Competitiveness through Integration in Process Industry Communication

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TEKES

Competitiveness through Integration in Process Industry Communities

Evaluation of Technology Programme “Process Integration 2000–2004"

Evaluation Report

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Tekes – Your contact for Finnish Technology

Tekes, the Finnish Funding Agency for Technology and Innovation, is the main funding organisation for applied and industrial R&D in Finland. Funding is granted from the state budget.

Tekes' primary objective is to promote the competitiveness of Finnish industry and the service sector by technological means. Activities aim to diversify production structures, increase production and exports and create a foundation for employment and social well-being. In 2006, Tekes will finance applied and industrial R&D in Finland to the extent of 460 million euros. The Tekes network in Finland and overseas offers excellent channels for cooperation with Finnish companies, universities and research institutes.

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Tekes' technology programmes are an essential part of the Finnish innovation system. These programmes have proved to be an effective form of cooperation and networking for companies, universities and research institutes for developing innovative products, processes and services. Technology programmes boost development in specific sectors of technology or industry, and the results of the research work are passed on to business systematically. The programmes also serve as excellent frameworks for international R&D cooperation.

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Abstract

This is a report on the evaluation of Tekes, the Finnish Funding Agency for Technology and Innovation, technology programme Process Integration 2000–2004. The programme was launched in order to enhance the value chain management of Finnish process industries by developing and applying integrated and system-oriented methodologies to the management of energy, material or information flows. The programme supported 35 public research projects and 22 company product development projects.

The evaluation was based on publications and background material produced by the programme, interviews of 30 persons participating in the programme in different roles, and a web- based survey for all programme participants (260 were addressed, 130 answered). The evaluation also included benchmarking with a process integration technology programme carried out in Sweden in 1997–2004 by the Swedish Energy Agency (Energimyndigheten).

The analysis of programme impact was based on a conceptual framework (Happonen 1999), where the R&D system is analyzed by considering both the actual outputs of the system and the underlying structure of Communities of Professional Practice that enables the results.

The Process Integration programme brought together research teams and industry professionals from many backgrounds. The scope of the programme included process integration related issues in a rather wide sense, covering generic optimization and design methods as well as methods for information management during the lifecycle of a process or a production plant.

The programme has activated research work in modelling and simulation. Some projects led to the successful industrial application of methods developed during the programme. In most cases, however, the results are at their best at a conceptual or prototype level. Major changes in industry strategies or practices due to new tools and methods are possible, but will take years.

The main result of the programme was the enhanced networking and creation of communities among process professionals of different backgrounds. This creates a platform for future new developments and contributed e.g. to an extensive industry initiative for the standardization of plant design and maintenance information.

Contents

1 Background of the evaluation

Tekes, the Finnish Funding Agency for Technology and Innovation, uses technology programmes to allocate its financing, networking and expert services to areas that are important for business and society.

Tekes technology programmes are always evaluated at the end of the programme. Evaluation seeks to provide feedback on how the programme aims have been realised, to find out how relevant the programme is and to produce information to support the strategic development of programme activities and the activities of Tekes in general.

The main target of this evaluation was to analyse the challenges of strategic change within process industries and the relevance of the evaluated Tekes programme in meeting these challenges. Recommendations for the development of Tekes technology programme activities in general were also looked into.

The evaluation also included a benchmarking study comparing Tekes' approach for the advancement of Process Integration technologies with the approach adopted in Sweden, where the national energy authority (Energimyndigheten) funded and managed an R&D programme of the same name (Process Integration).

2 Process Integration programme

The programme **"Process Integration 2000–2004, Enhancing the Value Chain Management"** (PI programme), was started at the beginning of the year 2000. The term Process Integration was given a broad meaning in the programme. Consequently, the programme supported industrial process technology development projects in which energy, material or information flows were involved. The focus was on projects where integrated and system-oriented methodologies were developed with a view to improving the competitiveness and productivity of the processing industries.

The programme covered generic optimization and design methods as well as methods for information management during the lifecycle of a process or a production plant. It also supported projects which implemented simulation tools in the processing industry and improved decision-making at all levels of the industry.

The PI programme supported 57 projects at an overall cost of 23 million euros during 2000–2004. Process Integration national seminars were organized each year, with participants both from the industry and research communities. These seminars presented the results of the projects and their future impacts on the processing industries.

The programme sought to enhance the productivity and competitiveness of process industries through the development of tools, models and methods for the design, optimization, operation and management of these industries.

The programme focused on three main development areas:

- Development of Methodologies for Process Optimization and Design
- Development of Methodologies for Information Management
- Development of Process Integration Measurement Tools.

