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Promoting **Innovation in the Industrial Informatics and Embedded Systems Sectors** through **Networking**



## EDITORIAL

South East Europe has a high potential for innovation yet is suffering from missing synergy between stakeholders to enable and maintain innovation transfer. The ongoing integration process within Europe must be seen as a chance to overcome this lack.

Europe's unique strength is being a union and at the same time having strong individual regions and states. Success therefore rests on two essential pillars: on the one hand uniting nations and on the other hand focusing on regional strengths. South East Europe needs to face the challenge to address European strategic research needs while at the same time focusing on its own needs to develop its infrastructure.

The I3E project had two major goals: to align research efforts of different research groups in the area towards commonly agreed directions in the embedded systems and industrial informatics sectors and to influence the transformation of relevant research results to innovation. With reference to the first goal the present document, a Strategic Research Agenda for South East Europe has been produced. The I3E partnership

enrolled in an effort to identify and integrate input from leading experts in the thematic areas of industrial informatics and embedded systems from academia, industry, business support organizations and the public administration.

This Strategic Research Agenda has been formulated through intensive cooperation and consensus building in South East Europe. It identifies synergies and potentials for the South East European region reflecting the strong confidence of stakeholders in the future of the region. Being Europe is reflected in working on common European research goals; the regional strength is presented by selecting topics where expertise is already available and that are required to upgrade the infrastructure to European level. The Strategic Research Agenda is a tool for policy makers at regional and national level so that South East Europe may benefit from its results, strengthening industrial informatics and embedded systems research and becoming more visible on the European research map.

The I3E consortium

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**One Research Position  
for Europe &  
South East Europe**





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“The purpose of the Strategic Research Agenda is to show the directions in which technologies and their related markets are moving and present potential technologies and products that will be relevant in the foreseen future.”

## CHALLENGES

South East Europe (SEE) is a dynamically growing area that is on the way to reach the economic level of Western Europe. In the last five years, SEE GDP's growth is on average twice the average of the European Union, yet the GDP per capita is 25-50% of the EU average, meaning on one hand an expanding consumer market and on the other hand inexpensive labour. A combination of these two factors gives an opportunity for the region to narrow the gap with the developed countries of Western Europe, because of the continuously growing foreign and domestic investments combined with the relatively cheap work force.

SEE has a significant mass with reference to research as well as standardization and quality improving

activities in the field of embedded systems and industrial informatics. Although, research is quite important in the diverse key technologies, there is a missing link towards innovation and entrepreneurship. Research is not transformed into innovative products and services that could help the overall increase of competitiveness in SEE and the EU.

Innovation and entrepreneurship lack the presence of a facilitator in the area. A transnational approach towards this direction could be quite beneficial, aligning research efforts in different countries towards a commonly accepted research agenda, creating the necessary critical mass of both academics and enterprises and improving international visibility. Networking of existing networks, clusters, technology platforms >>

## STRATEGIC RESEARCH AGENDA

This Transnational Strategic Research Agenda (SRA) is a major output of the I3E project, which is dedicated to the improvement of innovation transfer between researchers and industry, relevant to the industrial informatics and embedded systems sector in the SEE area. It helps developers and researchers to focus their research plans on relevant topics as well as to avoid barriers in transforming their ideas and research results into innovations.

The Strategic Research Agenda is formed based on the feedback and intensive cooperation with leading research and government institutions and industry in the respected represented countries in the SEE area.

A consensus of the different stakeholders has been reached and the Strategic Research Agenda is the result of this consensus. The strategic research agenda also seeks synergies with relevant European initiatives to multiply its impact. The SRA aims to help different stakeholders to align their activities in the industrial informatics and embedded system sectors. Stakeholders comprise all participants from research and academic institution, the enterprise world, the facilitators of innovation, such as clusters, technology platforms and existing networks of excellence, as well as the public sector and private funding organisations.

and the public sector with its funding capabilities could boost innovation and entrepreneurship and attract investment.

Education in the fields of technical and natural sciences in the SEE area has been traditionally well developed, producing well qualified manpower. However, once large research and development potential employed by the relatively strong industry has deteriorated through the loss of the latter during the period of transition in many SEE countries. Industrial informatics and particularly embedded systems offer an excellent opportunity to utilise the advantages of still existing human potential to increase the innovation in newly devised products and thus to increase their added value.

It seems that mutual impact of industry and R&D institutions still have potential for development. Although the governments foster the collaboration among them by funding joint programmes and projects, the real exchange of ideas, solutions and innovations, as well as industrial experience, economical needs and problems to be coped with does not provide satisfactory results.

Thus, the purpose of the I3E Strategic Research Agenda is to adopt, adjust, upgrade and apply the basic goals and outcomes of Europe-wide programmes to the social, economic and technological specifics of the SEE region in the sectors of industrial informatics and embedded systems in order to align research efforts in the area towards common goals and provide a critical mass that will increase international visibility of the area.

For example, in the area of embedded systems and industrial informatics, ARTEMIS – a European platform for embedded systems – has been founded in 2004. Its goals are to stimulate the research and innovation in the above mentioned areas.

Since it is based on the challenges and circumstances of highly developed European industrial countries, it provides a framework tailored to the needs of Europe with an eye to the Lisbon agenda. For the SEE region, however, some customization is needed so that the specific features of the local economy, infrastructure and social conditions are better taken into account. For example, one of the essential principles of European Artemis platform (Artemis JU and Artemisia) represents a public-private partnership funding mechanism, based on public and private investments in the industrial informatics and embedded systems sectors. Industry in the majority of the SEE countries is still not strong enough for essential large scale investments in research and development, and therefore, the SEE region cannot fully integrate the roadmaps described into these programmes due to the low capacity of local industry to invest into research and innovation.





## TARGETS & VISION

One of the basic tasks of the SRA is to analyse the existing infrastructural, economical and social conditions. The countries and economies in the region differ to a considerable extent, yet due to the diversity of the I3E project partners a cross-national and cross-domain understanding can be set up, which allows to make use of the differences to find synergies and opportunities.

Furthermore, the advantages but also the drawbacks that the region has in these domains in comparison to the rest of the European Union are identified. Then, specific regional interests in the fields of industrial informatics and embedded systems, relating to the above and to the development plans of local industry are defined.

The outcomes of these studies will help national, regional and European funding institutions to prepare adequate programmes and to identify research with the highest potential in the SEE region. By bringing together the stakeholders at national and regional level, productive and sustainable collaboration among them will be established.

Summarising, the ultimate goal of the SRA is to identify the most lucrative areas and sub-domains of industrial informatics and embedded systems, where the regional and national industry could be most successful, and to establish creative collaboration among the stakeholders in order to exploit the outcomes of the project.

The vision to follow in the Strategic Research Agenda of the I3E project is to contribute to the growth of all stakeholders in the area of industrial informatics and embedded systems in the SEE region by fostering collaboration between them at both regional and national level in order to essentially increase the innovation and thus the added value and overall growth of the area.

# Strategic Research Domains





“This transnational Strategic Research Agenda focuses on the technical areas of embedded systems and industrial informatics as well as on the opportunities of these technical areas in the South East European Region. The time scope is a midterm enhancement of transfer of research to innovation within the next 5 to 8 years.”

## EMBEDDED SYSTEMS

An embedded system is a computer system designed to perform dedicated functions with real-time computing constraints. It is embedded as part of a complete device, which often includes hardware and mechanical parts. Often, a human/machine interface is not included, thus making it “invisible” within the embedding environment.

It is not a well known fact that approximately 98% of all processors produced are used in embedded applications. There are more than 16 billion embedded devices employed by 2010. The value added to the final product by embedded software is much higher than the cost of the embedded device itself.

Specific properties of embedded systems emerge from their nature. They should be reliable, robust, safe, and able to respond to requests within real-time constraints. They also must be efficient, low cost, and small-sized and their power consumption must be low.

Embedded systems play an ever increasing role in a high number of sectors where the EU economy has a competitive advantage. Embedded systems are critical for a number of application areas covering such principles as flexible manufacturing, renewable energy and efficient energy use, safety and security, health monitoring and assisted living, smart mobile environments, logistics, etc.

## INDUSTRIAL INFORMATICS

Looking into different domains, various definitions of industrial informatics can be found. In the context of the I3E project, we do not see industrial informatics merely as means to enhance industrial fabrication and manufacturing processes. We consider industrial informatics as a technology that integrates embedded systems in holistic systems in order to cope with the complexity of embedded applications and their growing requirements like the use of data technologies (databases, data mining etc.), cognition and distributed artificial intelligence paradigms, and similar informatics areas.

In the start of this millennium, embedded systems became more wide spread and pervasive. Embedded applications evolved from relatively simple micro-processor systems into complex distributed systems (even systems of systems) which are tightly connected with underlying informatics. Security and safety were positioned at the forefront of industrial informatics, mirroring their emphasis in the ICT domain. The marriage of advances in embedded systems and in informatics yielded a new discipline – industrial informatics.

## INTELLIGENT MANUFACTURING

The vision of intelligent and collaborative industrial environments with dynamic, agile and reconfigurable enterprise structures is becoming a reality. As industrial systems have become more intelligent, automated, dynamic and distributed, monitoring and control of operations has shifted towards the Internet as is the case of sales and e-services. Industrial dimension is fostered through the creation of intelligent, flexible manufacturing environments materialized today in the emergence of holistic digital manufacturing ecosystems in which collaborative automation is the only way to thrive and progress in the global knowledge economy.





Figure 1: South East Europe

## EMBEDDED SYSTEMS & INDUSTRIAL INFORMATICS IN THE SOUTH EAST EUROPE AREA

On the one hand the SEE region has a significant mass with reference to research as well as standardization in the areas of embedded systems and industrial informatics. On the other hand, a fast growing economy and the EU integration processes provide needs for innovations in embedded systems and industrial informatics while the current level of R&D expenditure in the SEE area is well below the average in the EU.

