Mittuniversitetet
MID SWEDEN UNIVERSITY

Progress Report 2016

Research Environment for Transformative Technologies at Mid Sweden University

About our terminology
This is a short summary of the most important terms used in this document.

Research Action
Structured research project, program etc. that has specified goals, implementation plan and schedule.

Strategic Action
Strategically important Research Action. Currently we have four Strategic Actions; **e2mp, FORIC, EISS** and **KM2**.

Development Area
Initiative to build a new Strategic Action. Currently we have two Development Areas; **Measurement Systems** and **New Cellulosic Materials**.

Research Area or Competence Area
A research direction whose definition depends on context and can change with the evolution of science and technology. Thus Research Areas can overlap and do not correspond to the organizational structure. Currently we have two internationally recognized strong Research Areas, High-yield Pulping and Embed-ded Sensors, and one area, Nanomaterials Systems, where our goal is to reach such a status.

Research Group
Organizational unit that has a group leader. 17 research groups currently belong to our Research Environment. Each of the strong Research Areas is driven by one strong Research Group and supported by others.

Research Environment
In our case, this means the environment called **Transformative Technologies** formed by the two research centres STC and FSCN. This work plan concerns the development of the environment into one strong and coherent entity. The Knowledge Foundation supports this development with their funding program KK Miljö (KK Environment).

Core and Edge
Core refers to to the core business of our partner companies. Edge refers to areas of new businesses of these and other companies. Edge business is the driver of industrial transformation that Core business can enable.

Please note our notation: Research Actions are marked with bold font, key concepts with Capital Initials, and strategic goals with *italics and underlining*.

Mid Sweden University in partnership with

Knowledge Foundation

Progress Report 2016
Dnr: Mid Sweden University 2016/695
Photo: Tina Stafrén
Feature: Processing of nanocellulose in the wood and materials laboratory,
FSCN Research Centre, Mid Sweden University
Print: Print Office, Mid Sweden University 2016

Contents

Overview

Transformative Technologies is a joint Research Environment of two research centres, FSCN and STC, at Mid Sweden University. Our long-term goal is to give the university a clear research identity in technology and natural sciences, and to help the surrounding society accelerate industrial renewal and regional growth in line with the *TIE Vision Transforming the Industrial Ecosystem.* Our research addresses three areas related to EU´s Grand Challenges, Bio economy (resources), Renewable Energy, and Internet of Things. We continue the dialogue with the research centre CER – Centre for Economic Relations in order to include Change Management in the educational programs and research of Transformative Technologies.

FSCN has its base in the collaboration with paper industry and STC with technology companies working with process steering. Both centres have worked a lot to improve resource efficiency in what we call the Core business of the partner companies. For example, we have recently demonstrated at industrial scale how to save 15-30% of electrical energy in mechanical pulping, depending on the paper grade. We have also illustrated that more savings in operating and investment costs are possible through process intensification.

The ambition for industrial transformation has meant that our research focus has increasingly moved to enabling new business development, or the Edge business. This has also meant that our industrial networks have grown broader. One example is the Strategic Action **EISS** for wireless control in industry where we collaborate with new technology companies.

Figure 1 shows how the share of projects with <u>new</u> industrial partners and support to the <u>Edge</u> of industrial development grew last year, in line with the *TIE Vision*.

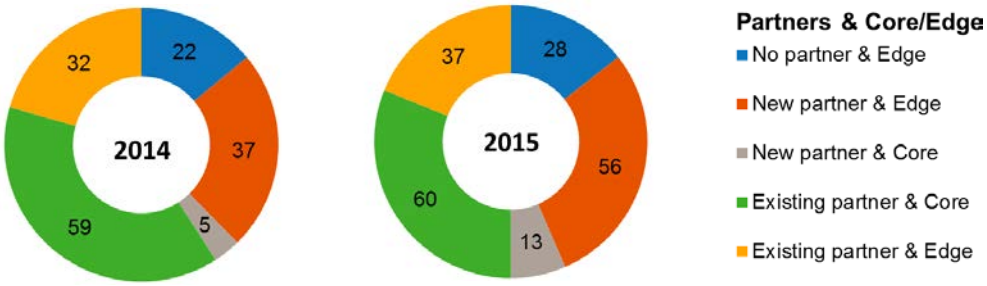


Figure 1: *Externally funded project portfolio (total size of active projects) divided in the nature of co-production partners and industrial development (Core vs Edge). Numbers show total granted volumes in MSEK for ongoing projects. "No partner" refers to e.g. VR projects.*

Last year we had in total 142 researchers, including 54 graduate students (see Indicators 1 and 2). After a drop year before the total number was back to the level we reached in 2012-2014. At the same time the education program is larger than ever, which means that the research effort per researcher is smaller: last two years the FTE per researcher has been 0.59-0.61 instead of 0.65-0.68 as before. This is a good trend because with time it will allow us to broaden our competence base through recruitments. Our goal is that the total number of researchers will grow to 160 – 170 by 2018.

INDICATOR 1. Total number of researchers

Year	2010	2011	2012	2013	2014	2015
No of Researchers	110	134	143	144	132	142
FTE		89,62	93,95	98,02	80,98	84,43

INDICATOR 2. Number of PhD students

Year	2010	2011	2012	2013	2014	2015
PhD students	45	57	63	60	47	54
FTE		42,57	47,56	46,55	31,9	36,72

The number of PhD students (Indicator 2) decreased after 2013, but is also increasing again and will continue to do so especially if the second stage of the industrial graduate school **FORIC** starts next year. The earlier drop was caused by the large number of graduations, 44 in the last three years. This also affected the academic production (Indicator 5). The level of FTE in Indicator 3 corresponds to 0.68-0.69 per PhD student in 2014-2015. This is lower than the level 0.76-0.78 two years earlier but can be explained by the fact that many students were in the final intensive phase of their studies in 2012-2013.

In addition to the industrial graduate students, more than half of the graduate students employed by the university leave after graduation. Some continue their academic careers elsewhere (including places such as Harvard University) but most who leave go to industry. This means that our graduate education makes a strong competence contribution to industry.

The scientific production has been fairly stable in recent years (Indicator 5). This is in accordance with the 3-year Plan that puts emphasis on improving the scientific quality instead of quantity. Examples of scientifically exciting results from 2015 include a new technology for adding RF functionality to large surfaces using low-cost printing, which enables new transformative applications. Other examples are observations on how the structure of nanocellulose-graphene/graphite composites affects electrical conductivity, and how metallic nanoparticles can be co-generated with cellulose to form antibacterial materials.

