PROJECT FINAL REPORT

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1 EXECUTIVE SUMMARY

Objectives - The main objective of this coordinated action is to promote the commercial exploitation of organic and large area electronics (OLAE) technologies for the benefit of European industry and economies. Aim of COLAE was to bring together the leading European companies and new start-ups along the present and potential OLAE value chains, harness the knowledge base and technology know-how of the European research partners and their regional clusters, and boost the development of a range of services to support new product and business development.

Actions – The Networking, Trainings, Feasibility studies, Virtual Foundry, User Centric Innovation Model and New Wave Research activities has been carried out collectively with partners with strong interaction between work packages. The Networking covered 60 interviewed SME and LSE companies, 12 booth presentations – latest in Hannover Industry Fair 2014, totally 48 presentations promoting OLAE and utilizing the colae.eu web page for communications in news, in announcing of workshops, trainings, partners presentations covering all COLAE activities. The 25 Trainings both entrepreneurship and technology - had 740 attendees altogether with 340 from industry. The 17 Feasibility Studies led by 9 partners of COLAE were successfully carried out according to the developed Way of Working. The Virtual Foundry aligned the OLAE centres towards becoming a joint service provider with tool kit, standardization and identifying the unique selling propositions. The User Centric Innovation Model developed the effective commercialization process of OLAE and run several workshops with end users to identify their business ideas where OLAE technologies are applicable and in which areas the development and manufacturing services are already available. The New Wave Research was collecting information by organising workshops to find recommendations for future research.

Results – COLAE has raised the awareness of OLAE in interviews, booth and seminar presentations, design workshops, technology and entrepreneurship trainings, etc. ending up to thousands of face to face contacts and 742 registrations out of 14 863 people who have visited colae.eu web pages. The penetration of trainings to industry has been successful for short informative courses, but the practical hands-on longer and more expensive trainings were not a success, although industry was asking for that kind of trainings. The feasibility studies were a success as served for free, but according to interviews the cost of 5k€ would be acceptable instead of 15 k€ calculated real average cost. Through entrepreneurship trainings 5 companies have been established and 3 cases are in the way to establish a company.

Key findings – The knowledge of OLAE technologies is still in low level in companies and the investment attitude to feasibility studies and prototyping is still in `waiting mode`, so the flow of designing and prototyping of these technologies to next generation products of companies is thin. This is partly due to fact that only a few persons in industry – designers and engineers – are familiar with OLAE technologies and due to fact that industrialization with available proven value chains to meet quality systems of specific business areas are also very few.

2 PROJECT CONTEXT AND OBJECTIVES

The overall goal of COLAE project was to speed up the European OLAE commercialization process through creating new models for cooperation and coordination between the OLAE clusters, enhancing the awareness of LSEs and SMEs to OLAE technologies, improving the access of industry and research to existing OLAE pilot facilities, organising technology and business training, and creating sustainable functional models for clusters. One major goal was to speed up the development of industrial products based on OLAE technologies and to shorten the time-market of these innovative products.

The objectives and concrete actions in COLAE aimed to shift focus from technology push to market pull in OLAE. In the COLAE project the word cluster means a regional cooperation entity having research, industry and community/government representatives and is represented in COLAE by project partners, Figure 1.

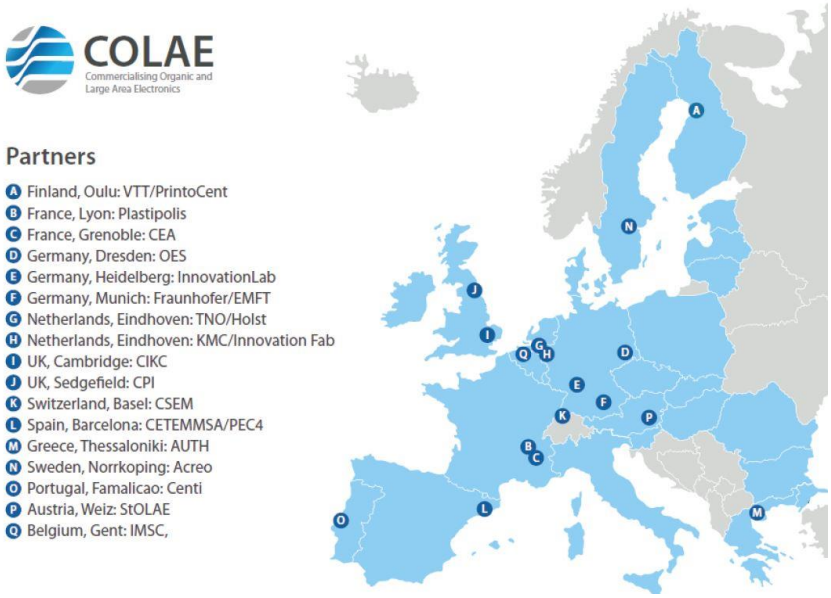


Figure 1. COLAE partners

OBJECTIVES

European level cooperation and coordination

The objectives in COLAE had inbuilt cooperation activities to get the best European OLAE partners to work together, developing and producing world class solutions for the benefit of European companies and businesses. Sustainability was ensured through sharing the cluster strategies on an annual basis; building the strategy and operational working practices for the OLAE Foundry and identifying and closing the gaps in European technology and services. This was a proactive model that makes it possible to coordinate the OLAE investment and research portfolios and to accelerate joint commercialization activities.

Enhancing awareness

The project enhances the awareness of European LSEs and SMEs to OLAE technology and business opportunities in order to improve their global competitiveness with new OLAE based solutions. COLAE promoted the competences of the COLAE network to a number of selected leading European LSEs and SMEs with an interest in exploring the new business opportunities. The objective was to offer a broad range of attractive services from clusters, such as interviewing SME and LSE companies (60), activating workshop for industrial designers (4 workshops), training on the technology, best practices in entrepreneurship, feasibility studies (15) utilizing the OLAE network and pilot manufacturing environments and get 100 SMEs engaged in COLAE clusters.

Demonstration kit

A Demonstration kit is to be created for promoting OLAE technologies and the COLAE clusters. The demonstration kit (totally 10) enables the clusters to present systems & solutions concepts, as well as the training opportunities offered by the COLAE network, to companies and larger business communities through one-to-one meetings or at major trade shows in the five OLAE topical areas. The purpose is to make the OLAE technology maturity level more visible and understandable to business and technical people, in order to initiate realistic innovation. The demonstrators should be complementary covering different technologies, different material and different manufacturing techniques. Additionally an integrated demonstrator will be developed.

Trained staff

Here the objective was to increase the quantity and quality of the flow of trained staff into the industry by creating a brokerage service to offer opportunities to work in OLAE companies and research institutes, developing programmes of advanced training to maintain the knowledge of OLAE technologists at the leading edge through summer schools, hands-on training courses and workshops and providing a programme of technical training for industrial designers and product developers who are new to the field and require a good understanding of the capabilities and performance trade-offs of OLAE technologies. This training will be targeted at the new end-users and integrators of OLAE technologies that were identified in WP1.

A training programme of OLAE entrepreneurship workshops will be developed to stimulate entrepreneurial activity in the sector by providing both entrepreneurship skills and knowledge of the opportunities presented by OLAE technologies.

Service model for Feasibility Study

The objective here is to build a European "**OLAE Feasibility Network**" with a single portal, which will take in questions and then use its network of European research centres to, where possible, give feasibility advice at a number of levels. The feasibility advice will be given within a short timeframe (e.g. 3 months). Significant R&D activities are not included. Existing networks, databases etc. will be used wherever possible, to keep the "overhead" to a minimum. EU funds will be used to support the creation of this service, but mainly for executing a number of trials (e.g. 10+5) of these studies in three years.

Our target is to involve around 5 specialists from each of the partners in the project, which leads to an intended number of 100 people in the database, with a broad set of backgrounds and experience. The level of detail required may differ from case to case, depending on the company or other organisation bringing in the product concept.

Towards virtual OLAE Foundry

By establishing a virtual OLAE foundry there will be improved access to existing OLAE pilot facilities for interested SMEs and LSEs. To support the alignment process of the OLAE clusters in becoming such a service provider (the so-called `foundry` concept) specific service models, and focused activities are planned on resource management, assistance with financial schemes, and IP licensing models for companies.

Potentially, there were ten areas along the innovation process of a product development, where service packages will be elaborated and adjusted to the needs of OLAE technology when necessary (Research & Development, Design & Application, Vendor Management, Purchasing, Tooling, Production, Logistics & Customer Service, Product Management, Quality Management, IP Management). The services will refer to standards as much as possible or de facto standards has to be defined in cooperation with OE-A and other stakeholders.

User Centric Innovation Model

The COLAE project started creating an Open Innovation model for cooperation of regional clusters and for rapid commercialization of OLAE research, but during the project it was renamed to a User Centric Innovation Model.

One of the specific areas relates to the innovative ideas received from companies, especially from SMEs, who want to use OLAE technologies in their product portfolio. COLAE will create a working model based on a Feasibility Service Network to give feasibility advice in terms of technology, timeframe, redesign, resources, freedom to operate, etc.

New Wave Research

The main objective of this WP is to collect and identify the important research challenges of OLAE technology and potential emerging applications. The information is collected from the key research and industrial partners of European OLAE clusters by using interactive workshops. The information will be analysed and distributed to the EC, Photonics21 WG4 SRA updating process and OE-A. The information will also be delivered to the OLAE stakeholders to assess their immediate reactions. At least 10 companies was to be participating in each workshop

PROJECT WAY OF WORKING

The COLAE way of working has been organised according work packages of WP1: Networking, WP2: Training, WP3: Feasibility studies, WP4: Virtual Foundry, WP5: User Centric Innovation Model and WP6: New Wave Research.

The interactions of the COLAE project are described in Figure 2. WP1 has a strong influence on the project in enhancing industrial interest and identifying industry needs. The workshops, tradeshows, etc. will attract interested companies to other work packages, especially to WP2, which offers a vast range of training and to WP3, which looks for concrete innovation ideas from companies and provides Feasibility Advice for the product portfolios of those companies. WP1, WP2 and WP3 are the so-called `Work on the fields ` work packages, whose goal, together, is to raise awareness of OLAE. WP4 and WP5 create sustainable solutions for OLAE clusters in Europe and build the basic blocks of continuity. The industry input, mainly through WP1 actions, is applied to the working models developed by the project. WP6 obtains input from WP1-5 work packages through workshops, which will gather challenges from research and which also brings potential emerging applications to the same table. This information is delivered to the overall research agenda oat both the cluster and EU level.

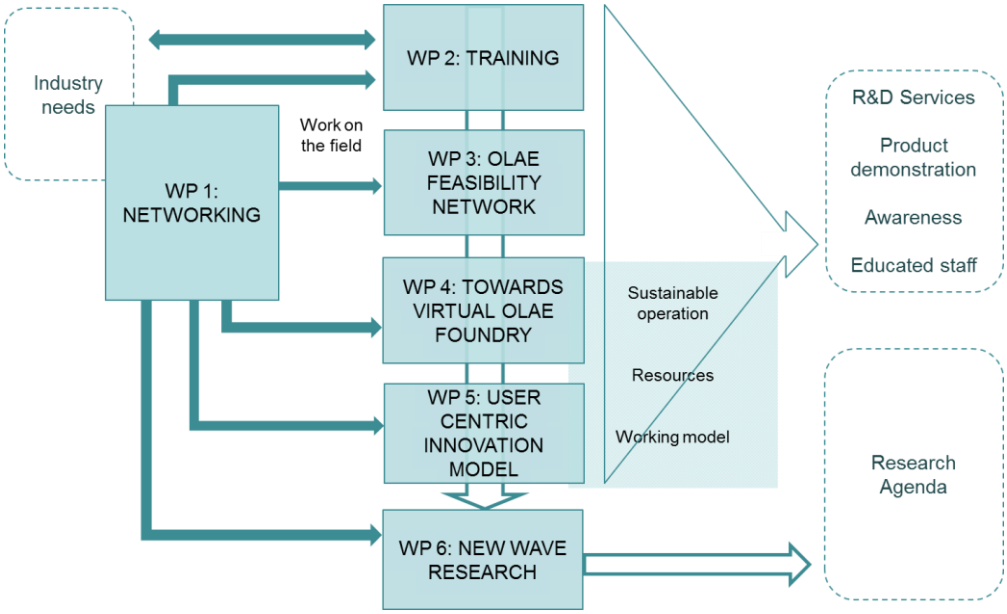


Figure 2. Schematic diagram of COLAE work plan and interactions

3 DESCRIPTION OF THE MAIN S&T RESULTS/FOREGROUNDS

3.1 Networking (WP 1)

The organic and large area electronics (OLAE) industry is still in its early phase of development, characterised by intensive research efforts and a lack of large-scale end-user product manufacturing. For this reason, the leading European competence centres have joined forces in the European funded project COLAE to actively support the industry on its way to Commercialize Organic and Large Area Electronics (COLAE).

The aim of WP1 was to define, develop and execute a coherent networking strategy and related plan of action. In doing so, the activities of WP1 pro-actively promoted the competences and services of the COLAE network to leading European larger enterprises [LSEs] and leading small and medium sized enterprises [SMEs] in selected vertical markets, with a verified basic interest in adopting and implementing OLAE value propositions for their next generation of products and services.

All networking activities of WP1 resulted:

- Several thousands of contacts generated through 12 booth presentations at 12 major European trade shows; Approximately 3000 participants attended the 48 COLAE conference presentations;
- Website: 742 interested stakeholders enrolled at the COLAE website.
- 63 companies (37 SME's and 26 LSE's) were interviewed
- Approximately 100 designers attended the 4 industrial designers' workshops;

The format of the workshops included a three step approach:

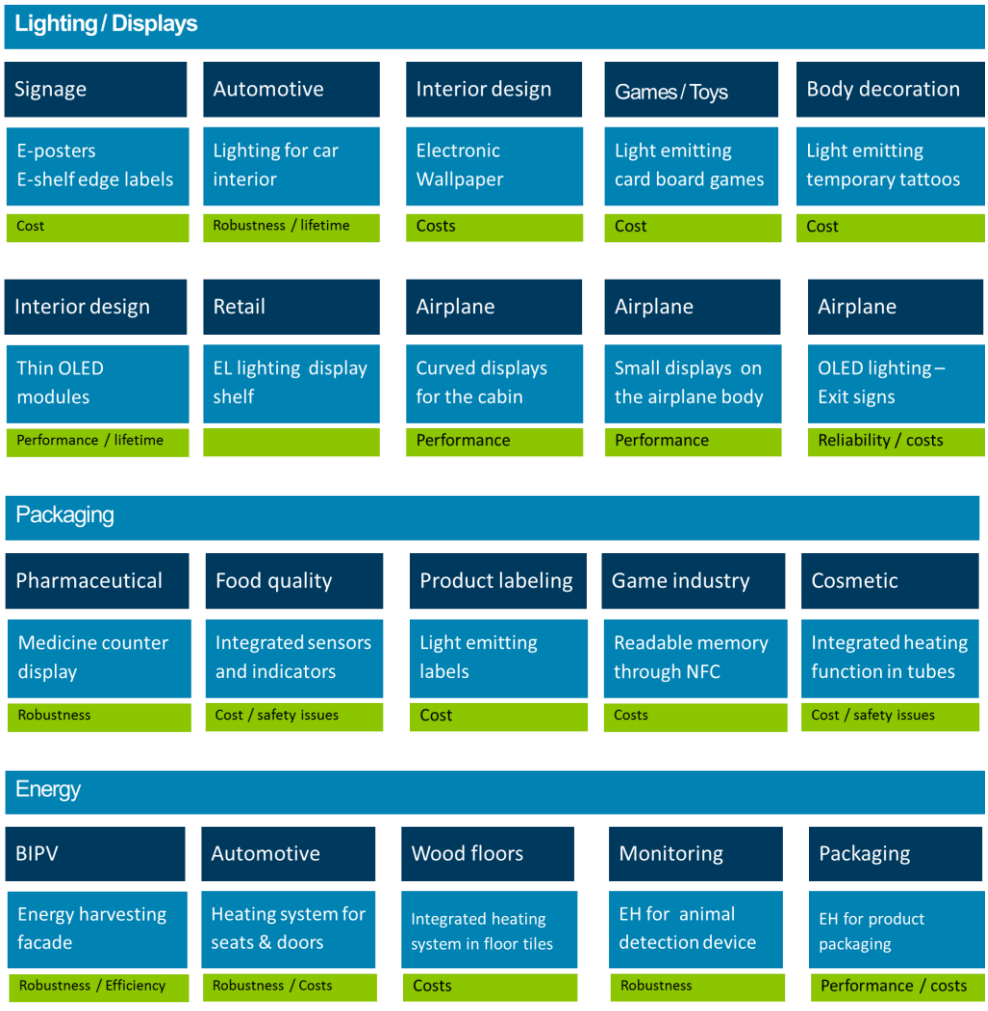
Figure 3. Approach for designers' workshops

Step 1. Focused design pre-workshop session focusing on articulated needs enhancing social learning [including awareness raising], initialization of actions [e.g. development of design and possibly prototype ideas], and networking and collaboration between technology developers and designers.

Step 2. Focused workshop session, engaging designers' communities, to create open and safe interaction as well as engagement at different settings, in order to have an effective and sustainable impact.

Step 3. Assessment of ideas session, where designers are requested to deliver their product designs, based on OLAE Technologies depending on the setting and the institutions involved in the COLAE workshop.