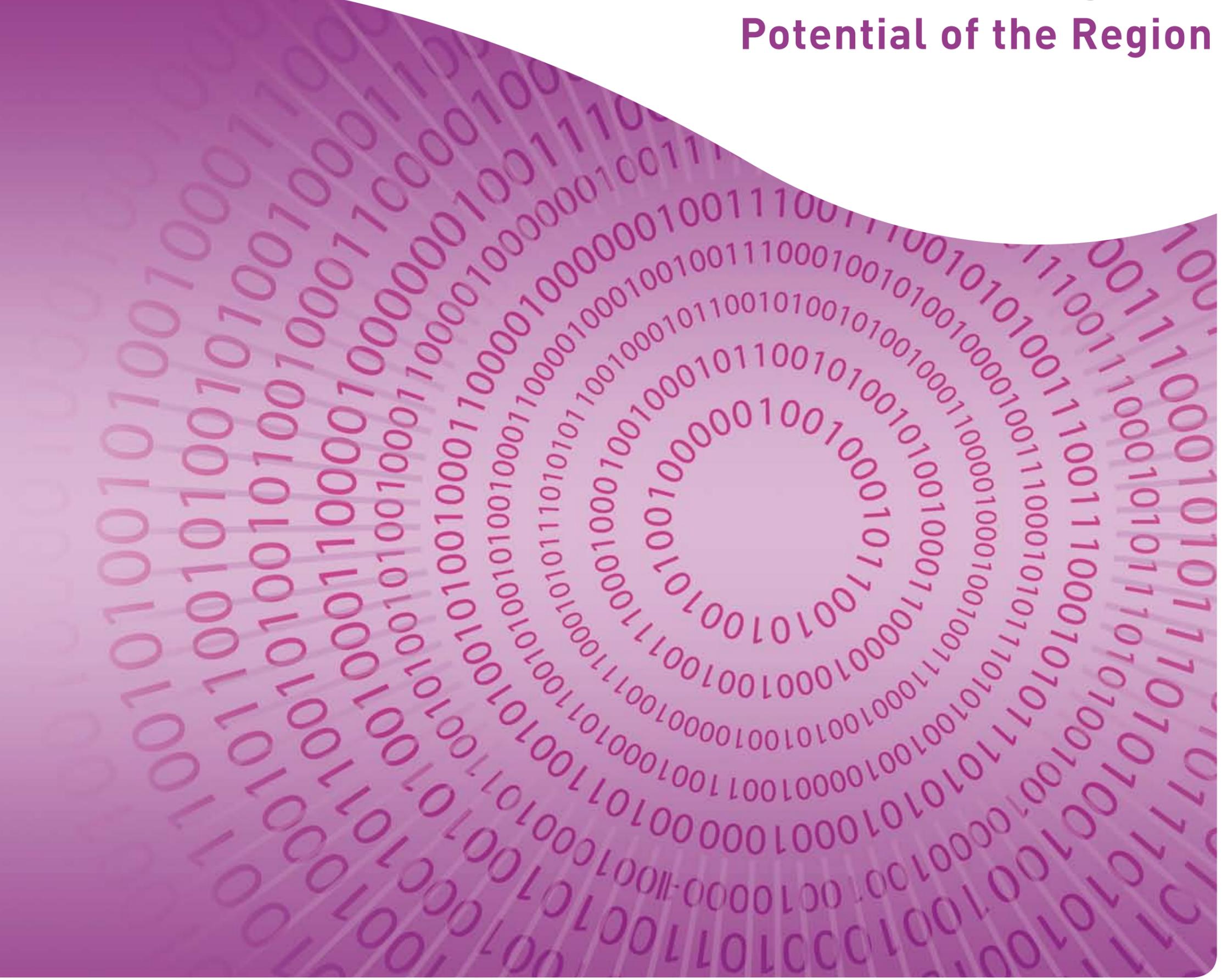
There is a missing link towards innovation and entrepreneurship. Research is not transformed into innovation that could help in the overall increase of the competitiveness of SEE. Although the ongoing collaboration between industrial and research partners in the SEE region shows strength and potential, mostly the results of such collaboration are only applied locally, usually initiated by a single company for a particular product. It involves a research partner as a subcontractor for certain tasks. Sustainability and the overall impact of such cooperation on the regional development is low. As a result, apart from one-time projects, there is limited ongoing research-into-innovation transfer in the SEE region.

In order to transform a region into an innovation powerhouse a facilitator is required that would:

- Provide a general strategic agenda that defines targets and shows directions towards common goals for the region.
- Carry on transnational coordination by providing a networking platform for connecting research and industrial partners in clusters of interest and technology platforms.
- Support the follow-up activities such as standardisation, promotion and spread of innovation within the region and beyond.
- Serve as an dynamic incubator for research, using the achieved results for creating spin-off and follow-up projects that would advance the innovations and involve more partners.

The aim of the I3E Strategic Research Agenda is to setup the platform on which such integration is possible, by providing a set of goals and focus areas, to combine industrial companies and research institutions under a common umbrella. The goal is to stimulate cooperation and support the embedded systems and industrial informatics areas on national and transnational level.

# Strengths & Potential of the Region





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“Developing the region with the region’s own resources can be an efficient motto to utilize the strengths and potential of the SEE region to reach the common European level.”

## POTENTIALS

The SEE area is the fastest growing market and economy in Europe with a growth rate two-times higher compared to that of Western Europe. Inexpensive labour force (average GDP per capita is 25-50% of the EU average; Bulgarian average hourly rate was 2.44 Euro in 2009 compared to EU-15 average of 28.47 Euro) and its strategic macro-economic position between Europe, Asia and Russia, e.g., the European natural gas market provide the region with the potential of fast evolution. Yet, to facilitate this potential, upgrades of methods and infrastructures are needed and focus has to be set on areas where the region has weak (easy to improve) or strong (basis for expansion) positions in Europe.

The region is on course to be fully integrated into the EU, but in order to do so SEE has to meet also the EU standards in areas such as communication or infrastructure. The economy, infrastructure and technological development in the region of SEE are behind the level of the rest of Europe. However, the high level of investment from the European Commission as well as the unutilised market capabilities give the SEE region a chance for fast innovation development that can additionally be used as a driving force for the local industry.

Innovation and research are triggers for the economic development and are two of the reasons why the developed countries economies have shown success over decades. Nowadays, developing countries (especially China and India) invest in education to reach the research level of the “Western world”. China and India produce five million graduates a year and attract research funds from all over the world. A combination of qualified personnel and inexpensive labour makes these countries a favourable base for research and innovation.

South East Europe combines the above mentioned features with the stable political system of Europe and the social similarities, such as business culture that make cooperation and integration smoother than in the case of collaboration with Asia. Furthermore, the SEE region average salaries are less than half of EU average salaries and combined with the high level of education and research gives the region a potential to advance in research and innovation development.

Moreover, peoples' mentality in the region is flexible and adaptive to changing requirements. The region can profit from unconventional decisions as well as non-rigid structures of business.

“Developing the region with the region’s own resources” can be an efficient motto to utilize the strength and potential of the SEE region to reach the common European level. However, the current level of R&D investments in the SEE is well below the EU level (less than 1% of GDP, compared to 2% of EU, 2.6% in USA and 3.4% in Japan). In order to be competitive the region has to dramatically increase its R&D expenditure.

Currently, the way of thinking in the region is generally focused on short term profitability and does not support the long term R&D, which limits the possibilities of the region and can harm its prospects for the future.

Later in this document we provide all research topics that are identified by the stakeholders from the SEE region and are needed to be developed.

Four main domains have been identified that meet European research needs and at the same time can be used to further develop the region:

- **Nomadic environments**
- **Public infrastructure**
- **Private spaces and**
- **Industrial systems**

In each of the domains the SEE region has a specific aspect where it has a potential for a high and fast growth and a base for a successful transfer of research into innovation.



## NOMADIC ENVIRONMENTS

### CURRENT STATE

In our living environment there are more and more different electronic devices present, which are becoming indispensable accessories for everyday life. Embedded systems are already an essential part of various enabling devices such as PDAs (Personal Digital Assistant) and on-body systems to communicate in changing and mobile environments, which offer user access to information and services while on the move. Yet despite the technical progress, the dream of being able to talk to people and access information and entertainment anywhere and at any time is still being frustrated by technical limitations that prevent easy deployment of new, creative services.



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### GOALS & ACTIONS

Issues to be resolved include the demand for ubiquitous, secure, instant, wireless connectivity (end-to-end) to the service. At the same time these services must allow unhindered convergence of functions as well as global and narrow-range (sensor) networks. Light, handy, high-functionality terminals are demanded, in which sophisticated energy management techniques "beat the heat" and ensure that "the battery never goes flat". This is becoming the dominant concern in low-power designs. Embedded systems will also improve the ultra-low-power connections and increasing processing, storage, and display capabilities. Advances in these areas themselves will open a huge secondary market offering mobile services. In order to encourage use by a broad cross-section of the population, friendly human-device interfaces need to be developed, with the active participation of future users from an early stage on.



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## PUBLIC INFRASTRUCTURES

### CURRENT STATE

Public infrastructures are major infrastructures such as airports, stadiums and highways that embrace large scale deployment of systems and services that benefit the citizen at large. Modern societies heavily depend on these infrastructure systems, e.g., road-traffic networks, water networks, and electricity networks. Nowadays infrastructure systems are large-scale, complex networked, socio-technical systems, that almost everybody uses on a daily basis, and that have enabled us to live closely together in large cities. Infrastructure systems are so vital that their incapacity or destruction would have a fatal effect on the functioning of our society. The complexity of these systems is defined by their multi-agent and multi-actor character, their multi-level structure, their multi-objective optimization challenges, and by the adaptability of their agents and actors to changes in their environment. Public infrastructures in SEE region are still not well enough supported with modern technologies of embedded systems and industrial informatics, however we can notice a big rise of their usage.



### GOALS & ACTIONS

Embedded systems and industrial informatics open real opportunities for improved operation and security of public infrastructures and many other challenges that must be met for modern public infrastructures in a competitive economy. The goal is to improve the mobility of people and goods (trains, metro, roads, maritime transport, energy transport...), and to provide solutions that will increase the simplicity of use, connectivity, interoperability, flexibility and security.

Buildings - public and private - integrating a variety of sensors and actuators, and intuitive interfaces, all in order to achieve natural responds to user needs, will be more comfortable yet economical and provide secure access and exploitation. Examples of such infrastructures include integrated end-to-end capabilities, vending machines, toll collecting, access control, traffic regulation and telematics, more cooperative vehicles, more secure bridges and tunnels, active sensing and decision making surveillance in undergrounds, railways and communication networks.

The future of an intelligent infrastructure in the utilities and energy sectors will require global integrity of large numbers of independent and autonomous systems from different organisations. This will pose new challenges for the integration of these intelligent sub-systems so that they can be used collectively. For all types of infrastructure, embedded systems will be triggered or activated at anytime, anywhere, anyhow, through the use of networking. To support this capability, embedded systems will have to be supported with industrial informatics technologies, i.e., "network enabled", and incorporate capabilities of self-management and self-supervision as well as mechanisms to auto-recover from failures.

Embedded systems will also support all aspects of the lifecycle of such infrastructures including ownership, long-term storage, logging of system data, maintenance, alarms, actions by the emergency services, authorisation of access and usage, and charging and billing under a range of different conditions of use.



## PRIVATE SPACES

### CURRENT STATE

In order to ensure comfort, well-being and safety in our living environment, i.e. private spaces, we need various systems, which are based on embedded systems and industrial informatics. These systems and devices are

coming into the use with a small delay in SEE compared to the Western Europe. Therefore it is necessary to provide all support for these needs effecting a variety of private spaces such as cars, housing or offices.



### GOALS & ACTIONS

The establishment of business cases around New (digital) Media is already in progress, though the goal of ubiquitous yet secure, safe and easy to use access to information and entertainment with appropriate content has yet to be realised. Reuse and certification of embedded systems will allow consumer electronics to better adapt to a very fast market with cycle times of as short as three months. In addition, in the near future almost every device will be connected to some network. Collections of such devices will form systems, such as today's audio/video systems in one's home. Managing the complexity of the desired and ensuring system behaviour in the context of a large number of connected heterogeneous devices will be a considerable challenge. Embedded systems and industrial informatics will enable further improvement in the comfort and economic efficiency going beyond short term New Media.