The PI programme aimed at fostering strategic change in the process industry. In this respect, it represents a rather novel type of Tekes programme. The programme was planned to gather together process design, optimization and information management expertise on a national basis in order to boost methodological development that would enable strategic change and a renewal of value chains within the industry.

The Process Integration technology programme addressed a system consisting of process industries in Finland, the companies providing equipment, systems, software or services for process industries and research parties such as universities and VTT (Technical Research Centre of Finland). Fig. 1 describes this field of actors and the role of Tekes as enabler, initiator and shaper of joint projects.

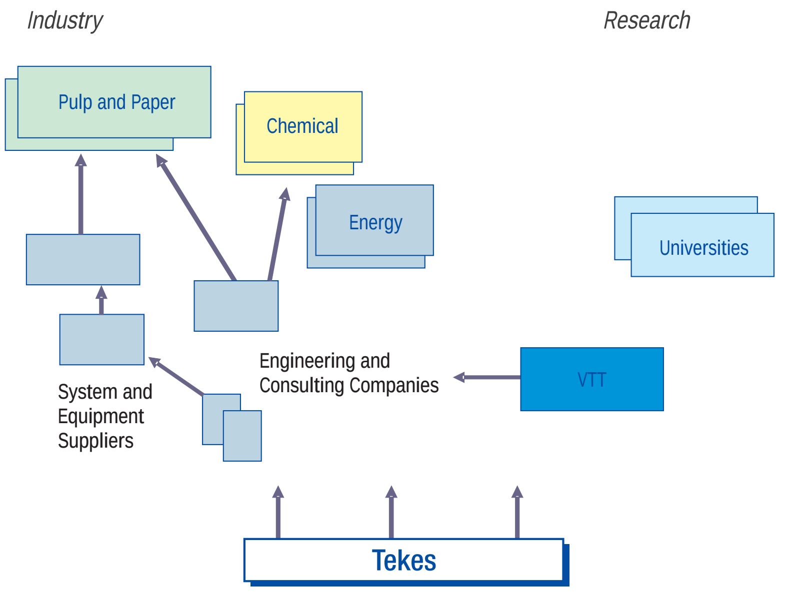

Fig. 1. The sector system of innovation for the PI programme.

The industry sector addressed by the programme is the traditional process industry, at the core of which is the pulp and paper industry. Similar process integration challenges are relevant also in chemical and energy production. Driven by pulp and paper producers, there is an established cluster of domestic equipment suppliers and engineering companies. The relationships between industry and research institutions are close.

3 Implementation of the evaluation

3.1 Theoretical framework

To a large extent, the PI programme was expected to result in new ways of thinking, organizational changes and operational practices in enterprises. To shed light on these types of phenomena, the evaluation was based on the theory of communities that create new knowledge. Evaluation of the technology programme and the interpretation of the results are based on the conceptual framework presented by Harri Happonen (2001). This framework combines the R&D process and the individual and collective knowledge associated with it. Happonen has applied a more general model presented by Ilkka Tuomi (1999) to large R&D projects consisting of many subprojects and involving persons from several organizations.

Happonen describes an R&D system as depicted in Fig. 2.

According to this model, an R&D system consists of the Process Dimension and the Knowledge Dimension. The Process Dimension includes all goal-oriented business, implementation, and production processes, procedures, tools, documentation, etc. Process dimension often allows quantitative evaluations of goal achievement, time schedules, efficiency of resource usage, etc.

Knowledge Dimension and Communities of Practice

The Knowledge Dimension is a social system consisting of partially overlapping Communities of Practice (CoP). Each CoP is defined by shared themes that are developed further by the contributions of its members. CoPs learn, evolve, and change while working together and they develop new, shared language, methods, values, etc. Also their target setting is evo-

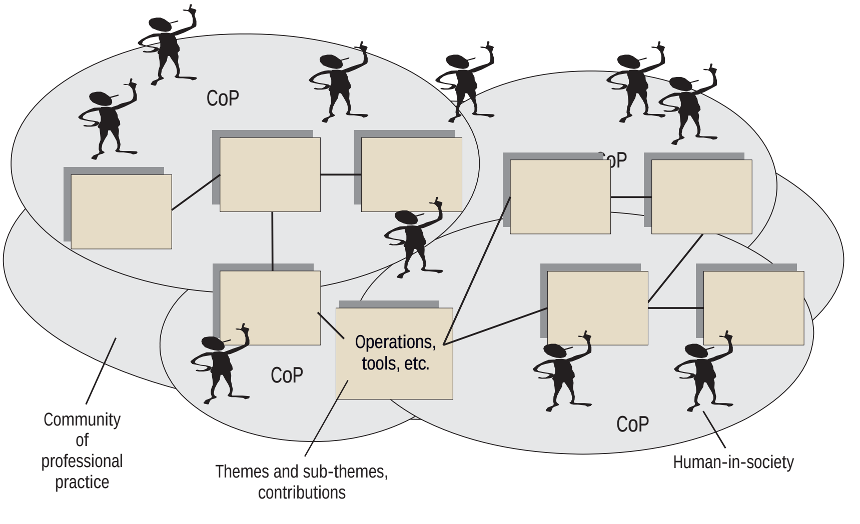

Fig. 2. R&D system. (Happonen 2001)