Executing the Networking Plan of Action included interviews that have been carried out with 63 companies (37 SME's and 26 LSE's). Interviews have taken place in different geographical locations in Europe, where the end-user industry companies were based (i.e. Germany, Austria, United Kingdom, Finland, France, The Netherlands, Belgium, Sweden, Greece, Portugal and Spain). Interviews provided valuable information about the requirements for functioning of end products in detail. The data was utilized as an input into work of WP3 as it allowed a better selection of cases for feasibility studies. It also allowed a better understanding in general of what applications are expected and what may be feasible to develop and manufacture in the short and long term. Examples of key driver requirements for strategic applications areas are shown in Figure 4.



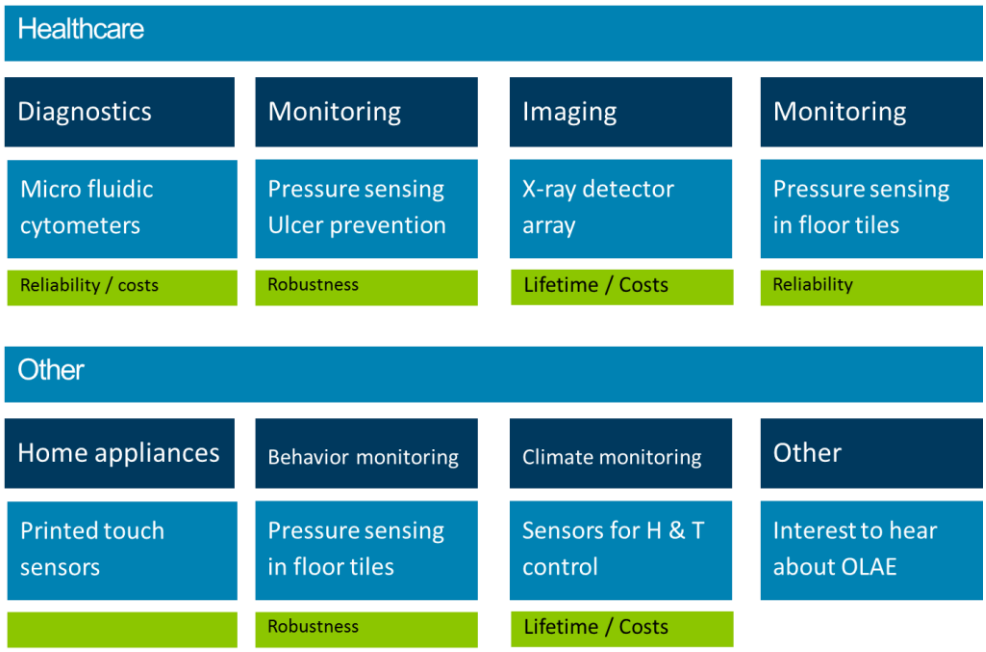


Figure 4. Examples of key driver requirements for strategic applications areas

The engagement approach (including contacting, interviewing and following up) has turned out to be an effective way to inform the end user industry general about the progress being made in the OLAE domain. Companies were eager to identify partners with whom they could innovate their existing or new product portfolios.

The COLAE project generated a considerable cloud of awareness for the OLAE technology & business area during the course of the project. Developments in miniaturisation in semiconductor technology and electronics in general and in OLAE more in particular has changed the paradigm towards form factors and devices favourable for the area of the internet of everything. It is the general opinion of most of the professionals contacted and interviewed in the cause of the project that thin film based OLAE devices can make a difference in building and packing new and low cost electronic devices. This should be the promise to build upon for the future.

3.2 Training (WP 2)

The COLAE Network aimed to provide a programme of training to meet the needs of companies involved in OLAE technology commercialisation or wishing to use OLAE technology in their products, through summer schools and workshops and through hands-on practical training on OLAE manufacturing equipment.

The objectives for WP2 Training were:

- Provide technical training in OLAE technologies to raise the level of understanding of companies new to the field and to maintain state-of-art knowledge among technologists (Task 2.1)
- Increase number of trained OLAE technologists and so prevent shortage of skilled staff holding back the growth of the OLAE industry in Europe (Task 2.2)
- Grow OLAE commercial activity by stimulating entrepreneurship in the sector (Task 2.3)

The measures agreed for this work package were:

- The number of attendees at training events is expected to be 500 people, mainly from industry, in approximately 20 training events (at least 4 introductory training events, 5 entrepreneurship events and advanced training events including at least 4 summer schools and at least 4 hands-on workshops).
- The secondment brokerage expects to facilitate at least 10 placements per year (25 in total).

25 training events have been organised in WP2. Seven of these were entrepreneurship events and five aimed at relatively introductory level of training and the remainder were advanced level courses, broadly in line with the original expectation of five and four events respectively. We only held two summer schools, compared to the original aim of four, this change was made to concentrate on the hands-on practical training course, and indeed we organised seven hands-on training events compared to original schedule of four. The total attendance was 740 with 341 (46%) of these being company employees, 111 (15%) from RTOs and the remainder (39%) from academic institutions or other (schools, independent, etc.)). These participants came from 39 different countries, and the training was offered in 15 different locations across the EU. The total of 740 from 25 events significantly exceeds the original target of 500 attendees from 20 events. Whilst the proportion from industry is greater than that from academia (with the remainder mostly from RTOs), it is slightly less than 50% so we cannot claim to have attracted attendees mainly from industry as we had intended but we did still achieve a high level of industry involvement. There was a fairly equal distribution between participation by SMEs and LSEs, although there were several events, for example Innofest, where a large majority of industry participants were from SMEs.

A number of training events will continue to be held after the end of COLAE support. For example, there is a plan to hold an Innofest event again in February 2015 and Enterprisers will run again next year with participation from the Austrian Photonics Network. Of the technical courses, the ISSON summer school will continue, and OES and partners such as Fraunhofer COMEDD have continued with training events on for example OLEDs, but mainly concentrating on their local cluster audience. Other events such as the Circuit Design course may be run in future depending on the level of demand experienced.

Provide technical training in OLAE technologies (Task 2.1)

Task 2.1 of WP2 was led by CSEM and had key two objectives:

a) the provision of a programme of technical training at an intermediate level for industrial designers and product developers who require a good understanding of the capabilities and performance trade-offs of OLAE technologies in general across the broad range of OLAE applications. This training is intended to raise the level of understanding of companies, designers and integrators who are relatively new to the field particularly those identified through the awareness raising activities undertaken by WP1.

b) the provision of a programme of advanced technical training to maintain OLAE technologists' know-how at the state-of-the-art.

The first task was to prepare a plan for the training programme based on a comparison of the current provision in the regional and national clusters involved in the project and the training needs of OLAE technology companies, which were established by surveying 110 companies (including 60 SMEs) in 10 countries. The review of pre-existing training provision found that much of it was aimed at students, was at an introductory level, was classroom-based and was usually offered as weeklong summer schools or as lecture series. This provision contrasted markedly with industry needs as reported to our survey: companies had a requirement for more training at advanced and intermediate level, they considered that hands-on lab-based training courses were more effective and they strongly favoured short workshops. In response, COLAE drew up a programme of tailored events including

- Intermediate training for those with only a little background in the field, such as 'Introduction to Organic Electronics', organised by OES, in December 2011
- Advanced technical training courses , including hands-on experience, for example 'Printing functional materials on standard printing presses' organised by Acreo in October 2012
- Training aimed at designers: 'Design meets organic electronics' organised by iL in July 2012
- Seminars on new application areas for OLAE such as 'Smart textiles meet Organic Electronics' which was organised by UGent in April 2012.

Figure 5. Participants in a COLAE training event

After the first project review, further discussions were held about how best to meet industry needs and to leverage the expertise of the COLAE network, as a result the COLAE partners decided to create a modular training course to give a good overview of each of the key technologies in OLAE and provide hands-on experience, with a target audience of early stage researchers in industry The course plan consisted of six modules covering the main OLAE devices and process: OLEDs, OPV, OLAE production technologies, organic TFTs, Smart Systems Integration and OTFT circuit design. In each case the focus was on hands-on experience n with the majority of the time spent in the laboratory. Four of these modules were offered at more than one date and location. The ISSON summer school in organic electronics (AUTh) was included as an alignment module to enable those new to the area to gain sufficient background understanding of the subject.

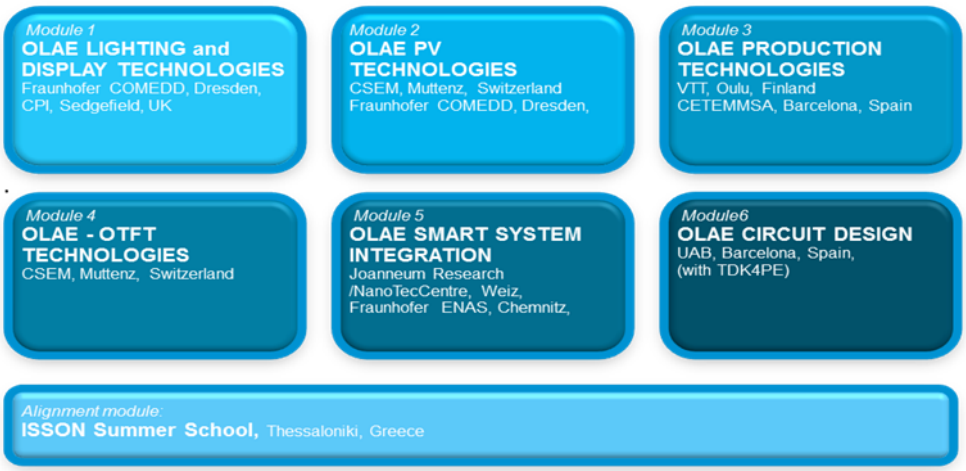


Figure 6. Summary of planned COLAE hands-on training course

The modules were advertised in the summer of 2013 for delivery in the autumn, but several of them were re-scheduled for spring 2014. In order for the modules to be viable the minimum number of participants in most cases was 6 registered attendees. In the event, only 4 of the modules were actually presented, and several of these only had 4 attendees. One explanation for the disappointing level of participation could be the costs, which were typically between €1000 and €2500, with travel and accommodation costs also to be met by the company. This would make participation a relatively large cost, particularly for SMEs (which are most common in the OLAE sector), and given the economic conditions this could have depressed demand. The response could also indicate that the OLAE industry is still in the early stages and there is not enough demand from companies entering the industry to support extensive training provision.

Increase number of trained OLAE technologists (Task 2.2)

Task 2.2 aimed to increase the number of trained technologists through the development of a brokerage service for secondments of staff to allow for extended periods of hands-on training in OLAE technology. However, as reported in D2.4, there was a relatively low level of interest expressed by companies as expressed in the training need survey, so we decided not to proceed with a

managed brokerage service, but instead to implement the secondment brokerage simply as a jobs portal on the COLAE website

The COLAE jobs portal was implemented on the COLAE website at www.colae.eu/jobs. 18 Job opportunities were advertised, from 10 companies (including SMEs and LSEs as well as academic institutes) from 5 different countries in the EU. The positions advertised were for a wide range of levels including a Scientific Director, R&D Scientists, and machine operators. Only 2 CVs were uploaded by candidates. Therefore this task did not meet the expectations of facilitating 25 secondments and from the relatively low level of responses found, it would appear that there was not a lot of need for a dedicated jobs board for the OLAE industry at this time.

Stimulate entrepreneurship in the OLAE sector (Task 2.3)

Task 2.3 of WP2 consisted of a programme to stimulate economic activity in the OLAE sector by providing OLAE technologists with the skills to develop and evaluate commercial propositions, to create companies and to attract funding and to communicate the capabilities of OLAE and the opportunities that OLAE provides to entrepreneurial communities throughout Europe.

The first action in this task was to understand what provision was already available in the various clusters and highlight examples of good practice. A survey of the entrepreneurship support currently available in the COLAE clusters identified a broad range of activities in at least 11 of the clusters. Much of that activity is based in the University sector and aimed primarily at the student and researcher population. Eight short case studies of successful entrepreneurship activities were prepared. In most of these cases, this entrepreneurship support is not tailored specifically to the OLAE technology sector. Through the COLAE project we organised a series of events with a focus specifically on promoting entrepreneurship in OLAE.

'Business for Printed Intelligence' was run by VTT and based on the pilot programme "Takomo goes Printed Intelligence". The first programme was May – July 2012 with 25 participants and the second programme was run October-November 2012 with 33 participants. Each course ran over 2 months and first provided participants with an overview of the technology and business principles of printed intelligence and then they worked in small teams on business cases which they presented to a selected audience at the conclusion of the course.

InnoFest was organised by VTT to form the innovation stream of the Midnight Pitch Fest in Oulu, June 2014 to boost business around printed intelligence. The idea was to hold an 'open innovation' event for teams to compete with their innovation ideas, share of experiences and receive support from specialists 25 teams competed and 132 people took part in the programme, including experts from 10 companies who assisted the business teams.

Figure 7. InnoFest was an entrepreneurship event in a tent

'Commercializing Organic Electronics through Entrepreneurship' was organised by AUTh in conjunction with the Nanotexnology conference in July 2013. It included presentations on the spin-off and start-up creation process and successful cases of entrepreneurial activities in OLAE in European countries.

Enterprisers: the COLAE partners organised a COLAE entrepreneurship training scheme for all the clusters to participate in based on the "Enterprisers" course run by UCAM. Enterprisers is an intensive 4-day, course aimed at early-career technical staff, designed to inspire and develop entrepreneurship skills and equip participants to spot enterprising opportunities, develop self-efficacy and apply more entrepreneurial ways of thinking to any project. COLAE participants joined the course in May 2013 (10 COLAE partners represented) and in May 2014 (4 partners represented).

In terms of the goal for the WP of growing OLAE commercial activity, we can see some promising outcomes:

- Three businesses were founded through the first Business for Printed Intelligence course, with a further three considered after the second course.
- Three of the business ideas from the Enterprisers 2014 course are still being developed.
- InnoFest attracted 25 teams to compete with their business ideas for applications of printed electronics. Although not all of these will develop into businesses, we can anticipate that several will continue on that path and eventually be successful.

The Entrepreneurship training events were all very well received by the participants, who will now have the capabilities, experience and potential to create new OLAE businesses in future.

3.3 Feasibility Network (WP 3)

The COLAE project offers companies, especially small and medium enterprises (SME) the opportunity for a feasibility study on a product idea. The outcome of the study should give the company an impression on how well the idea can be executed using organic and large area electronics (OLAE) technologies. Since such a service is new, but is an important tool to make OLAE a commercial success, the COLAE project develops and executes feasibility studies for SMEs interested in OLAE. This report describes the achievements relating to the infrastructure and portal (T3.2), the expertise database (T3.3), and the way of working (T3.4). These tasks are all in place to sustain the feasibility studies (T3.5), the main goal of work package 3, the Feasibility Network Service.

Infrastructure and portal (Task 3.1/3.2)

The work package makes uses of a few computerized infrastructures. The main tools are the portal on the COLAE.EU website and the expertise database on the COLAE intranet. An internet portal to attract new cases proved not to work. Without exception the companies needed one on one contact with project members in order to build trust to start a feasibility study.

Expertise database (Task 3.3)

In the original plans an experts' database was envisaged. An expertise database however proved to be much more manageable. In the course of the project the expertise database was updated and combined with the database of WP4. The database has extensively been used to find suitable expertise and experts for the feasibility studies. Experts were appointed by the contact persons from the COLAE project partners.

Way of working (Task 3.4)

The way of working for the feasibility studies is for a large part based on standard systems engineering processes. In the course of the project a smooth recipe evolved that proved to be highly successful. Especially in a later stage of the project where the partners started to work on the feasibility cases by themselves, the documented way of working and the available templates led to a consistent output. The main steps are:

- ***The intake procedure***. Where the intake via the portal was not successful, the interviews performed in WP1 provided the majority of cases, directly followed by cases delivered by the partners directly. The interview/intake often provided a good insight in the nature of the cases, but one or more follow up meetings/contacts were necessary to understand the product in detail. IP issues (NDA, advice to patent etc.) were also dealt with in this phase.
- ***System analysis.*** Based on the intake and further discussions with the customers sets of requirements were put together. The requirements were not exhaustive, but good enough to serve as the basis for the next steps. This phase is typically ended with the conception of a system design concept. Most companies found this an important deliverable.

- ***Experts' advice.*** Detailed information on the cases was obtained from the experts. Advice was given on typical issues such as the processes to be used, the availability of components and fabrication tools, the pros and cons related to a concept design of process flow etc. The concept of experts' advice from COLAE consortium proved to function very well both in the direction. The corresponding bill of materials and process flow was used as input for the cost of ownership calculations. The companies found the advice vary valuable and in many cases this led to a one on one contact between the customer and the experts.
- ***Cost of ownership estimation.*** Based on the requirements, concept design, bill of materials and process flow a total cost of ownership estimation was calculated. For this we used and improved a model that was available at TNO. The model essentially calculates the fixed, operational and consumable cost per process step. This process not only combines all the input obtained in the previous steps, it also provides a sanity check on the proposed concept. For many companies, the cost of ownership calculation is the most important deliverable
- ***Reporting.*** All feasibility cases where finalized with the delivery of a report to the customer that describes and discusses all the steps and results of the study. After the report was send a one on one discussion with the customer was held to clarify eventual issues.