Intelligent and efficient energy use in private homes, multi-vendor environment, encompassing both user-centred reliability and security are important topics for SEE in view of the demographic changes that are apparent in society, for families as well as solo's, elderly and disabled people. In addition, the significant cost reduction is possible in portable medical care equipment through the use of embedded systems, which facilitates the introduction of home care and e-Health services. These intelligent, portable systems form the basis of improved health monitoring. Investment in this field additionally enables the augmentation of education (eLearning), as well as participation in socially beneficial e-Government schemes. To exploit all this potential, there is a need for multidisciplinary, multi-objective, systems design techniques that will yield appropriate price and performance.



## INDUSTRIAL SYSTEMS

### CURRENT STATE

Industrial systems are large, complex and safety critical systems pervasive in a variety of industries such as manufacturing, automotive and avionics industries as well as specific growing areas such as biomedical applications. One of the most important application domains of embedded systems and industrial informatics in SEE region is the area of industrial production. During the past twenty years, a number of information-technology products have been developed. Today, online production data is available to a production manager for use in cost-effective production control. However, the production-management-level functions are covered only partially, dealing mostly only with the technological part of production and production documentation and neglecting other aspects of production (e.g. profitability, stability of both production process and product quality, non technical issues like employee satisfaction, environmental challenges, sustainability challenges, etc). The problems regarding the design of an agile and adaptive production control system still remain. Even more this applies to the industries of the SEE region, which are still not as well equipped as relevant industries in the Western member states.

Many of the industries in the SEE area are of lower added value and are more oriented towards supporting bigger western industries. Another still not completely resolved problem is relevant to the environmental aspects of industrial production.



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### GOALS & ACTIONS

The goal is to ultimately have a “100% available factory”. That kind of factory tends to reduce the environmental strain of manufacturing industries while maximising manufacturing efficiency. Embedded systems are needed to precisely control process parameters, including the active reduction of pollutants, which reduces the total cost of manufacturing. Further competitive advantage in manufacturing industries is assured by efficiency, meaning 100% plant availability and low maintenance that reduces cost. This will not only augment manufacturing employment in SEE, but also assure jobs in the design and manufacturing of the manufacturing equipment itself.

To achieve this goal flexible manufacturing is mandatory, which will be adaptable to market demand. Improved man-machine interaction through advanced embedded systems and “human-in-the-loop” control systems improves quality and productivity by assuring zero operator errors, as well as reducing accidents. For this reason new advanced control methods have to be envisaged and are a big potential for the area.



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# Emerging Application Areas



“New solutions should enable maximal flexibility and adaptability of a production company to current customer’s demand, market conditions and technical capabilities of a shop-floor.”

## FLEXIBLE MANUFACTURING

### INDUSTRIAL SYSTEMS

The SEE region shows a steady success in the development and production of industrial manufacturing systems, but in order to keep being competitive with the rest of the world and being well integrated in the transnational supply chains, the region has to embrace the modern trends in the industrial automation that demand vertical integration between the enterprise and the field control level.

Conventional centralized production planning and execution systems face challenges in adapting to the requirements of modern production environments:

- Unpredictable order flow; customer and production orders are issued dynamically, often when production has already started.
- Dynamic shop floor; configuration of the resources on the field level may change during production, which makes it difficult to plan the execution of orders.
- Complexity of the shop floor and orders; modern production systems are characterized by increasing complexity and flexibility required by production orders as well as the dynamic nature of the shop floor configuration.

Due to their hierarchical nature, centralized systems are highly static and difficult to adapt to events such as late changes of customer orders and new or broken field level devices. Additionally, the decision making process is concentrated on the top layer of the automation pyramid (usually Enterprise Resource Planning (ERP) and related systems) and therefore the production planning is hardly able to react to changes or exceptions on the shop floor.

For instance, conventional manufacturing suffers from decreasing competitiveness due to its rigid structure. Flexible, lean, just-in-time manufacturing is required to reverse the process. Otherwise, chances to withstand global competition are limited.

In environments where high flexibility is required – such as highly customized small lot productions – the absolute optimization of production can be partly neglected in favour of flexibility. The point is that in a permanently changing environment, flexibility is a requirement for achieving any optimization.

Increasing flexibility can be implemented by three general strategies:

- Moving the decision-making process from Enterprise Resource Planning (ERP) down to the Manufacturing Execution Systems (MES) layer which has a shorter planning horizon and, hence, is able to react faster to changes.
- Distributing control over a set of independently acting entities that take a part of responsibility for fulfilling the order. This provides concurrent processing and, therefore, minimizes the drawbacks of the hierarchical structures.
- Architectural concepts that ensure the capability of a system to deliver an acceptable level of service despite the occurrence of transient and permanent hardware faults, design faults, imprecise specifications, and accidental operational faults.

Decentralised control systems and distributed decision making algorithms are required for the future of the industrial control systems in particular and production systems in general in the region.

New solutions should enable maximal flexibility and adaptability of a production company to current customer’s demand, market conditions and technical capabilities of a shop-floor. The general goal is improving of shop-floor control, production flexibility, production efficiency, resource exploitation, safety of production, profitability, lower maintenance costs, improved product quality and at the final stage to reach a lean and “100% available factory”.



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In order to support such systems, new software and hardware has to be developed and integrated into the system to provide system visibility to the customers and systems operators. Solutions such as using RFID for the shop floor identification of products and resources show the way to deal with the ever growing complexity of production systems as well as to blend the barrier between the human and the machine by including personell in the automated manufacturing process.



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## AUTOMOTIVE INDUSTRY

Today the SEE region is not a big player in the automotive industry but it is becoming an important supplier of various parts and subassemblies for the car industry and in this way it can participate in a variety of activities leading towards more safe, sustainable and comfortable vehicles. Similarly, to reduce road fatalities, the “100% safe” car is envisioned, where neither the driver nor the vehicle is the cause of any incident. This very ambitious goal can only be reached by using more intelligent systems, so called ‘active safety’ systems, where context awareness in the Human Machine Interface (HMI) is needed to reduce the workload of the driver, with sensors, actuators and smart software embedded throughout the vehicle. Ad-hoc networking is a prerequisite for car-to-car communication in the background of active safety systems. Another megatrend affecting embedded systems is to reduce fuel consumption and pollution, the target is set on the “near-zero emission” car. Embedded systems are also key technologies for smart production in the field of car manufacturing in general, the integration of the supply chain and related logistics.

# EUROPE GOING GREEN

## PUBLIC INFRASTRUCTURES, PRIVATE SPACES

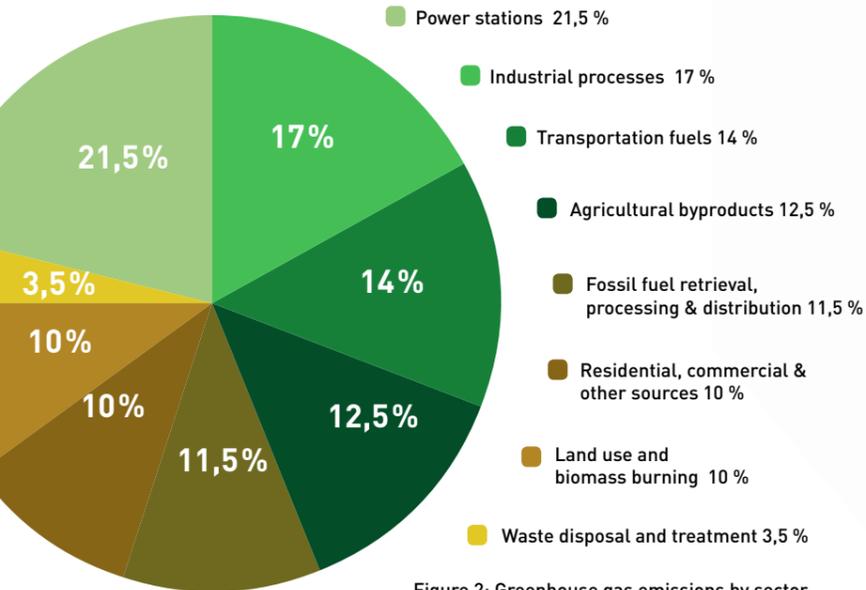


Figure 2: Greenhouse gas emissions by sector

A major trend in the world and especially in Europe is “going green” meaning reducing greenhouse gas emissions by cutting down on the use of fossil fuels, transitioning to renewable CO<sub>2</sub> emission free energy sources, and introducing schemes for trading the greenhouse gas pollution. At the moment the main contributors to the greenhouse effect are power generation, industrial processes, transportation and agricultural by-products (Figure 2). In the following related sectors are addressed in more detail.

At the moment the SEE region is among the leading regions in the world by the reduction of CO<sub>2</sub> emission (Figure 3 & 4). Nevertheless, this achievement comes primary from the economic crisis that hit the region after the collapse of the socialistic countries block. Currently, fast developing

economies and the growing consumer market of the region will produce CO<sub>2</sub> at accelerating rate. However, the current state of the region’s infrastructures such as power stations, industrial objects, residential and commercial buildings, transport facilities and other concerned objects and mechanisms are not capable to cope with the increasing production and consumption and cannot satisfy both the targets of the European Lisbon agenda and global targets of the Kyoto protocol. In order to integrate into the EU and stay competitive, the region’s energy approach has to 1) increase the share of renewable energy sources, 2) make industrial and residential energy consumption more efficient and 3) reduce the consumption in general. The following sections define these actions in more detail.

### ITALY'S DEPENDENCE ON FOSSIL FUEL

The Italian situation is quite critical. According to the Kyoto protocol the CO<sub>2</sub> emission will cause heavy penalties on Italy. It is estimated that in the period 2008-2012 these penalties will amount to 2 billion dollars.

Italy’s situation originates from its dependency on non-renewable sources and on fossil fuels. Moreover, the freight transportation is mainly done by trucks. Furthermore, the railway network is not used to its full potential. A great potential also lies in shipping since Italy could benefit from its geographical location.

Finally, due to the deficiencies in the underdeveloped public transportation system Italians are forced to use private vehicles which cause significant CO<sub>2</sub> emissions and congested roads. Embedded systems can help to mitigate this dependency.