lutionary. Communities of Practice are the enablers and operational environments of innovation processes. Individual persons are members of several overlapping CoPs. Thus in a development project of several parties participating persons each represent their own primary organization, share its language and values and give only a part of their time and attention to the joint project.

Evaluation of Communities of Practice is performed through identifying CoPs, observing their evolution and evaluating their capability to host learning and innovation processes. The selected approach can be applied to a single industrial plant, an enterprise, project, or e.g. to an entire technology programme.

The model presented is applied in this study through the idea that the evolution of themes in communities is essential for the generation of new knowledge. Evolution is driven by the mutation, combination and copying of themes and by the competition of themes for the limited attention capacity and valuation in human minds. The capacity of a community to create new knowledge can be assessed by evaluating how favourable an environment the community provides for evolution. The characteristics of favourable environment would then be e.g.

- The community (project team) includes complementary expertise and variety of points of view.
- The participants share enough common language to enable communication.
- The participants have enough time and means to communicate with each others
- The participants consider the work to be important so that the team can generate an atmosphere of enthusiasm, which is strengthened by successes and mutual encouragement.

On the other hand, a lack of results may be caused by different reasons:

- Different outside communities, where the project team members belong, set priorities, targets and values that conflict with each other. Failure to create a shared value base for the project.
- Communication within the team does not work for some reason.
- The competence portfolio of the team is too narrow.
- The team has insufficient capability for appropriate knowledge from outside.
- Project targets lose in the competition for time and attention.

This kind of analysis may help us to understand what is happening in the Knowledge Dimension, which is the enabler of the more concrete and visible processes in the Process Dimension. The functioning of the Process Dimension allows a more direct evaluation in terms of results, intermediate results, quality, time schedules and costs.

In this study, the model shown in Fig. 1 was applied to the structure of a technology programme. All visible activities of the programme and the results of its projects form the process dimension of the system. The methods developed, software, implemented changes of processes, reports, dissertations, etc. are included in this dimension. However, the visible results are only a part of the impacts of the programme. This is especially the case in a programme aiming at changes in industrial processes and value chains with very long lifecycles. Much of the change induced by the programme consists of the development of knowledge within participant communities, which in turn enables more concrete and implemented improvements in the future. The impact of the programme can be better covered by also observing the knowledge dimension.

3.2 Material and methods

Interviews

Thirty persons were interviewed for the evaluation. These persons had been active either in the R&D projects or in the administration, e.g. steering groups. They represented different parties as follows:

- Research, 10 persons
- Process industry enterprises, 6 persons
- Equipment, system and service providers, 11 persons
- Tekes, 3 persons.

The interviews were semi-structured theme interviews. The persons gave quite informally their views and experiences about the programme and significant issues within it. Abackground guideline was used consisting of evaluation questions addressing the whole programme as a whole:

- How relevant was the challenge provided by the programme from the process industry point of view?
- Was there room and/or a need for a new type of thinking in the different industries? Are there differences between industries (e.g. pulp & paper, chemical,) in this respect, and if so, what factors have influenced this?
- What kind of results were obtained in the research and enterprise projects of the PI programme?
- Did the programme manage to incorporate process integration thinking into the planning practices of the industry?
- Which factors promoted/prevented the adoption of the results in the industry?
- What did adoption of the new way of thinking require and will require of process industries and research?

Because many of the interviewees had seen the programme in practice through one of its projects, the following project-related questions were addressed as well:

- Which parties participated in the project?
- What are the important and relevant themes in the different phases of the project?
- What has each party seen as important?
- What did the different parties contribute to the project?
- How did the thinking change during the project?
- Were common tools, methods or language created?
- Has the project influenced the strategy?
- What was useful in the project and what not?
- What kind of things in general would be useful from the process integration point of view?
- The role of Tekes?
- What was learned, what not, why not?

Two key persons on the process integration research programme in Sweden were separately interviewed for benchmarking.

