japan has identified similar problems as the EU.
When it comes to the innovation system, the government plays more the role of the mediator than that of a leader. More than 75% of research was done by the industry, mainly by big companies doing research mostly within the company without public support or international collaborations. SMEs do not play an important role in R&D. Special SME support programmes exist but are not strongly focusing on R&D, especially not technology oriented. (SME Agency, METI 2012) In 2010 an overall 3.26% of the GDP were spent for R&D, which is well above EU levels. (OECD 2012)

Basic Plans, a basic policy to systematically and comprehensively promote Japan's science and technology policies, as a national strategy for 5 year periods, have been introduced in the 90s. The 4th basic plan (2011-2015) now focuses on social challenges and target pictures of the Japanese nation, addressing a sustainable growth, a safe and high-quality society, dealing with natural disasters, maintaining science and technology and creating IP. (MEXT 2012) This is somewhat similar to the FPs/H2020 of the European Commission, however in Japan the basic plan is concentrated in one single law, the Science and Technology Basic Law. (Cuhls, Wieczorek 2010) The current basic plan states the intention to increase the overall R&D expenditures to over 4% of the GDP, of which 1% are governmental. (MEXT 2012; MOF 2011)

Several **measures** are taken **to support R&D**, among others direct funding, a non-specific taxation support for R&D, local initiatives to allocate companies, e.g. through R&D funds. Using public procurement as an innovation policy measure is not a general topic so far. Further programmes support markets with subsidies, e.g. for clean-energy vehicles. (METI 2011; Woolgar 2011)
A large research and development organization, the National Institute of Advanced Industrial Science and Technology (**AIST**), which integrates the large national research facilities under one roof, is a strong non-governmental research institution mainly financed by METI and partially the industry. It focuses on applied research for industrial purposes. (AIST 2013; Cuhls, Wieczorek 2010)
Several **industry associations** exist in KET relevant fields, such as bio-industry, optoelectronics industry, rapid prototyping, electronics or robotics. (Export-Japan.com 2013)

Despite the applied science direction, the Japanese public R&D system suffers from inefficiency and lack of return on investment. This is something that needs to be changed and many innovation policies want to build a bridge between the industry and government research, as well as universities. (Woolgar 2011) The **New Growth Strategy**, a policy outline until 2020, also drives the research to a more economical basis. The policy is however still rather supply than demand side driven even if it is intended to change. (Woolgar 2011)

Overall, the **main stakeholders** are the ministries (MEXT, METI) as well as their Intermediaries NEDO and JST, large Japanese companies and independent administrative institutions, these being the former public universities which were privatised in 2004.
The new government (since 2012) aims at strengthening the basis for innovation that includes a joint public-private fund, venture support, a fund by the Development Bank of Japan, and other new initiatives accompanied with an increase in expenditures for R&D. (Woolgar 2012)

All in all, the Japanese policy is very similar to the EU policy and faces similar problems that are currently addressed. Its main focus lies on closing the gap between academic research results and the industry to realize innovation and to boost Japan's economy.

- The main political stakeholders are NEDO (intermediary of METI), METI itself and MEXT and its intermediaries
- Most of the KETs are reflected in the Japanese innovation system, sometimes referred to as key industrial technology fields
- ¾ of R&D expenditures are done by industry, of which 98% are not publically supported; SMEs do not play a huge role in R&D.

- Basic plans similar to the framework programmes with social challenge exist.
- Research is rather applied, however still lacking in return on investment and industrial relevance, and is still technology push oriented. Within the New Growth Strategy this is addressed to be changed.
- Public support comprises of taxation support for R&D, loans, grants, public-private networks, clusters and platforms, some of which being dedicated to the KETs.

1.2. Organisation of mKETs policy

As the concept of KETs is not directly manifested in the Japanese innovation policy, the idea of multi-KETS is also not explicitly pursued. However, it is implicitly contained in the public programmes through the overall identified most important technologies that partially resemble KETs and multi-KETs ideas. In the following section the innovation policies that are related to the multi-KET concept are introduced.

Strategic Technology Roadmap
METI refers to a strategic technology roadmap (**STR**) to allocate public R&D funding within NEDO and METI. The roadmap is used to identify technological fields of importance. (METI 2005) Some of the main fields are strongly KETs related, e.g. Nanotechnology and Materials or New Manufacturing Technology. Due to the generality of the main fields, the multi-KET approach is already somewhat implemented. Besides that, there is also a “crossover” field. The STR is subdivided into 31 more precise fields, of which several have relevance to multi-KETs. (METI 2010a) The idea of the roadmap is explicitly stated to promote cross-field and cross-industrial alliances, technology fusion, and coordinated implementation of relevant policies, but also to assemble the comprehensive strength of industry, academia and public institutions. The roadmap is developed and updated by a task force with representatives from universities, private companies, METI, NEDO, and AIST reflecting the expertise of industry, academia, and public institutions. It is further evaluated by several industrial and political councils and committees as well as users and manufacturers. By understanding technological and market trends, prioritizing critical technologies, and developing policy infrastructure for planning R&D projects, the roadmap is used to allocate R&D resources. The STR, as the basis for the R&D strategy, takes into account market pulls and technology pushes. (METI 2005)