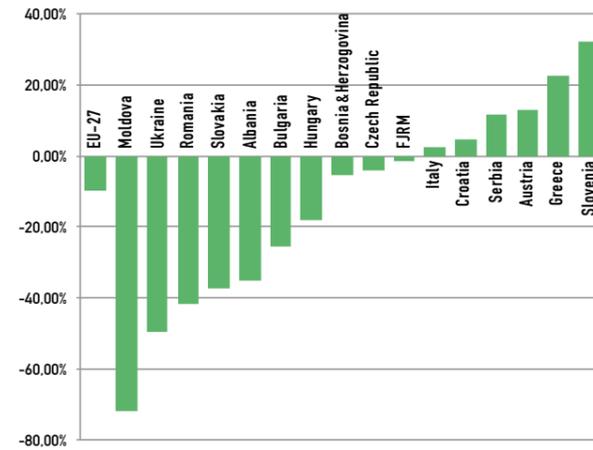


Figure 3: CO<sub>2</sub> emission change in 2000-2008 years

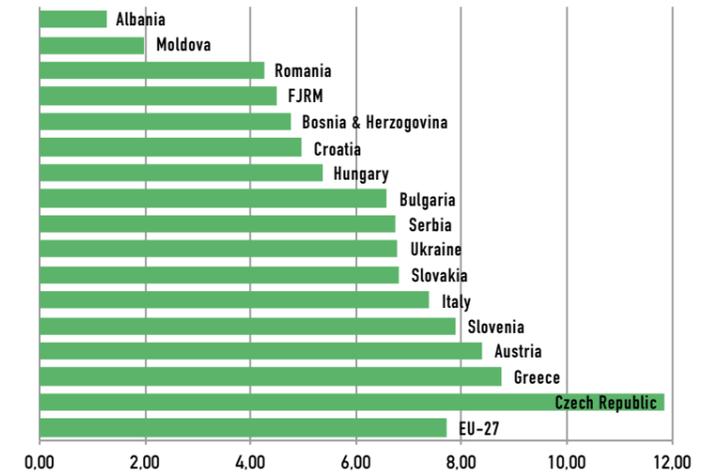


Figure 4: Carbon emissions by country (CO<sub>2</sub> emission t/person/year)



## GREEN ENERGY MARKET

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### PUBLIC INFRASTRUCTURES

By 2020 the EU set a goal to increase the share of renewable energy sources in the final energy consumption to 20%. Green energy is an emerging market in Europe fuelled by the EU doctrine to reduce CO<sub>2</sub> emissions by using renewable energy sources such as wind, solar, wave, tide, biofuel and geothermal energy (Figures 5 & 6).

World energy consumption (projected in EU)

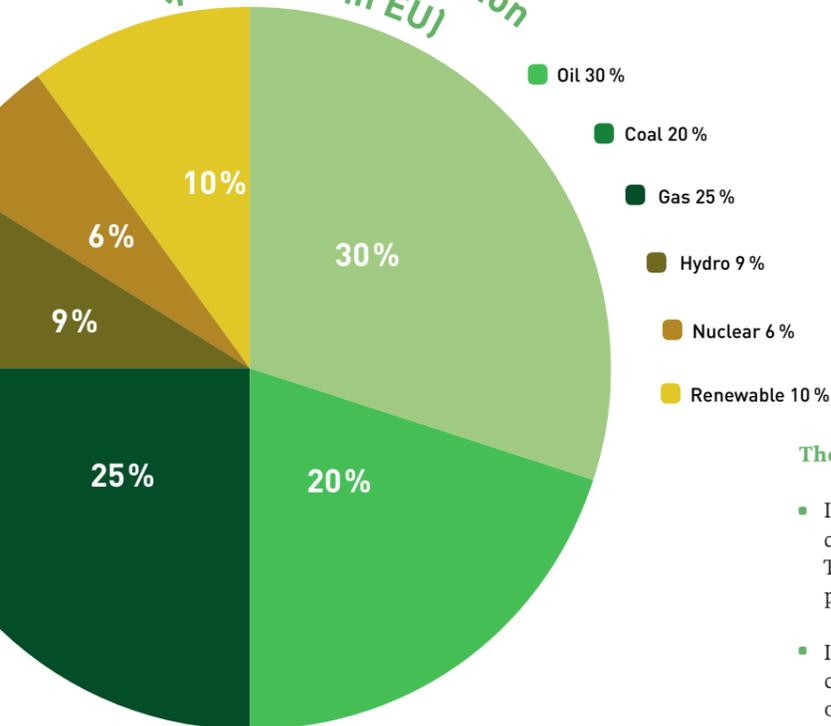


Figure 5

World energy consumption (current)

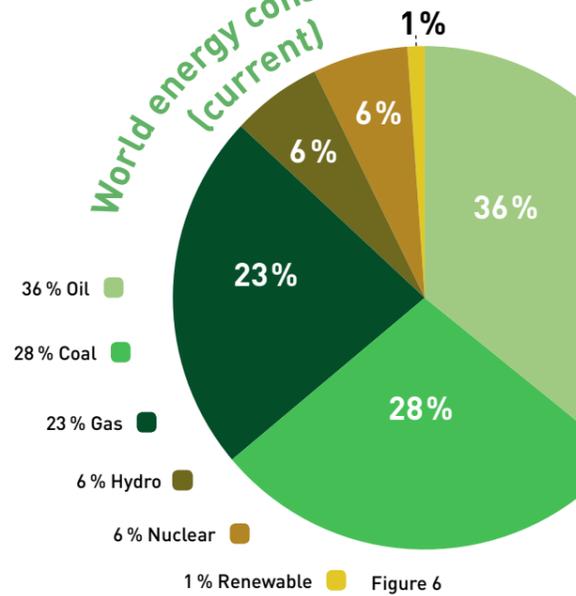
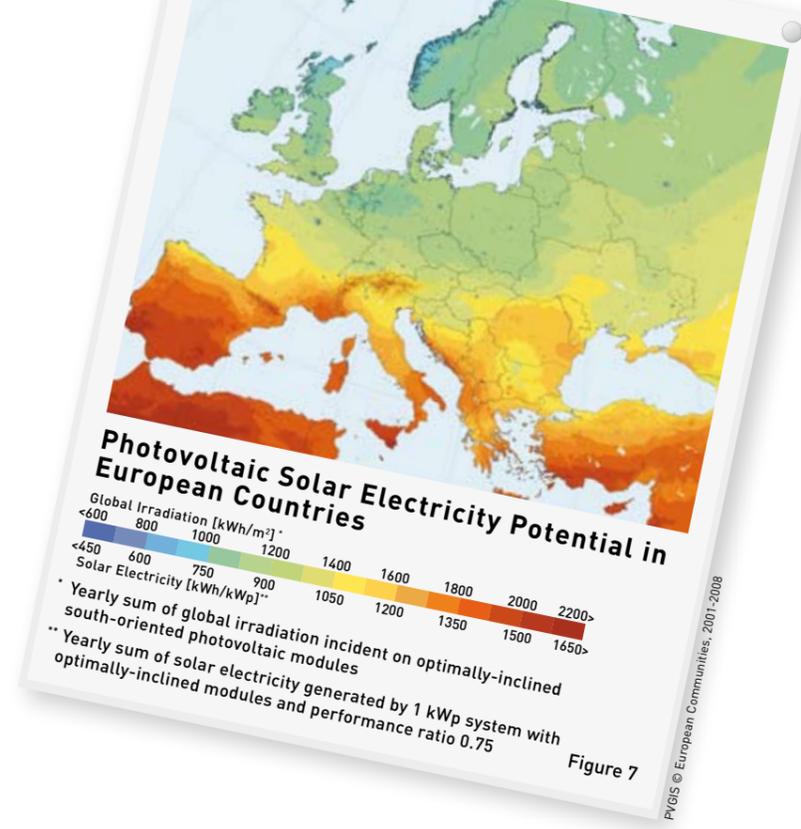


Figure 6

There are two main ways to achieve this target:

- Increasing efficiency of energy use, 80% of which still comes from non-renewable and polluting sources. Transportation and industrial use are the main source of pollution with 25% of total energy consumption each.
- Increasing the share of renewable sources that mainly comes from the electricity production. More than 50% of renewable energy is electric power. Electric power generation accounts for 40% of the total energy making this sector a priority in achieving the 20% target.



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Today's green energy market is characterised by a dominant position of hydro power (Figure 8). Yet, its capacity in Europe is currently at the limit. Therefore, the real potential is in wind, solar, geothermal, waste and biomass. Currently, SEE region lacks behind the rest of EU in utilisation of renewable energy. Apart from the conventional hydro power, the SEE region relies on fossil and nuclear power. The worst proportions are in Greece and Italy where more than 90% and 80%, respectively, of total energy is produced from fossil fuel, although the countries have one of the highest geothermal and solar resources in Europe. In average, the SEE region produces less than 2% of its electricity from renewable sources (not counting hydro power) compared to 11% in the Netherlands, 12% in Germany and Spain and 20% in Denmark. However the region has one of the highest renewable energy resources in Europe especially in solar and geothermal making this field very attractive.

Renewable electricity generation in EU in 2003

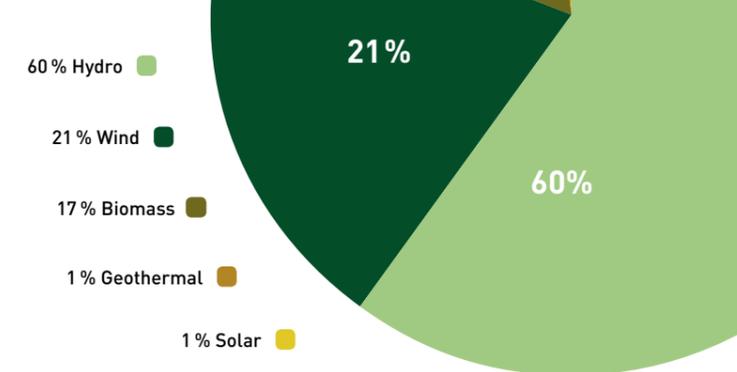
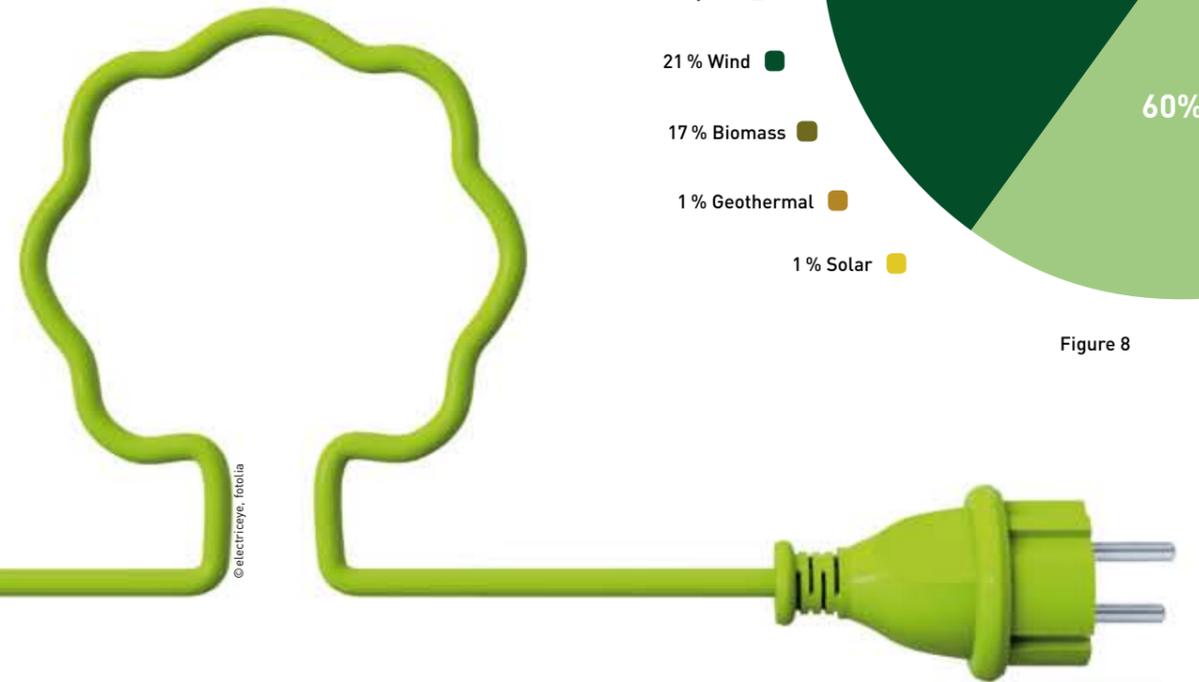


Figure 8





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## SOLAR ELECTRIC POWER

Until recently Germany having an irradiation of only 1000 kWh/m<sup>2</sup> was the biggest producer of solar power electricity in the world. Greece and Italy, countries with some of the largest solar resources in Europe (1200-1400 kWh/m<sup>2</sup>) produces almost no solar electrical energy (Figure 7) although Greece is in the top three countries following Cyprus and Austria with reference to solar thermal installations.