Web-based survey

A web-based survey was sent to all persons who had participated in the programme. Altogether 260 persons were invited to take part in the survey and 130 of them replied. Half of them represented universities and research institutes, and half were from enterprises. The survey examined the community structure within the programme, and the preferences, expectations and opinions of the participants about the programme. There also was a project related part, where participants of individual projects could assess the characteristics and results of their project. Free form feedback and suggestions on how to improve Tekes programme activity could also be given through the questionnaire.

4 Evaluation results

4.1 The term "Process Integration"

In its strictest sense, the term Process Integration is used to mean the optimization of energy flows in industrial systems. Generally, the term Process Integration has meant integrated and system-oriented planning, operation and the optimization and management of industrial processes. The Process Integration 2000–2004 technology programme in Finland took a new view on process integration by setting the overall mission to develop tools and methods to enhance value chain management of the processing industries.

The term Process Integration was given a broad meaning in the programme. The programme supported industrial process technology development projects involving energy, material or information flows. It covered generic optimization and design methods but – based on a broadened definition of process integration – also methods for information management during the process or plant lifecycle. Additionally, it also supported projects which implemented simulation tools in the processing industry and improved decision-making at all levels of the industry.

Although "stretching" an internationally established term for programme internal use can be questioned, the selected approach may have contributed to the success of the programme. The programme has created around the enhanced process integration theme a community consisting of industry, service providers and researchers. The flexibility of the theme enabled this community to address more useful substance than would have been the case if the programme had been limited to pure energy optimization.

The forming of new enhanced concept of process integration has been a measurable indication of an emerging new community of practice.

4.2 Strategic change as an objective of the programme

Basis for slow change has been created

The most ambitious objective of the Process Integration programme was to encourage the process industry towards strategic change so that entire value chains would be renewed through enabling new methods and more holistic thinking. Already in the preparation phase, this was known to be a challenging target.

In practice, the results of the programme consisted of two parts: the development and implementation of new methods on the one hand and the creation of innovative communities around the themes of process design, optimization and information management on the other hand.

The generation of communities formed by researchers, process industry key persons, engineering service providers and equipment suppliers has probably been the most important and lasting impacts of the programme. If the change of process industry practices and the value chain renewal targeted by the programme materialises in future, it will be through the cooperation of these people.

Whilst the strategic target setting has been challenging, change is necessarily slow and the visible results during the five-year period of the programme are not big. However, the communities created have futhered the intended change. Individual results were obtained, and changes due to the programme are under way. Visible strategic changes will take place maybe within a time span of ten years.

Tekes' programmes and added value of the programme

A technology programme seeks to bring together research and enterprise and to direct joint development effort towards areas of national importance. A programme should be more than the sum of its parts. The PI programme definitely meets this criterion.

The programme was led by a steering group comprising industry representatives, together with a programme manager and Tekes representatives. The PI programme steering group shaped the programme strategy and selected the research projects to be funded. The idea was to give steering influence to the party that would ultimately benefit from the results and to gain the commitment of the companies to the programme strategy. The influence of the steering group was somewhat limited by the fact that it had meetings only a couple of times a year. Between the meetings, some steering group members have had a significant role in promoting programme goals in their own organizations and networks, while others have been participating only in meetings.

Since there is strong demand for research project funding, the research activity can be directed by selecting those applications best suiting the goals of the programme. Enterprise project applications are typically scarcer in technology programmes and it is not always obvious how an individual project is part of the programme. In some cases this question is also valid in the PI programme, although the enhancement of Process Integration definition during the programme has enabled a broader spectrum of different research initiatives. Ideally, a research project is carried out earlier in the programme and its results are later implemented in enterprise projects. Good examples of this kind of linkage can be found in the PI programme as well.

If all funded projects in a technology programme are successful, this probably means the risk level for the funding was set too low. The PI programme has been sufficiently challenging in this respect.

4.3 Process industry point of view

The role of the PI programme subject area in companies' strategies

In general terms, companies see process integration as part of their strategies. Energy and material efficiency are key strategic themes in the process industry. However, it seems that in practice the process industry is not always very willing to experiment and develop new efficiency improving methods. The industry would like to have process technologies and methods developed and offered by reliable vendors who have proven products in competitive prices. Own risk taking and development tends to be directed to operations towards own customers, like the development of new products and marketing.

The persons interviewed widely agreed that the challenges and targets of the PI programme are relevant for process industries. This is the case especially after the programme scope was enhanced to include plant information flows and their development during the entire lifetime of the plant. The results can also be interpreted to mean that process industry enterprises see the programme themes as a collection of potentially useful operational tools rather than as strategic drivers.