Initiatives, Programmes, Strategies and Political Stakeholders
Several initiatives deal with KETs and multi-KETs, for example the recently founded Tsukuba Innovation Arena Nano, which is supported by METI (AIST) and MEXT, with research focuses on nano-electronics, micro- and nano-electromechanics, nanotubes, etc. 80% of the 80m€/year are publically financed, whereas the remaining 20% are funded by private entities. (Rehn 2013)
The **AIST** itself is a highly interdisciplinary organisation also focusing on the main fields as identified in the STR. Within these activities, the transfer of knowledge between disciplines and academia and industry is always highlighted in the public strategies. (AIST 2013) Furthermore, there exist several initiatives to create networks, e.g. the Knowledge Cluster Initiative by MEXT. (ASTF 2013)
The intermediaries (e.g. **NEDO, JSP**) address the identified key technologies in their programmes. KETs can be found within the addressed topics and also the idea of mKET is somewhat incorporated through crossover fields. The supported programmes of **METI** closely resemble the KET and multi-KET spirit, for instance in the programme “Realization of technology for the future” mKETs are promoted: Development of magnetic material technology for high-efficiency motors:¥2.0 billion (15 m€, advanced materials, manufacturing), Development of ultra-low-power optoelectronics implementation system technology:¥2.8 billion (22 m€, photonics, advanced materials, electronics), Development of key technologies for “green,” sustainable chemical processes:¥3.3 billion (25 m€, advanced materials and industrial biotechnology), Development of artificial gene synthesis technology for creating innovative biomaterial:¥0.7 billion (5 m€, industrial biotechnology). (METI 2011)

The **4th basic plan** is devoted to the New Growth Strategy and states several multi-KET related interdisciplinary issues even if not mentioned explicitly, being strongly related to the needs for target picture of the future nation. The involved technologies are not explicitly mentioned, the challenges are e.g. green innovation and life innovation. Some initiatives related to multi-KETs and to a better integration of industrial and basic research are: “Enhancement of knowledge networks among industrial sector, academic sector and government”;

"Creation of new places to promote collaborations among industrial sector, academic sector and government (Formation of centers of open innovation, etc.)"; "Improvement of circumstances for strengthening of supports of commercialization"; "Utilization of regulations and institutions to promote innovations"; "Building of regional innovation systems"; "Promotion of intellectual property strategies and international standardization strategies"; "Strengthening national security and key technology"; "Building S&T bases for pioneering new frontiers"; "**Strengthening interdisciplinary S&T**"; "Advancement and networking of common and basic S&T infrastructures".
Also programmes with international aspects not explicitly related to special technologies are prevalent. (MEXT 2012)

Evaluation of Success of Support Programmes
Large programmes are evaluated in an outcome-oriented and mostly standardized way, which leads to a strong target orientation in the programmes. (Cuhls, Wieczorek 2010) For example NEDO has a PV project, where the target is to achieve a particular record efficiency with a particular technology. The success is oriented at the achievement of the efficiency only. (Interview)

Legal Aspects
Japan has a set of laws and regulations dealing with innovation and transfer of science and technology into market. Among others, the basic law is the basis for the basic plans mentioned above. A flexible corporate law by means of the choice of the business form simplifies the initiation of start-ups and foundation of technology oriented companies. Furthermore, the taxation system sets incentives for R&D. (Cuhls, Wieczorek 2010) A very important role in the legal framework plays the protection of intellectual property, which is condensed by introducing an "Intellectual Property Strategic Program", that places importance on international standards based upon Japanese technologies and increasing the prominence of the Japanese IP system for Asian companies. (Woolgar 2011) The IPRs are managed at the Intellectual Property High Court. (Cuhls, Wieczorek 2010)

Summary of mKET Policy and the Political View
The political view on mKET is governed by the identified key industrial technology fields in the New Growth Strategy determined by the STR and basic plans. mKETs are mostly implicitly included and only a few initiatives address crossover fields directly.

- Multi-KETs are not explicitly mentioned in the Japanese innovation system but crossover fields and interdisciplinary approaches exist
- Many programmes implicitly reflect the multi-KETs concept on a more detailed level
- A strategic technology roadmap (STR) and a basic plan specify the policy/technology orientation
- IPR and standards play an important role in innovation policy

1.3. Main policies for pilot activities

The second focus of our study lay on Pilot activities. The following chapter deals with public support structures for the implementation of technology based pilot activities. Besides this, an emphasis is laid on shared facilities as supported by the Japanese government and two distinct examples are described.

Public Support for Private Companies
The Japanese innovation system focuses strongly on applied and experimental R&D (70% of public expenditures in 2010), which is mainly done in public labs. Companies self-finance their R&D to a great extend (98%). Public support for R&D in private companies mainly exists through tax incentives, but direct funding is increasingly pursued. About 1/3 of public support for companies were grants, loans and contracts in 2009. (OECD 2012) No programme exists that in particular focuses on pilot activities, however the idea of technology to market transfer is prevalent throughout the Japanese innovation system. In particular cases, demonstration activities and commercialization of technologies are explicitly mentioned.
Several governmental programmes address the problem of technology to market transfer. Among others, the so called "A-Step Program" (Adaptable and Seamless Technology Transfer Program through Target-Driven R&D,

2009) shows the government's efforts to push programs which increase industry-academic partnerships through grants and tax incentives (including reduction of social charges) to support prototype development. (Woolgar 2012) Together with the New Growth Strategy and the basic plan, a shift towards more demand oriented R&D and innovation policy to trigger economical growth can be observed.

Pilot Activities: Public Support through NEDO (METI) and JST (MEXT)

Besides the overall governmental guidelines, Japan has several programmes for supporting industrial research. The most important stakeholders for the support of pilot activities are NEDO and METI.

NEDO, as the R&D management and organisation subsidiary of METI, plays the most important role in the support of pilot production activities. Pilot lines are not explicitly mentioned in their programmes, however activities related to pilot lines are rather strong, as the focus lies on industrialization and demonstration projects for novel technologies. One of the main missions of NEDO is "Development, demonstration and introduction of promising technologies that private sector enterprises cannot transfer to the practical application stage by themselves due to the high risk and long development period required". (NEDO 2012b) They explicitly mention support of technology demonstrations for private enterprises and in collaboration with RTOs focusing on "key industrial technology fields, including green innovation and life innovation". (NEDO 2012a) This strongly implies the support of pilot activities (with mKET relevance). Typically, pilot lines identified to be necessary to be a forerunner in industrialization of a novel technology are funded 50-66%. (Interview) NEDO's budget is about 1 b€ (10% of state R&D expenditures), see **Figure 2**. NEDO also supports international pilot projects. Within the identified fields of action, pilot activities can be supported if they have relevance for the deployment of novel technologies. A programme especially focussing on SME R&D is only playing a minor role.