The SEE region has to use the available solar power resources to reach the EU standards and break dependence on fossil energy.



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## GEO THERMAL POWER

The SEE region has long been on the cutting edge of the geothermal power that provides a sustainable (with 90% efficiency) stable energy source that has virtually no pollution and provides additional benefits in terms of residential heating, which accounts for 40% of residential energy use. The first geothermal plant in the world (and still in operation) has been built in the South of Italy over 100 years ago. Countries like Greece and Italy have some of the largest geothermal energy sources (150MWh/m<sup>2</sup>) that can be used to meet the requirements of the EU for the green energy agenda. SEE can become leading in utilising this energy source.



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## WASTE-TO-ENERGY

It is a process of creating energy in the form of electricity or heat from the incineration of waste source. At the moment different technologies – thermal, non-thermal – are already available. They have to satisfy strict emission standards. With an exception of Austria, the SEE region lacks behind the rest of Europe concerning waste-to-energy installations. However, it can not only provide clean energy but also solve a waste management problem that the region faces.



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## WIND

Although this energy potential is weak in the region compared to the Atlantic coast countries, the SEE region has sufficient wind resources. The current trend in innovation will improve the perspectives of the wind power usage also in SEE.



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## AUSTRIA – A LEADER IN RENEWABLE SOURCES OF ENERGY

Austrian electricity production is characterized by the large percentage of renewable sources primary hydro power that generates over 60% of electricity. In 2004, net electricity generation was 64.6 billion kWh, of which only 38% came from fossil fuels, over 60% from hydropower, none from nuclear energy, and the remainder from other sources.

However, Austria is facing a challenge in adapting to an ever growing demand reaching the limits of its hydro power capacity. The general trend is to focus on small scale hydro power stations that require sophisticated grid infrastructure is the niche for innovation in embedded systems.

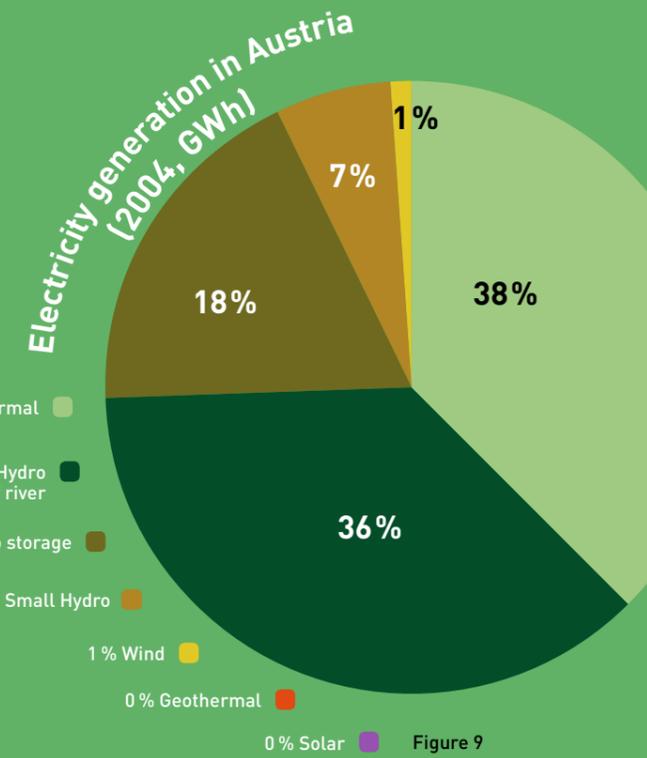


Figure 9

Although electricity production is out of scope of the I3E agenda, the shift to renewable sources of power that are usually smaller in capacity and more distributed in scale require communication and transmission infrastructure to control both production and distribution. Considering that around 25% of energy is lost during generation and transmission, there is a large potential for innovation.

In addition, the efficiency of renewable energy sources heavily relies on the management of peaks and lows due to the uneven distribution of the electricity generation (especially in case of wind or solar power). Sensor systems to monitor production and consumption of electricity and appropriate control systems are required (Figure 10). The smart grid of the future is full of embedded systems and intelligent software such as forecasting algorithms.

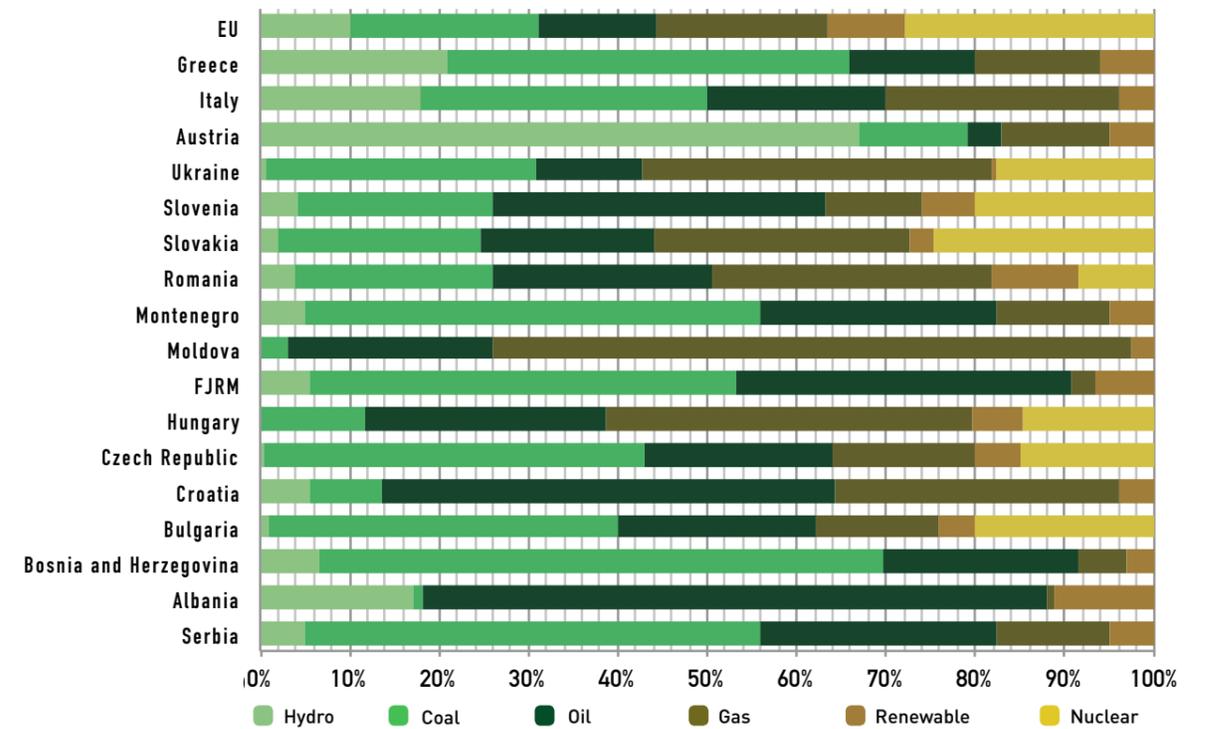


Figure 10: SEE region electricity production by source

“According to the Lisbon 2000 agenda by the year 2020, EU set a goal to increase energy efficiency by 20%. As a result, the European Commission made a high priority for funding in the area of energy efficiency.”

## EFFICIENT USE OF ENERGY

### PRIVATE SPACES, PUBLIC INFRASTRUCTURES

According to the Lisbon 2000 agenda by the year 2020, EU set a goal to increase energy efficiency by 20%. As a result, the European Commission made a high priority for funding in the area of energy efficiency. In addition, the average electricity consumption in Western Europe is 7000 kWh per capita, where in the SEE region it is only 4300kWh. With the increasing integration of the region into the EU, it is expected that SEE consumption will come close to the EU average. Figure 11 shows the energy consumption by sectors in SEE.

However, the current state of energy infrastructure, especially at customer premises in most of the SEE countries is highly rigid and operates by the rules and regulations set during the period of centralised planning. At this time energy resources were highly subsidised and these government regulations make energy savings mechanisms of no interest to the customer.

Therefore, a set of simple measures can dramatically increase the energy efficiency:

- Installation of sensors and counters for the local energy monitoring making the customer able to control the level of energy consumption and pay for the consumed energy instead of paying a flat rate. Such a motivation can dramatically reduce energy waste at the customer side.

- Development of smart grid applications at the utility companies that would redistribute the energy and improve utilisation of the energy facilities.
- Introduction of flexible tariffs for electricity that would allow the customer to reduce energy consumption during the peak periods and therefore, improve utilisation of the energy facilities.

All the above mentioned measures require innovations in the area of intelligent sensors and embedded devices that would monitor energy consumption locally as well being integrated in smart grids environment. The need for distributed systems of intelligent embedded devices is driven by the general trend of distributed generation where multiple sources with small and non-constant power supply have to be integrated into a global balanced network that can efficiently react on changes in demand and supply. That requires local decision making, complex networking and distributed monitoring and management. The key application areas for such systems are in industrial and residential buildings that collectively consume over a half of energy.

### Energy management in manufacturing

The industrial production sector is a major consumer of energy provided either from a public infrastructure or from internal power plants. Additionally, industry also provides significant amounts of waste energy in the form of steam, hot water or hot flue gases as the output of its technological processes.

For all these reasons to save energy and reuse energy, new industrial informatics solutions need to be developed; systems for total on-line monitoring of energy flows in a company, systems for energy consumption smoothing, systems for reducing peak energy consumption and new concepts of energy management (e.g. smart grids) can significantly reduce energy consumption and costs in industry.

Efficiency of industrial buildings' energy use can be dramatically increased by integrating the building into the manufacturing planning, therefore including energy use into production cost considerations.