INDICATOR 5. Number of scientific publications

Year	2010	2011	2012	2013	2014	2015
Article in Journals		75	90	58	83	69
Conference Articles		67	63	69	49	45
Total		142	153	127	132	114

In the 3-year Plan we thought of selecting our own list of "high-quality" journals to measure quality, but that could have been biased towards our current publication preferences. We have therefore decided to use the Norwegian score to follow how the scientific quality improves. The results measured in this way show positive progress in the scientific quality. In the ARC13 evaluation the 2012 Norwegian Score of FSCN and STC together was 104 or 0.68 per publication. Last year the score was 94, or 0.82 per publication, which is clearly better.

Research Program

During 2015 we have continued to sharpen the content and national positioning in each of the Strategic Actions. Several strategy processes were also run. The progress and main challenges in each of the Strategic Actions are described next.

Manufacturing in industrial scale – e2mp

Here the starting point is in improving the Core business of paper industry. For a university we have the unique ability to run productions-scale research at mill sites and scale laboratory results up to industrial production. After the 3-year Plan was written we have realised that the competence we have in high-yield pulping actually covers most of the industrial processes in pulping and papermaking. This is why we accordingly updated the title line of the strategic action.

The national industry initiative **e2mp-i** finished last year and the results were compiled to a large report. The profile **e2mp-rp** will end next year. The technical research in these two programs has been successful. The partner companies are satisfied with the concrete results and have strong interest to jointly continue the collaboration with us. However, the appropriate structure for the next step after **e2mp-rp** (tentatively called **RETTWOOD**) is still to be decided.

The fundamental research in **e2mp-rp** has rendered some publications in high-impact journals but overall the results have not been as many as expected. We are therefore evaluating possible areas of more *exciting* academic studies (cf. *TIE Vision*) that can lead to international collaborations. Funding from different sources

have been received for particle modelling of chip feeding and studies of crystalline nanocellulose on the new pilot machine in Örnsköldsvik. The HÖG project now starting in the latter area is particularly valuable for our academic visibility.

The research profile and industry initiative have primarily addressed energy efficiency in the manufacture of different paper grades. Research on packaging materials has grown in parallel because of strong industrial interest in the renewal of product portfolios. The synergy proposal **e2cmp** in Work Plan 2016 and a new HÖG prepared to Work Plan 2017 have been initiated by two separate company groups. A third constellation is behind the nanocellulose project that aims at a new packaging material (and hence the business Edge). The research line on packaging materials is important for strategic reasons, (1) it gives us a strong role in the industry transformation from printing paper to packaging materials, and (2) it demonstrates the generic nature of our competence on industrial pulping and papermaking. Both are in line with the updated focus on manufacturing in industrial scale. In Work Plan 2017 we will further strengthen that identity through the recruitment of another professor with industrial background. Appendix A reports systematically our progress in relation to the action plan of June 2015 that was submitted after the half-time evaluation of **e2mp-rp**.

Process control and monitoring – EISS

Our purpose in **EISS** is to apply the concept of Internet of Things to change how industrial manufacturing processes are controlled and monitored. There are many such initiatives areas around the world. Our approach is special in that it combines the development of hardware, software and communication in strong collaboration with companies. Our research targets are therefore connected to real challenges and characterised by a multi-disciplinary approach that we believe will enable unique solutions. The industrial value comes both from new business models (Edge business) as well as from securing competitiveness in existing markets (Core business).

The research program and strategy are built around the Synergy **ASIS.** We will develop a smart sensor that can harvest ambient energy to process measurement data in the sensor and communicate it wirelessly to control system. The new adjunct professor and international guest professor of Work Plan 2016 bring in technical expertise that is vital for success in **ASIS**. Another two recruitments are planned for Work Plan 2017 to strengthen the industrial and international networks. With these enforcements we will be well equipped to plan for a KK Profile application in this area in Work Plan 2018.

In addition to industrial sensors we study infrastructures for Internet of Things. As the ERDF program (ERDF = European Regional Development Fund) did not accept any research applications last year, the large **SMART** project has been postponed to start this summer provided funding is granted. To secure the necessary resources we have applied for two KK Prospects, one starting this year and one planned for 2017. Within Transformative Technologies, the Strategic Action **EISS** has a key role in building new international collaboration. Three international scientific missions were made last year that led to a Horizon 2020 application and planning of a COST network in wireless communication and in-sensor processing.

Development Area Measurement Systems

Here our starting point is the strong and wide competence base that was created in the KK Research Profile **STC - Sensible Things that Communicate**. The challenge is to form a coherent strategic action with a clear identity. This is something that very few research organisations have succeeded in and measurement technology has become just a supporting technology for other areas. We want to create a strategic action because we see a lot of opportunities for both new business creation in new application areas (Edge) as well as improved competitiveness in already existing applications (Core). During 2015 we have developed a strategy so that the development area now can be defined as a Strategic Action. The strategy has two components that are connected through the common competence base. The vision for new industrial business development (Edge) will be “Including the environment into the industrial control loop”. It is supported by a Core part “Enabling inline industrial measurement for improved efficiency”.

In this area we have the strongest international networks, both with industry and academia. Major achievements last year were two new European projects: a large Horizon 2020 consortium in which we will collaborate on the installation of the European Spallation Source ESS in Lund, and a Marie Curie training network on imaging methods. Furthermore we were elected to organise the 2017 International Conference on Distributed Smart Cameras in Sundsvall. Our strategic challenge is to fully utilise these networks in the implementation of the new strategy. The guest professor who will come this spring from Italy is a step in this direction.

Of the new HÖG projects that are starting in 2016, one is enhancing surface analyses with X-ray methods, and another one will support our research on nanocellulose. We also started a collaboration on optical measurement systems with NTNU in Norway. These projects support the Core part of our strategy. The third new HÖG project initiates industrial co-production on environmental measurements, in line with Edge part of the strategy. In Work Plan 2017 it will be complemented with a synergy proposal and HÖG project.

Competence development for regional renewal – FORIC

The special feature of the industrial graduate school **FORIC** is that it attracts a breadth of companies and industrial sectors. The spirit in the school is very good. In the first year the number of publications exceeded our original plans. Status Report is shown in Appendix B as agreed with Knowledge Foundation. Now 20 companies are interested in enrolling students in the second intake. The only critical issues is that we must secure sufficient supervisor capacity for the new PhD students, if necessary through new adjunct professors. The new professor mentioned under **e2mp** will also help.

Our aim with the Strategic Action **FORIC** is to support the regional industrial transformation of bio-based business (Edge). For this purpose we are building collaborations with Processum and BioBusiness Arena. Funding for new projects is applied from the regional ERDF program (3 applications), Knowledge Foundation (2) and Vinnova (1 in preparation). The strategic value of the project proposals depends on the engagement of companies. International collaboration (especially InterReg) is also valuable but not specially targeted because of the regional focus. Some of the project groups definitely should also publish results in high-impact journals given the funding they have from VR and FORMAS.