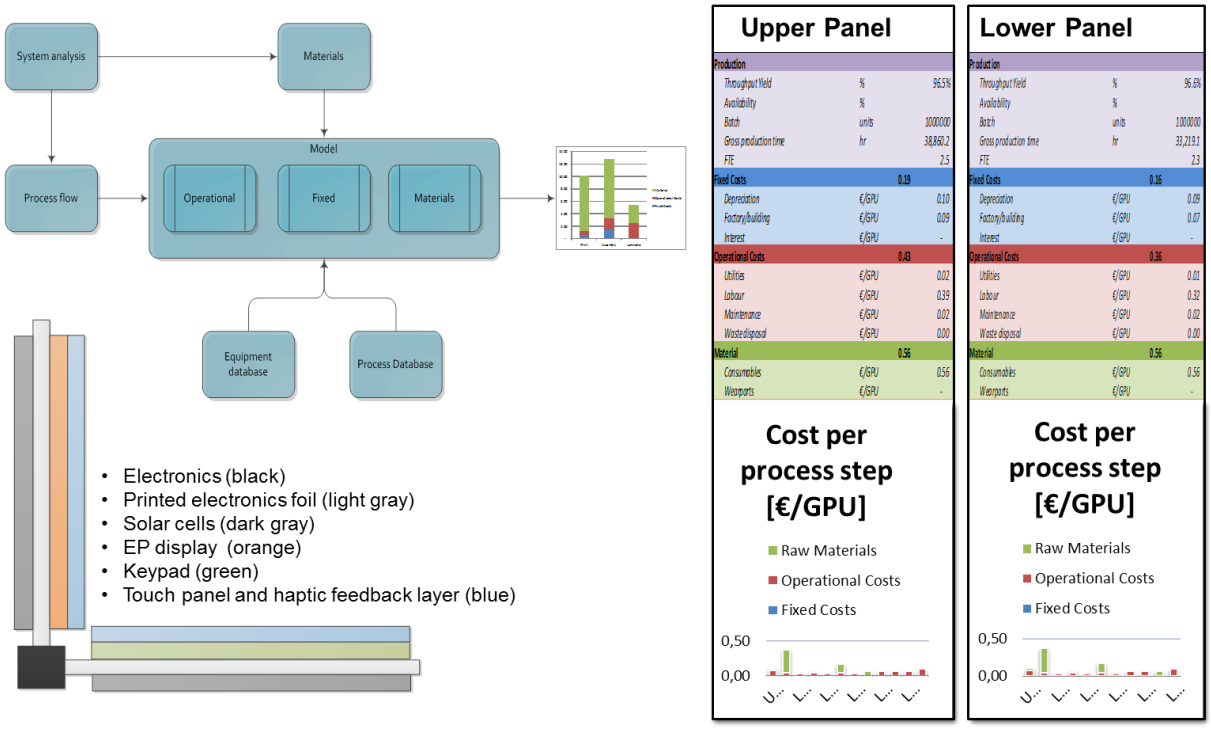


Figure 8. An example of system analysis and cost of ownership estimation in a feasibility study; eBag for education by LeiaMedia Ltd

Feasibility studies (Task 3.5)

In the original project plan was envisaged to perform 10 case studies. In the course of the project it became evident that the feasibility studies (as the cases were more aptly renamed) where an

important outcome of the COLAE project and the number could be increased to 15. In the end we started 18 feasibility studies of which 17 were completed. Of these cases, 15 where for companies: µ-SME (5); SME (6), LSE (4). 2 cases were EU project related (Flexsmell and COLAE).

Micro-SMEs and start-up companies typically requested a feasibility study to back up their new business plans. SMEs were more interested in improvements on existing products without using disturbing technologies. SME companies also were more interested in short term solutions. The typical required time to market rarely exceeded 1 year. The LSE's seem to use the studies mainly for technology scouting, although they came up with relevant cases for their businesses. These cases where mostly cost driven and therefore rarely feasible within the (cost) requirements. Only in a few cases companies really wanted a completely new product.

On the short term OLAE technologies seem fit to replace flexible circuit boards (based on polyimid) especially in combination with simple printed sensors (resistive and capacitive switches for instance) and large areas (typically >10cm2). However in all cases it was found that the largest part of the cost price is coming from the components that are needed to meet the required functionality. OLED and OPV, the usual OLAE components, are still not available for a low enough price or in a flexible form factor and prove therefore not to be applicable in the cases that we studied. Non organic thin film solar cells are available (for instance CIGS and a-Si) and LEDs are widely available and can be integrated to yield an affordable product.

Sustainability of the Network (Task 3.6)

The COLAE project offers within WP3 feasibility studies to firms that are generally interested in testing OLAE technologies for their products or processes. Over the course of the project more studies were conducted than initially scheduled. This hints towards a demand for this particular service and consequently for a potential business opportunity for an OLAE service firm. We investigated this opportunity with the aim to provide a holistic analysis of aspects relevant for a business plan. The content ranges from market & customers, and value proposition & enablers, to organisation, and financial planning.

The analysis shows that price is the determining factor for business sustainability. During interviews business representatives identified a price of around 5.000€ to be reasonable. The financial planning for this OLAE service firm defines a price beyond 15.000€ to be necessary to cover costs and expenses. Interviews with firms that participated in COLAE feasibility studies indicate that a written study is just the first step in the innovation process which does not add sufficient value to justify this price. This hints towards the need for additional complementary services for bringing the written results "from paper to lab". By adding design and prototyping the consultancy would act as a one stop shop for OLAE product development. This could result in higher willingness to pay and consequently to a sustainable pricing model.

3.4 Towards Virtual OLAE Foundry (WP 4)

The main objective of WP 4 was to support the alignment process of the OLAE centres towards becoming a joint service provider in the form of a virtual foundry. By establishing such a supportive structure between the European OLAE centres, it will be possible to have an improved way to accept enquiries from SMEs and LSEs seeking business opportunities in OLAE in the future.

In order to reach this goal, the project partners have joined forces in work package 4 to work on advancing the foundry concept for OLAE by exchanging information about R&D and manufacturing capabilities, by customizing a common design tool kit that connects these R&D and manufacturing capabilities across Europe, by progressing the standardization of OLAE, and by jointly identifying and disseminating the unique selling propositions of OLAE through a macroeconomic analysis in the form of a SWOT and PESTEL analysis.

When COLAE, specifically WP4 “Towards a virtual OLAE foundry”, started out in 2011 with the aim of taking first steps towards transferring the foundry concept to Organic and Large Area Electronics, standardization of the technology was very sparse and design tool kits were not available. Initially, WP4 focused on enhancing the cooperation between the European OLAE centres involved in COLAE by identifying their R&D and manufacturing capabilities. The resulting competence matrix was later fused with the expertise database of WP3 “Feasibility Network” and utilized to identify suitable experts for feasibility studies. The subsequent attempt to match these capabilities to industry requirements for service packages was complicated by the fact that foundry services can, by definition, not be developed without standardization and design tool kits. Thus, the services identified were not closely related to the foundry concept, but rather focused on connecting the different offerings under the term “The COLAE approach”, i.e. user-centric innovation workshops, product requirement interviews, feasibility studies and trainings.

During the second half of the project, a reorientation towards the main objective of the work package namely advancing the foundry concept for OLAE technologies became possible due to two developments: (1) the uptake of standardization activities by the International Electrotechnical Commission and (2) the completion of a technology design kit by the FP7 project TDK4PE, that was available for customization using COLAE manufacturing techniques. The partners of WP4 reacted to these developments by taking both active and supporting roles in the standardisation process and by customizing the TDK4PE technology design kit in order to be able to jointly offer foundry-type design access, based on a shared design tool kit in the future.

A first step towards the alignment of these centres was to set up a database containing the capabilities and service offerings by all project partners. For this purpose a survey was conducted at the beginning of the project that contained two parts. The first part aimed at collecting general contextual information about a centre, such as its strategic strengths and weaknesses or the membership structure of associated regional clusters in terms of size and industry to academia ratio. The second part focused on specific R&D competences and capabilities that are present in a respective centre. Based on these data points, WP4 was able to develop a competence matrix that

illustrates COLAE partners' knowhow along the OLAE value chain. In order to test this matrix for its practicability, the project partners in WP4 decided to execute a virtual use case. After a system analysis for an OLAE enabled fire-fighters' jacket, subtasks were distributed to partners in accordance to the competence matrix. The results of this case proved that the new transparency increased efficiency and effectiveness of decision making among the COLAE partners. In the second half of the project, semi-structured interviews were conducted with representatives of each centre in order to update the database and account for changing capabilities over time. These interviews also complemented the survey data with qualitative information. At this point in time, the COLAE consortium decided to bridge efforts between WP4 and WP3 to benefit from synergies: the competence database was merged with the expertise database developed in WP3 to improve the selection process for experts to contribute advice to feasibility studies.

The result of this approach was an increased transparency among the project partners concerning the distribution of problem solving capabilities for OLAE in Europe. This transparency enables an effective alignment of resources in future activities aiming to support companies seeking business opportunities throughout Europe.

Standardization is a fundamental prerequisite for the evolvement of a foundry-type industry model. Therefore, the COLAE partners took on an active role in the development of standards and supported the International Electro-technical Commission (IEC) by raising the awareness for the ongoing standardisation process. The following contributions have been made: four partners of COLAE joined IEC Technical Committee 119 "Printed Electronics", a mirror group to IEC TC 119 has been founded in Switzerland by CSEM with support from iL (Electrosuisse TK 119 Gedruckte Elektronik), two standardisation projects have been proposed in IEC TC 119 that can be traced back to WP4 activities: one on semiconductor inks for printed circuits by CPI and one on data formats for technology design kits by PEC4 (UAB), a white paper on the status of standardization including a guide on how to participate was published on the COLAE website and a workshop was organized jointly with the German Electrotechnical Commission (DKE) to evaluate the interest of the OLAE community in standardization.

In summary, standardisation of OLAE is a young field that is rapidly growing in importance. It is currently strongly driven from Asia with limited interest in participation by European companies. Further efforts should be taken to raise the awareness for this process and to demonstrate the benefits of participating in standardization such as early access to information, facilitated market access or reduced risk in R&D efforts.

A design tool kit that was developed by the FP7 project TDK4PE was adapted to manufacturing technologies provided by CPI (photolithography) and CSEM (gravure printing). CEA is providing screen-printed CMOS technologies developed in the frame of FP7 project COSMIC. For this purpose a customization routine based on extracting technical parameters and implementing rules in design tools was developed, which now allows customization in approximately 3 months. The resulting design tool kit was validated by designing a circuit controlling a tic-tac-toe game. In future work further improvement of the manufacturing processes and iterations of the design tool kit are required to enhance the functionality that can be realized with this technology. The design kit is now

available for four different OLAE manufacturing technologies (including inkjet by TDK4PE) by four different research institutes throughout Europe, which represents a large step towards a virtual foundry for OLAE in Europe.

The customization of the design tool kit has enabled CSEM, CPI, and CEA to offer low volume contract manufacturing services for circuits designed using the tool kit. CSEM and PEC4 offer assistance for using the design kit and also design services based on the tool kit. In future work, the design tool kit could be customized for a larger number of European OLAE centres and the resulting range of services offered could be connected to a platform like Europractice, which would create an efficient way to make the services accessible to companies throughout Europe.

As part of the Workshop on the results of WP4, nine presentations were given on the dissemination of the work on design tool kits and to highlight the current state of the art in general. Several speakers and attendees highlighted the need for a broad range of development requirements in the reduction in cost of materials, better understanding of parameters of materials and processes as well as in the use of design tools to enable designers to work more effectively with Organic Large Area Electronics. There is a need for more applications where OLAE demonstrates clear advantages over microelectronics. There is also a need for design tools and process limitations to be understood by designers, as well as the opportunities that OLAE characteristics such as short / bespoke run capability and design flexibility can bring when developing systems. Overall the feeling was very positive about the progress the COLAE project had achieved in setting rules and parameters for designers of circuits and devices. In the interactive session following the dissemination section, the attendees of the workshop identified current challenges for the development of design tool kits such as batch-to-batch variations in material properties, lack of file format compatibility between design software and software used for manufacturing (e.g. of gravure cylinders, silk screens or photolithography masks), lack of component libraries, and lack of standardization for system integration. Suggestions made by the workshop participants on how to overcome these challenges included, for example, dedicated material purchasing strategies, facilitation of cooperation between design software vendors and printing master manufacturers, financial support for developing open access component libraries and stronger European involvement in standardization in general. The result of the workshop was a schematic proposal for a large scale technology demonstration project centred around inkjet-customizable gate arrays with special focus on topics such as the development of libraries of frozen processes, setting up a marketplace for components and standardization. Such a project should have an obligation to publish the results widely for the benefit of the entire community. The results of this session were also reported to WP6 “New Wave Research” for further consideration.

In order to contribute to the identification of the path towards commercialization of OLAE, the partners involved in WP4 have performed a PESTEL and SWOT analysis of OLAE with a specific focus on the four vertical markets Lighting and Signage, Energy Harvesting and Storage, Medical/Wellness, and Packaging. From this analysis the most important unique selling propositions (USPs) of OLAE were extracted: innovative form factors, weight reduction, environmental friendliness, low energy consumption, and enhanced freedom of design. A PESTEL analysis is a tool that was used to analyse external drivers that can have an impact on the development of OLAE. These drivers include Political,

Economic, Social, Technological, Environmental, and Legal factors. A SWOT analysis was used to investigate strengths, weaknesses, opportunities and threats for OLAE in the respective markets.

In order to compare these USPs to the current market need, product requirement interviews with more than 40 European companies in the respective markets have been conducted in WP1 and analysed quantitatively in the context of the SWOT and PESTEL analysis. It was found that the most important requirements from a market perspective for OLAE match well with most of the USPs: Innovative form factors, compliance with standards, lifetime of more than five years (less for packaging), energy usage, and appearance. The requirement for compliance with standards is a particularly interesting point that has not been identified as a USP. In a large number of the product ideas discussed during the product requirement interviews, the compliance with standards was a necessary requirement for the applicability of any new technology. Consequently, a comprehensive study of such standards could be used to systematically identify application cases for which OLAE can improve on incumbent technologies, or at least set target specifications for the further improvement of OLAE. The requirement of a lifetime of more than five years for most applications is still challenging today for many applications. It is a major technological driver as discussed in the PESTEL analysis.

The full report about this macroeconomic analysis was published on the COLAE website and is available for open access.

With these activities WP4 successfully started the alignment process of the OLAE centres towards becoming a joint service provider in the form of a virtual foundry in the near future.

3.5 User centric model for OLAE industry (WP 5)

The main objective of this work package is to deliver a radical shift from approaches based on passive studies and events towards the development of a pro-active open innovation environment, based on proven scientific principles, which will deliver integrated solutions in terms of commercialisation readiness assessment, adaptable open innovation methodology, a portfolio of practical implementation measures and training and dissemination activities in support of dramatic acceleration of value creation through OLAE manufacturing.

The objective of this work package is to develop and disseminate the relevant open and user centric innovation models for OLAE sector by taking account of:

- The leading markets requirements and needs (market pull)
- The strengths of the OLAE industry value chain.

A review of best EU and worldwide practices in open innovation for OLAE (Task 5.1) has been done. Indeed, it is clear that knowledge no longer resides in a single company, which forces us to work on open innovation instead of in company innovation. Therefore, the study of Task 5.1 was done on

Europe, as well as the U.S., China, Taiwan and Japan. The best practices revealed from literature were identified to be adjusted and adapted to Europe.

The work continued with Task 5.2 *Development of EU-specific open innovation model for rapid commercialisation of OLAE research*, and Task 5.3 *The user centric innovation process flow*. A survey was established to feed those tasks. This survey permitted to gather information about awareness of open innovation and its practices in Europe, as well as to highlight the principal success factors and barriers and to investigate the interest of companies in the COLAE innovation model. At first, the user centric innovation model was described in theory, and then led to the realisation of 4 workshops, Figure 9. The workshops' results permitted an improvement of the user centric model described in Task 5.4 *Qualification of the COLAE user centric innovation model and recommendations & best practices for effective commercialisation of OLAE*.

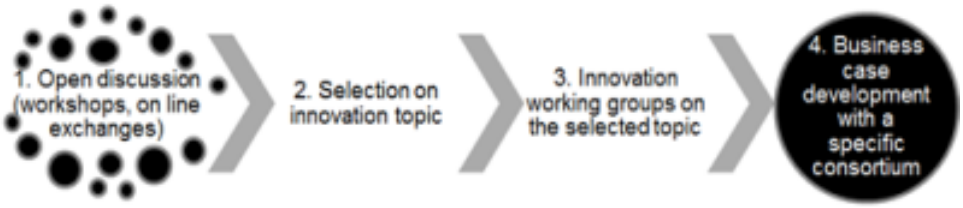


Figure 9. The user centric innovation model for OLAE industry

Task 5.4 was the qualification of the COLAE user centric innovation model and recommendations & best practices for effective commercialisation of OLAE. As T5.1, T5.2 and T5.3 were the pillars to the improvements made on the user centric innovation model, this task was targeting a final qualification of this model to extract recommendations and best practices of the commercialisation of OLAE. After the final adjustments of the user centric innovation model, 3 workshops were done in Lyon (France), Gent (Belgium) and Porto (Portugal), that targeted 3 large markets (packaging, textiles and construction).

From this process and especially thanks to the 3 last workshops, we have been able to involve 10 end-users in detailed discussions with COLAE partners and to get out 2 new feasibility studies and 3 bilateral collaborations between industrial end-users and technology providers.