The use of new tools and ways of thinking are more likely to spread through engineering companies and system suppliers, for whom the themes of the PI programme are at the core of their strategies. In the long run, there will also be a change in the practices and priorities of the process industry itself.

4.4 Influences and resources of the programme

The projects

A great deal of the work in the PI programme involved modelling and simulation for industrial processes. In this field there is an obvious need in all branches of process industries. The implementation speed is perhaps not so much dependent on the way of thinking than on the speed at which the enabling technologies evolve. As the basic grade of automation, information processing tools and the competences of solution providers improve, there will be room for industry applications within the limits set by general caution and case by case payback requirements. In this development it is notable that the process industry is normally not very willing to use small suppliers, and would prefer to work with established vendors at least in projects that are operation critical.

Figure 3 shows a map of the projects of PI programme. The ovals represent research projects and the boxes enterprise projects grouped according to application areas and generality. In some cases research projects led to enterprise applications during the programme time. Such cases are indicated by blue arrows in the map.

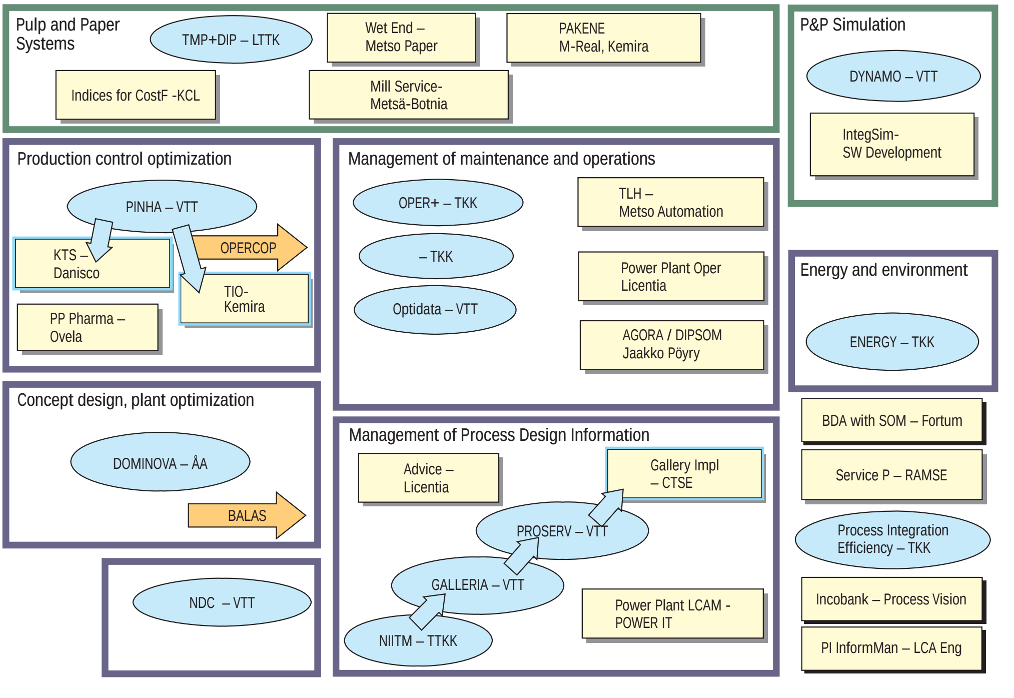

Fig 3. Project map of PI programme. Ovals are research projects, boxes enterprise projects. Blue arrows show “heritance” of the subsequent projects.

Some comments about the achievement of the target and relevance of strategic areas of the programme:

Generic planning and optimization methods

The objective was

- *"to develop generic methods which support Value Chain Management in the processing industries and which have significant industrial applications as a basis"*

In this area, the role of basic research was significant. The results of one research project (PINHA) were applied in two enterprise applications within this project for optimization of batch processes. The applications can be classified as pilots. How widely the methods will come into use remains to be seen. Otherwise the research projects and enterprise projects within the programme were separate.

Implementation of simulation systems and tools

The objective was:

- *to implement simulation systems and tools for process design and optimization during plant operation, and*
- *to generate competitive simulation tools and prove their benefits in process design"*

Simulation models for pulp and paper processes were built, and a VTT power plant simulation tool was extended with forest industry specific features. Developing the tools into packaged and sellable products would still need effort. Another paper industry simulation tool was developed in a separate enterprise project.

Development of multicriteria decision making tools

The objective was

- *to develop a methodology which supports multi-criteria decision-making during the life cycle of a process,*
- *to develop software tools and generate service businesses based on the methodology, and*
- *to develop a system for the measurement and evaluation of the benefits of Process Integration*

The programme developed a methodology which was applied to the design of industrial plants in case studies. The method forms a doctoral thesis to be published in 2006. Whilst the method is promising, the implementations yet remain to be seen in practice.