Development Area New Cellulosic Materials

This is the smallest of our Strategic Actions. It is still under formulation, meaning that also the name is not final. As the working title implies, our goal is to build research that enables new materials and products (i.e. Edge business). The research so far has had a strong Complex Materials character, represented by the HÖG projects. These projects are building fundamental understanding of paper and fibre networks in general. We are unique in the use of particle mechanics as opposed to the continuum approach that dominates the research of paper materials in Sweden and globally. Our research is highly valued by paper industry. The crucial strategic question is what happens when Prof. Uesaka retires in the end of 2017. For time being we are not planning for a direct replacement.

Instead of fibre networks we have chosen to focus on the dissolution/regeneration and functionalisation of cellulose because of better outlook for transformative technologies. We are the first in Sweden to make use of a radically new concept of cellulose solubility. As a token of the scientific potential we received funding from both VR and FORMAS last fall. The first results of this research (e.g. the hybrid materials mentioned above) are very exciting. They are also an important demonstration of the potential that lies in cellulosic composites. We can therefore be much stronger in our nanomaterials research when we complement **KM2** with **New Cellulosic Materials**.

The new HÖG project that is now starting is the first industrial research project in this area and thus central for creating a strategic action. Another HÖG is under discussion but may not be in time for Work Plan 2017. We are already involved in two other industrial projects in BioInnovation and Horizon 2020 (on paper-based textiles and "plastic-like" paper) but there the target is demonstrations and thus little funding is allocated to research. The recent Vinnova application for a **Centre for Industrial Lignocellulosic Materials – ILC Pro** was an effort to accelerate the build-up of the strategic action, but the chances of actually getting the funding

are low, among others because of limited industrial support. However, we are confident that the interest from several branches will grow once we start to publish scientific results. International exchange is already growing and the outlook for new international projects is good.

Large surfaces for electronic functionality – KM2

Our target here is to build a technology agenda that combines the materials science and electronics expertise of FSCN and STC. We have worked on the research strategy and will complete it this year. The Strategic Action covers the manufacturing of large functional surface and the electronics components needed in products, which we believe will give us a unique position in Sweden. Central element in this plan is the Synergy application **LEAP**. The final application that was submitted to Knowledge Foundation has two important merits: STAGA AB is a credible partner for small-scale industrial manufacturing of the functional surfaces, and likewise AlfaLaval for products that could generate electricity from waste heat.

In the HÖG project on solar cells the research on material components and large-area manufacturing delivers results that support both **LEAP** and the development of large-area positioning. However, it seems that we cannot achieve sufficient photovoltaic efficiency with the inorganic materials we have evaluated. Our partner company Sol Voltaics is doing better with their nanowire technology (with 15% conversion efficiency). We will await the final results of the HÖG project before deciding if we should narrow our focus in **KM2** to waste energy sources (kinetic and thermal).

The development of kinetic energy recovery for vehicles progresses well, and new funding will be applied from several sources. On the equipment side the work on the necessary power converters is planned to continue in a new HÖG project. For the electronic connectors we plan another HÖG project to Work Plan 2017 on additive manufacturing. With these projects we will have a strong program on renewable energy recovery devices.

The research on positioning systems shares technologies with the other projects in **KM2**. It is important in bringing in other companies and leveraging on international networks. We will prepare such proposals to Work Plan 2017.

Development of Education

Since last year, we have worked on the educational programs more than stated in the 3-year Plan. The "employer councils" (samverkansplattform) for the IT Sector and Resource Efficiency give good support to the development of the master programs. Two KK-funded development actions are starting now, and we are preparing two more applications. If they are approved, our master programs will cover all of our Competence Areas, and each of our Strategic Actions will have a related education program. When writing the 3-year Plan we thought that industry would send their employees to these programs. The goal of 5 such students now seems challenging. Instead, company employees mostly attend individual courses. In addition, all our master students will work with companies through our research projects.

International collaboration and mobility

Table 1. *Main international collaborations during 2015.*

e2mp	Boards of Mechanical pulping conferences and Nordic Pulp and Paper Research Journal
EISS	H2020 application, 3 scientific missions to Southampton, Belfast and Klagenfurth, and 1 from Poznan
Measurement Systems	H2020 project, Marie Curie Network and InterReg project, all granted 2015
FORIC	New post doc from Guilin, China
New Cellulosic Materials	H2020 project and H2020 application, 1 new post doc from Canada; 2 scientific missions to Wuhan and 1 to Stanford (started 2014); membership in the EPNOE network
KM2	New post doc from Brasil

We have started to make good progress in internationalisation (Table 1 on the preceding page). Of the two research centres, STC has traditionally more international collaborations. Also at FSCN, the international mobility is now starting to increase. Three international post docs were recruited and one more is starting soon. In spite of all the activities the number of international guest professors has not yet increased (Indicator 3). However, two new professors will start this spring with funding from Knowledge Foundation. We expect the increase to continue as the volume of international collaboration grows.

INDICATOR 3. International guest professors

Year	2010	2011	2012	2013	2014	2015
Guest professors	2	2	2	3	3	2
FTE		1,35	0,55	1,2	1,2	1,25

Plans for further improvements are under preparation for Work Plan 2017. Given the importance of international exchange for research quality we will introduce new indicators: (1) number of international post docs, (2) number and total duration of international research missions (excluding conferences) in and out, (3) funding from international programs, and (4) number of publications with international co-authors.

Research Funding

The evolution of research funding for the Strategic Actions from 2013 to 2016 is shown in Fig 2. The volume for 2016 shows funding that has been or is expected to be granted, and it will still rise since many applications are pending decided. The delay and temporary closure of the regional ERDF program has strongly affected some of the Strategic Actions but the funding should recover somewhat now that the calls are opened. The differences in faculty funding come from our consolidation process, with a large proportion bound to persons and therefore changing only gradually. The Strategic Actions with well-established industry networks have more funding from the Knowledge Foundation. **e2mp** and **KM2** that focus on energy questions have high funding volume from the Energy Agency.