New technologies based on exploitation of renewable sources and industrial wastes are also emerging.

### Energy management in private houses

The private houses sector is a relatively big consumer of various energies in the SEE region. The consumption can be effectively lowered also by constant monitoring and control of energy consumers, reusing waste heat energy, intelligent heating and ventilation systems (HVAC), use of effective combined heat and power co-generation systems and new types of energy sources (e.g. solar panels, wind turbines, fuel cells or geothermal energy). An implementation of new solutions requires the design of a new kind of new embedded systems, sensors and algorithms being capable of online management of all energy consumers and sources in an intelligent way. The "passive house" is an emerging concept, especially in Germany and Austria that by introducing closed HVAC systems can save up to 95% of energy and therefore reduce the heating costs.

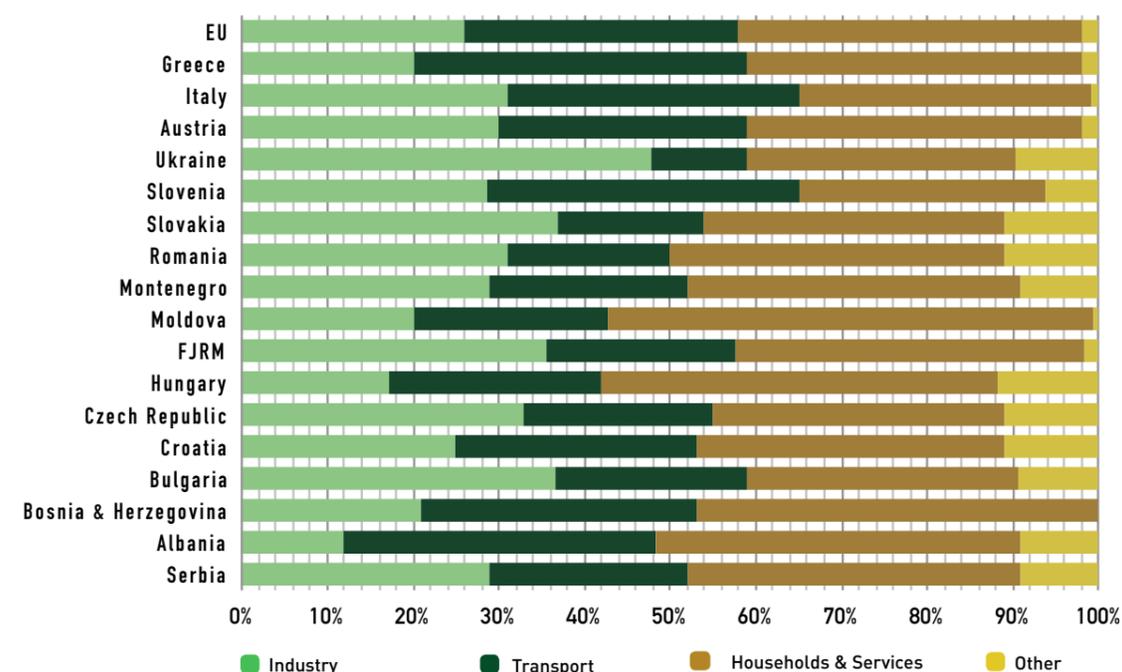


Figure 11: Energy consumption by sector



## ENERGY EFFICIENT BUILDINGS

Austria has more than 2 million buildings at the moment with 75% of which are single family houses and 14% of non-residential buildings.

Austria developed a first National Action Plan for energy efficiency that aims to reduce energy consumption in residential buildings by 22.34 TWh by the year 2016. In order to fulfil the goals of the plan the following measures are to be implemented: 1) government program, 2) energy concepts, programs and guidelines for the Austrian regions, 3) promotion

schemes for residential buildings and 4) domestic environmental promotion schemes. Depending on the region minimal requirements have been set up that a newly constructed house has to meet (65 MWh/m2 in Styria, 40 in Burgenland, 45 in Vienna etc). Additionally several levels of energy efficiency are introduced that are subsidised by the state: 1) Low energy house, 2) Super low energy house and 3) Passive house. Solar power, ventilation, cooling and heating are some of the areas embedded systems will have high importance.



## HEALTH SUPPORT, MONITORING, DIAGNOSTICS & LIVING ASSISTANCE

### NOMADIC ENVIRONMENT, PRIVATE SPACES

With the increasing elderly and retired population of Europe there is an increasing demand towards research and innovation in the area of health monitoring and support systems that mostly benefits elderly people.

In the next ten years the elderly population in Europe will double and will reach 20%. That would cause challenges not only in terms of pension system but also the healthcare system for all the European countries.

The demographic situation in Europe in general and in the SEE region in particular shows the growing number of childless elderly people that is caused by the low birth rate in Europe. A low level of reproduction (Figure 12) combined with longer life expectancy than in the world in general break the traditional social structure of children caring for their (elderly) parents. The next generation of elderly people will have to rely on their own. Therefore, health support and monitoring



systems are of crucial concern for the aging population of Europe. In the area of embedded systems there are several sectors with high innovation potential:

- Health monitoring systems that monitor certain parameters such as temperature, blood pressure or heart rate and inform either a person or a doctor remotely if one of the parameters is out of accepted range.
- Health diagnostic systems that go a step beyond and are able to determine the diagnosis based on the collected sensor data.

- Assisted living systems would substitute social and medical personnel for an elderly person living alone by providing both a set of devices helping in the household as well as to recognise a situation when a person needs assistance and call for help.

Such innovations would increase the comfort of life for the ever growing elderly population and at the same time reduce a burden for society and health care.

### LEADING MEDICAL SYSTEM

According to the study compiled in 2007 by Health Consumer Powerhouse, a Swedish organisation of health experts, based on the Euro Health Consumer Index, Austria has had the best medical system in Europe. Austria spends 2,186 Euros per head per year, Luxembourg spends 3,526 Euros, Switzerland & Norway roughly 2,820 Euros. The study measured national health systems according to following criteria: patient rights and information, e-Health, waiting times, outcomes, range and reach of services and pharmaceuticals.

The Austrian health care system's greatest weakness is patient information. When a patient in Austria wants to know something about health, he is told to go to the doctor. It would be more cost-effective and efficient to encourage the patients to get initial information over the phone or on the internet, as is the practice in Great Britain or Denmark. Therefore, advanced health monitoring and self-diagnostic systems can greatly improve the level of health system in Austria.



Country	Position in the world	Fertility rates
Ukraine	219	1.27
Slovenia	216	1.29
Slovakia	211	1.36
Serbia	207	1.39
Romania	218	1.27
Moldova	217	1.28
Italy	213	1.32
Hungary	208	1.39
Greece	209	1.37
FJRM	186	1.58
Czech Republic	222	1.25
Croatia	201	1.43
Bulgaria	204	1.41
Bosnia & Herzegovina	220	1.26
Austria	206	1.39
Albania	195	1.47
EU	—	1.50

Figure 12: CIA Factbook total fertility rates (children per woman)



## HOME APPLIANCES

### PRIVATE SPACES

With the fast growing economy, and increasing disposable income of the SEE region the market for home appliances is expected to expand dramatically in the following years.

The current situation in this sector is characterised by low penetration of appliances in the SEE area: +

On average in South East Europe, only 4% of households have dish washers, 65% washing machines, and 40% freezers.

In 2009, the average penetration of broadband connection was at 15% of households, which is half of the EU average.

But the general trend of the past years is the high growth of home appliances in the SEE region, which is on average 10-times higher growing than in Western Europe. There is no indication that this tendency would disappear in the future, at least until the level of home appliances penetration will reach the level of EU average.

What characterises the home appliances market (apart from the traditional appliances such as fridges and washing machines) is the high level of product line changes and new implementation ideas. Therefore, this sector is open for newcomers having a benefit of an expanding domestic market. The SEE region has potential for establishing its position in this domain.

A particular importance of this area for the region is derived from the fact that innovations in private spaces can be developed by SMEs which are the driving forces of the region's economy, and they have short idea-to-market cycle which is preferable.



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## SMART HOUSES

### PRIVATE SPACES

Increasing Internet, cable and satellite television, flexible energy and HVAC systems penetration are transforming a house into the integrated automated and self-regulated system where every device in a house is connected with each other and open to the outside world. The scary stories of robots taking over control of our life are becoming a reality in a seamless way, by taking over the tasks that do not need a human supervision. Yet such systems are human-centric, where the smart environment focuses on prediction of needs of the person(s) living in the house.



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The smart house application area deals with an emerging practice of increased automation of household appliances and features in residential dwellings, particularly through electronic means. The techniques employed in smart house include the automatic or semi-automatic control of lighting, doors and windows, heating, ventilation and air conditioning, security and surveillance systems, control of home entertainment systems, house-plant watering, pet feeding, changing the ambiance „scenes“ for different events (such as dinners or parties), and the use of domestic robots. Wireless communication systems and a central controller are essential parts of a smart house control system that should provide increased functionality, accessibility, reliability, security and good ambient atmosphere/living comfort in a residential house.

A typical example of a smart house would combine:

- TV, Internet, Telephone, Sound system of the future being an integrated portal to the outside world as well as a control panel to the house – Integration and automation are the key words for the home systems where everything is connected and things that do not require human supervision are automated.
- HVAC – integrated close-loops system that uses low tech advantages of the house design to minimise the energy consumption with providing maximum comfort.
- Security and safety – seamless provision of security and safety of the house based on sensor networks will be a key issue in houses of the future. With openness to the virtual world, people tend to keep their real world more private.
- Sustainable design of houses reducing dependency of people on the centralised systems and increasing the level of comfort.
  - ✦ Natural lighting – use of natural lighting in the house design reduces energy consumption and bring people closer to nature.
  - ✦ Solar energy – the use of solar panels provide independent and sustainable source of energy and saves upkeep costs.
  - ✦ Green roofs – reducing solar gain, filtering rain water for underground reservoirs for irrigation or other use, as well as providing an environment closely related to nature. This is especially important with respect to a growing urban population.

The focus of smart houses will not be primarily on creating new buildings. The challenge will mostly be the conversion and adaption of existing infrastructures to meet new requirements.



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## NOMADIC ENVIRONMENTS

The nomadic environments area is the most dramatically developing field of research and innovation nowadays and the trend does not seem to be changing. The two main directions of its development is the wireless connectivity of a person to limitless information at all time and transition of computation and data into cloud computing. Both directions became possible due to the advancements in embedded devices.

Although the SEE region is behind North America and Western Europe the region will follow this obvious trend. For example Figure 13 illustrates the deeper penetration of smart phone devices that allows to be “online” at any moment of time.

### UBIQUITOUS ENVIRONMENT & AMBIENT INTELLIGENCE

In our life we are surrounded by sensors that can be a simple thermometer or our car or a satellite in space. What they have in common now is connection to the global networks that integrate them in the giant

knowledge base that can assist people. The missing link between this automated environment is now filled with the smart phones that identify a person in the virtual as well as in the real world.

The simplest example of that is the GPS system that recognises a human's location and assists with navigation. But such products as Google Maps and Earth went a step further by offering nearby restaurants, bars, hotels, gas stations etc. And that is only the beginning.