Those workshops permitted also the identification of the 5 recommendations to effective OLAE commercialisation; the market segment, an understanding of the needs, awareness of the technology, an easily accessible process, and finally, creating an urge, as well as recommendations for a future consortium (a consortium that could put in place pilot lines accessible to all industries and that could permit an industrial quantity production of OLAE. The pilot lines would be specialized in product production, not components and are a simple way to insure a future for the end-users' prototypes. The consortium would also have to work on the dissemination on OLAE as well as the improvement of the lifetime of the technology).

As a summary result of the WP 5 activities:

- More than 160 contacts for step 1 (interview and first contact) among which more than 60 end-users from various market activities.
- 17 end-users reached step 2 of the user centric model (Select a topic of discussion), and 17 carried on to step 3 (workgroups and exposition of recommendations) among which 10 that came of the last 3 workshops (final version of the model).
- 8 end-users continued to step 4 (feasibility study/bilateral collaborations) among which 5 from the last 3 workshops following the final version of the model.

3.6 New Wave Research (WP 6)

The main objective of WP6 is to collect and identify the important research challenges for OLAE technology and potential emerging applications. The information will be collected from the key research and industrial partners of European OLAE clusters by using interactive workshops. The information will be analysed, key recommendations will be created and distributed for the attention of EC, Photonics21 WG4 SRA updating process and the OE-A. Also the information will be delivered to the COLAE clusters creating the opportunity for immediate response.

Workplan for workshops and reporting

Main tool to collect information about the important research challenges of the OLAE field was arrangement of interactive workshops focusing on different sub-areas of OLAE. The one day workshops consisted of an invited session 60 minutes (2-3 talks), an idea session 90 minutes of short elevator pitches (10 invited and 5 ad hoc), interactive group workshops (on selected topics) and results presentations, and the conclusion. The workshops were also organized in connection with major OLAE conferences, OE-A meetings and other relevant EU project and commission meetings (e.g. consultation meetings) in order to facilitate especially industrial participants to join the work. Following five workshops were arranged during the project:

1. OLAE systems and applications
2. OLAE devices
3. OLAE processing and manufacturing
4. OLAE materials
5. OLAE system and applications

In addition to obtain input from other COLAE work packages intensive collaboration was done with other WP leaders.

Workshop on OLAE systems and applications

The workshop on OLAE systems and applications was organised just after Prinse`12 seminar in Oulu 15.3.2012. First the three of COLAE partners presented their experiences and then the company

pitch talks gave the introduction to industry needs, although the lack of product companies was essential. Some 50 people were participating from 47 organisations.

As result the challenges in Organic and Large Area Electronics (OLAE) are strongly seen at the integration of the already developed OLAE components and conventional electronics and in the material related topics as barriers reducing the lifetimes, not to forget the early stage of standardisation with design rules, component models and performance for industrialization. All this has resulted to a situation that we are in urgent need to find product ideas for real applications and to show the technology maturity to be manufactured in large scale quantities. Detailed results of this workshop are reported in deliverable 6.1.

Workshop on OLAE devices

The workshop on OLAE devices was organised just before start of Plastic Electronic Conference 2012 in Dresden. The workshop has been introduced by 4 invited presentations by recognized experts in OLAE. Subsequently this was followed by an interactive discussion among the experts. 27 people from 16 companies and 9 institutions were participating.

A general result of the discussion has been that devices should not be discussed by excluding system aspects of an application. For this the outcome is partly overlapping the first workshop on OLAE systems. Major conclusions from the workshop discussion are

- Future OLAE devices are identified in the field of sensors, biosensor and sensor arrays. This should be accompanied by advancing devices for the electronic periphery like devices for energy harvesting, energy storage and simple output devices.
- Conventional electronics including ultra-thin and flexible silicon should be taken into consideration for fabricating system core electronics, besides organic integrated circuits.
- Heterogeneous integration: In the area of large-volume small area applications integration of functional devices to smart objects will be a major concern. For the time being and the near future heterogeneous integration on plastic films will play a pre-dominant role for OLAE commercialisation

Workshop on OLAE processing and manufacturing

The workshop on OLAE processing and manufacturing was arranged 11th of May just before LOPE-C2013 conference in Munich. Thirty people managed to attend the workshop and around 10 people were interviewed the day after in the LOPE-C booth area. 2/3 of the attendance came from the industry. The workshop agenda was structured in three main parts in order 1) to introduce the attendance to LOPE-C and COLAE, 2) to inform the attendance on general figures from EU activities in OEA and 3) to initiate and drive parallel discussions on R2R / S2S processing & manufacturing as well as process control.

As result of the workshop several different bottlenecks were identified in materials, components, equipment and processes. In addition challenges were visible also in other topics like collaborative actions, markets, standardization etc. Because the OLAE industry is not mature yet it is too early to

set up flexible toolkits for producing any kind of OLAE products. OLAE is still in a technology-push phase and this do not guarantee product performance, reliability and cost requirements regardless of the case of application but would rather deliver variable and hardly predictable performance, reliability and cost. Creating early market opportunities is a critical issue for the OLAE industry. Along these opportunities, creating and unifying strong EU industrial clusters with focused OLAE products as a target benefiting from the support of relevant public-private partnership & infrastructure will be the driving force to success.

Workshop on OLAE materials

The workshop on OLAE materials took place at Porto Palace Hotel in Thessaloniki in 8th-10th of July 2013. It was organized as a part of 6th International Symposium on Flexible Organic Electronics (ISFOE13). The workshop revealed, discussed and contributed to solving the fundamental issues that cover the synthesis, thin film fabrication of new organic semiconductor (conjugated polymers, evaporated small molecules or solution processed small molecules) and electrode materials, efficient charge transfer mechanisms, optimization & control of morphology.

OLAE materials workshop was more conference type event than interactive workshop where participants came mostly from academia. The presentations included scientific knowledge of synthesis of novel polymer and small molecule organic semiconductors and optoelectronic materials and well as organic and inorganic hybrid materials. In addition carbon based novel materials including grapheme, fullerenes and nanotubes were presented. Presentation as also included high lights of European gas barrier and encapsulation material research carried out in EC funded projects. General outcome of the workshop was that the OLAE material research is very high level and generates plenty of new innovations and scientific publications.

Workshop on OLAE system and application

The workshop on OLAE system and applications was organized at afternoon 26th of February and co-located with the Prinse2014 Seminar at VTT Oulu, Finland. 99 people participated to the workshop of which 76 came from the industry including consultants, market analytics and regional development people as well as EC representative. Number of academic partners was 23. The workshop consisted of introduction part, industry and EC presentation, Interactive group work was performed and it focused to identification of challenges and solution along the COLAE value chain – materials, equipment/processes, components, system integration/vendors and application development.

Organized workshops collected lot of information about different research challenges in OLAE field. Summarized key recommendations for future research topics are:

- SME companies should be supported more. Focused shorter term industrial driven demonstrator projects and pilot actions parallel with longer term research projects are needed. Technology transfer from lab to fab should be faster. Existing and new pilot production facilities could be utilized more to accelerate technology ramp-up.

- Longer term research projects are still needed to develop new materials and increase performance and lifetime of OLAE components. Actions to strengthen development of modelling and design tools are needed.
- Hybrid integration (combining OLAE technologies with microelectronics) is an important opportunity to utilize OLAE technologies in electronics manufacturing chain and bring commercial application to markets. In order to achieve success, modelling and design tools should be developed further so that materials and processes for integration with existing electronics design flow. This also requires stronger standardization activities. Internet-of-things offers huge market potential for OLAE technologies together with conventional electronics.
- Novel business models to commercialize OLAE technologies need to be developed. Service type of business is future. In addition more business developers who understand the OLAE field are needed.
- Awareness of OLAE field should be still increased. Dissemination activities of research projects should be aimed more towards end users

Other actions in WP6

COLAE project was actively participating to preparation of OLAE vision paper[2] together with EC DG CONNECT, Photonics21 and OE-A. The vision paper was published in June 2013. The main goal of this vision paper was to serve as an input for the Horizont2020 priority setting process.

Findings from COLAE project to New Wave Research

During the project information about research challenges of OLAE technologies was also collected from other work packages. Identified OLAE challenges were collected from WP1 – Networking, WP3 – Feasibility Network, WP4 – Towards Virtual Foundry and WP5 – Open Innovation Model.

In WP1 when doing company interviews it was often expressed that if OLAE-based products and their technologies are to progress at a sufficiently rapid pace through their learning curve to overtake the incumbent technologies, which also experience learning and ensuing cost reduction. So, we are witnessing the battle between the learning curves of different technological options. Fast progress in performance improvements and cost reductions will determine choices of decision makers.

Generally, companies are still taking a waiting position for adopting OLAE technologies until different components have reached a minimum level of maturity (in terms of costs and performance) to be applied in their products. Most of the companies are not willing to invest heavily in developing applications of OLAE.

In WP3 the feasibility studies we tend to start from industrializable processes. That means we try to advise processes and solutions that are out of the research phase. The biggest challenge in getting OLAE technology in the market is the availability of integrators. The reply to the question of many of

[2] A European strategy for Organic and Large Area Electronics (OLAE), June 2013, http://www.photonics21.org/download/Brochures/AEuropeanStrategyonOrganicandLargeAreaElectronicsOLAE_2013-06-2622.pdf

the companies: “who is going to provide me with the components and who is going to integrate these for me” often is replied with “we don’t know”!

Companies that can print circuits in simple electronic components are out there (membrane switch manufacturers for example), however the typical feature sizes that they feel confident with are still not what is needed for hybrid and completely printed solutions. Integration companies are also there but lack experience with printed circuits on polyester substrates. Especially reliability is the major issue to be solved. One stop shops (printing and integration = integrators) are simply not there (except for a few).

A part of WP4 work was focusing to identify the progress made in the area of design rules for printed logic and printed circuits. This revealed following challenges

1. Material challenges for design rules:

    a) Batch to batch variations in material production: Material properties can change from batch to batch without notice from the material manufacturer. This is critical for design of logic and circuits, because design rules can only be fulfilled with high reproducibility, if all material parameters are fixed.

    b) General performance: For the design, especially of functional logic circuits, general material performance parameters must be improved: Most notable are the charge carrier mobility, life-time, multilayer processability and permeation properties of barrier materials.

    c) Environmental issues: Disposability, recyclability, biodegradability and the connected legislative barriers have not been sufficiently investigated for (single-use) printed electronics products.

2. Equipment/ process challenges for design rules:

    a) File formats: Currently, design software tools cannot produce files that are compatible with file formats that are used for tooling in the printing industry (e.g. for manufacturing printing cylinders). As a first step, format converting tools need to be developed that also take specific process requirements into account (e.g. distortion compensation). In the long run design tools should be able to export suitable file formats (some converters, e.g. for inkjet printing, already exist as open source software).

    b) Large volume printing: Due to high material prices only limited experience exists in Europe for very large volume print runs. This knowledge is however very important for understanding the process stability and the yield in real production scenarios.

3. Component challenges for design rules:

    a) Libraries: Vast component libraries for all combinations of component type and manufacturing process have to be developed and integrated into design software tools.

In many cases this requires an agreement on the underlying physical model for the theoretical description of a component.

b) Reliability, stability, yield and cost of components needs to be improved for a faster market uptake.

c) The access to components currently available is fractured and an overview of the state of industry is difficult to obtain and keep updated.

4. System integration challenges for design rules:

a) Standardisation: System integration of printed logic and circuits requires interoperability of post-press machinery (e.g. laminating, folding, cutting etc.). Therefore, standardisation is a relatively critical topic for system integration: For a wide range of topics from functional inks over connectors (e.g. foil to foil or OLAE to conventional electronics) to rolls of substrate materials (e.g. size, transport procedures or registration marks) standardization is require.

b) The lifetime of the OLAE products seems to be too short for the companies to be integrated in their products. Silicon has a much longer lifetime whether we're talking about shelf lifetime of operational lifetime. The lifetime of OLAE products should be improved to facilitate the user acceptance.

c) The OLAE batteries don't last long enough compared to the lifetimes of the products in which the OLAE system will be integrated. We should then try to make better batteries but also less energy consuming OLAE systems.

d) For the moment, pilot lines for OLAE printing are available and accessible for average companies. The problem is the integration process and the integration cost (for example switching from ordinary labeling to in-mold labeling). An option is to make integration shared platforms or to find solutions for easier integration.

e) Many companies don't know the potential of the OLAE technology. Some work should be done on the dissemination.

3.7 Lessons learned and recommendations

European level cooperation and coordination

Lessons learned

The transparency in COLAE brought OLAE competence clusters closer to each other. The experts from different organisations had `Working together in OLAE` –spirit in workshops, trainings, feasibility studies and COLAE booths. The smart specialization was enabled through surveying of

facilities, which offered to partners a way to identify complementing facilities in different locations in Europe, which could be jointly offered to client companies.

Recommendations

It is of most importance to continue the coordination of smart specialization of different locations and the creation of piloting services in Europe. Especially for SMEs the transparency in European level to find the best technology for their applications will ensure the competitiveness of their products in global business.

It is also important to implement funding schemes for practical co-operation in design and manufacturing of functional prototypes.

Enhancing awareness

Lessons learned

The practical face to face -approach in interviews, booth presentations and workshops was a successful way to get OLAE technology migrated into the designers and engineers not familiar with OLAE technologies. Interviewing SME and LSE companies (63), activating workshops for industrial designers (4 workshops), offering training on the technology and best practices in entrepreneurship, running feasibility studies (17) utilizing the OLAE network and pilot manufacturing environments and getting 100 SMEs engaged in COLAE clusters enhanced the awareness. Companies found it useful to learn how the value chains will be changing when utilizing OLAE and hybrid integration and how the miniaturisation in semiconductor technology will also enhance the usability of flex substrates.

The colae.eu –web page supported all COLAE marketing and dissemination activities effectively. The number of registrants (742) and followers in social media (6794) showed very clearly the importance of communication and taking in account the social media. On the other hand a feasibility study template in the web pages was not a successful way to collect ideas for feasibility studies. The personal contact was the right way to gather the ideas for feasibility studies.

Recommendations:

There is an urgent need to get OLAE technologies to the next generation products of many companies in Europe, so that industrial value chains will be created. There is a need for active marketing of available resources, pilot factories and success stories. Face to face interviews and design workshops with research and industry participants are the most effective way to get OLAE to spread inside companies. OLAE is for now still a niche technology, not very well known and accepted. We therefore strongly recommend a good dissemination campaign on OLAE.

It is also important to promote opportunities and capabilities of OLAE technologies to product designers and business developers with more concrete concept case presentations and component data sheets.

Demonstrators and showroom

Lessons learned:

Concrete demonstrators showed up their efficiency in presentations, workshops, booth presentations and trainings. The demonstrator kit (10 kits rolling over Europe along with COLAE partners) with over 10 different topics and practical showroom in Hannover Fair 2014 gave the possibility to show the maturity level of OLAE technologies. The challenge in early COLAE project was that the demonstrators were components not systems. For Hannover an integrated system was prepared.

Recommendation:

The demonstrators are the essential tool in promoting OLAE technology and the available functionalities with the exceptional OLAE form factor. There is a need to make the OLAE technology maturity level more visible and understandable to business and technical people, in order to initiate realistic innovation. The demonstrators should be complementary covering different technologies, different materials and different manufacturing techniques from various locations in Europe.

In OLAE technologies and manufacturing processes a huge potential for mass-manufacturing is seen. Therefore, we recommend launching of give-away demonstrator cases to bring the mass-manufacturing clearly visible to a wider audience.

Trained staff

Lessons learned

The COLAE survey of the training requirements of 110 EU companies in the OLAE sector indicated that there was a need for 1 week training courses offering hands-on experience of OLAE fabrication and testing techniques. A comprehensive sequence of practical modules covering the major OLAE technologies and production methods to be delivered at a number of clusters was developed. But, the take up of the modules was lower than expected and several modules did not attract sufficient attendees to be viable. It seems that the industry has not yet identified the technologies which will fly and thus the industry is not willing to invest to 1 week trainings of valuable staff. On the other hand there was much interest to the shorter 1-2 day trainings.

The entrepreneurship courses supported by COLAE were very successful and generated more than 10 business cases from which at least 5 businesses have been established. The researcher`s ´comfort zone` could be enlarged with only a 1 week training (Enterprises 2014) in international group. Acceleration of technology and business development of an idea was achieved by gathering groups together for two days (Printocent Innofest 2014) and by building mixed teams with product company representatives, researches, experts from various fields and supporting technology provision companies.

Recommendations

It is important to continue the offering of both 1-2 day courses and the above mentioned 1 week modules for technical training.

We would also recommend that activities to promote entrepreneurship and provide training in related skills in international groups and organising of accelerated business case development meetings are valuable and should continue to be supported.

Service model for Feasibility Study

Lessons learned

Feasibility studies (17 in total) were conducted for 15 companies and two projects. An important lesson learned from this activity is that companies clearly have different needs depending on their size. Start-up companies (micro-SME) typically are interested in the feasibility studies to obtain a solid base for investment requests or project proposals for completely new products. SMEs on the other hand liked the feasibility studies because it gave them a good insight into the state of the art of OLAE technologies and how these can be integrated into their specific product. In these cases it was mostly about replacing parts of existing products. The large scale enterprises on the other hand used the studies mainly for technology scouting.

From a process point of view, the way of working was evolved from experimental trials to a widely applicable and flexible work flow. All partners were able to successfully conduct feasibility studies based on this work flow. Based on the resulting reports, the level of the studies is similar. The customer feedback indicated that the results were satisfactory and highly useful for the intended purposes.