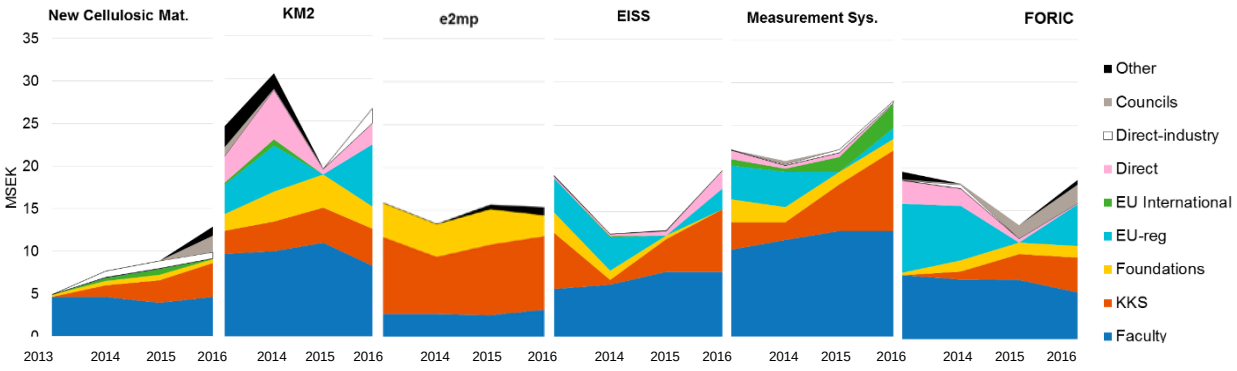


Figure 2. *Annual research volume in MSEK acquired by Strategic Actions during 2013 - 2016. The volume for 2016 will increase because many project applications are still waiting for decision.*

Figure 3 shows the project portfolio in 2015. **e2mp** and **Measurement Systems** are the extreme cases in the project structure and business focus. The former has a few large, mainly Core projects, and the latter many medium-size projects that cover all the three types of business focus. Versatility in the project structure gives flexibility but also demands continuous work with new applications.

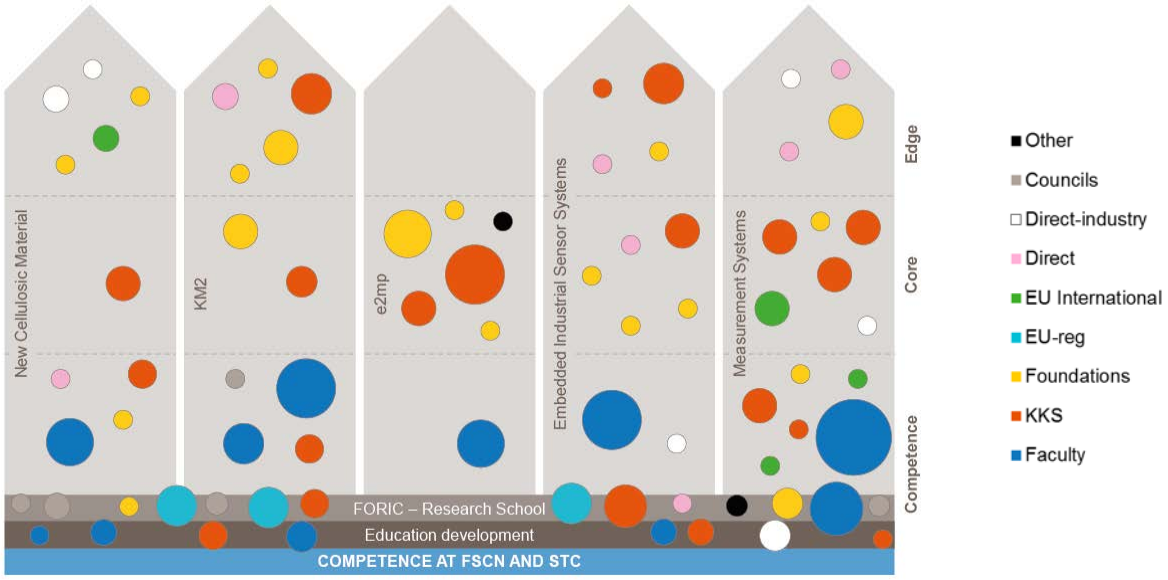


Figure 3. *All projects funded in 2015 according to the Strategic Action and the nature of industrial development (Core vs Edge). The volume of each project is shown by the area of the symbol: The smallest symbol ≤ 0.5 MSEK, and the largest = 12 MSEK.*

In Work Plan 2017 we will have funding targets for each of the Strategic Actions in order to broaden our funding base and, in particular, to win more international projects in the areas where the prospects are best. In comparison, funding from Swedish Councils (VR, FORMAS) has already reached a good level, even better than what was foreseen in the 3-year Plan. This year we have three own projects that are funded by Councils, compared to one in 2015 and none in 2014. Figure 4 shows the preliminary funding plan and past performance for the Research Environment.

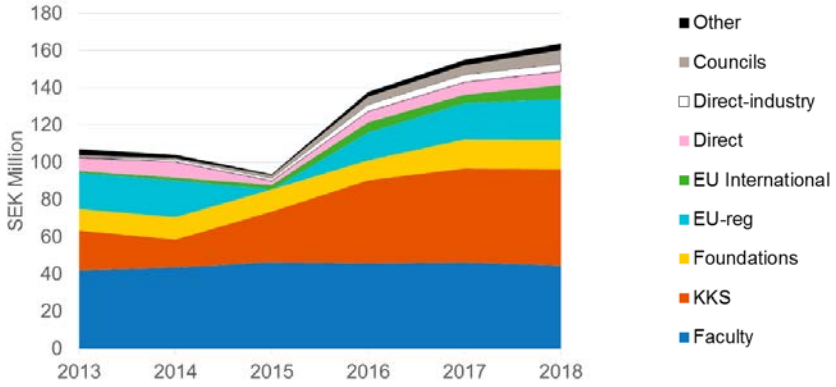


Figure 4. *Funding structure of Transformative Technologies, including preliminary targets for 2016-2018.*

Co-production and Industrial Networks

The expansion of industrial networks follows our 3-year Plan where both deeper and broader co-production is the target. Development of the networks and co-production occurs in Strategic Actions that differ in the forms and volume of industrial collaboration. We have with strong and intensively engaged partners such as Holmen, SCA, Stora Enso and Valmet in **e2mp**; and ABB, Bosch Rexroth and Shortlink in **EISS.** In **FORIC** a broad and expanding industry network is based on the industrial graduate school. Also **Measurement Systems** has a strong industrial network that is expanding through the innovation cluster Fiber Optic Valley. The industrial networks of **KM2** and **New Cellulosic Materials** are still shaping up.

The total number of partners grew significantly in 2015 (Indicator 4), in in line with our 3-year goal. Many of the new partners are addressing Edge business where less research funding is available. Therefore the volume of co-financing does not follow the number of partner companies. Strategically important new partners include SAAB - Defence and Security (**Measurement Systems**) and TetraPak (**e2mp**).