Forest industry applications

A number of system development projects addressed specific problems in the pulp and paper industry, and gave participating enterprises know-how and solutions. The projects typically neither have links with research projects of this programme, nor with any other research party initiatives. By funding these types of projects Tekes has supported research subcontracting from VTT or universities and so promoted networking and information exchange between the research world and enterprises.

Development of information management systems

The objectives were

- *to develop flexible procedures and operations for information management during the lifecycle of a plant, and*
- *to develop software solutions based on open standards which are specific to branches of industry and support cooperation between multiple partners.*

Process design information management formed a sequence of projects during the programme. The basic work of the NIITM project was continued by creating a design model gallery in the GALLERIA project and a plant lifecycle service framework creation in the PROSERV project. The model gallery has been implemented in an engineering company in a subsequent enterprise project.

A breakthrough in process design information management was reached near the end of the programme when it was discovered that several parties in the country had been working on attempts to define and standardize partially same field. This led to a wide joint initiative of the industries to work on the development of standards and tools for design data management.

Energy and environment

The role of traditional process integration, i.e. the optimization of energy flows, remained very minor in the PI programme. Using traditional methods, a study of the investment options for regionally integrated heat and electricity production was carried out. The steering group did not think that substantial methodical innovations in energy integration would be likely and did not allocate major funding to this subject during the latter half of the programme.

Separate enterprise projects

The programme funded some enterprise projects that do not fit into the grouping above, but whose themes were sufficiently close to the selected Process Integration interpretation.

What was expected of the projects?

In the survey, the participants were asked what kinds of expectations were initially set for the project results. What the participants had most expected was the deployment of new methods. Networking with subject matter experts, product concepts that could possibly be commercialized and scientific results were expected to a moderate extent. All the results mentioned were also obtained. However, the most widely achieved result was learning. Patented inventions and commercial products were neither expected, norobtained.

Forming Communities

Building communities of practice was a central form of implementation of the programme and also of its result. A community is created when the participants generate shared language and also when the participants' valuations of the central themes are aligned to some extent. Diversity and disagreement are a prerequisite for the generation of new points of view, but on the other hand some amount of consistency is needed to enable meaningful communication and the building of shared knowledge around common themes.

The evaluators had a hypothesis that there would be significant systematic differences between the research and enterprise parties regarding the priorities of some issues meaningful in joint projects. The survey reveals, however, that on the whole, research and enterprise people agree about the priorities of essential issues.

Fig. 4 shows a comparison of the answers of research parties and enterprise parties to the question of what is important in design and lifetime maintenance of an industrial plant.

We see that the priorities are very similar on both sides. There are few significant differences. Research people emphasize process safety, low emissions and suiting community needs more than enterprises, whereas enterprise people place more value on financial indicators and process availability.

Although there is quite much variation in the answers of individual persons, it seems that the research community and business world do not, as groups, have significant differences in the valuation of the observed issues. It would be very interesting to know to what extent participation in the same programme has created consensus and to what extent consensus comes from other background factors. Unfortunately

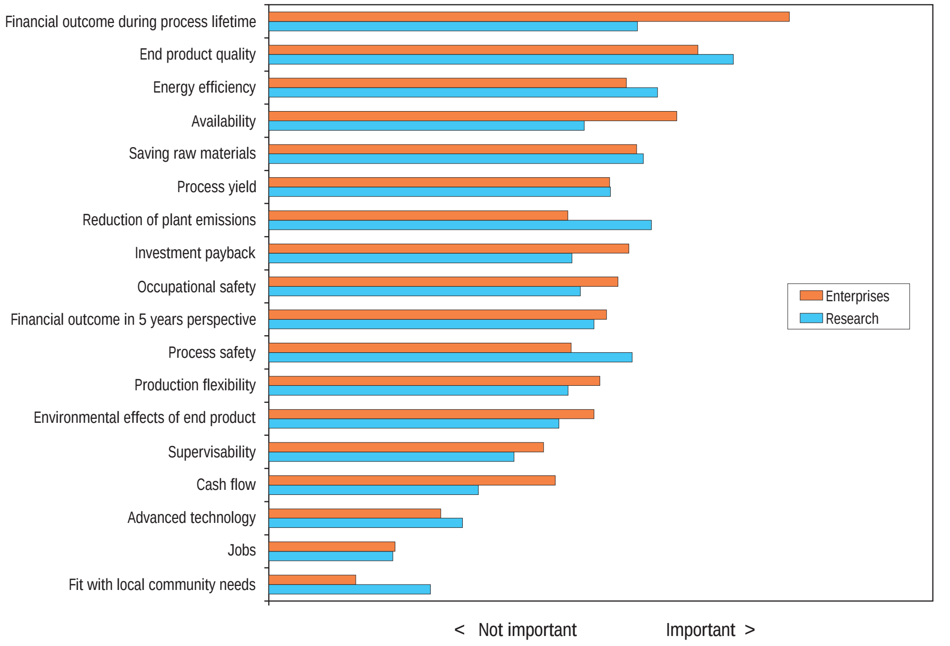

Fig. 4. The answers of enterprise and research parties to the question: What do you think is important in the design and lifetime maintenance of an industrial plant?