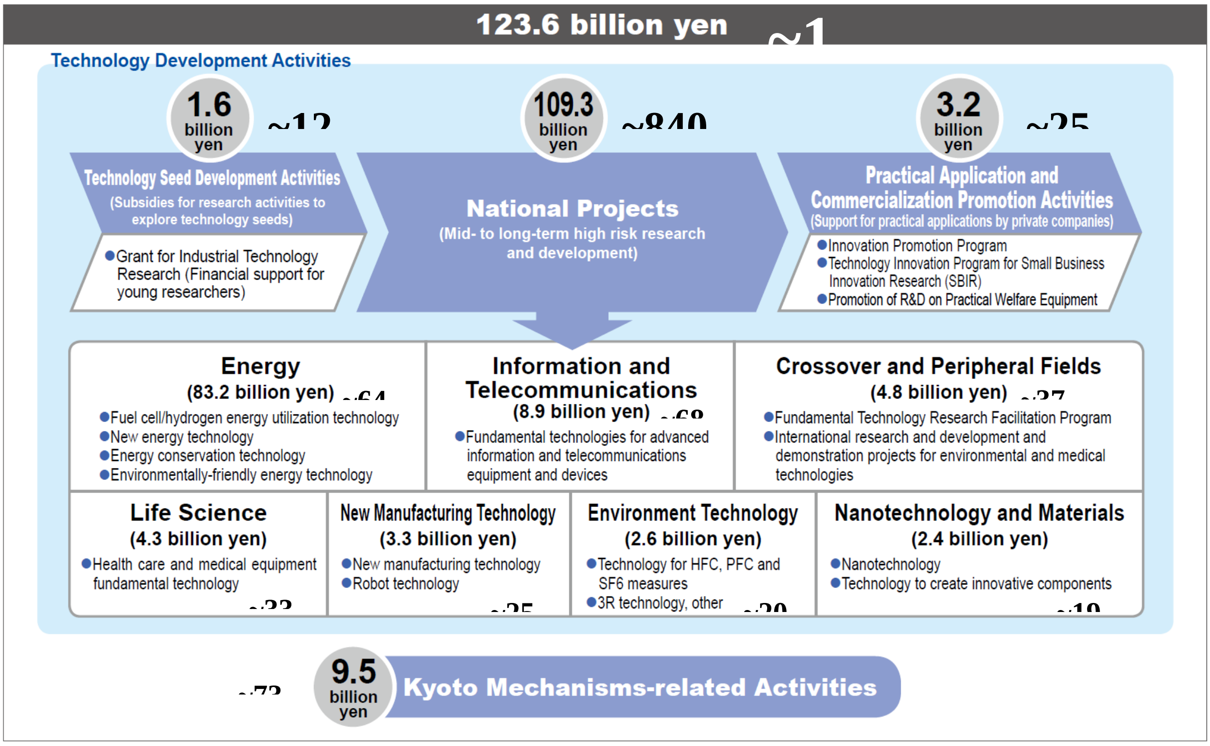

Figure 2: Budget and orientation of research and development of NEDO. Adapted from (NEDO 2012b).

Some highlighted projects are additionally financed by **METI** in a priority programme "New growth driven by invigorated internal demand, globalization and innovation", e.g. "Acquisition of emerging markets through public-private collaboration" containing:

- "Demonstration of technologies and systems to improve international efficiency of energy consumption:¥20.4 billion (~157 m€) and
- "Large scale demonstration and development of innovative carbon dioxide capture storage (CCS):¥10.2 billion (~78 m€)".

The topics are chosen according to the identified social challenges and technologies in the STR, and the basic plan. Another priority lies on "**Realization of technology for the future**", where "technologies not being extensions of existing technologies" are supported from R&D to commercialization.

The transfer of technology to market is strongly pursued by METI and in some cases large demonstration projects in private companies are publically funded with large amounts of money. Typically up to 50% of capital expenditures and running costs can be covered. (Interview)

The **Industrial Cluster Policy** (started 2001) by METI aimed at initiating regional industry clusters prone to particular industries to foster the strength of the sector and region through network formation within the industries, with the RTOs and universities and the creation of start-up companies. Subsequently, the clusters

are intended to become financially independent of METI and METI only seeks the creation of new businesses through networks among clusters. (METI 2009)
The **AIST** focuses on applied research for industrial purposes, as mentioned above. It is a public platform for pilot activities in several fields and drives several shared facilities (vide infra)

JST, the intermediary of **MEXT**, also initiated programs for industry-academia collaborative R&D actions.

- A programme called "S-Innovation" supports industry-academia collaborations and covers the whole research chain from basic R&D (first 2-3 years), R&D of component technology (3-4 years) up to R&D of applications (verification testing aimed at commercialization of product, 2-3 years) with 0.5m€.
- A further "Collaborative Research Based on Industrial Demand" program focuses on the support of industry-academia collaborations to solve an industrial problem. The support is typically for 3-5 years with a volume of 2m€/year and topic.

Pilot lines in general can be found mostly in enterprises but also at research institutes. (JST 2013)
We identified several regional pilot activities that can be seen as publically and privately funded shared facilities or services typically on a pre-competitive level. Here, MEXT also plays a (minor) role through pilot lines at national universities or institutes. Examples are given below. So called platform programs, e.g. the Nanotechnology Platform Program, bundle the competences and equipment of RTOs and universities also making them available to industry. (Interview)

Publically Supported Shared/Open Facilities:
In Japan, several shared/open facilities with slightly different models exist. They all have in common, that they were initially publically or partially publically/privately funded. Some of the shared facilities can be seen as pilot activities, either with respect to prototype and small scale production or with respect to the development of processes and testing of novel materials in processes.
The shared facilities are typically situated at and operated by AIST or universities. They are mostly for pre-competitive research and development and aimed to address big companies and also SMEs.