The feasibility cases having experts from different innovation centres of Europe and an idea owner is a very effective way to develop the practical cooperation in Europe and get the best experts involved in next generation product development.

Recommendations

In the feedback and discussions, customers did indicate that the lack of having the opportunity to manufacture prototypes is seen as a serious omission in the project. For all three types of companies (µ-SME/SME/LSE), prototypes would have been a very valuable addition. Especially, as only a few facilities are available for prototyping at the moment, we need more volume in prototyping in Europe. Therefore we believe that in similar projects in the future, a combination of feasibility studies as and design and manufacturing of prototypes, are highly recommendable.

Towards virtual OLAE Foundry

Lessons learned

The first steps towards virtual OLAE foundry and related services were taken in COLAE. A deep understanding among the project partners about their problem solving capabilities for OLAE was developed – especially in Feasibility Studies. As a further step standardisation, the test case improving the design-fabrication flow with design kit and the validation of the design kit were covered as a basis for OLAE foundry.

OLAE related experts both in companies and in academia have generally limited knowledge and willingness for contributing to the standardization processes. The processes are seen very byrocratic, although this claim is not always true.

The design-fabrication flow was developed by COLAE and TDK4PE to extract process technology information, i.e. design rules, to build design kits. This procedure can be applied to any “frozen” process that can be maintained without modifications for an extended period of time. The experiences show, that the validation of design –fabrication flow needs several iterations of the design kit and that the semiautomatic testing is a necessity for effective working.

A special topic related to the risks with the material supply chain realized in the used OTFT platform, as the only supplier withdraw its product ink from market.

Recommendations

It is important to join the resources in European-level since Japan and Korea are putting a lot of effort in standardisation in IEC and US in doing the same in IPC. Interest of researchers and companies to engage in standardization could be encouraged by financial support.

Active discussion with standardisation bodies like IEC is needed to understand which things benefit from standardisation activities. Especially timing is important; when there are enough business opportunities and when the technologies are mature enough.

The speeding up the development of design-fabrication processes and related design kits is crucial for industrialization of OLAE. We need `frozen` processes offering design kits for product development, so that manufacturing will be established in Europe.

User Centric Innovation Model

Lessons learned

Based on the experiences in COLAE we have listed specifically important topics for an efficient commercialization of OLAE: selection of market segment, understanding of the user needs, maturity of the technology, easily accessible design-manufacturing processes and agile feasibility study & prototyping. If the development cycle has too many risks the lead companies retain in `wait mode`.

When applying the User Centric Innovation Model the key lessons learned were:

1. A clear need exists for theme oriented forums – seminars, workshops - enabling open discussions to link the end user needs and industry to OLAE innovation centers and potential value chain companies.

2. There has to be an identified end user need for an innovation topic and a lead company, which aims to bring the innovation to market. The lead company is willing to present the market context, product types and requirements, and current product bottlenecks to a working group. Sometimes the IPR topics are critical and could stop the process.

3. The innovation working groups have to be organized so that the user needs will guide the process. The potential actors for the value chain are screened beforehand and are invited in cooperation with the leading company. The presented OLAE's offer of accessible services and processes has to have a sharp focus for the requested demand in the innovation. Also maturity level of technology has to be clearly shown. The NDA agreement is normally in use. The feasibility study is recommended for this phase. Without prototyping services the development process is stopped and interest of lead companies is lost.

Recommendations

There is a clear role for innovation centers to organize theme oriented seminars and workshops to link end user needs, potential lead companies bringing the innovation to the market, OLAE innovation centers and potential value chain companies. The User Centric Innovation Model helps to build the consortiums to be the value chain and to prepare feasibility studies supporting the next steps of lead company towards prototyping.

The prototyping services and industrial scale production of OLAE pilot lines has to be available in Europe. This will reassure the lead companies that the R&D efforts in OLAE will give good return on investment.

As the integration of OLAE implicates a great change in the production process of traditional products, we need to facilitate this integration. Therefore, the pilot lines would have to be adaptable to different configurations of production processes.

The wider user acceptance of the OLAE technologies needs still improvements in performance, life-time and cost. Systematic gathering of reliability data is needed the show the maturity level of technology.

New Wave Research

Lessons learnt

During the COLAE project 5 workshops related to OLAE field were arranged. All workshops were arranged in together with major OLAE event/conference. This was good strategy since the workshops

collected reasonable amount of participants, total approximately 250 people of which 150 came from industry. In this way collected information characterized relatively well the whole OLAE value chain. However, in all workshops same technology limitation and bottlenecks were emphasized time after time. In some workshops the structure of the program was not clearly defined and in future it is important to plan a systematic workshop structure. This may ensure that obtained data is comparable to others.

Major challenge in OLAE field is that there are no commercial products and technology is still in push mode. New mega trends like Internet-of-Things and related technologies are emerging to the markets enabling novel type of applications. This also generates lots of need where unique features of OLAE technologies can respond, maybe not as full product, but as a part of the functional system.

There is an increasing need for implantable, stretchable, transient- and bio-electronics as well as other biosensing devices, large area electronics applications beyond the silicon wafer and cost effective smart system integration. Silicon will be used when it is required and when it is already available to fit into application requirements. Flexible hybrid systems will be the first wave of novel application combining OLAE field with conventional electronics. After this fully printed system and application follow.

Recommendations

SME companies should be supported more. Focused shorter term industrial driven demonstrator projects and pilot actions parallel with longer term research projects are needed. Technology transfer from lab to fab should be faster. Existing and new pilot production facilities could be utilized more to accelerate technology ramp-up.

Longer term research projects are still needed to develop new materials and increase performance and lifetime of OLAE components. Actions to strengthen development of modelling and design tools are needed.

Hybrid integration (combining OLAE technologies with microelectronics) is an important opportunity to utilize OLAE technologies in electronics manufacturing chain and bring commercial application to markets. Modelling and design tools should be developed further so that materials and processes for integration with existing electronics design flow. This also requires stronger standardization activities.

There is need for future research actions in areas of design tools and kits, low-temperature assembly and bonding processes, hybrid system reliability testing method development and standardisation as well as for hybrid system machinery, line automation and functional testing.

4 POTENTIAL IMPACT

4.1 Impact assessment and key performance indicators

Improved coordination of the OLAE competence clusters and creating synergies, common strategies, and pooling of resources

In early phase of COLAE project the resources of partners - both facilities and personnel - were surveyed, which formed the baseline for the cooperation in the work packages. The data base was used in resourcing of trainings and feasibility studies and in organising of workshops to get the best possible experts involved. The data bases also opened the possibility to partners to have complementing schemes of facilities to be built in different locations in Europe – smart specialization based on regional competences and industrial profile. All COLAE partners have been have presented their competence and offering in colae.eu web pages.

The registered actors in colae.eu will have the information and profile of the other registered actors from different locations in Europe.

During the project besides the nine steering group meetings and other work package meetings the COLAE partners have worked together in various occasions – workshops, feasibility studies, COLAE booths, which has promoted the `Working together in OLAE` –spirit.

Improved access for SMEs and LSEs to the pilot facilities through the set-up of a virtual `OLAE Foundry`

The services for SMEs and LSEs have been presented in various seminars, workshops, interviews and during the feasibility studies. The first offered service - Feasibility Study - was a very successful way to share best available European level knowledge to support the early phase of product development for a market need presented by a company.

The transparency of services was highly improved in between the clusters as partners visited each other due to the various joint actions and company needs. This information was shared to companies in clusters.

The development of a virtual `OLAE foundry` proved out to be a mission impossible due to lack of standardisation and design tools/kits for components in terms. We are still in early phase of industrialization and high volume of prototyping and utilizing of de facto standard processes in different locations in Europe are needed. But as a first step to build the chain from Design to Manufacturing – the development of tool has been started and first validation was done in cooperation with TDK4PE –project.

Access actions should foster broader take-up of OLAE technology, and transfer OLAE expertise across Europe

The awareness of companies to OLAE opportunities was raised with various face-to- face and marketing type of actions. Interviews of 60 companies new to the field were very effective way to identify an application and then to guide the company to a feasibility study, training or just giving them an expert`s contact information for further steps. Industrial Designer`s workshops (4) gave an practical approach to see and feel the OLAE technologies. The colae.eu web page made itself very popular compared to the others in the field with 740 registered users and of 14 863 people who have visited colae.eu web pages.

The feasibility studies (15) put really on table the reality check related to OLAE technologies as the realization process and cost of ownership were typically presented in a very pragmatic way. For industry designers and engineers this was in many cases the first real touch to OLAE technologies, as so few have industrial experiences so far. Special Industrial Designer`s workshops (4) were organised to attract both students and industrial designers to feel the OLAE technologies and User Centric Innovation model was applied to workshops (5) to get end users involved to meet the potential value chain.

Education and training actions should increase knowledge and expertise across Europe in OLAE

The COLAE trainings have brought visibility to the European level training offering especially in technical trainings. The entrepreneurship trainings are in many cases local by nature.

The challenge in technology trainings has been that there are various OLAE technologies offered to companies new to the field and the companies have difficulties to identify how tackle this new area – what do we need in our next generation products. It seems that COLAE has activated the companies to start the training of their personnel in short courses. The offering of longer COLAE trainings with higher prices was a disappointment, as only very few got interested of those trainings.

The entrepreneurship trainings – quite few in numbers - directed to OLAE technologies proved out to be important as from six companies has been established from the two `Business for Printed Intelligence` - trainings organised during 2012 and Enterprises 2014 had stimulated at least three cases to continue the development. During Innofest June 2014 one company was established.

On the other hand related to industrial designers, they need to have a touch and idea what would be the first trial. Some of the COLAE workshops led to prototyping behind the curtains of NDA.

So as an conclusion for the trainings there is evidence that COLAE has been partly involved in more than 10 business cases of which at least 5 companies has been established (to be confirmed in final version).

4.2 Dissemination

4.2.1 Dissemination activities

The project dissemination activities were designed to gain highest possible coverage and were focused on several activities, Figure 9, including

- Creating a Demonstration kit to promote OLAE in face-to face meetings and at booths;
- Creating awareness of OLAE in Companies;
- Creating awareness of OLAE for industrial designers;
- Presenting OLAE systems & solutions at major European trade shows;
- Presenting OLAE systems & solutions to relevant B-to-B conferences; and
- Training activities

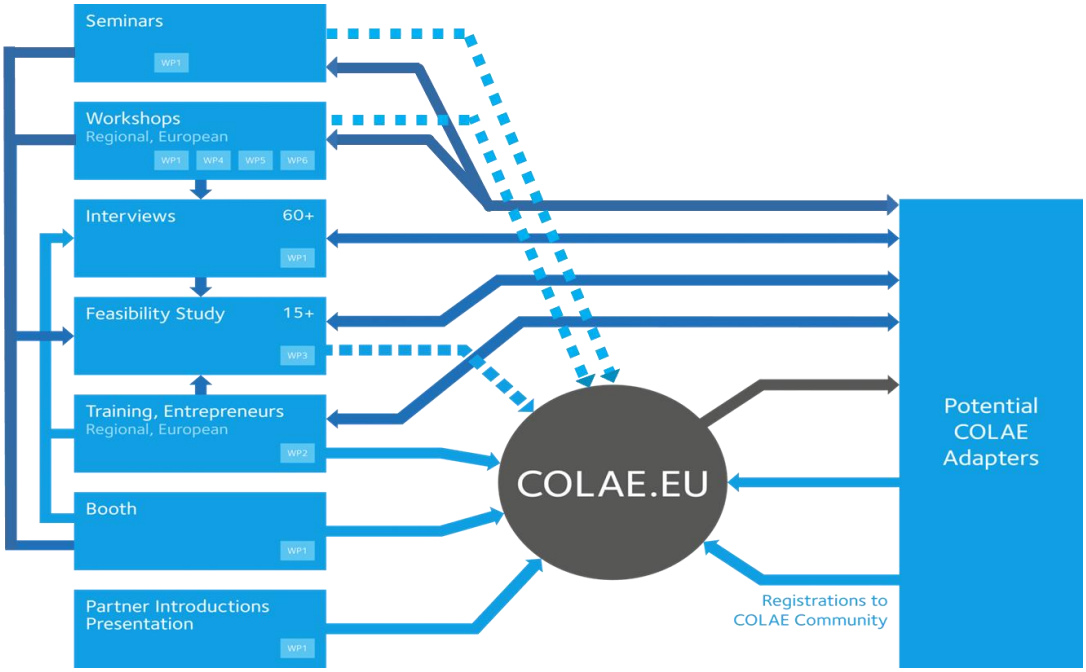


Figure 10. COLAE project communication and dissemination activities.

The Figure 10 presents the multiple communication and related dissemination activities to potential COLAE adapters and also shows roles of the work packages. The crucial role of COLAE.EU webpage was one of the most important lessons learned in COLAE project.

4.2.2 Dissemination material

COLAE in internet and social media

One of the key dissemination channels for the project was COLAE website: http://www.colae.eu/. Besides the website, the project had active followers also in LinkedIn, Twitter and Facebook, Figure 11.

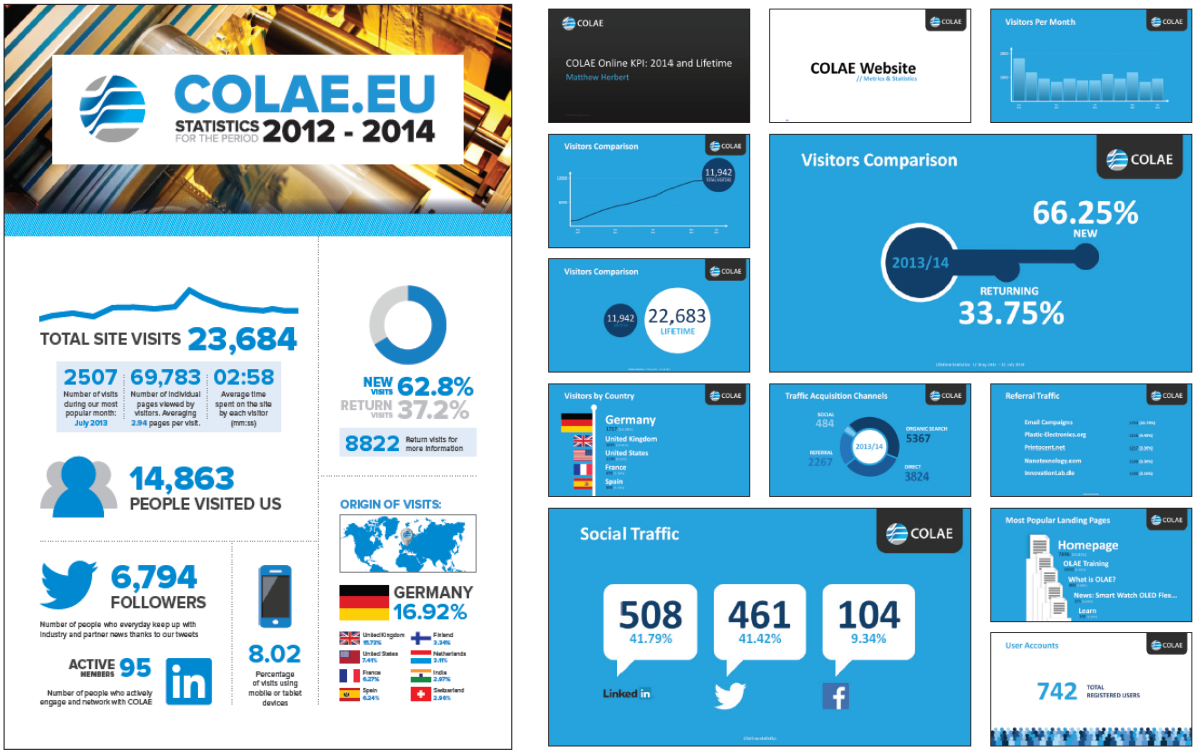


Figure 11. COLAE.EU Statistical Infographic Flyer and online key performance indicators

COLAE video

A COLAE video, *Best of amazing organic electronics*, was made to promote OLAE possibilities and the project. The video is available in YouTube: http://www.youtube.com/watch?v=wxGXCUr8G5w

OLAE demonstrators

The demonstration kit was designed and it comprises a number of relevant OLAE demonstrators and/or preproduction or production-ready prototypes, which show the variety of the OLAE industry and research partners. The kit contained for example following demonstrators:

- Microfluidic Card
- Flexible Micro display
- Flexible Organic Photovoltaic Cell
- Piezoelectric Sensor

- OLED
- Printed battery
- Flexible colour plastic display with OTFT (organic thin-film transistor) backplane

The OLAE demonstrators were also designed for trade shows (booth use). The demonstrators are large-scale, eye-catching and attracting as much attention as possible to the trade fair visitors. They are illuminated, blinking, rotating or touchable demonstrators as well as real production-ready prototypes, Figure 12.

Figure 12. OLAE demonstrators at COLAE booth, Hannover Messe 2014.

Other dissemination material

A wide range of different dissemination material was designed and used during the project. The material included brochures, flyers, banners, press releases, articles, and newsletters, Figure 13 and table 1.

Figure 13. COLAE dissemination material; banner and z-card**.**

Table 1 summarizes the key dissemination activities during the project lifetime.

Table 1. List of dissemination activities.

LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title / Event	Date/ Period	Place	Type of audience[3]	Size of audience	Countries addressed
1	*Article*	CPI	COLAE Brings Together R&D Leaders to Help OLAE Industry Grow		Printed Electronis	Industrials, Scientific community		Global
2	*Article*	CPI	European collaboration fast-track organic & largearea electronics	27/02/2012	Printed Electronics World	Industrials, Scientific community		Global
3	*Article*	CPI	COLAE	vol. 5, issue 5	Plastic Electronics	Industrials, Scientific community		Global
4	*Brochure*	CPI	COLAE Z-Card; Commercialising Organic and Large Area Electronics			Industrials, Scientific community		Global
5	*Conference*	*PLAST*	*Rencontre électronique imprimée*	*26/03/2014*	*Paris, France*	*Industrials*	*>100*	France
6	*Conference*	*PLAST*	*Rencontre électronique imprimée*	*March 2012*	*Paris, France*	*Industrials*	*>50*	France
7	*Conference*	*PLAST*	*Printed Electronics*	*09-11/10/2012*	*Dresden, Germany*	*Industrials and RTO*	*>50*	Europe
8	*Conference*	*Cetemmsa and VTT*	*Flexible Electronics Seminar*	*15-17/10/2012*	*Barcelona, Spain*	*Industrials Academics and RTO*	*>50*	Europe
9	*Conference*	*PLAST*	*Rencontre électronique imprimée*	*27/03/2013*	*Paris, France*	*Industrials*	*>50*	France
10	*Conference*	*CEA*	*9th International Conference on Organic Electronics*	*19/06/2013*	*Grenoble, France*	*Industrials Academics and RTO*	*>50*	Global
11	*Conference*	*PLAST*	*Rencontre électronique imprimée*	*26/03/2014*	*Paris, France*	*Industrials*	*>50*	France
12	*Exhibition*	*PLAST*	*Industrial Technologies 2014*	*09-11/04/2014*	*Athens, Greece*	*Industrials Universities and RTO*	*>50*	Global
13	*Exhibition*	*PLAST*	*Salon FIP, Smart Plastics*	*17-20/06/2014*	*Lyon, France*	*Industrials and RTO*	*>50*	Global
14	*Exhibition*	*PLAST*	*Plastipolis Forum*	*1-2/10/2014*	*Lyon, France*	*Industrials*	*>50*	Global
15	*Exhibition*	OES, VTT	Plastic Electronics 2011	11-13/10/ 2011	Dresden, Germany	*Industrials*		Global

16	*Exhibition*	OES, CENTI, iL CETEMMSA, Acreo, CPI, CEA	drupa 2012	03-16/05/2012	Dusseldorf, Germany	*Industrials*		Global
17	*Exhibition*	OES, CPI, PEC4, KMC	LOPE-C 2012	19-21/06/2012	Munich, Germany	*Industrials*		Global
18	*Exhibition*	AUTH	Nanotexnology 2012	30/06 – 07/07/ 2012	Thessaloniki, Greece	*Industrials*		Global
19	*Exhibition*	CENTI, UCAM, CPI	The Advance Engineering	07-08/11/2012	Birmingham, Great Britain	*Industrials*		Global
20	*Exhibition*	CETEMMSA, AUTH, CENTI	IMAGINE NANO	24-25/04/ 2013	Bilbao, Spain	*Industrials*		Global
21	*Exhibition*	OES, VTT, PLAST, CETEMMSA, Acreo	LOPE-C 2013	11-12/06/ 2013	Munich, Germany	*Industrials*		Global
22	*Exhibition*	UGent	Tech Textil	11-13/06/ 2013	Frankfurt, Germany	*Industrials*		Global
23	*Exhibition*	AUTH	Plastic Electronics	8-10/10/2013	Dresden, Germany	*Industrials*		Global
24	*Exhibition*	CPI	The Advanced Engineering	12-13/11/2013	Birmingham, Great Britain	*Industrials*		Global
25	*Exhibition*	COLAE, CSEM, OES, VTT, Joanneum	Swiss E-Print	21-22 /11/2013	Basel, Switzerland	*Industrials*		Global
26	*Exhibition*	COLAE, OES, VTT, Acreo, CEA, CENTI, CPI, CETEMMSA, Joanneum	Hannover Messe 2014	07-11/04/2014	Hannover, Germany	*Industrials*	*1350*	Global
27	*Exhibitions*	*PLAST*	*Plastipolis Forum*	*18-19/09/2012*	*Lyon, France*	*Industrials*	*>50*	*Europe*
28	*Exhibitions*	*PLAST*	*Innov'days*	*06/12/2012*	*Oyonnax, France*	*Industrials*	*>50*	France and Switzerland
29	*Exhibitions*	*PLAST*	*Hannover Messe*	*08-12/04/2013*	*Hannover, Germany*	*Industrials*	*>50*	*Europe*
30	*Exhibitions*	*PLAST*	*Forum Plasturgie et Composites*	*May 2013*	*Paris, France*	*Industrials*	*>50*	*Europe*
31	*Exhibitions*	*PLAST*	*Salon K*	*16-23/10/2013*	*Dusseldorf, Germany*	*Industrials, Academics and RTO*	*>50*	*Europe*
32	*Exhibitions*	*PLAST*	*Industrial Technologies 2014*	*09-11/04/2014*	*Athens, Greece*	*Industrials Universities and RTO*	*>50*	*Europe*
33	*Exhibitions*	*PLAST*	*Plastipolis Forum*	*1-2/10/2014*	*Lyon, France*	*Industrials*	*>50*	*Global*
34	*Flyer*	CPI	COLAE.EU Statistical infographic Flyer			Industrials, Scientific community		Global
35	*Flyer*	CPI	COLAE/CPI Circuit Design Workshop Flyer			Industrials, Scientific community		Global
36	*Flyer*	CPI	COLAE A4 2pp Module Training Course Flyer			Industrials, Scientific community		Global
37	*Flyer*	CPI	COLAE A4 Flyer			Industrials, Scientific community		Global
38	*Other*	CPI	COLAE 3-Bay Popup Exhibition Stand			Industrials, Scientific community		Global
39	*Other*	CPI	COLAE 800mm Rollup Banner			Industrials, Scientific community		Global
40	*Other*	CPI	COLAE 1500mm Rollup Banner			Industrials, Scientific community		Global
41	*Other*	CPI	COLAE DRUPA 2012 Event Rollup Banner			Industrials, Scientific community		Global
42	*Other*	CPI	Twitter feeds			Industrials, Scientific community		Global

43	*Other*	CPI	3 COLAE Updates; Surveys, news, site features (e-mail)			Industrials, Scientific community		Global
44	*Other*	CPI	14 COLAE Newsletters			Industrials, Scientific community		Global
45	*Other*	CPI	12 COLAE Partner Focus (e-mail)			Industrials, Scientific community		Global
46	*Presentation*	KMC	The Future of Electronics in Europe / ISS Europe	27/02/2012	Munich Germany	Industrials, Scientific community	330	Europe
47	*Presentation*	KMC	The Future of Electronics in Europe/ Smart system Integration	21/03/2012	Zurich Switzerland	Industrials, Scientific community	200	Europe
48	*Presentation*	UGent	Wearable future: inclusive design	27/03/2012	London United Kingdom	Industrials, Scientific community	~50	Global
49	*Presentation*	UGent	Smart Textiles meet Organic Electronics	25/04/2012	Ghent Belgium	Industrials, Scientific community	~45	Global
50	*Presentation*	AUTH	Commercializing OE through entrepreneurial activities & the fp7 COLAE project / Workshop commercializing organic electronics in Greece	27/04/2012	Thessaloniki Greece	Industrials, Scientific community	~100-150	Greece Mainly
51	*Presentation*	CeNTI	Optimization of printing and assembling processes for large area organic electronics / Drupa innovation - printed electronics park - stage 1	05/05/2012	Düsseldorf Germany	Industrials, Scientific community	~15	Global
52	*Presentation*	VTT	COLAE - Commercializing Printed Elelctronics /SMT Hybrid Packaging	08/05/2012	Nurnberg, Germany	Industrials, Scientific community	~40	Global
53	*Presentation*	Acreo	Printing and integration of electronics on flexible substrates / DRUPA	09/05/2012	Düsseldorf Germany	Industrials, Scientific community	~15	Global
54	*Presentation*	CPI	CPI's New Printed Electronics Line for Print and Packaging Sector/DRUPA	11/05/2012	Düsseldorf Germany	Industrials, Scientific community	~15	Global
55	*Presentation*	UGent	Networking Event on Textiles	11/05/2012	Boras, Sweden	Industrials, Scientific community	~30-50	Global
56	*Presentation*	HOLST CENTER	The COLAE project/EURIPIDIS FORUM	13/06/2012	Graz Austria	Industrials, Scientific community		Global
57	*Presentation*	KMC	Demonstrating COLAE Project /LOPE-C	19/06/2012	Munich, Germany	Industrials, Scientific community	600-800	Global
58	*Presentation*	HOLST CENTER	The COLAE Project / LOPE-C	20/06/2012	Munich Germany	Industrials, Scientific community		Global
59	*Presentation*	CeNTI	Photo-Cured Electrolytes for Low-Cost, Printable and Flexible Electrochromic Devices /LOPE-C	20/06/2012	Munich Germany	Industrials, Scientific community	~20	Global
60	*Presentation*	CeNTI	Comparative study of metal-oxide/diacrylate polymer multilayer stack barrier films for organic electronics encapsulation in a continuous roll-to-roll process /ISFOE12- International Symposium on Flexible Organic Electronics	02/07/2012	Thessaloniki Greece	Industrials, Scientific community	~40	Global
61	*Presentation*	AUTH	The COLAE Project/NANOTEXNOLOGY ISFOE-International Symposium of Organic Electronics	05/07/2012	Thessaloniki Greece	Industrials, Scientific community	~300	Global
62	*Presentation*	CETEMMSA/ PEC4/UCAM	Education Activities within COLAE/28th Working Group Meeting of the OE-A	6-7/11/2012	Mataró Spain	Industrials, Scientific community	~95	Global
63	*Presentation*	KMC	Fachpack	25/09/2012	Nuerenberg, Germany	Industrials, Scientific community	37.000	Global
64	*Presentation*	KMC	EPoSS General Assembly	26-28/09/2012	Paris, France	Industrials, Scientific community	~100	Europe
65	*Presentation*	KMC	Plastic Electronics 2012	10-11 /10/2012	Dresden, Germany	Industrials, Scientific community	~250	Global
66	*Presentation*	PLAST, VTT	Commercialisation Clusters of Organic and Large Area Electronics /Forum PLAST 2012	18/11/2012	Lyon France	Industrials, Scientific community	~150	Global

67	*Presentation*	VTT	Printed Hybrid System Integration: Optics-electronics-mechanics combined /Forum PLAST 2012	18/11/2012	Lyon France	Industrials, Scientific community	~150	Global
68	*Presentation*	AUTH	Clustering & Commercializing OEs in Europe: The FP7 COLAE Project /Stakeholder Meeting & Workshop "Development of Organic Electronics Industry in Greece"	19/11/2012	Thessaloniki Greece	Industrials, Scientific community	~200	Greece Mainly
69	*Presentation*	Fhg	Commercialising organic and large area electronics / 11th Workshop on flexible electronic systems	24/11/2012	Munich Germany	Industrials, Scientific community	~70	Europe
70	*Presentation*	PEC4	PEC4 presentation	01/01/2013	Bellaterra, Spain	Industrials, Scientific community	~80	Local
71	*Presentation*	AUTH	Commercialisation of Organic and Large Area Electronics – COLAE Project /International Conference on Nanosciences & Nanotechnologies NANOPORTUGAL	13/02/2013	Porto, Portugal	Industrials, Scientific community		Global
72	*Presentation*	KMC	COLAE Presentation at Strategy meeting Horizon 2020 organized by OE-A	05/05/2013	Frankfurt, Germany	Industrials, Scientific community	~30	European
73	*Presentation*	Acreo	PACSEM	6-7/03/2013	Karlstadt, Sweden	Industrials, Scientific community		Global
74	*Presentation*	PLAST	Approach of COLAE and feedback from End-Users/3rd Meeting on printed electronics; électronique imprimée	27/03/2013	Paris, France	Industrials, Scientific community		Europe
75	*Presentation*	CPI	Media Marketplace	26/04/2013	Leeds, UK	Industrials, Scientific community	~500	Europe
76	*Presentation*	PEC4	Keys for the industrial success in Printed Electronics	29/05/2013	Barcelona, Spain	Industrials, Scientific community	~15	
77	*Presentation*	Fraunhofer EMFT	30th Working Group Meeting (OE-A)	10/06/2013	Munich, Germany	Industrials, Scientific community	~50	
78	*Presentation*	OES, VTT, PLAST CETEMMSA, Acreo	LOPE-C	11-13/06/2013	Munich, Germany	Industrials, Scientific community		Global
79	*Presentation*	Acreo	FESPA	25-29/06/2013	London, Great Britain	Industrials, Scientific community		Global
80	*Presentation*	AUTH	Commercializing OLAE through Entrepreneurial activities & the FP7 COLAE Project /Commercializing OLAE	7-10/07/2013	Thessaloniki, Greece	Industrials, Scientific community	~60	Global
81	*Presentation*	KMC	Waiting games around OLAE and role of Demand Articulation. Experiences of COLAE /ISFOE	7-10/07/2013	Thessaloniki, Greece	Industrials, Scientific community	~60	Global
82	*Presentation*	TNO, CETEMMSA, AUTH, UGent	Commercializing OLAE through Entrepreneurial activities & the FP7 COLAE Project /ISFOE	10/07/2013	Thessaloniki, Greece	Industrials, Scientific community	~60	Global
83	*Presentation*	TNO, iL	Introduction to COLAE and the COLAE approach to commercialization /COMS 2013 Conference	25-28/08/2013	Enschede, The Netherlands	Industrials, Scientific community		Europe
84	*Presentation*	Acreo	Smart transport av livsmedel på väg	07/09/2013	Helsingborg, Sweden	Industrials, Scientific community		Global
85	*Presentation*	OES, VTT, AUTH, Joanneum	Plastic Electronics Conference	8-10/10/2013	Dresden, Germany	Industrials, Scientific community		Global
86	*Presentation*	CETEMMSA	Course about Printed Electronics at FNMT (Fábrica Nacional de Moneda y Timbre)	10-11/10/2013	Madrid, Spain	Industrials, Scientific community	~15	Spain
87	*Presentation*	UGent	INNOTEX 2013	17/10/2013	Lodz, Poland	Industrials, Scientific community	~100	
88	*Presentation*	KMC	Stakeholder Meeting in the framework of the European Project ROleMak	30/10/2013	Thessaloniki, Greece	Industrials, Scientific community	~40	Local
89	*Presentation*	iL	Current status of OLAE and implications for design rules of OLAE /Fachverband Elektronik Design e.V.	21/11/2013	Neuss, Germany	Industrials, Scientific community	~25	Germany
90	*Presentation*	CSEM OES, VTT, Joanneum	Large–area fabrication of nanostructured and interactive	21-22/11/2013	Basel, Switzerland	Industrials, Scientific community		Global

			surfaces; Digital Manufacturing of Printed Smart Objects /Swiss e Print					
91	*Presentation*	AUTH, VTT	ISFOE'14	7-10/07/2014	Thessaloniki, Greece	*Scientific Community*		Global
92	*Press release*	UCAM	Encouraging enterprise in the organic electronics sector	25/07/2013		Industrials, Scientific community		Global
93	*Press release*	CPI	Learning from the Experts in Organic Electronics	25/07/2013		Industrials, Scientific community		Global
94	*Video*	OES	Best of amazing organic electronics	2012		Industrials, Scientific community		Global
95	*Web*	CPI	COLAE Website			Industrials, Scientific community		Global
96	*Workshop*	*CPI*	*OLAE Circuit Design Workshop*	*May 13th 2014*	*CPI, Sedgefield, UK*	Industrials, Scientific community	*25*	Europe
97	*Workshop*	*PLAST*	*COLAE Open innovation workshop*	*23/04/2014*	*Lyon, France*	*Industrials*	*4*	*France*
98	*Workshop*	*PLAST and UGent*	*COLAE Open innovation workshop*	*19/05/2014*	*Gent, Belgium*	*Industrials*	*2*	*Belgium*
99	*Workshop*	*PLAST and Centi*	*COLAE Open innovation workshop*	*17/06/2014*	*Porto, Portugal*	*Industrials*	*4*	*Portugal*
100	*Workshop*	IL, KMC	Integration of printed lighting in house decoration solutions	24/10/2013, 13/12/2013	Weimar, Heidelberg Germany	*Industrial designers*	80	European
101	*Workshop*	CETEMMSA / KMC	Integration of printed electronics in Textiles	16/12/2013, 18/02/2014	Barcelona, Spain	*Industrial and fashion designers*	12	European
102	*Workshop*	UGent	Smart Textiles Design Workshop	11/03/2014	Ronse, Belgium	Graduate students	20	European
103	*Workshop*	KMC, PEC4	Design workshop on developing interactive games	26/06/ 2013	London, UK	*Game designers*	9	UK
104	*Workshop*	VTT, UCAM, il, AUTH, CETEMMSA, ACREO, CEA, FhG.	Workshop on New Wave Research: Challenges in OLAE systems and applications	26/02/2014	Oulu, Finland	*Industrials, Scientific community*	99	Global
105	*Workshop*	AUTH, VTT	Workshop on New Wave Research: OLAE materials	08-10/07/2013	Thessaloniki, Greece	*Industrials, Scientific community*	30	Global
106	*Workshop*	CEA, VTT, FhG	Workshop on New Wave Research: OLAE processing and manufacturing	11/05/2013	Munich, Germany	*Industrials, Scientific community*	30	Global
107	*Workshop*	FhG, VTT	Workshop on New Wave Research: OLAE Devices	09/10/2012	Dresden, Germany	*Industrials, Scientific community*	27	Global
108	*Workshop*	VTT	Workshop on New Wave Research: OLAE Systems and Applications	16/03/2012	Oulu, Finland	*Industrials, Scientific community*	50	Global
109	*Workshop*	*Plastipolis*	*COLAE Open Innovation workshop*	*May 2012*	*Grenoble*	*Industrials*	*>10*	France
110	*Workshop*	*Plastipolis and AUTh*	*COLAE Open Innovation workshop*	*July 2012*	*Thessaloniki*	*Industrials, and RTO*	*>10*	*Europe*
111	*Workshop*	*UGent*	*Workshop on Smart Textiles*	*21/11/2012*	*Ronse, Belgium*	*Industrials*	*>30*	Europe
112	*Workshop*	*Plastipolis and CEA*	*COLAE Open Innovation workshop*	*March 2013*	*Paris, France*	*Industrials*	*>10*	France
113	*Workshop*	*Centi*	*Workshop printed electronics digital fabrication*	*04/04/2013*	*Porto, Portugal*	*Industrials*	*>50*	Europe
114	*Workshop*	*Plastipolis*	*COLAE Open innovation workshop*	*23/04/2014*	*Lyon, France*	*Industrials*	*4*	*France*
115	*Workshop*	*Plastipolis and UGent*	*COLAE Open innovation workshop*	*19/05/2014*	*Gent,Belgium*	*Industrials*	*2*	*Belgium*
116	*Workshop*	*Plastipolis and Centi*	*COLAE Open innovation workshop*	*17/06/2014*	*Porto, Portugal*	*Industrials*	*4*	*Portugal*

4.3 Exploitation of results

The COLAE project was designed to simplify and speed up the commercialisation and adoption of organic electronics technology through the creation of industry clusters. It developed mechanisms, such as targeted interviews and Feasibility Studies, which proved to be effective in engaging companies of all sizes. These techniques will still be important in exploiting the technology for the benefit of European companies. Indeed, the consortium is currently examining ways in which the inter-organisation transnational co-operation employed in building robust feasibility studies can be continued beyond the project lifetime.