this question remains open in an ex post evaluation like this.

Because personal motivation is an essential factor in creative R&D work, the survey also included a question about the importance of various personal motivation factors associated with participation in PI programme work.

Also the personal motivation profile is amazingly similar for the two groups. All participants report issues associated with learning and new knowledge creation as being at the top of the list and career opportunities and salary are reported as being of less importance as motivators.

Expansive networking

The influence of the programme as generator of new expanding communities of practice and expert networks can be estimated by observing the amount of new contacts brought by the programme to the participants. If the group of programme participants was always the same set of national actors that had been co-operating before, the programme promoted by Tekes would have had no effect on creating a new, expanding network.

The participants were asked how many new cooperation contacts with different kind of parties were established as a result of the programme. It became clear that the programme had an essential influence in creating contacts that would not otherwise have been in place. Because of the programme, most respondents obtained new contacts to more than one domestic research institute and more than one domestic enterprise. The national character of the programme is evident in the fact that only few respondents within this programme have got to know anybody outside Finland.

Knowledge transfer through persons changing place

Communication between the persons in communities is not the only way for the communities to learn from each other. An essential part of knowledge liquidity and accumulation has to do with persons that move from one community to another, retaining their social bonds with the persons of their old communities. These bonds often live longer than the communities do, and they form an essential part of organizational learning infrastructure.

Fig. 5 from Harri Happonen illustrates the idea of social bonds as a valuable “heritage” of dying communities

In order to study the knowledge transfer by the people changing positions, the survey also studied movement between employers after participation in the programme. Twenty-three persons of all respondents (18%) had changed to another employer. Fig. 6 shows the movements between different employers.

The movement of people between research and enterprise worlds is almost exclusively in one direction. Some people who started their career with VTT or universities move to the enterprise world and stay there. Only one respondent has moved from an SME to VTT.

This uni-directionality, caused mostly by differences in salary levels, is rather natural and benefits the enterprises. However, it would be beneficial for the research work and for multiparty projects if there was more industry experience in the research community. It rests with the innovation infrastructure designers and promoters to find ways to impact on this.

Participants in the projects of the PI programme have stated that it takes between approximately six months and a year to create a common language in a group consisting of research and enterprise parties. Only then does the teamwork really get going. This observation is relevant when the duration of funded projects is considered, but it also emphasizes the benefits of having more industry expertise within research communities.

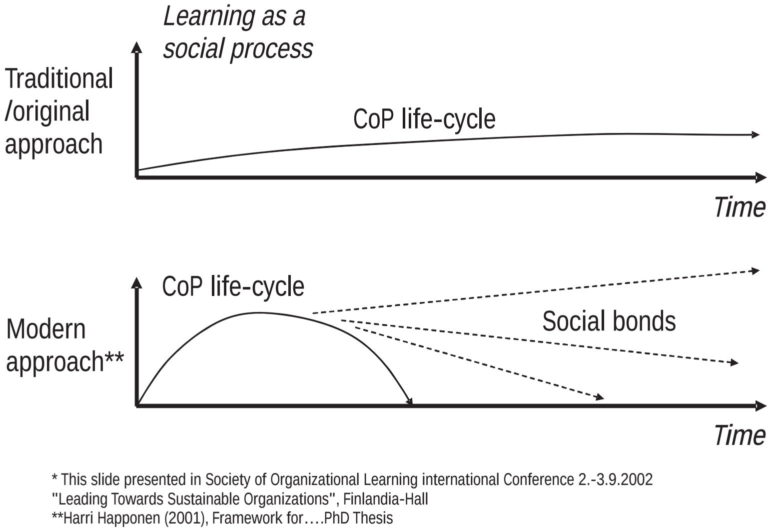

Fig. 5. The social bonds between people live longer than communities.