Example 1: Hands-on-access fabrication facility, Micro System Integration Center (µSIC) at Tohoku University
The basic concept of the Hands-on-access fabrication facility is to provide access to versatile and advanced equipment for prototyping but also small volume production typically for high added value products in micro- and nano-electronics and advanced materials and manufacturing, such as MEMS. The model of this facility is "pay-per-use", which means that a company pays a facility fee, technical assistance fee, equipment fee and material cost by the hour (about 150€/h at max). Interestingly, the companies have to provide their own personnel in order to use the facility, as it only provides technical assistance with the equipment but not with the processes. This avoids legal issues related to IPR, as the IP stays within the company. Non-disclosure agreements regulate the interaction with the facility staff. Only in rare cases, additional contracts are necessary, if the facility staff is deeper involved in the research processes. More than 100 companies (roughly 1/3 SMEs and 2/3 larger companies with >300 employees) use/have used this service. The running costs (~1.6 m€ per year) are to one fourth covered by the fees, the remaining costs are covered by MEXT through JSPS and the Nanotechnology Platform Program. The key success factors are the proximity of the university which provides knowledge and skilled personnel and the accessibility and flexibility of the equipment. Typically, after the facility was used to the satisfaction of the customers, the companies go to foundries or in-house small or high volume production. In this model, the customers are therefore the users of the products.

Example 2: AIST PV modules and testing
The pilot plant, used for the assembly and production of solar PV modules and further testing, was initiated by AIST after requests from industry. The initial costs were all covered by METI and the running costs are covered by industry (60%) and AIST (40%). The users are mainly large companies, which supply materials or equipment to the PV module producers, with the incentive to bridge the gap between suppliers and module producers. The incentive to use this pilot plant is the lower cost compared to own in-house pilot lines. It is used for gaining and sharing knowledge in the application of the provided materials independent of the potential customers. The users are a fixed consortium, paying an annual amount. The overall budget is about 2 m€/year. The

consortium partners bring their own materials and equipment and keep their know-how internally, only the application knowledge is shared.

Summary of Innovation Policy for Pilot Activities and the Political View

As can be seen, the idea to support pilot activities is given in the Japanese policy, even if not always explicitly mentioned. As the role for technological innovation in economic growth is aimed to be more specified and the policy is targeted to focus on inducement mechanisms, the role of pilot activities and public-private collaboration will play a more and more important role in Japan. For further stimulation of diffusion, it is planned to introduce regulatory reforms and standardizations, especially in the fields of energy efficiency and medical industries. (Woolgar 2011). Table 1 summarizes the policy measures in Japan.

One of the interviewees mentioned that currently similar issues as in the EU are discussed with regard to the transfer of technology to market, the need to gain a higher return on investment and the strengthening of the economy by funding research and technology.

So far an explicit mKET Pilot Activity project does not exist and is only included implicitly in the technology oriented programmes.

- New Growth Strategy 4th basic plan shift towards more demand oriented R&D and innovation policy to trigger economical growth
- Focus on commercialization of technologies by METI and NEDO (also KETs/mKETs related)
- Support for private companies through loans, grants, venture support, public-private funds and tax reduction
- Demonstration projects in public-private collaborations and also private-only
- AIST focuses on economically relevant research and pilot activities in several fields
- Shared facilities are supported and used

Table 1: Classification of policy measures and examples in Japan

A. Policies for knowledge base support	**B. Policies for commercialisation support**
1. Instruments to encourage applied research (R&D tax credits, public funding through loans and grants, joint public-private fund, venture support) 2. Instruments for strengthening co-operation among stakeholders and disciplines (several specifically founded transfer agencies/platforms (e.g. AIST, Nanotechnology Platform, Clusters), staff exchange programs between research and private businesses, public research agencies)	1. Instruments to build up technological capabilities for the industry (subsidies, tax concessions for investments, loans) 2. Instruments to encourage the collaboration between public and industrial research. (funding of collaborative projects, public-private initiatives)
C. Demand oriented polices	**D. Legislation**
1. support of private demand (Support to communication initiatives, Subsidies for the use of new technologies, vouchers) 2. standardization and regulation	1. (De)regulation activities

2. Business perspective

The business perspective was gained in several telephone interviews. Here, the main conclusions are summarized. It is noteworthy that some issues might be related to special sectors and might not be applicable to others or may reflect particular personal opinions of the interviewees. As the multi-KET approach does not explicitly exist in Japan, the interviewed companies were chosen according to multi-KET applications and the focus was generally on the high technology and multi-KET related industry.

2.1. Implementation of multi-KETs pilot lines

Within this chapter the significance, meaning and characteristics of pilot activities are described. Success factors and barriers are discussed and collaboration and support models identified within the interviews are introduced.

Pilot Activities: Definitions, Function and Costs

Pilot activities are important measures to facilitate the technology to market transfer.
They can have several denotations depending on the sector, the TRL/MRL and even within the same company. Terms such as: pilot lines, pilot plants, (small scale) trial production, test plant, pre-production, mini line, test production line, demonstration plants/line, prototype production line/plant were mentioned. It appears that no consistent or clear classification or assignment to sectors and TRL/MRL is possible.