When examining the outcomes of each of the work packages completed in the COLAE project, it is clear that there are some common factors that will be highly relevant to all organisations engaged in the OLAE field.

The clear importance of adopting a hybrid electronics approach to all of the market areas examined was obvious. This was underlined in practical terms by the activities in WP3, but it was also clear from the discussions held in WP1, WP5 and WP6. All of the organisations involved in OLAE need to bear this in mind, when working with clients in their target markets.

It is quite clear that various aspects of the technology are not yet at the required TRLs. This necessitates a different exploitation strategy in the short term. The OLAE community needs to target appropriate market segments: ideally those with a short duty cycle in an environment that is not too harsh and where the device specifications can easily be met by the technology at its current state of development. The technology will continue to improve: exploitation needs to focus on the value that can be achieved from the technology in the market at every stage of its development.

In many of the companies interviewed, it was clear that the business development functions were keen to explore the new product opportunities that OLAE could bring. However, projects were more likely to be developed if the industrial design and engineering functions embraced the technology. This is why the project organised design workshops. Any future exploitation will need to engage the design and engineering communities in the target market sectors and the use of design workshops is a method by which this may be achieved. The results of such workshops will be considerably enhanced if, in addition to Research and Technology organisations, representatives of as many links in the supply chain as are available are included. Again, the workshops need to identify what is possible now, and to discuss what is possible in the medium and long terms.

Another aspect to this approach came out of interviews in WP1 and WP5. The consortium felt that certain customers did not understand the benefits of OLAE and that there was therefore a need for better dissemination of the technology. However, the technology is far more likely to be exploited successfully, if technology and service providers working in the area change their approach to the target markets. For example, companies operating in packaging or sensors are experts in packaging and sensors: it is unreasonable to expect them to be experts in OLAE. Technology and service providers working in OLAE need to express the benefits of OLAE in straightforward terms relevant to the markets that they are targeting. These benefits will be weight saving, ruggedness, the ability to

create new form factors, the ability to make larger area devices more economically than Si-equivalents and - in a few well-defined cases - potentially cheaper devices. The key factor here is the capability that the OLAE components bring to the proposed solution.

The caveated remark on cost comes from feedback gained in WP1, where the companies engaged took the low price promises very seriously. In actual fact, OLAE technologies require significant development and benchmarking before concrete promises on cost savings can be given. The potential is certainly there, but exploitation following the COLAE project should focus on factors that are unique to OLAE (such as weight saving and form factor, as mentioned before). Majoring on cost savings and then failing to deliver can lead to customer disillusionment.

This means that any exploitation of the technology must concentrate on the market needs and the problems the market is trying to solve, rather than the intricacies of the technology. In reality, companies who engage with OLAE are mainly interested in seeking a solution to a problem: they are in reality technology agnostic. If a solution that combined conventional Si with OLAE could solve their problem, they would not mind that the solution was not a full OLAE solution. Indeed, if the solution proposed were based entirely on conventional Si, this would not be an issue for the end user, as long as the proposal met their needs. One could actually question the need for reference to 'OLAE' when exploiting the technology: the solution and its unique properties are of far greater importance and the OLAE technology will simply be seen as a new form of Electronics by the customer.

Access to a network similar to COLAE will be important in exploiting the technology. The combined expertise of a number of European RTOs operating with an agreed model to support SMEs was demonstrated by COLAE WP3 and led to tangible benefits for customers. These benefits were either the receipt of a solution to a particular problem, or the prevention of following a technology course that would not work. The consortium is examining how this network can be maintained in future and individual partners are identifying actions that could help to maintain the cooperation that was established in the project.

Interestingly, the findings of WP3 are very relevant to exploitation of the technology. In WP3 it was found that micro SMEs and start-ups were seeking feasibility support to enable them to create more robust business cases. Larger SMEs were looking for solutions that were not disruptive, i.e. built around improvements to their existing products and processes. LSEs typically used the studies to scout the technology. This suggests that there is an exploitation model built around the use of consortium expertise in collaboration to help SMEs to engage with funding instruments that would help them to develop. At the European level, there is a case to combine an activity resembling that of COLAE WP3 and WP5 with the European SME funding instrument. This would be of value to SMEs and could well persuade them to invest more than the €5000 they would readily commit to for the feasibility studies alone. If one considers the LSEs, the WP3 model is a valid method for such organisations to understand the capabilities of OLAE, especially if the recommendations above are implemented.

Technology and service providers in the OLAE sector need to be far more pragmatic in exploiting the technology. They need to understand what the technology can do well at each stage of its development - and what it cannot. And they need to communicate this to the end users in terms the

end users can understand. They need to recognise that the solution to a market problem may involve very little OLAE and a lot of conventional electronics: but the OLAE should confer something that complements the conventional electronics. This will inevitably result in many of the projects being focussed on niche applications. However, as the technology develops and becomes more robust, higher volume applications will also become achievable, which will ultimately deliver the cost saving potential. The methods developed in WP1, WP3, WP5 and WP6 have proved effective in assessing the real market needs and provide a model for future exploitation of the technology.

COLAE Partners' Exploitation strategy

Acreo Swedish ICT (Acreo)

As a result of the interviews there are two ongoing discussions between Acreo and the interviewed companies about future collaboration projects where the companies want Acreo, and if needed other COLAE partners, to undertake development work for the realization of OLAE based demonstrators.

In a feasibility case study, a company was asking for an electrochromic device to be integrated into a smart card and activated by a suitable RFID signal. Acreo has demonstrated such device in a published article, http://www.pnas.org/content/early/2014/07/03/1401676111.abstract. Acreo will definitely follow up on this contact and try to establish collaboration. The expert database has been and will, at least for a few more years when the information is still valid, be a valuable tool to find the proper knowledge and collaboration partners in industrial driven development projects.

Aristotle University of Thessaloniki (AUTh)

AUTh according to the involvement in the COLAE project intends to exploit the following project outcomes in terms of WPs:

WP1: AUTh was involved in several dissemination activities by participating in international exhibitions. Furthermore AUTh organized exhibitions within NANOTEXNOLOGY multi event. Thus, all the experience gained from these activities will be the basis for new dissemination and promotional activities in the field of OLAE by inviting the key players in the field.

WP2: AUTh during COLAE utilized the International Summer Schools (ISSON) for the training aims of the project. The ISSON programme was modified by a separate session on Organic Electronics that consisted of lectures and demonstrations on all the related subjects. AUTh will continue the organization of the organization of this activity by adding extra training events for companies.

WP3: The Feasibility Study work conducted in WP3 was a very good example of co-operative working between a number of Europe's major Research and Technology Organisations. AUTh and LTFN have all the capacities to carry out feasibility studies and services in the future by utilizing the new infrastructure acquired: pilot R2R with in-line monitoring and LASER scribing units, CVD unit for Graphene production and Organic Vapor Phase Deposition (OVPD) unit for organic electronics

WP6: AUTh as a Higher Education and Research entity contributed in this WP by organizing session on OLAE materials during ISFOE13. In this frame this activity will be continued by organizing similar events on OLAE materials, OLAE device manufacturing and OLAE Commercialization through its network of collaborators (Universities, Research centres and Companies).

Finally, AUTh will continue the collaboration with the other COLAE partners either in bilateral basis either in a future EC project and built stronger relationships.

InnovationLab (iL)

InnovationLab GmbH (iL) intents to exploit the results of COLAE beyond the general exploitation strategy of the COLAE consortium in the following ways:

During COLAE, iL has gathered extensive know-how about conducting product requirement interviews with end-user companies. iL will continue to apply the methods developed in COLAE to conduct product requirement interviews in the future.

The main exploitable result of the training session that was organized by iL in the frame of COLAE was the contact to the design department of Bauhaus University. The cooperation between COLAE and Bauhaus University was intensified by the design workshop organized in WP1 later in COLAE. The relation that has developed between iL and Bauhaus University through this cooperation will last beyond COLAE so that future generations of design students of Bauhaus University will be introduced to printed electronics by iL.

The activities in COLAE have enabled iL to offer feasibility studies based on the WoW developed in WP3. The corresponding business plan has demonstrated that it is challenging to offer such studies without financial support. Nevertheless, iL will offer feasibility studies in the future with slightly reduced content. iL will discuss future cooperation models with Holst Centre to integrate the Cost of Ownership analysis performed by Holst into these studies.

iL will actively work to maintain the close partnership with the entire COLAE consortium. This will allow iL to access complementary expertise and efficiently connect industry request to the most suitable OLAE centre in Europe.

Commissariat à l´énergie atomique et aux énergies alternatives (CEA)

On Networking, CEA further extended its network at the European scale, especially with non-French SMEs. Being quite active on OLAEs, having funded one start-up (Isorg) and being part of several forthcoming EU CP projects, CEA is in a pole position to serve the European industry and to set up bi-lateral collaborations with industrial parties (including SMEs). Thus, extending CEA network offers more opportunities to nucleate new strategic alliances (e.g. on printed electronics, OLEDs, sensors).

On Virtual OLAE Foundry, CEA provided its Design Tool Kit to the consortium for fusion with other tool kits. CEA's kit is based on standards rules and is coded in a commonly available EDA, namely the one from Cadence. CEA Printed Platform is opening its technology to external partners in a so-called "foundry-mode". External parties can download the Design Tool Kit free of charge (or for a moderate

fee), after signing a Non-Disclosure Agreement. Once the design, simulation and layout are completed by the applicant, CEA manufacturers, tests and sends circuit samples (typically between 1 and 10). Having aligned this strategy with Innovation Lab, CEA can now be recognized as an OLAE foundry. CEA will benefit from the COLAE web portal as a new source of queries for foundry services at the European level (in addition to Regional/National levels as it was set for originally). Initial pricing will be defined accordingly to the surface used by each circuit and by the number of samples requested. Differentiation might be added, depending on the circuit complexity (higher complexity means decreasing yield thus increasing number of processed samples and price) or on the type of partnership (customers, collaborative, bilateral, academic projects). In this way, CEA is expecting to maximize the exploitation of the project results, helping external parties to jump into OLAE technology.

On Open Innovation, CEA was very active in supporting PLASTIPOLIS to frame a new {pre-workshop/workshop/post-workshop} process. This fruitful exercise helped CEA to identify end-users with which no contacts had been established before. Some of these new contacts have an actual interest in following-up Isorg's enabling products. Also, feasibility studies will be pushed forward for the most promising cases, thanks to bilateral financing. Clearly, such workshops open new possibilities provided that end-users are properly selected and meetings are well structured and animated. CEA will pursue this OI workshop exercise within other CSA projects, on other technologies, consolidating the current model set by PLASTIPOLIS.

Centro de nanotecnologia e materiais tecnicos funcionais e inteligentes associacao (CeNTI)

At European level the creation of COLAE consortium and the benefits that has brought in bringing together all the partners is something that must be explored. The project allowed not only to increase the awareness about OLAE to the external community but also to establish deeper connections between the partners. Despite the overlapping of some of the particular expertise from different partners, the combined individual know how of each partner may speed up the resolution of some of the problems currently faced. Thus an effort in combining this expertise should be pursued either through European funded projects or the creation of formal cooperation.

During the project, technical and economic issues related to the use of OLAE technologies were raised (such as price, integration, durability, production of large quantities, moving from technology push to market pull) and an additional effort on solving those problems in a European level should be considered for a follow up on the project.

At a national level, the contact with Portuguese companies that were involved in the project (feasibility studies, interviews and workshops) has effectively increased the interest of the companies in being more active in the field and to find approaches to integrate OLAE technology in their products and generate/create new added value projects. The creation of a formal cluster at a national level, in a similar process to other countries and in which COLAE partners are involved, could be an outcome, based on the experience acquired during the project.

The project aimed to increase the awareness of companies about the available technologies and products not only of companies that are already active in this field but also, and most importantly, of

other companies from different sectors. The work that was performed at a national level reflects this approach since companies from traditional sectors have been involved and are now actively pursuing the integration of OLAE into their products. The effort that was placed during the project is being continued in further projects with the companies focusing the product development.

Centre for Process Innovation (CPI)

The participant CPI (Centre for Process Innovation) has identified a number of specific project outcomes that it intends to exploit itself in future. These are in addition to the generic exploitation features identified by the COLAE project and described elsewhere in this report.

CPI was involved in the development of the COLAE website and communication platforms, both of which had significant uptake. Having invested this time in the development of these tools and in building the COLAE brand, CPI will continue to maintain the COLAE website beyond the end of the project. It is our intention to use this tool within the OLAE community for the purposes of dissemination. We are still working on the details of how other OLAE community members could access this vehicle, but we are willing to make the time and resources available for the site upkeep.

Additionally, the work on design tools in WP4, which was a joint effort between the TDK4PE and COLAE projects, is very relevant to the activities and interests of CPI customers in the organic semiconductors field. We intend to find other vehicles to fund this work effort and we are already in discussions with the University of Barcelona on finding suitable sources of funding to keep this work going. We would also be willing to invest small amounts of time and resource in keeping this effort going until a suitable funding vehicle could be found. The investment in design tools of this nature is seen by CPI as a very necessary component in the commercialisation of this technology.

The Feasibility Study work conducted in WP3 was a very good example of co-operative working between a number of Europe's major Research and Technology Organisations. The outcomes of this workshop were translated into a very pragmatic set of technology capabilities that could be used in dealing with customer applications. These are also described elsewhere in this document. CPI is very interested in working with the other members of the consortium to find a way in which this service can be maintained. Whilst an initial fiscal analysis indicated that it may be difficult to fully fund this activity, it is our belief that a method can be found to maintain the collaborative effort required. Key to the success of this approach will be converting one or two feasibility studies into real products, thereby demonstrating the value of the approach. It is also our belief that more targeted marketing of this activity will be useful.

Finally, one of the more intangible and yet one of the most important outcomes of the project was the development of strong relationships with individuals in each of the partner institutions. CPI will have no issue with approaching these people directly with regard to project opportunities. These approaches may involve signposting customers to the other project partners in the cases where CPI cannot provide the services requested, or approaching them as potential participants in collaborative and/or commercial projects. The value of the trust built up in the COLAE project between the partner institutions cannot be ignored.

Centre Suisse d'Electronique et de Microtechnique (CSEM)

First of all, CSEM intends to maintain and upgrade the design kit for gravure printed OTFTs developed in WP4. Further and along the same lines, CSEM would welcome a concertation with pilot lines at COLAE partners for design books to enable process and upscaling development. These are crucial steps to enable a fabless model, allowing companies (especially SMEs) to access process development, prototyping and production.

Following the experience gained in the project, CSEM will offer feasibility studies following the COLAE methodology especially to industries in the Alpine region. This format and methodology was found to be valuable especially to engage companies with no prior experience in the domain. The databases of competences and experts built in the project will be further used to identify COLAE research centres to assist in the cases if needed.

In order to exploit the CSEM will continue to offer the OTFT and OPV training modules built for COLAE. This will be done preferably in conjunction with professional training institutions (e.g. FSRM) or academic institutions (e.g. FHNW, or University of Basel). The focus will remain on engaging industrial participants as much as possible.

CSEM is interested in finding ways with CPI and other COLAE partners to support and maintain the COLAE website, an asset to the community.