Integration of all available sensor data and its analysis could provide with assistance bordering the privacy issues. However nobody would mind if a phone suggested taking an umbrella while leaving home because there is a high chance of rain. Or when a cup measures your pulse while you are drinking coffee and informs that you need to visit a doctor, even making an appointment for you.

The reality of the future is the impossibility of grasping all available information. The only way to handle it is to delegate some of the decisions to the distributed intelligence that surrounds a person. The challenge is providing a balance between privacy and comfort.

“The reality of the future is the impossibility of grasping all available information. The only way to handle it is to delegate some of the decisions to the distributed intelligence that surrounds a person. The challenge is providing a balance between privacy and comfort.”

## CLOUD COMPUTING

There is a simple observation – to run 10 servers for 1000 hours costs the same as to run 1000 personnel computers for 1000 hours. The idea of sharing resources by outsourcing computation, RAM and storage to the “cloud” is gaining momentum. Amazon already offers resources of a single PC for a price of 3 cents an hour and a server capacity of 68Gbyte of RAM, 1690 Gbyte of storage and 26 computing units each equivalent of 1-1.2 gigahertz processors for a price of 2.28 dollar an hour.

And that is only resources you buy explicitly. Products as Google App engine, which have been developed to run web applications, monitors an application's popularity. When an application becomes popular the App engine automatically increases the computing resources

dedicated to it allowing a dynamic share of resources. These examples show only the top of the iceberg of how cloud computing is developing. With cloud computing shared development and shared knowledge is growing. Platforms like Google Docs allow shifting the storage and processing of the office files into the Internet but also open to the possibility of working on the same documents making human intelligence a cloud. The same goes for the Google Earth 3D modelling tool – SketchUp that is a free tool created to stimulate people to play with it and therefore create models for Google Earth.

One of the main reasons for the concept success is the spread of today's smart phones that allow people to access the cloud at all times.

## SMART PHONES

Being online all the time becomes a reality and changes the paradigms we approach life. There is no need to know, because you can always find it. And combined with cloud computing a smart phone becomes a portal to a person's virtual computer making PC a part of a museum. In 2007, sales of smart phones surpassed sales of laptops. It is predicted that by 2014 more people will use smart phones to browse Internet than traditional computers. This is especially useful in rural and isolated areas because they are self-contained needing neither additional network infrastructure nor even reliable power.

The main feature of the smart phones in the future will be in its personification of a human in the virtual world of automation where the ambient intelligence and ubiquitous environment show the full potential of the smart phones.

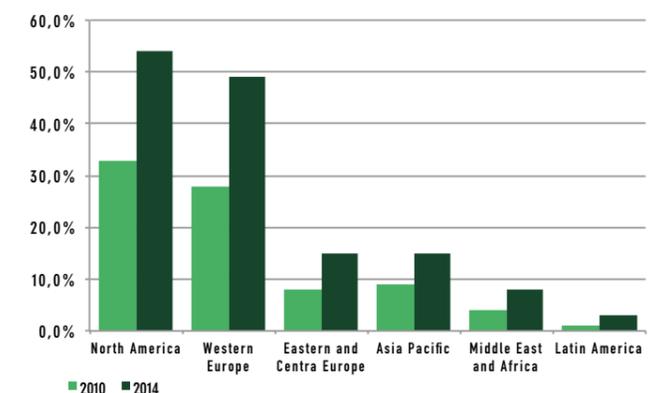


Figure 13: Smartphone penetration

“In the SEE region there is a need for improvement of logistics in public transport systems in order to assure fast, efficient, safe and accessible transport and mobility of people and goods.”

## PUBLIC INFRASTRUCTURES

The level of public infrastructure in the SEE region limits the potential of development. It serves as a basis that can push the region forward or hold it back. Improvements in such sectors as transportation facilities, energy and waste management are responsibilities of the state. This sector is out of the realm of possibilities for the SMEs or even large companies due to the slow return on investments and questionable profitability. Yet, the social and even economical impact of public infrastructures is highly important and sustainable.

### PUBLIC TRANSPORT

Concerns over environmental issues in transportation, which contributes 20% of carbon dioxide emissions in the EU, not only motivate the development in individual vehicles emission reduction but also stimulate public transportation. Most of the transportation pollution comes from road transportation (Figure 14), and most of this pollution is caused by private cars (Figure 15). With 70% of the European population being urban, there is an objective need for private cars, especially in large cities. Therefore, public transport should substitute private cars to a maximum.

However inefficiency and unreliability of public transport in the SEE region does not stimulate people to use it.

In SEE region there is a need for improvements of logistics in public transport systems (trains, bus transport, traffic information, maritime transport, etc.) in order to assure fast, efficient, safe and accessible transport and mobility of people and goods. Embedded systems innovations in public transport can dramatically improve the situation in the region's transportation by monitoring and prediction systems. It would make public transport accessible and reliable – some of the main concerns that make it unattractive to people. This is an opportunity to facilitate new intelligent solutions in the area of embedded systems which can assure improved traffic monitoring and control

integrated solutions between different branches of public transportation such as buses, trains and ferries to guaranty fixed time tables and high level of comfort. In addition, social and political measures can discourage people from using private vehicles, such as limited traffic in certain areas, parking fees and etc.

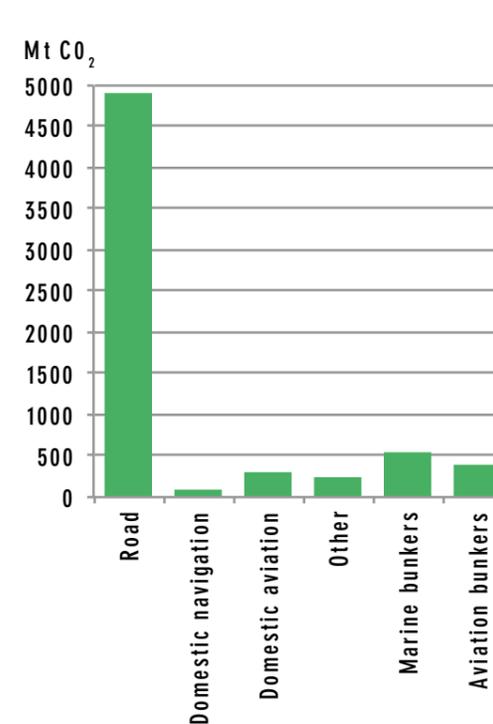


Figure 14: Transportation pollution

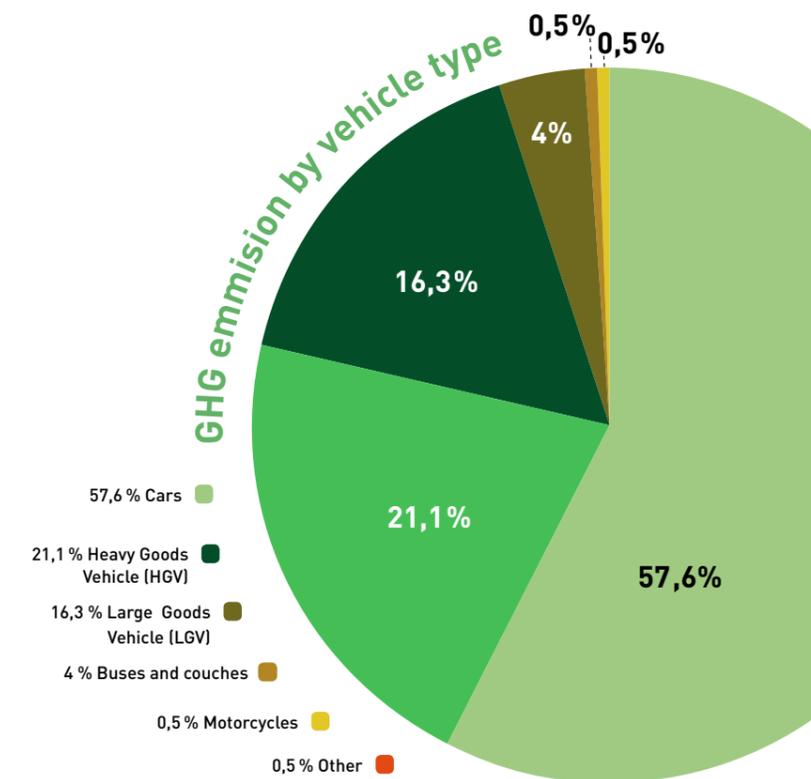


Figure 15



“The South East European approach to waste management is landfilling which is a serious problem for the region. Landfilling is not only the least environmental friendly but has the long lasting consequence to literally pile up the problem.”

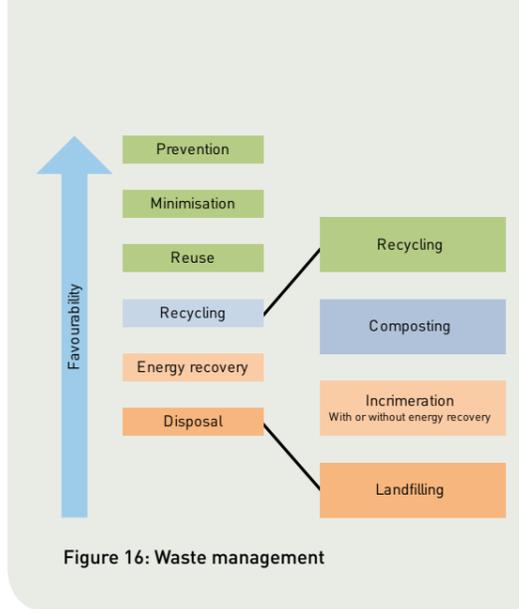


Figure 16: Waste management



Waste management is always an important issue in the world in general and in Europe in particular. Although, waste generation of 350-450 kg per person per year in the SEE region is below the average in the EU amounting to 550 kg, the way the region approaches waste management will have long lasting consequences in the future if the governments of the region will not change the waste treatment paradigm.

There are six main ways to treat waste (Figure 16), of which the top three are the most preferred but not wide spread. Most of the waste management is focused on the bottom three that can be divided into four main mechanisms. Landfilling is not only the least environmental friendly but has the long lasting consequence to literally “pile up the problem”. The SEE region's approach to waste management with the exception of Austria (where 70% of waste is composted or recycled) is landfilling and that is becoming a serious problem for the region. The existing waste deposits and waste treatment plants are old fashioned and do not meet the regulations of EU. Nearly the same problem is witnessed with the existing wastewater treatment plants. For these reasons, there is a strong governmental initiative to stimulate waste selection, establish on-line monitoring and build new waste treatment and recycling facilities. Both industrial informatics and embedded systems can contribute to this aim with new intelligent solutions in the fields of waste monitoring and advanced control of new waste treatment and recycling facilities.

Apart from the obvious construction of waste treatment facilities there are a number of concepts that help to reduce waste generation:

- The “3 Rs” concept of “**reduce, reuse and recycle**”, which classify waste management strategies in terms of waste minimization. The main goal is to generate the minimum amount of waste. This concept focuses on sources of waste and not on consequences. Public awareness and extended sensor networks for notification and tracking waste generation is one of the ways to implement elements of this concept where embedded systems have high potential.