The function of a pilot activity is versatile: from prototype production and validation of novel developments to small scale or larger scale production, everything is perceivable: to test novel technologies, new equipment/product designs, debugging, improvement of hardware/products, specifications, small volume production of evaluation samples/equipment for customers, to validate process/product capabilities, evaluation of cost and quality of new products prior to mass production, to verify products and technology in a relevant environment, to validate technologies based on R&D achievements etc. A pilot activity is typically seen as a very important step in the technology to market transfer and can be seen as a pre-production based on R&D developments. It is therefore a good instrument to check the matching of R&D products with market needs on a small scale, to provide samples to customers for testing and validation as well as to create awareness of the new technology. Pilot activities are thus also marketing tools to test the acceptance of new products. In general, pilot activities have lower risks than instantaneous mass production and they are used to check what the market demand is. Typically, after pilot activities were successful, e.g. after being convinced with clients, mass production line investments become less risky.
Equipment suppliers have own pilot lines, sometimes in joint development projects with key customers.
The tenor was that pilot activities buffer the risks of new technologies, as bringing a product/technology to market as soon as possible bears too many risks, which can be reduced by pilot activities.

Pilot lines are often close to the mass production lines or even parts of them or turned into them after verification. For high investment industries (semiconductor), pilot lines are typically upgradable to a mass production line, so they can be incorporated into following mass production lines, which keeps continuity of the production technologies. Sometimes, pilot lines are kept for further improvement/development and separate mass production lines are set up.

Mainly, two types of models can be differentiated: pre-competitive pilot lines and in-house competitive pilot lines. Pre-competitive research is typically done in shared/open facilities to test novel technologies with no precise relevance for the market, yet, and a high risk of market failure. In-house pilot activities are typically done, when a clear market is already available or highly probable. The latter is typically not done in collaboration to avoid knowledge drain.

Typical costs of market relevant pilot activities are >5m€ up to >100m€ depending on sector and function. Running costs can be as high as 100m€ per year. Pilot lines run 2 up to 5 or more years, but typically 2-3 years.

The Role of Market Needs, Business Plans and the Right Timing: Success of Pilot Activities

Pilot activities relevant for already available markets will in most cases be done in-house to secure the knowledge and keep the business scenario and new product confidential, only for SMEs shared lines can be of relevance even in fields with market relevance in case the pilot activity is too costly for the SME alone.

The most important factor to initiate a pilot activity is the **market demand**. The future commercialization of the new product is relevant and must be as clear as possible. A **business plan** is very important and in the best case, a customer is already at hand. The market pull is therefore more important for businesses than the technology push. Very important factors for pilot activities are: A wide range of preparation to start the business (even more important than the developed technologies), sufficient investment amount (strong financial support on the cash flow until a sustainable profit is reached), suitable people for the factory including the recruiting and their training (human resources), quality control and assurance, reproducibility in the process, the aim to make a profit, a sales force, a sales network for both domestic and international potential customers, accounting and sustainability. So more important than R&D is how to make a profit through the purchase of the novel products/components by customers.
The typical **pre-processes** before installation of a pilot activity are: Technologically, a mature prototype needs to be available and verified by R&D. Additionally, from the economical point of view, the feasibility study needs to be good enough and the market pull is important ("market in"-strategy compared to "product out").
It appears that a **good timing** for market demand (to be convinced of market demand) is crucial for the success. It was regularly mentioned, that the timescale is very important and that success strongly depends on the right timing. Nowadays, fast changes are normal, and pilot activities help to keep track of the market before investments in mass production becomes necessary.
In Japan, a change has been identified in businesses and policy. Formerly, technology push was important, but nowadays market pull plays a more important role, as today market demands are different: the best technologies do not necessarily govern the market. Therefore, market demand analyses are very important to place the technology in market demands.
One interviewee mentioned, that for a company, an initial foreseeable market of >20 m€ is needed to enter a new field. However, Japanese companies are interested often at existing markets. Hence, it is not easy to get novel technologies to the market in Japan.

Finally, a last very important factor is **human resource**. To find and support good business people with experience of success and skilled engineers and scientists is crucial for pilot activities to be successful. The planning team should thus contain scientists, engineers and entrepreneur/business people (in best case people who already were successful in similar projects). To summarize, besides the pilot line as a test bed ("hardware") a good consortium ("software") is very important and both have to work hand in hand.

The role of **public funding** is seen ambivalently. Some companies expect and get support for product development in early stages, but typically not for pilot lines and it is also not desired, that the government plays an important role in relevant pilot lines (getting money from the state also comes with responsibilities). Others mention that public funding for in-house pilot lines is (too) low or not available, even if the sector is a key sector for the Japanese economy and has a high strategic importance (micro- and nano-electronics).

Pilot activities with good market chances are typically financed with company money only. In some cases support by METI is given to companies for high-risk industry-owned pilot lines in the identified fields of relevance of the STR and the basic plan, related to the social challenges. Typically, the public support accelerates the innovation and triggers a forerunner position of the company. However, sometimes the technology can be ready, before the market is ready for the application.
It appears that tax benefits and local R&D funds are mostly desired and used by industry.

Public support might be however needed for novel technologies that have not yet penetrated the market. If this is done in industry alone, typically the endurance of a program is not long enough and a lot of technology transfer fails and a technology might get lost. It is however not enough to financially support the initial setup of a program (equipment and infrastructure), also human resources and running costs need to be partially covered by public funding.

It appears, that pilot activities are seen to be a **success**, if a mass production and a good market acceptance and of course a return on investment occurred.
There is also a "semi-success" model for pilot activities: Pilot lines are a good intermediate scale of production and if the market demand is not yet so high but present, the pilot line can satisfy the market needs in the first place and as soon as the market grows a mass production can be initiated. Hence, its identification as a way to bridge the valley of death is absolutely supported by the interviewees.

Barriers for Successful Pilot Activities
Three main barriers for pilot activities could be identified.

1) Even if the commercialization of a technology can be quite rapid, the creation of new markets is often a bigger obstacle. **Market acceptance, market prediction and penetration** are high barriers. R&D therefore needs to be oriented at market needs. A lot of market knowledge is needed to foresee the next needs and react early in R&D.
2) To **secure secrets**, IP and human resources and to get access to highly skilled people.
3) Availability of **money** for pilot lines (e.g. from banks, venture capital). Sometimes money to support the business model is missing, even if the technology is ready.