INDICATOR 4. Indirect funding (in-kind) from partners

Year	2010	2011	2012	2013	2014	2015
No of companies	93	100	101	94	124	155
Indirect funding (MSEK)	22,41	20,98	27,40	35,40	26,98	33,18

The number of adjunct professors will increase to eleven in 2016, provided funding is approved for two adjunct professors that were proposed in Work Plan 2016. The rate of increase roughly follows the 3-year Plan. Most of the adjunct professors are from institutes, four supporting **Measurement Systems**, two **KM2**, and one **EISS**. One adjunct professor from institutes and three from industry support both **e2mp** and **FORIC**. The focus on research institutes is important for the scientific quality. For Work Plan 2017 we are preparing to recruit another adjunct professor from institutes to support **EISS.** Future recruitments should be from companies and also support **New Cellulosic Materials.**

Development of personnel

Last year the most important step forward in personnel development was the university-wide career program for junior staff. We have ten out of totally thirty participants, which is in proportion to our share of the university´s total research volume. The number of post docs increased last year by three persons and they all came from abroad (See Table 1). In comparison, most of the new PhD students last year came from Sweden, and a large share were industrial PhD students enrolled in **FORIC**.

The strategic recruitment needs at the senior professor level were recognised in Work Plan 2016. Most important is a new professor with pulp and paper industry expertise. This is under preparation for Work Plan 2017. Thereafter come another three recruitments to replace retiring professors.

Management of the Portfolio of KK Actions

Most of the ongoing KK Research Actions are progressing according to plan. The financial outcome for last year is shown in Table 2. This spring the ongoing projects were evaluated from the status reports like before, but in order to support strategic learning the management group also started hearings with the project leaders. Following changes were decided in the research plans of two HÖG projects:

- **AHYP - Advanced HYP for paperboard**: The subproject on extractives removal will change from fundamental mechanisms to development of a measurement method and testing of chemicals. The reason is a personnel change. The companies hoped that we nevertheless work on the problem.
- **FLIS- Characterisation of wood disintegration processes**: The results on the measurement and classification of the wood chipping knives and process are much more promising than those on the modelling of the wood disintegration process. The second part is therefore cancelled and all resources are moved to the first part.

Most of the new KK Actions from Work Plan 2016 are in the normal start-up phase. For **OCXIS - Operation and change of complex industrial systems** we wanted to secure co-production. This is now in order and the project has started. Better co-production network was also needed for the Synergy proposal **LEAP – Large-area Electronics Platform**. The management group helped in this through a series of advisory meetings and the proposal was then submitted to the Knowledge Foundation.

Table 2. *Financial outcome of KK projects in 2015, costs related to revenues from Knowledge Foundation.*

Project (reference no.)[3]	Total project period	Costs for 2015	Accumulated costs	Granted from KKS accord. to budget up to 2015*	Company contribution 2015 (In kind)	No. of companies in project	Comments
AHYP (Dnr 140322)	150401-170331	1 380 110	1 380 110	1 490 000	650 000	3	
ASIS	150501-190430	1 514 969	1 514 969	2 044 931	2 020 000	3	1)
DAWN	150501-180430	595 937	595 937	966 072	966 000	4	2)
e2mp - rp (Dnr 20100281)	110401-170331	3 851 738	29 072 264	29 641 508	8 000 000	6	6)
FNMech (Dnr 20140320)	150201-180131	497 512	497 512	827 412	853 672	3	5)
FLIS (Dnr 20130321)	140401-170331	1 037 241	1 613 826	2 090 529	1 162 000	3	3)
FORIC (Dnr 20130319)	140601-210531	3 418 078 [1]	4 172 611 [2]	3 954 000	4 587 151	13	
ID-POS (Dnr 20130324)	140301-170228	771 570	1 145 223	1 670 526	1 270 000	5	4)
kW Converters (Dnr 20130323)	140401-170331	738 396	1 413 740	1 576 393	838 000	4	
Light-weight structural composites (Dnr 20130320)	140301-170228	1 364 231	2 396 886	2 511 953	2 491 110	2	
M2M COMM	150401-180331	715 432	715 432	1 016 709	1 517 118	3	2)
Paper Solar Cells (Dnr 20130322)	140401-170331	2 632 415	3 485 975	3 035 132	1 787 000	7	7)
SURF	150401-180331	852 347	852 347	1 073 956	1 000 000	4	
Total					**27 142 051**		

* Excluding OH. [1]Excluding MIUNs own costs 476 995 SEK in accordance with the agreement. [2] Excluding MIUNs own costs 546 995 SEK. [3]Excluding finished and reported projects Plenocap (Dnr 20120328) and Robust Wireless Communication (Dnr 20120330).

Comments: 1) Due to parental leave of a professor the cost is lower than budget. No risk as over 3 years left of the project. 2) Lower costs because of late start due to problems with co-production and recruitment. 3) As earlier reported, the project start was delayed. The schedule has been prolonged correspondingly. 4) Had problems with a change of staff in the beginning. The project will meet the budget in the end. 5) Staffing started late due to administrative delay. 6) Lower activities in some sub-projects, will increase during 2016-17. 7) Annual progress has varied with available resources. The past overspending will even out in the end.

In accordance with the request from Knowledge Foundation we have submitted amended proposals and motivations for two recruitments of adjunct professor in Work Plan 2016, Johan Åkerberg and Mats Sandberg. These recruitments are now awaiting the decision from the Foundation. The third one, Jan Andersson, was funded with other means.

The initiation process for new actions to Work Plan 2017 generated 31 drafts. In the screening process with the Reference Group the number was reduced to 19. They include the second stage of two short HÖG projects and the industrial graduate school **FORIC**, and a follow-up to the Research Profile e2mp-rp. In addition, the preliminary portfolio contains four recruitments, two education developments, seven HÖG projects, one Prospect and one Synergy. The motivations for all these are given above (cf. Research Program). After the quality control and setting of the strategic priority order we expect to land on a portfolio that matches the preliminary funding plan in Fig. 4.

Strategy process

We chose the name Research Environment of Transformative Technologies last year in order to emphasise our commitment to drive development towards the *TIE Vision*. Clearly we must continue to reiterate the transformation message externally and systematically reinforce the fact that the joint research environment is the strongest research initiative of Mid Sweden University. FSCN and STC are important for specific industrial target groups, but in general the joint transformation environment is more interesting.

Research strategies were developed in several formations last year. The research strategy of Transformative Technologies was drafted. It will be completed this year. Researchers formulated Strategies for **Measurement Systems, EISS** and all the scientific disciplines. The strategic directions are under reconsideration for **e2mp** with the companies in **e2mp-rp,** and for **KM2** to secure cohesion between FSCN and STC. For the strategy of **New Cellulosic Materials** we have evaluated internal and external project ideas as part of the development of BioInnovation. Next improvement point of the strategy process is to learn to evaluate the outlook of academic competition in areas of emerging technology, for which we will run the first Future Scenario workshop in April.

The management group used its strategic view in the steering of portfolios submitted to the Knowledge Foundation and the regional ERDF program. The importance of discussions in the Reference Group increased especially in the assessment of the competitive landscape, and we are therefore taking in new industrial and academic members. Also the FSCN Steering Group is giving increasingly sharp feedback in this respect, which we greatly appreciate.