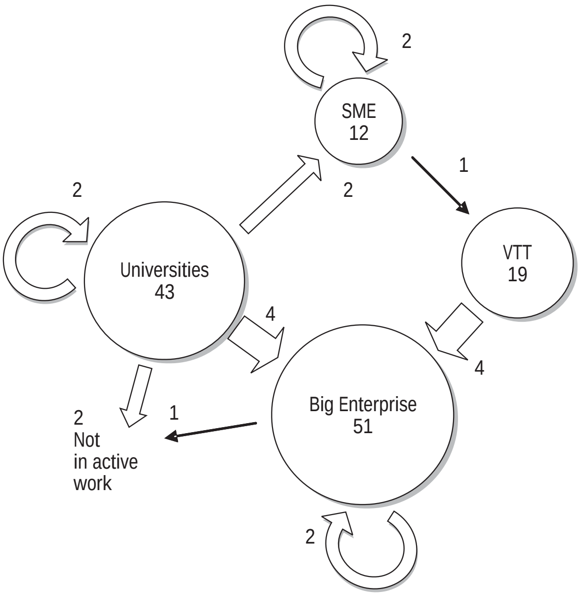

Fig. 6. Number of persons that have changed employer since participation in the PI programme.

The results of the PI programme from industry's point of view

The PI programme has to date not led to any visible changes in process industry plant design practices or widely implemented new methodology. Many enterprise projects started during the programme are, however, still going on and are expected to deliver actual results.

The industry is ready to widely employ only proven and validated methods and tools, preferably offered commercially by more than one reliable and established vendor. Before a prototype developed in a joint project between research institutes and enterprises has been developed to such maturity, there is a need for new types of actors in the chain. The layer of entrepreneurs who would take responsibility for finalizing the prototype method, package it as a product, commercialize it, market it and arrange maintenance is at present too thin.

Table 1 summarizes the evaluations of the programme by different parties.

In addition to industrial enterprises, many engineering companies participated in the PI programme. Engineering companies have a central role in implementing and developing methods of process integration. The deployment of new process integration methods is slowed down by the very long lifecycles of industrial production processes. This means plants almost always have to operate under the conditions of design that is decades old. Large process modernizations are rare and building new plants even rarer. Process changes normally take place only when the capacity is increased. During the time of the PI programme, the markets have not allowed many capacity increases in the process industries.

In practice, the possibilities to implement research project results in industry have often required the company to have a committed individual who has assiduously advocated application in the organization and ensured the resources in competition with all other important themes of the company. Where this kind of champion does not exist, nothing happens.

Table 1. Opinions of different groups of participants about the programme.
+++= Strongly agree with the statement, - - - = Strongly disagree.

	Research	Large Enterprise	SME
Goals of the programme are clear to me	++	+++	++
Participation made us redirect our resource allocation	+	-	+
We developed new things that we would not have developed otherwise	+++	++	+++
We got valuable support and guidance from the programme manager	++	+	+
We got valuable support and guidance from the steering group	+	+/-	-
The PI programme studies issues that are essential to business	++	+++	++
Our technology know-how increased remarkably because of the programme	++	+	++
The PI programme has changed our practices permanently	+/-	- -	+
The work that started in the programme continues after it	+++	++	+++

4.5 Benchmarking

The evaluation also included interviews of key persons of the Swedish programme Process Integration funded by the national energy authority Energimyndigheten. Although the programmes have the same name, the starting points and target scope of the Swedish programme are very different from the PI programme. The two programmes have had contacts with each other and in 2001 had a common introductory seminar.

The Swedish programme stays within the borders of the international definition of process integration ad thus concentrates in the optimization of energy flows and energy systems, considering the interfaces with other systems. The programme is linked closely to the work of the IEA.

Although the starting points of the two programmes differ and there is only a minor overlap in scopes, both programmes have met similar challenges. The practical implementation of the results has been slower than expected. The enhancement of the scope by the Finnish programme enabled a broader programme and more results, but made communication with colleagues in Sweden and internationally more difficult.

5 Evaluation of the selected approach

Looking at the communities of practice has been a useful approach, because the actual results do not show everything a programme has accomplished. The visible changes in processes and practices are anyway years away in the future. Evaluation of the communities and networking caused by the programme has helped to visualize the programme-originated changes that in a favourable case will lead to the renewal of industrial practices and value chains.

Analysis of the knowledge dimension and the communities of practice associated with the programme have been limited by the ex post nature of evaluation. The archive of visible results and intermediate documents of the project enables analysis of the process dimension afterwards, but the history of the knowledge dimension and conception and growth of communities are only in the memories of the participants. Survey tools and interviews can reliably examine only the present status of values, terminology and contact networks. It would be useful for future programmes if there was a toolbox that would be consistently used to analyze the knowledge dimension dynamics from the beginning of a programme all the way to its completion.

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