In special cases, such as for medical applications, too general **regulations** can also be a barrier for novel technologies that could be easily lowered.

B2B Collaboration: Vertical Collaboration along the Value Chain or Horizontal Collaboration with Same Core-Technology but Complementary Market Interests
The collaboration with customers in a pilot activity was very often mentioned and appears to be a very effective way of co-operation. For the future product, it is very important to consider potential customers' opinions in the development process to adapt the product/component to the market need and to convince the customer of the benefits (feedback loop). Hence, **collaboration along the value chain with key customers** is maybe the most viable and realistic way of joint development projects. The same holds for collaboration with suppliers, which is however less often mentioned and might be adaptable only to special cases.

A second way of B2B collaboration is a **vertical collaboration** for companies using the same core-technology but which are interested in complementary markets. This "closed" shared facility could be pre-competitive but also competitive depending on the market and allows for gaining of shared knowledge that can be applied for the specialization of the product/component for the later addressed different markets. This collaboration could be publically supported in conjunction with the involvement of RTOs, see Figure 3.
A mentioned example was the public support of a collaboration of two solar cell manufacturers by NEDO that both worked with the same core-technology. One company was interested in rigid solar cells, the other in flexible solar cells. The core-technologies were similar and thus could be developed together. The adaptation to the substrate ("the last 20%") was then done alone.

Besides shared pilot activities, the **access to networks/communities** of RTOs and companies in the same field using the same core-technology, in best case with complementary market interests, was also mentioned as an interesting knowledge platform. These structures (collaborative core-technology development with RTOs and complementary interests of competitors) are supported by NEDO.

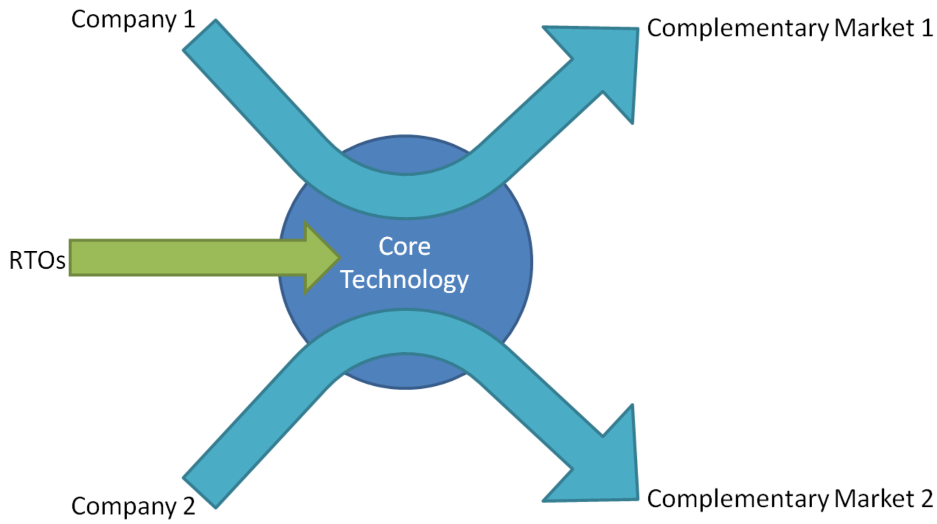

Figure 3: Possible model of a horizontal B2B collaboration.

Summary: Business Perspective on Pilot Activities

Pilot activities are seen as very important tools to bridge the gap between R&D and mass production and to access new markets and deploy novel technologies. They reduce risks and help to serve initial markets and to provide samples to customers for validation and testing. Public support is mostly desired in terms of tax reductions and partially by subsidies through local funds or grants. Very important issues are the access to skilled human resources, money and most importantly market relevance, proper business plans and the right timing. Further concerns are related to IPR especially when it comes to collaborations. Collaborations with customers are highly acknowledged.

- Pilot activities are very important and often needed
- Market relevance, business plans and timing are most important
- Access to networks and skilled human resources is crucial
- IPR issues can problematic in collaborations and shared facilities

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

In what follows, the experiences of the interviewees with political support for pilot activities are summarized and a picture of the innovation system as derived from the interviews is drawn. The following part is divided in two subsections, one dealing with the concept and acceptance but also the problems of shared/open facilities and their support and the other dealing with desired and practiced public support beyond shared facilities. The chapter concludes with a short view on legal aspects and a summary.

What Shared/Open Facilities Can and Cannot Do

Most of the interviewees mentioned, that open facilities need to be multi-purpose facilities to be appealing. Open facilities exist in several disciplines and are typically partially funded by the state (MEXT or METI) and by industry, e.g. in a pay-per-use model (vide supra: Hands-on facility) or in a membership model (vide supra: AIST PV facility). The public funding is important for equipment and maintenance. Shared facilities are used for pre-competitive research and address SMEs and large companies. It can be seen as an intermediate step between laboratory and larger volume pilot lines/manufacturing. They are used by industry to develop new fields, due to the limitation of own facilities, to save costs for equipment and to gain know-how. It seems to be a good model to provide the facility and basic staff, but to let the companies do the experiments and development themselves by their own personnel to avoid IP issues (pay-per-use and bring-your-own-personnel model, vide supra: hands-on facility). It is generally accepted, that shared facilities improve and accelerate innovation and lower barriers for new technologies. For higher volume production and further more delicate (IP with strong market relevance) developments, companies have in-house pilots or use foundries. The accessibility and flexibility of the equipment is a crucial point and it is important to have access to experts in the field (universities, RTOs in best case nearby). Legal aspects are typically treated with non-disclosure agreements.

The largest concerns of industry are to secure knowledge and secrets. Therefore, for market related pilot lines, it is almost impossible to use shared facilities. Only if complementary markets are addressed, or if suppliers use the facility for testing and verification of benefits and efficiencies of the equipment and materials in a non-competitive environment, shared facilities are an option. However, SMEs, start-ups and system manufacturer (e.g. automotive) need shared pilot lines also at later development and more competitive stages. Here the IP aspects are more severe. IP issues are in general sometimes problematic.