Researchers learn of industry business strategies through meetings with the seminar speakers of the Business Innovation Seminars (see http://www.miun.se/universitetet/evenemang/business-innovation-seminars). The SID and BID concept has been further developed to offer a meeting ground for open strategic discussions. Important is that these events promote the innovation system of which Fiber Optic Valley and Åkroken Science Park are important parts.

Quality system

During last year we started to use ProjectPlace for better project management. We extended the use of systematic hearings to the follow-up and steering of active projects. A decision log tracks the decisions made on the project portfolio. The Strategic Actions and the implementation of the 3-year Plan are now analysed and planned continuously and documented in the Mid Sweden University BOX. The extended Reference Group will play a big role in evaluating the proposals for Work Plan 2017.

Summary of progress compared to the 3-year Plan

We have made generally good progress towards the 3-year goals. In the area of external impacts, we suffered some setbacks and delay in our efforts to support regional development and growth. On the other hand, co-production has improved as planned. In the area of educational support to industry we have worked more than originally planned. Most important now is to secure that strategic input and learning from industry covers all our research, and to strengthen contacts with industry through adjunct professors.

In our research program we recognised that our competence base is stronger than expressed in the 3-year Plan. The expertise that we have in high-yield pulping actually covers most of the manufacturing processes of paper industry, and in materials research the combination of cellulosic and inorganic nanomaterials improves our chances for an international position. In general work also remains to be done to raise the scientific ambition level in publications. The 3-year goals per Strategic Action should be updated since we can now define specific targets for each of them, including internationalisation and funding. We propose to complement the 3-year Plan correspondingly.

Appendix A: Progress after the half-time review of **E2mp-rp**

After the half-time review of **e2mp-rp** last spring, we made a plan to answer to the points raised in the review. Following steps and progress have been made since then:

Operationalise the concept "world leading" and explain what is included in the goal "to further develop the leading position"

In the Research Area of High-yield Pulping (HYP), Mid Sweden University is the strongest organisation in the world as measured in terms of the main conferences. In 2015 FSCN had 50% of the publications, up from 23% in 2014, while the closest competitors PFI and Chalmers had 15% each while in 2014 VTT was the second largest with 12% of the papers.

The research profile **e2mp-rp** forms the foundation of Mid Sweden University´s co-production with paper industry. The relationship is based on our experience to work with paper and pulp mills and suppliers. Several new projects were granted last year that build on this relationship and broaden the research scope to packaging materials (**ENCCP**, **Ytmodifiering av CTMP**) and fundamentals of the refining process (**MoDD**). We are not aware of any other research program on industrial pulping and papermaking that would be of similar size and breadth.

We are working on plans and proposals that secure we maintain our leading position in research on the high-yield pulping processes. Several new applications have been submitted this spring to the Energy Foundation in order to continue research on energy savings and new papermaking together with the paper companies. The synergy application **e2cmp** and new HÖG application **Sus-Bags** shift the balance of the Strategic Action towards packaging materials. The future scope and focus of research on energy savings and process intensity is under discussion with industry in the Profil+ plan **RETTWOOD**.

In the strategic perspective we increasingly recognise that we have for a university unique competence in the industrial manufacturing processes. Its relevance is not limited to mechanical pulping but rather covers all the industrial pulping and papermaking operations. With the increasing focus on "Bioeconomy" the manufacturing processes of forest industry will start changing, and we are well positioned to extend our leading role and industrial networks to manufacturing in industrial scale. As a step in this direction, we submitted a competence centre application **Centre for Industrial Lignocellulose Processes – ILCPro** to Vinnova in January 2015. In the centre HYP group would be responsible for upscaling of manufacturing processes to industrial scale.

Clarify the final scientific goals that cover the research profile

The goal of **e2mp-rp** is to reduce electricity use by 50%. In mill experiments we have so far demonstrated a 30% reduction. Another important result was the demonstration at mill level that significant process intensification is possible. In this case a number of process steps were by-passed. Product quality did not decrease but process became much simpler to steer. The grand goal of 50% energy reduction thus seems feasible to reach, but will require more time than what is left in **e2mp-rp**. The next stage after **e2mp-rp**, tentatively called **RETTWOOD**, is therefore under discussion with companies. The appropriate funding instrument is open. In Work Plan 2016 we preliminary indicated a KK Profile on defibration mechanisms to start in 2018, but actually this comes too soon considering the recruitment of a new professor (see point 5).

When planning the research after **e2mp-rp** we will reconsider the fundamental research issues. They must be relevant for the emerging transformation of industrial pulping and papermaking processes and at the same time be of international interest. In the *TIE Vision* we use the word *exciting* for this character of research. The fundamental issues we have studied in **e2mp-rp** were related to the rheology of wood material (thermo-chemical softening and wood mechanics). A number of high-impact publications have resulted, but this area is perhaps not in the absolute front-line of scientific excitement.

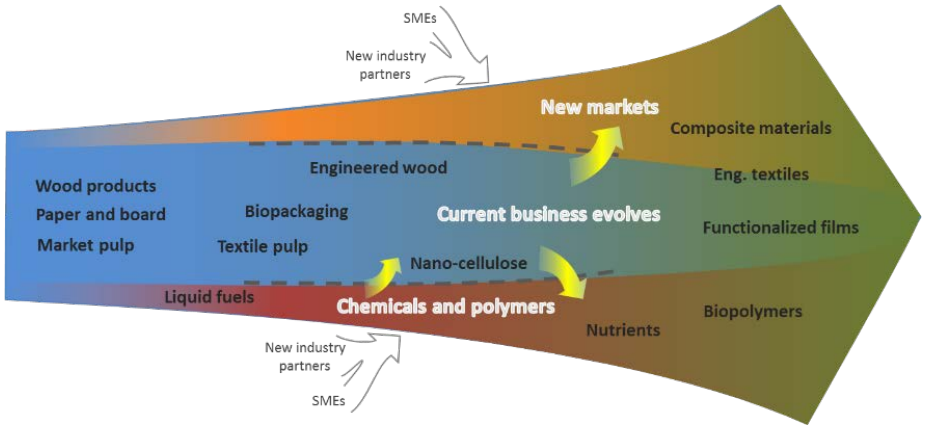
Within the Strategic Action we have already started to develop two new lines of scientific study:

- As a spin-off from **e2mp-rp** we have acquired funding for particle modelling of the fundamentals of chip feeding (**MoDD**) that is now starting. It is too early to say if our research approach will attract broader international interest, but it has connections to the research on refining rheology that has been studied at the University of British Columbia. Also, better understanding feeding mechanisms (e.g. particle "jamming") is crucial in the mechanical processing of biomass fractions. This is one of the issues in the **ILCPro** application.
- Related to papermaking, there is still high international research excitement on nanocellulose, manufacturing and uses. In this area we have the new project **ENCCP** that is starting. Funding for a new nanocellulose project in the Örnsköldsvik pilot was recently granted by Kempe foundation. It continues the research earlier started in the HYP group. Uses of nanocellulose are also part of the **ILCPro** application.