Finally, CSEM enabled the formation of the IEC / TC119 / Swiss mirror committee Tk119 and will continuation its participation in standardization committees, interfacing when needed with other COLAE partners

Fraunhofer EMFT

In general Fraunhofer exploits its R&D activities on different levels starting with services for industry on quote & offer basis, performing contract research for industry, participating in collaborative research projects and leading to technology transfer to industry. COLAE as a coordination and support action is expected to enhance especially knowledge transfer to industry in the form of consulting, conceptual studies or demonstration projects for OLAE applications.

It is expected that COLAE even after the end of the project is very beneficial for the acquisition of projects that require competencies from different parties. The COLAE network covers comprehensively knowledge and technology in organic and large-area electronics and is therefore prime candidate to bundle R&D capabilities and initiate collaborative projects. Also such a joined approach benefits largely from the preparatory work achieved in COLAE.

For this Fraunhofer EMFT is planning to continue the activities for network, feasibility and virtual foundry should be ongoing as long as practicable. Ideally a further common project should help to keep the joined approach alive and will be targeted for the future. However, for the time being communication and networking will be sustained by participating in common training and OLAE dissemination events.

Key Management Consult (KMC)

KMC will not pursue to exploit the results of the projects since the activities of the company in this area will be closed down.

Asociacion PEC4 (PEC4)

The focus of PEC4 will be the support to regional industries and start-ups (South Europe) to build sustainable business models around OLAE technologies either by helping to solve their challenges using local design, training, prototyping and characterization facilities or by redirecting them to the key partners at European level. PEC4 will also continue to support a federated model of key partners in the TOLAE domain to address complex projects. In this sense we intend to exploit the most the relationship with our COLAE partners because we have realised that we are technological complementary in most cases. In fact, we would like to offer our associates a wide range of technologies that PEC4 cannot offer itself.

PEC4 as a cluster organization will exploit the complete model developed and validated in the COLAE framework: Services like CoO analysis, Prototyping, Feasibility Studies, Industrial Design Training or access to external foundries, are part of the goals of our cluster. PEC4 intends to organize at least 1 annual awareness conference about OLAE domain and 2 training courses, jointly with other COLAE members, in order to attract agents of the OLAE value chain, always focused to the market, not in the technology. Besides, taking into account the experience provided by WP3, we will develop as much as possible feasibility studies in cooperation with COLAE partners, because we consider this service key in order to attract private investors to the exploitation of OLAE technology.

We will also share experiences and future cooperation with our COLAE partners in order to strength OLAE technology and its implementation in the market, through support in collaborative projects, either private or public.

Concerning the Third Parties that have actively participated in COLAE project:

- **CETEMMSA** is used to work in scaling up process since its mission is transferring technology and knowledge to companies to improve their competitiveness through innovation. Following the feasibility studies performed in WP3, CETEMMSA will support ALBEA and FNMT at different levels in an end user driven innovation process to make the commercialisation of the devices a reality. In both cases CETEMMSA is pending on the companies' internal decision processes about what next steps will be. More specifically, a joint collaboration process with ACREO could be envisaged in the case of FNMT, since they've developed electrochromic devices in operational environments in the past. In the ALBEA case, CETEMMSA is experienced enough to manufacture the prototype by their own. Wherever possible, CETEMMSA will actively seek synergies, including possibilities for funding, with relevant national/regional innovation programmes to help the companies to finance the product. The results of these activities as well as the envisaged further activities in this respect will be followed-up involving relevant partners.

- At UAB we plan to exploit our results, demonstrated working together with gravure CSEM and evaporation CPI technologies, in two main offers:
    1. Our EDA and PDK experience, together with our partner in the TDK4PE project IMB-CNM (CSIC), to OLAE foundries willing to have such design facilities. This includes (if required) the extraction of design rules and simulation models, and also the customizing EDA design flows for specific applications.
    2. Offering, as R&D consultancy services, design capabilities and the corresponding paths to prototyping and developing microelectronic printed electronic circuits. We expect to exploit such capabilities to customers such as Germark to whom we continued exploring implementation options (together with CETEMMSA) after the CoO analysis we did for them in the framework of COLAE.

Organic Electronics Saxon (OES)

The participant OES was deeply involved in WP1 and WP2 of the COLAE project. OES had a great benefit out of the project and the gained achievements will be used to continue the close collaboration in order to foster OLAE development in Europe. OES has identified several issues that will be exploited in the future.

Cooperation

During the project OES has established several cooperation's with COLAE partners. Agreements were signed with Joaneum Research (Austria), CSEM (Switzerland) and HOPE-A (Greece). The aims of these cooperation's are joint workshops, an exchange of researchers and students and a direct contact to the allocated industry partners. For all involved parties research and development of new OLAE devices and technology is therefore easier to be realized since the expertise of industry and research institutes is better known and shared. The development of the existing cooperation and further cooperation with more COLAE partners is one of the main targets for OES in the near future.

Trade shows

OES' focus within COLAE has been on trade shows dealing with OLAE, like LOPE-C http://www.lopec.com/ or, Plastic Electronics http://www.plastic-electronics.org/, (embedded in SEMICON Europe). Especially at the Plastic Electronics it was important to evaluate the potential of hybrid solutions together with the traditional semiconductor industry and to show the potential of OLAE technology.
Additionally OES organized joint pavilions at large industry fairs such as the Hannover fair in order to approach industry outside the OLAE area. The experts from many different industry areas were highly interested in the potential of OLAE technology.
In the future OES will encourage all COLAE partners to join pavilions at different fairs in order to push the new technology and OLAE devices into the market. For now a joined booth at the World's largest printing fair, drupe in Düsseldorf, in 2016 is planned by OES and all COLAE partners are invited to take part.

Contact data base

One of the most important outcomes of COLAE project were new contacts to networks, industry partners, research institutes and experts all over Europe. For OES members, mainly SMEs, it is of most importance to have direct access to a wide range of different technology providers. COLAE project made an important contribution on that.
In the future OES intends to enlarge the database of industry contacts together will all COLAE partners in order to include as many OLAE related industry and research industry in Europe as possible. Additionally contacts to industry outside OLAE which is interested in adapting OLAE technology will be added to the database.

Marketing

The “brand” COLAE is well established within Europe’s OLAE community. Next to the COLAE logo, homepage and newsletter the promotion COLAE video „Amazing Organic Electronics“ had a large contribution to the promotion of OLAE potential in Europe.
OES will continue the promotion of the brand COLAE in order to strengthen und unify and extend the OLAE community in Europe.

Plastipolis

First, thanks to this project, a real European network of centres working on OLAE has been created. Strong links between the project partners now exist and some complementarities in the technologies and processes were identified. Plastipolis will keep in mind to put its members and the companies in need, in contact with the project partners if an interest is revealed.

Second, the WP5 has established a user centric innovation model that uses Open Innovation to accelerate the idea fertilization process, Figure 13. This model used a pre-workshop/workshop/post-workshop process to collect data from end-user, use it in the workshops, and make a follow-up afterwards to make sure the ideas exposed in the workshops are not wasted. The results of this process were mainly satisfying so Plastipolis is willing to use this model in other projects as well.

Moreover, as the model includes a post-workshop follow-up, Plastipolis is willing to continue the follow-ups with the end-users that led to a feasibility study or bilateral collaboration. The aim of these follow-ups is to understand better the efficiency of the model, and the evolution of the projects, as well as to understand the importance of OLAE for the different fields of activities, and insure support for the end-users if needed.

Finally yet importantly, Plastipolis is willing to use platforms like Pictic and S2P to continue the dissemination and development of OLAE, and put in place future projects involving end-users and using this technology.

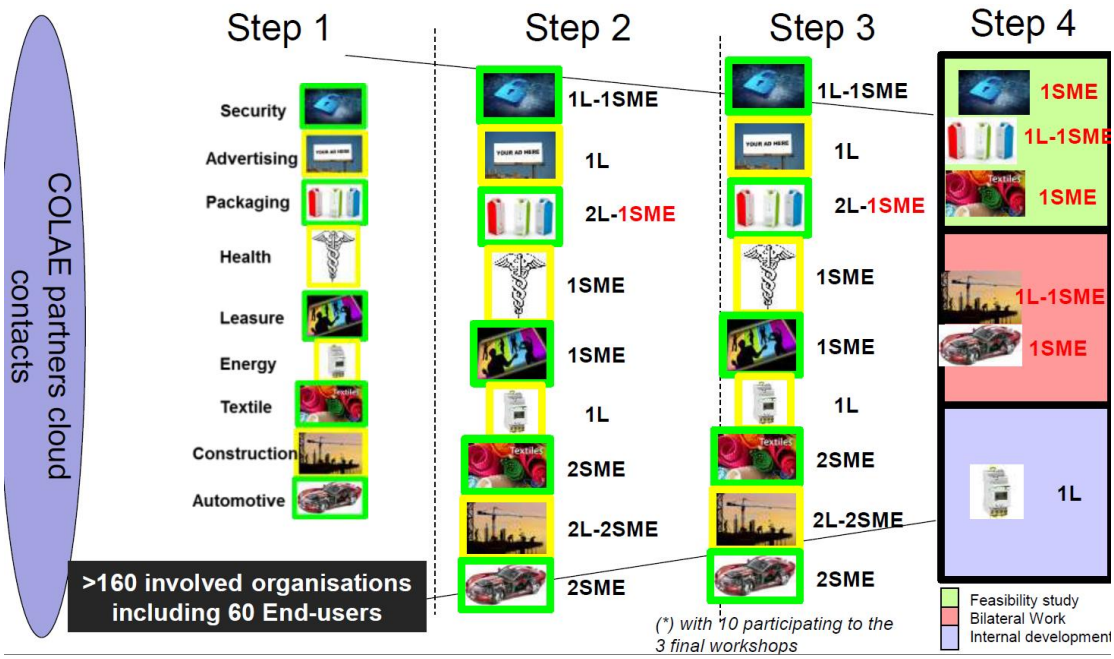


Figure. 14 Results of the user centric innovation model and workshops.

Joanneum Research Forschungsgesellschaft (STOLAE)

Networking/Dissemination: The following actions for enforcing the dissemination of STOLAEs' portfolio – (i) additive (Ink Jet Fab @ NTCW, Printing lab @ JOR) and subtractive (R2R-NIL pilot line) manufacturing of OLAE components, (ii) printed large-area sensors and (iii) high-performance organic electronic circuits – are planned under the flag of the well-established COLAE brand:
1. Disseminating results and breakthroughs on an international level via the COLAE Newsletter
2. Public presentation of appealing demonstrators at relevant trade fairs such as Hannover Trade Fair and LOPE-C (in a common COLAE booth).

Training: Upon sufficient request the hands-on training course on Nanoimprint Lithography, Inkjet Printing and Surface Characterization that has been developed in the course of the COLAE project will be offered to regional and international members of the OLAE and Non-OLAE community, being it technicians, engineers, scientists or company-related technology scouts. If there is a need, this or similar courses can again be included in a COLAE-based training network programme.

Service: STOLAE is strongly willing to support the continuation of the one-stop service platform after the end of the project and is keen to initiate or contribute to upcoming feasibility studies. This will enable STOLAE to learn more about application scenarios and customer needs. STOLAE is also interested to go one step further by complementing the established COLAE service instrument (advice and cost-oriented theoretical feasibility study) with the assembling and development of simple demonstrators, thereby working together with the other COLAE partners depending on the particular requests. However, the operational framework of this one-stop service platform w.r.t. organizational structure, financing, reporting etc… has to be defined and agreed among the interested partners after the end of the project.

Further collaboration with COLAE project partners and new opportunities: Due to the strong network and excellent relationships which has/have been established with the consortium members during COLAE, STOLAE will not hesitate to contact partners in case of any further emerging project opportunities where appropriate. This may include forwarding inquiries of potential clients to other COLAE partners, if STOLAE cannot help or ask partners, if they would like to join new collaborative projects with STOLAE.

TNO Holst Centre

In the COLAE project TNO/Holst Centre was responsible for work package 3, the feasibility network. The most important results of the work are very useful for further exploitation, both by TNO/Holst and the other partners.

The feasibility network showed that the major European Research and Technology Organizations cooperate to help companies from a wide range of countries and backgrounds. The way of working that was developed seems applicable for most of the customer demand that we see. TNO/Holst Centre is highly interested in continuing the cooperation with the other project partners in the future. Because the project has shown that commercial exploitation is very unlikely, we and the COLAE partners are probing various other possibilities to sustain the network.

An important development within the project was the improvement of the cost of ownership estimation model. It has been optimized for OLAE applications and is applicable for both roll to roll as sheet to sheet processes. We are investigating the possibilities to make this expertise available for the partners in the COLAE project either in future project or in any other form.

Finally the project partners developed strong understanding and trust between the partners. As a result of that we feel that working together in projects and referring customers to partners that have expertise we have not, has become much easier.

University of Cambridge (UCAM)

Cambridge will continue to run the Enterprisers entrepreneurship course which was successfully used in the COLAE project. We will seek to continue involvement of the OLAE technology sector in the course, in the first instance through the participation of the Austrian Photonics Network in 2015, which was arranged through the cooperation of COLAE partner STOLAE.

Cambridge would support the continuation of COLAE service offerings such as the feasibility studies which were developed under WP3. We would be willing to contribute to any future feasibility studies, once a mechanism has been agreed to take forward this valuable collaborative approach. The success of this aspect of the project was due in large part to a European network of experts assembled across the clusters, and this could not be replicated as effectively by an individual centre.

The COLAE project has developed a strong brand and web presence and if possible this should be maintained and grown to benefit the OALE technology sector. We would wish to continue to make use of this asset in order to disseminate outputs and news from our cluster and advertise events to the broader COLAE community. The strong collaborations and personal networks built up between

the partners through the project will continue to develop and we look forward to working together to develop future project opportunities as they arise.

Universiteit Gent (UGent)

The Department of Textiles has a strong link to the traditional textile industry and therefore does act as a bridge between the two technologically driven fields - textiles and organic electronics. As experienced, the textile industry needs to be proactively brought in contact with the OE community, Figure 12. The OE community does not perceive textiles as a promising application area and therefore, does not spend the effort for generating the link. Holding the open innovation workshop at the University's premises and supporting the meeting preparation would be one option to contribute apart from adding value on a scientific basis related to smart textiles.

Figure 15. Textile companies testing OE demonstrators at ISFOE 2014**.**

In conclusion, the COLAE consortium should continue the consulting work. A preliminary consulting session informing the company about what is possible for their specific product seems to be indispensable for the textiles traditional industry. This information session will decrease the hesitation for applying new OE technology and generates trust in the expertise of the COLAE consortium**.**

Another link between traditional textile industry and the OE community was established through the SYSTEX Student Award. The annual award is given to a student who shows superior research work in the field of smart textiles. The accompanying ceremony was held at the ISFOE (Nanotexnology) conference in Thessaloniki in July 2014. Already in 2013, the Department of Textiles participated at the OE focused event. By establishing this link, the organizers decided to organize an annual smart textiles session. Consequently, the Department of Textiles is already invited to the following year's event.

As for the feasibility study on intelligent event carpets, UGent is continuing the work with the goal to produce a demonstrator for an exhibition at the International Rugby Event in Dendermonde, BE (22-24 May 2015, www.flandersopenrugby.be). The demonstrator will be shown at the exhibition in the

Business Village which is the networking event in the frame of this sports event. Currently, the company which took part in the feasibility study and UGent are discussing the functions the demonstrator should fulfill. UGent will help in prototyping and general dissemination of the results. The integration of the suggested OE technologies (resulting from COLAE open innovation workshop/feasibility study) will be discussed. Lessons learned from research at UGent and the production of the textile based demonstrators (antenna, transistor, battery) can influence the decision. UGent realized that integrating the organic electronic function on a textile substrate might be resulting in more problems than if the initial integration is conducted on film or foil. This is exactly what the COLAE community could provide.

UGent would like to take part in textile related feasibility studies. Research at the Department of Textiles evolves, besides others, around organic electronic materials. Participation in other feasibility studies could further develop the knowledge portfolio at the Department of Textiles a Ghent University (UGent) in view of the practical and industrial application of OE materials.

Teknologian tutkimuskeskus (VTT)

VTT was coordinating the COLAE project and based on the COLAE we have created active links to COLAE partners, which we will utilize in future work both in research and in business development.

The interviews, workshops and the increased face-to-face contacting with companies has brought VTT new customers, has opened wide range of new application areas and has stimulated more than five of the interviewed companies to join in PrintoCent Industry Cluster. The entrepreneurship trainings have influenced to the way how commercialization of research results will be carried out in future to take the researchers into international business trainings with their idea. The next 8-week entrepreneurship training in PrintoCent regional community will be organised in spring 2015 and the next Innofest - 2-day open innovation event to accelerate the idea & team development by bringing together the teams, researchers and industry – has been scheduled to take place on 11-12.6.2015.

The developed process to carry out feasibility studies have been decided to be implemented part of the offering in PrintoCent regional program starting in spring 2015. This will continue the work with COLAE partners in practical level to help the start-ups and SMEs to get the feasibility evaluation and, further on, in finding the best partners for their prototyping and scale-up.

VTT is continuing the work in standardization, in developing the pilot factory environment and in developing the services in design, development and manufacturing chain for TOLAE related technologies together with the COLAE partners and with the companies providing the services.

Finally, the versatile and attractive COLAE.EU communication platform will have an important role in our public communication related to TOLAE related activities and it already offers an effective communication channel to the start-ups and SMEs of PrintoCent Cluster.