The benefits of shared facilities are there cheapness compared to own pilot lines. They are good for companies who want to enter new application fields for their technology.
In Japan, external pilot lines have become more important since the economic crisis (companies hesitate to invest and utilize common platforms/activities).
In an interview, two ways of usage of shared facilities were mentioned:

1. Use in parallel an in-house pilot line for delicate developments and gain knowledge from shared facilities
2. With minimum investment use public pilot lines (pre-competitive) or have **exclusive collaboration** with other companies or RTOs with non-disclosure agreements for competitive research with the best case of using the same core-technology addressing different markets.

In Japan, public facilities for R&D have been common, for commercialization they are still new but upcoming. The biggest issue regarding their usage is always to check how confidentiality can be kept. Depending on the projects, confidentiality agreements become necessary. In general, a needed paradigm shift was mentioned: to keep everything confidential is not good and will lead to being behind market demands. An acceptance of losing some confidentiality by gaining knowledge is needed.

Public Support beyond Shared/Open Facilities: Technology Push and Market Pull
For pilot activities, it is important to gather “human resources” and knowledge and to provide a good connection to junior scientists and RTOs for supply of knowledge and people, here, support through the government is highly acknowledged.
It would be further desired to have **follow-up programmes** and commercialization perspectives for basic research programs in important technology fields.

Besides networks, clusters and open facilities, **in-house pilot activities** are also partially funded by the Japanese authorities. To begin with, it appears that **sometimes only parts of pilot activities are funded** instead of the complete facility. For instance, only a single important process step/technology/equipment was publically supported to reduce the risks for the company in one example. Here, parts, processes and equipment of a pilot line were developed with machine vendors under non-disclosure agreements and supported by NEDO.

The Japanese policy system is still partially based on **technology push**. For highlighted projects, large investments are supported by METI. Some demonstration plants related to the priority program of METI were supported, e.g. in Carbon-Capture and Storage (CCS) an industry-owned pilot plant was supported 50% of 100 m€. In this case without the support, the technology would have been tested in a pilot plant of that size much later, so that in this case the support led to an acceleration of innovation. The main barrier for an earlier realization was the high cost and the not available market. With the subsidies, the **technology is now ready** (and the company is a forerunner), **but the markets are not yet**. Smaller demonstrators are realized independently. The support **bridged the time until a real market pull is existing**, however bearing the risk, that the market pull is not occurring at all.
Further technologies related to the challenges were financed to **show the potential of the technology**, e.g. in biofuel production.

Another mentioned **model to support in-house pilot activities** by NEDO was to supports pilot production activities of three competitors with 3-5m€ each per year (covering about 2/3 of the costs) and after a few years one was chosen to be supported further. The interviewee however was skeptical about the effectiveness of this process.

It was further mentioned that in some cases a **long term support** (although the industry is fast changing) would be desirable, with an evaluation every few years, and a not too early possibility of failure (a presumably failed pilot line can still become profitable). In some cases, after the support ends, the company might have to stop the initiative, even if it is promising. According to the interviewee, policy should give initial incentives/investments to start promising activities and give tax incentives to prolong activities and continuously support.

A major problem regarding the transfer of emerging technologies to market in Japan is that companies are often interested only in existing markets. A mentioned expected market value and return on investment of at least 20 m€ as a threshold for pilot activities was mentioned as a barrier for very new technologies. Public support could therefore **bridge the gap between low markets and >20m€ markets**.

The **creation of awareness of novel technologies** and products were mentioned to create a market more easily. A promotion of novel technologies in conservative industries and an assessment of their benefits seem to be crucial to trigger for a market pull. Incentives for companies to buy new high technology equipment might be a way to create market pull.

Regulations can help to establish a market pull (e.g. CO_2 emission reduction, feed in tariffs for biofuel based on non-food feedstock) for mKET technologies as well. On the other hand, too general regulations of e.g. the medical sector and high approval costs are a barrier for the implementation of novel technologies. These adjustments have to be evaluated case by case.

Finally, more **international collaboration** in high-tech areas between for instance EU & Japan was mentioned to be a tool to strengthen both economies and to create synergies, as cross-border collaborations between different countries become more and more efficient. The use of the synergies of development and the application to localized markets are some benefits. A technology/process could be developed 80% in an international collaboration, and the remaining 20% in-house and adapted to a local market. Within this respect FTA (Free Trade agreement) and EPA (economic partnership agreement) become important.

Legal Aspects

As mentioned above, IPR dealing is the most important legal aspect, however, the loyalty of people was also mentioned. For shared facilities on a competitive level, agreements and contracts beyond non-disclosure agreements (NDA) are needed (NDA works at early stages but not during commercialization). Furthermore, IPR of products in the market is a very important issue.
Besides that, standardization and regulations can help to create market demands, but can also be a burden for novel markets (vide supra). Furthermore, for international collaborations FTA (Free Trade agreement) and EPA (economic partnership agreement) are important (vide supra). An awareness of state-aid problems and subsidies was not explicitly mentioned and topic of the interviews. Even if addressed, no concerns were mentioned.

Summary of the Business View on Policies

In summary, the use of shared facilities mostly for pre-competitive research was generally accepted and the public support for B2B collaborations was granted. The support of networks, clusters and public-private partnerships was acknowledged and seen to be important. However IPR issues are a main concern. Beyond shared facilities, the direct support of in-house pilot lines was mentioned for special technologies to speed up the innovation, which however led to the technology being ready, but the market not. In one case only parts of a pilot activity were developed in collaboration and with public funding. In general a demand oriented funding is desired. The creation or initiation of market pulls through regulations or incentives was seen to be a major issue where policy could help to bridge the gap to sustainable markets.