Clarify the role of the research profile at FSCN and the university

The Research Profile **e2mp-rp** and the Strategic Action **e2mp** form the basis for paper industry collaboration within Transformative Technologies. Those networks and the trust built within **e2mp-rp** enable us to build projects with paper industry also outside **e2mp**.

In the **ILC Pro** plan the HYP group was responsible for the industrial upscaling (TRL ≥ 5) of academic research results (the yellow arrows in the following graph). That is a valid role even in the Transformative technologies context. Nanocellulose is a good example of industrial upscaling where the HYP group is in the international front line of technology development.



The saturation of printing paper market has partly moved the development focus of the industry from energy savings to the manufacturing of strong packaging materials that can replace plastics. Packaging materials are now the second important area within the Strategic Action **e2mp**. The projects that are running or in preparation have been initiated by and developed together with industry. The companies involved see a good potential that the technologies we are studying can be implemented in reality. The projects are:

- **AHYP** and **Ytmodifiering av CTMP** develop the pulping and high-temperature wet pressing for packaging grades. The removal of extractives was not studied as originally planned because of personnel changes but otherwise the project is proceeding as planned. Last year this research direction has resulted in a new patent application.
- **ENCCP** is just starting. It has two strategically important motivations, (1) start research on an industrial process applying nanocellulose, and (2) the industrial partner TetraPak that for the first time collaborates with us.
- KK Synergy **e2cmp** must still pass the evaluation process of Knowledge Foundation. The focus here is an alternative to manufacture high-yield pulp for packaging at BillerudKorsnäs who has not participated in the **e2mp** projects before. The company is in the front-line of new material development in paper industry and therefore **e2cmp** is very valuable for us.

- After **AHYP** ends next year, a new HÖG project **Sus-Bags** is planned to move the development of the high-temperature pressing to pilot stage. In parallel, funding for the required pilot-scale equipment is applied from the Energy Agency.

Create a strategy for internationalisation of the research profile

Strategic Actions serve different roles in making Transformative Technologies strong. Industrial networks are the most important deliverable of the Strategic Action and must be kept in its focus. These networks benefit the other Strategic Actions, such as **New Cellulosic Materials** and **Measurement Systems**. These Strategic Actions have the main role of building international scientific collaborations that are relevant for paper industry.

Within **e2mp** nanocellulose is the direction where international collaboration is expected to grow. It is a good example of industrial upscaling where the HYP group is working in the international front line of technology development, at TRL ≥ 5. The results will naturally be published in engineering journals.

In light of the development of research frontiers (where papermaking research has almost vanished) it is currently not realistic to expect that we could *increase* out international role through research in the area of **e2mp-rp**. However, we should be able to restart the Nordic collaboration.

International projects confined in the area of pulping or papermaking are not at all as common as before. Cross-sectorial projects are favoured in Horizon2020, e.g. towards process intensification or biorefinery (calls of BBI). Opportunities for higher international ambitions in **e2mp** will thus depend very much on the research direction chosen after **e2mp-rp**.

Create a strategy for recruitments and competence development

Central to success in the Strategic Action **e2mp** is expertise in the manufacturing processes of pulp and paper industry. In the HYP group we have several junior researchers who have accumulated such expertise during the research projects. They are good candidates for strong academic career. They have and must have increasing opportunities to build their own parts of the research agenda through the projects that are planned in **e2mp**.

On the senior level we plan the KK Action **PulpingPro** to recruit a new professor in industrial pulping processes in 2017. The purpose is to secure continuity in our strong industrial networks. That person should be involved when a new KK Profile is planned, meaning that the profile could start first in 2019.

Appendix B: Status report of the industrial graduate school **FORIC**

Samtliga forskarstuderande inom Företagsforskarskolan FORIC				**Projektperiod: 2014-06-01 t.o.m 2015-12-31**					
Namn	**Arbetsgivare**	**Företag /lärosäte /institut**	**Antagnings-datum**	**Doktorandens utgångsläge vid start**** *(tillgodoräknande)* **Veckor / hp / ekvivalent**	**Planerad examen**	**Progression* under året** **hp 2015**	**Progression totalt från start** **% enl FDB MIUN**	**Ekv.**	**Förbrukad doktorandtid, månader** *(omräknat till heltid)*
Aktiva doktorander									
Alexander Hedlund	Frontway AB	Frontway AB	2014-11-18		Lic 2018	30 hp	25%	0,5	6,0
Anna-Karin Stengard	Sundsvall Energi AB	Sundsvall Energi AB	2014-12-16		Lic 2018	30 hp	25%	0,22	6,0
Bakhram Gaynullin	SenseAir AB	SenseAir AB	2014-12-16	6v	Lic 2017	24 hp	20%	0,4	4,8
Carl Moser	Valmet AB	Valmet AB	2014-12-16	6v	Dr 2019	35 hp	15%	0,3	7,2
Elisabeth Björk	Innventia AB	Innventia AB	2014-12-16		Dr 2019	30 hp	25%	0,5	12,0
Hafizur Rahman	SCA Forest Products AB, SCA R&D Centre	SCA Forest Products AB, SCA R&D Centre	2015-04-14		Lic 2017	29 hp	24%	0,48	5,8
Jonas Johansson	SCA Timber AB	SCA Timber AB	2014-12-16		Lic 2017	41 hp	34%	0,68	8,2
Magnus Larsson	Skogforsk	Skogforsk	2015-01-01	47v / 81hp	Dr 2017	31 hp	80%	1,6	38,4
Mathias Lundberg	PulpEye AB	PulpEye AB	2014-10-21		Lic 2017	36 hp	30%	0,6	7,2
Mats Paulson	Sylvestris AB	Sylvestris AB	2014-06-24	2v	Lic 2016	18 hp	28%	0,56	6,7
Olof Ferritsius	Mittuniversitetet	Stora Enso Kvarnsveden	2014-12-16	27v / 41hp	Dr 2019	60 hp	42%	0,84	20,2
Robert Norgren	Ragn-Sells AB	Ragn-Sells AB	2014-12-16		Dr 2019	45 hp	38%	0,76	18,2
Sinke Henshaw Osong	Mittuniversitetet	MoRe Research	2011-11-15	1 (Lic)	Dr 2016	34 hp	100%	2	48,0

*Progression anges i examensekvivalenter. Doktorsexamen motsvarar 2 examensekvivalenter, Lic.examen 1 examensekvivalent och dokorsexamen med tidigare avlagd licentiatexamen räknas som 1 examensekvivalent.