- Shared facilities for pre-competitive research & development, or even competitive in some cases and for SMEs
- Creation and penetration of markets is crucial and should be publically supported by regulations or market incentives
- Support for networks and public-private consortia is good, B2B collaboration can be also valuable, but IPR is always problematic

3. Conclusions

This chapter will summarise the above findings leading to conclusions and recommendations for the mKET: Pilot line project.

3.1. Summary of policy perspective

Japanese policy is currently discussing similar problems of technology to market transfer as the EC. Programmes and initiatives focus on the transfer of technology to market within the New Growth Strategy to gain economically added value through R&D. The main political initiatives are summarized in Figure 4.

Government incentives: tax reduction, loans, grants, venture support, regulations, standards, subsidies		
Concept	**METI (NEDO, …)**	**MEXT (JST, …)**
In-house pilot activities	✓	
B2B collaborations	✓	
Shared Facilities	✓	✓
Public-Private Collaborations	✓	✓
Networks, Platforms, Clusters	✓	✓

Figure 4: Summary of policy initiatives to support pilot activities and the responsibilities.

Industrial R&D support goes to a great extend to large companies, as they are mostly engaged in R&D, which might be a special situation and due to the industrial structure in Japan: the majority of Japanese SMEs are rather medium technology oriented in not R&D-intensive fields (Woolgar 2012). A technology or R&D specific SME support only plays a minor role. To the best of our knowledge there exist programs to support SMEs in general, but they have been not strongly focusing on technology development.

Technologies similar to the KETs play a very important role in Japanese support strategies. They are identified by roadmaps (STR) and basic plans, similar to the framework programmes of the EU. The system is still technology push driven, but changes towards a more demand-driven support are persistent. Besides grants and subsidies, un-specific tax reduction for R&D seems to be a large part of the Japanese public support for R&D. The access to venture capital and loans seem to be a major obstacle at the moment.

3.2. Summary of business perspective

The pilot activity is a very important tool towards commercialization and to bring the results of R&D to market. In this perspective, business models and market demands are most important and in most cases the technology plays a minor role. If the market and a clear business perspective are available, large companies will use in-house pilot activities to keep and secure the IP. Public support would in this case be mostly needed for SMEs in terms of loans, venture capital or grants. Only in highly risky and novel fields, shared facilities and collaborations are sought (mKET relevant). Shared facilities are used by SMEs and large companies in Japan. For SMEs, shared facilities are also interesting when it comes to more competitive innovations. SMEs need further support for pilot activities, as the investments are typically very high.

A paradigm shift would be needed towards "open access" and "share knowledge to gain knowledge" to achieve similar approaches in competitive research fields for large companies. The collaboration with customers seems to be the most suitable way for industry to collaborate in order to develop and place novel technologies at the market, as the acceptance is triggered simultaneously.

In case of public support for industry pilot activities, a consortium of professionals of government and industry should review technologies and decide which to support (industry is very important, as they have knowledge and expertise and the government has power and money).

3.3. Recommendations to support pilot lines

Unfortunately, no general solution for pilot activity support exists. The support depends on sector/KET and on the TRL level of a technology. For emerging technologies, not based upon or upgrading existing technologies, shared/open facilities for pre-competitive research addressing different parts of the value chain (e.g. suppliers or customers only) are valuable to reduce risks for companies and to create an understanding of the potentials of the technology.

Shared facilities appear to be an interesting concept with several possible models. Two interesting models of **shared facilities** for pre-competitive research could be identified:

1) a pay-per-use and bring-your-own-personnel model and
2) a testing and developing facility to bridge the gap between equipment suppliers and producers in a membership model.

Typically the collaboration seems to work best vertically along the value chain rather than horizontally. However, with technologies having already clear market relevance, shared facilities can be problematic. They seem to be especially applicable to mKET-intensive applications that need various technologies and processes and a smaller volume production in the beginning.

For more competitive research these models are not viable, mostly due to IP issues. Here, the **B2B collaboration vertical along the value chain** with customers or suppliers appears to be a promising model, as all participants share the same interests to get a technology to the market, and as the companies closest to the market are in best case incorporated in the collaboration. The collaboration with customers further creates a market relevance and awareness and lowers the risks of market failure.
In special (and maybe rare) cases, **horizontal collaboration** with “competitors” using the same core-technologies but being interested in complementary markets can be fruitful (somewhat a closed shared facility). Especially for highly risky technologies, such as mKETs, all these models seem to be promising and could be supported (and are supported in Japan) by public money.

The **support of in-house pilot activities** is questionably and is only viable, if the company has to bear a large amount of the risk and expenditures itself, to create a commitment. A support of **non-collaborative in-house industry owned pilot activities** for large companies can be thought of in very rare cases, but it appears that this technology-push approach does not necessarily lead to a market pull, if it is not created artificially in the first place (e.g. through regulations, CO_2 emission reduction).

However, another support issue would be to rather **support only a part of the pilot activity** (a process/equipment/crucial technology), that could be developed together with RTOs or suppliers, instead of financing the whole pilot activity. In this case, the IP issue would be limited to the single process and not the whole pilot activity.

Besides the direct support of pilot activities, the **economical environment is also very important**. Support with business models and market analyses and access to competence networks and skilled people from science, technology and business are very important factors. Furthermore, the commercialization perspective of basic research programmes should be taken into account (“follow-up programs”).

Last but not least, **regulations and standards** to trigger certain technologies are also a measure to create market demands and to strengthen technologies in the first place.

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4.2. Interviews

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- A large semiconductor producer
- A large engineering, electrical equipment and electronics company
- A thin film photovoltaics company
- A large electronics and electric company
- A large precision machinery and aviation company
- A shared/open facility dealing with MEMS
- A shared/open facility dealing with photovoltaics
- A Research institute dealing with nano-devices and nano-machines with biological applications
- A research institute dealing with biofuel production from algae

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