**När en forskarstuderande vid antagningstillfället har poäng från tidigare utbildning (tillgodoräknande).

Scientific results

The research graduate school comprise 13 research students and their related projects. Most of the students started their research in 2015 but some of the students have experiences from research studies prior to the start of **FORIC**. Three articles are accepted for publication and five more articles are submitted for publication in scientific reviewed journals. 12 papers are presented at scientific conferences. This means that the production of scientific results 2015 is more extensive than expected. Highlights from the scientific results are:

- Sinke Henshaw Osong showed valuable results on how to produce and evaluate mechanical and chemical pulp based micro- and nano-fibre materials (MFC, NFC and NLC) and how to utilise them to enhance the strength of paper as well as to facilitate novel functionality of paper based products, e.g. paper based super capacitors.
- Carl Moser evaluated different methods to monitor the production of pulp based nanomaterials and to identify transmittance measurement as a promising candidate for routine evaluation of nano-materials. The authors have also developed an energy efficient method to produce nano-material and this process further developed in collaboration with Valmet AB.
- Olof Ferritsius developed a more fundamental understanding about how the fiber characteristics affect the final properties of the paper products (cf. Publications). This result may lead to development of more energy efficient production processes but also improvement of the paper product properties.
- Robert Norgren evaluated different methods to utilise bio sludge from pulp and paper industry. Five methods are identified as mature enough to produce e.g. energy products, bio materials chemicals from bio sludge in a reasonable near future.
- Magnus Larsson showed how disturbances and uncertainties can affect the value creating and efficiency in the forest value chain. Enhanced communication and alignment can lead to better planning, operations and coordination and thereby improved surplus.

Co-production process

The general assembly meetings are important events for interaction among the PhD students but also among the participating companies and the academic staff. The general assembly meetings are organised to promote an intensive interaction between the participants. This means that these meetings serves thus as a glue that integrates the various research projects, show their relations to each other in the perspective of industrial transformation. Furthermore, the general assembly meeting is the arena where the identity of **FORIC** is defined and developed. The general assembly meetings were held three times per 2015.

The operation and development of **FORIC** is monitored and managed by a board with representatives from the academy, companies and the research students. The board gathered five times 2015.

The co-production process differs among the various projects. All research students are supervised by mentor teams with participants from the university (main supervisor and assistant supervisor) and the specific company (1-2 industry supervisors). This means that not only the research projects but also the individual study plans are monitored and adjusted to fulfil the parallel perspectives of the academy and the industry. Some students spend most of their time at the company while others spend more time at the university. The research task varies from theoretical studies to laboratory intensive research projects. This means that the co-production process is individually adopted for each doctorial project. Co-production activities for each student are described in the PhD-student's activity reports.

Deviations

- One of fourteen research students has not been appointed due to financial reconstruction of the concerned company. Domsjö Fabriker will take this place.
- Resources spent on course development 2015 is less than planned as **FORIC** has utilised courses within the FPIRC collaborative framework.

Strategic impact

FORIC is an important instrument to operationalise the *TIE Vision* and to promote and facilitate implementation of research results in the industry. The holistic approach of **FORIC** stimulates new multi-disciplinary collaborations within the university and seems to improve Mid Sweden University's ability to participate and support the ongoing industrial transformation. It is likely that this will lead to new collaborations and deeper co-production with companies related to forest industry, e.g. in the area of business development and organizational change.

We can see a benefit to combine more fundamental technological research with research concerning business models and value creating chains as a working model for securing the industrial relevance of the research focus, specifically in longer terms.

The **FORIC** program has also broadened Mid Sweden Universities interaction with some other related Swedish universities; some PhD projects are included in their companies' broader academic network. As a result of this we see an increased interest from researchers from other universities to collaborate with Mid Sweden University.

We started the development of the second phase of **FORIC** already during the end of 2015 and this phase is planned to start in January 2017. The process of formulating PhD-project proposals is ongoing with several potential industry partners that are engaged in the subject "forest as a resource" in order to find ways to transform the present forest based industry. This is a time-consuming start of co-production research as it is essential to understand the research and competence demand of the partner and to work together to rephrase this demands into a research questions that is relevant both to the academy and the industry.

We foresee that the next **FORIC** phase will include new partners at the same time as some of the current partners expand their activities within **FORIC** with new PhD students. Today we have identified 38 potential partner companies and 47 potential PhD-projects. 25 of the potential projects concern non-traditional forest based products or new value chains while 6 projects deal with more traditional products. We have concrete or preliminary discussions with 20 of the companies.

Publications excluding conference papers and other publications

1) Journal articles

- Larsson, M. Roos, A. Stendahl, M; "Supply chain management in the Swedish wood products industry – a need analysis", Scandinavian Journal of Forestry Research (Accepted for publication) (2015)
- Moser C., Lindström M.E., Henriksson G.; "Toward Industrially Feasible Methods for Following the Process of Manufacturing Cellulose Nanofibers", Bio Resources, Vol 10, No 2 (2015)
- Osong, S. H., Norgren, S. & Engstrand, P.; "Processing of wood-based microfibrillated cellulose and nanofibrillated cellulose, and applications relating to papermaking: a review". Cellulose (2016) 23:93–123, DOI 10.1007/s10570-015-0798-5 (2016)

2) Submitted to journals

- Larsson, M. Roos, A. Stendahl, M. Erlandsson E. 2016; "Business relations, coordination and ordering between roundwood supply units and sawmills – four Swedish cases". Submitted to Silva Fennica, 2016
- Osong, S. H., Norgren, S., Engstrand, P., Lundberg, M., Reza, M., Tapani,V.; "Qualitative evaluation of microfibrillated cellulose using the crill method and some aspects of microscopy", Submitted to Cellulose. 2015d
- Osong, S.H., Dahlström, C., Forsberg, S., Andres, B., Engstrand, P. Norgren, S., Engström, A-C.; "Nanofibrillated cellulose/nanographite composite films", Submitted to Cellulose. 2015e
- Reyier Österling, S., Ferritsius, O., Ferritsius, R., Johansson, C.A. and J. Stångmyr: "Weighted averages and distributions of fibre characteristics of mechanical pulps Part II: Distributions of measured and predicted fibre characteristics using raw data from an optical fibre analyser", Submitted to Appita Journal, 2015
- Moser C., Lindström M.E., Henriksson G.; "Minor part of the energy input in the mechanical disintegration of cellulose to nanofibers creates novel surfaces", submitted to Bio Resources, 2015b

Contact

Phone	+46 (0)10-142 80 00
E-mail	kontakt@miun.se
Website	www.miun.se

Campus

Östersund	Kunskapens väg 8, 831 25 Östersund
Sundsvall	Holmgatan 10, 851 70 Sundsvall
Härnösand	Universitetsbacken 1, 871 88 Härnösand

Mittuniversitetet
MID SWEDEN UNIVERSITY