- “**Extended Producer Responsibility (EPR)**” is a strategy that integrates all costs allocated to a product including its recycling and not only the production costs. This concept that imposes responsibility (including financial) for the lifecycle of products on companies which manufacture or sell products. Applying this concept would require both investments in industrial informatics for production improvement as well as in embedded systems for tracing the product life cycles in determining its origin or intelligent repair.

- “**Polluter Pays Principle**” is a principle where the polluting party pays for the impact caused to the environment. In this respect waste is considered as a sort of pollution and the waste generator has to pay for its disposal, where the type of disposal determines the costs for the polluter. A dynamic trade mechanism and governmental regulations are necessary for this policy to be effective.

The combination of all three concepts would lead to improved waste management on all levels. Customers will consider devices with longer life cycle and recycling possibilities. Industry will focus on device support from the production until utilization that would include modification and adaptation of existing devices to new standards and trends as well as developing self-monitoring and self repairing mechanisms in devices to prolong their time in operation. Such approach will require not only new generation of embedded devices as final products but extensive monitoring and support systems requiring new innovations in industrial informatics, networking, sensing and local distributed decision making.





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“Optimise field-level management by matching farming practices more closely to crop's needs, to environmental protection by reducing the footprint of farming and to economics by boosting competitiveness through more efficient practices.”

### EMBEDDED SYSTEMS IN AGRICULTURE

The global trend of increasing food prices is determined by two major factors: 1) increasing population, 2) simultaneous wealth growth in developing countries such as China and India and 3) biofuel. Together with secondary factors such as environmental conditions for agriculture (deteriorating land due to the industrial exploitation and shortening water supply) it is apparent that in the nearest future demand for food and other agriculture-related products will rise.

The SEE region still depends on agriculture, fishing and forestry (Figure 17). This is especially visible in terms of labor. In countries such as Albania and Moldova over 40% of population are involved in agriculture. Yet the level of productivity in the sector is well below the standards of EU. Investments in support sectors such as logistics of storage, harvest collection, weather forecasting together with irrigation systems, predictive analysis based on distributed sensor systems, alarm and monitoring systems, etc. can dramatically improve productivity of the agricultural production without adding environmental impact.

Precision farming or precision agriculture is a farming management concept based on observing and responding to intra-field variations. It relies on new technologies like satellite imagery and information technology. It is also aided by farmers' ability to locate their position in a field using satellite positioning system like GPS. It aims to optimize field-level management with regard to crop science by matching farming practices more closely to crop needs, environmental protection by reducing the footprint of farming and economics by boosting competitiveness through more efficient practices.

Already today embedded systems are well spread in common agricultural items such as grain elevators, grain analysis equipment, feeding systems, milking machines, and other agricultural machines and vehicles. First initiatives such as the ISO 11783 (or ISO Bus or ISO-BUS) communication system based on the SAE J1939 protocol (which includes CANbus) for the agriculture industry show the way to more advanced interoperable and networked agricultural systems.

For example, precision farming requires networked machinery but also complex infrastructures including satellite systems and computational centers for simulation models. Such systems on the one hand offer high innovation potential for SMEs but on the other hand also require to involve regional acting players coordinating complex infrastructure issues and interoperability that are out of reach of individual farmers and companies. Only country- or region wide approaches can economically address such systems.

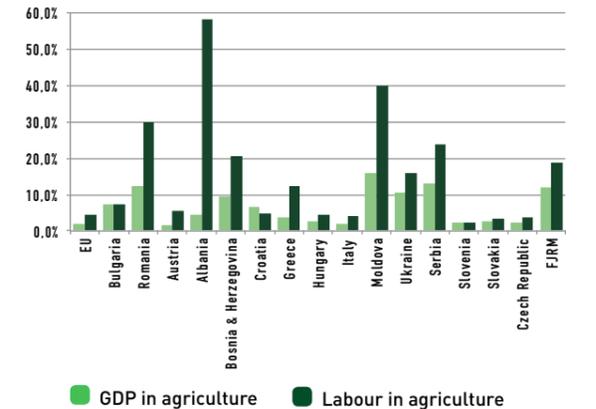


Figure 17: Role of agriculture



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# Research Priorities



“While in the previous chapter the most potential application areas for the South East Europe Region are identified, the objective of this part is to define the research priorities for future embedded systems and industrial informatics.”



## RESEARCH PRIORITIES

While in the previous chapter the most potential application areas for the SEE region are identified, the objective of this part is to define the research priorities for future embedded systems and industrial informatics in these areas. In the table below the horizontal rows represents the application areas whereas the columns identify the key developments to strengthen the SEE area.

Research topics have been identified in the consensus building process including various stakeholders from the whole SEE region. All indicated research topics for embedded systems and industrial informatics are described in more detail on the following pages.

	SAFETY & SECURITY	DISTRIBUTED SYSTEMS	INTEROPERABILITY & STANDARDISATION	INTELLIGENT SYSTEMS	NETWORKS	ARCHITECTURES & PLATFORMS	DESIGN METHODS & TOOLS
Flexible manufacturing		● ●	● ● ●	●	●	● ● ●	●
Green energy market	● ●	● ● ●	● ●		●		●
Efficient use of energy	●	●	●	●	●	●	
Health support, monitoring, diagnostics and living assistance	● ● ●	●	●	● ● ●	●	●	
Home appliances	●		● ●	● ●	● ●	●	
Smart houses	●		●	●		●	●
Public transport	● ●	● ●	● ●	●	● ●	●	●
Embedded systems in agriculture		●	●	● ●	●	●	
Waste management				●	●	●	
Nomadic environments	●	● ●	●	● ● ●	● ● ●	●	



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“With the growing openness and interconnectivity of all aspects of our lives, security is becoming a crucial aspect of the success of any innovation.”

## SAFETY & SECURITY

Safety and Security will be important requirements for future systems in all application areas. With the growing complexity and interconnectivity of these systems and their pervasiveness of all aspects of our lives they are becoming a crucial aspect of the success of any innovation.

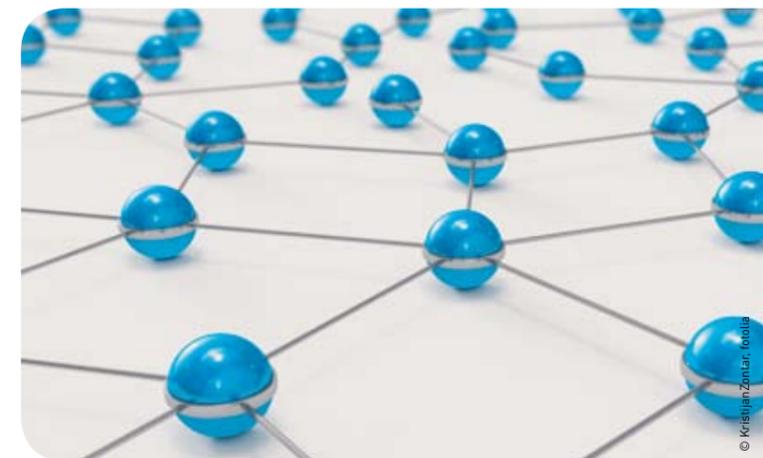
Safety will gain higher importance the more systems directly cooperate with humans and influence their environment. Safety will not be focused on particular applications such as fire alarms or process control, but be a requirement for the architecture of multiple application areas. In particular functional safety and "emerging behaviours" has to be handled, since environments devices are working in will be heterogeneous and multi-vendor based. Testing of safety critical systems will be a key issue combining experimental evidence and simulation based results. Fault-containment regions and a formal dependability model are key topics resulting in an overall dependability model.

Security will also be ubiquitous since new embedded systems will on the one hand penetrate private spaces to an unknown degree and on the other hand also make this information accessible through wide range public networks. Challenges will be addressing the combined interaction of humans and machines, maintenance and configuration, ad-hoc capabilities and efficiency on small embedded devices such as sensor nodes. Additionally, the matter of security updates will be a big conceptual challenge in particular for the new majority of small sized embedded systems without direct user interaction.

Although both safety and security has a successful history, the existing techniques risk not being able to follow the rapid evolutions of markets and technology presently seen. The focus of future development is expected to be on methods and tools that can analyse and evaluate complex architectures with strongly interrelated requirements. Additionally, these measures must support certification to penetrate the market requiring a proof of the advertised capabilities.

## DISTRIBUTED SYSTEMS

Design and development of a distributed control system is a major challenge since those systems are more and more complex. The spread of distributed systems is driven by an increasing complexity of the application environment. The focus in distributed control systems development is in the initial design stage where the structure and distribution of functionalities and components are set making it essential to the success of the final product. On the other hand the verification of correct behaviour is the second main challenge. There are different methodologies such as service-oriented (SOA) or role-based (GAIA) architectures that provide the framework for distributed systems development. However, there is no general methodology and mechanisms that would allow not only to develop a single system but to provide mechanisms for integration into System of Systems (SoS).



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“The advances in industrial informatics and market demand impells companies to engage in new forms of collaboration, such as collaborative networks.”

## INTEROPERABILITY & STANDARDISATION

Complexity of systems is reaching the point where it would be impossible to control or even observe their processes from a central point. The new systems are both geographically and conceptually spread over multiple locations with different organisational, logistic and functional structures that have to be integrated. Systems will also comprise components of multiple vendors.

The advances in industrial informatics and market demand impel companies to engage in new forms of integration, such as collaborative networks. Systems of Systems, Service Oriented Architecture, Distributed Control Systems are actual keywords. Challenging properties of these systems will be a high degree of heterogeneity, high geographical distribution and demand for interchangeability of services. Interoperability and standardisation are therefore of utmost importance to allow the design and deployment of systems of the future.

Research has to focus on adequate frameworks to assemble systems of systems, merge interface gaps or validate system behaviour. Research in equal measures have to support the construction of new systems as well as the improvement of efficiency and migration of existing systems. Developed concepts need to be applied to all devices in a system, e.g. sensor nodes, process controllers and data centers, offering seamless interconnectivity and scalable performance.

Apart from technical innovation to establish interoperability also political efforts have to be undertaken to achieve proper standardization that in the medium term will improve companies' competitiveness by providing standard-based extended environments.



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## INTELLIGENT SYSTEMS

The challenge is the development of advanced industrial informatics products to support and upgrade new concepts, which are capable of adapting themselves continuously to the requirements and tasks of changing market requirements or changing product technologies. The development of new industrial informatics and embedded systems products also focuses on the integration of reconfigurability, adaptability, flexibility and predictive behaviour of a system. That requires integration of technical intelligence from sensors and actuators based on the combined logic of multiple components.

There is a need to develop different software and hardware products to support holistic management including support for decision making as well as the use of advanced control methods and embedded devices in the field.

With the growing complexity and flexibility of the environment in all application areas, an ability to learn and make fast and local decisions is the key aspect of the intelligent systems potential in the modern market.



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## ADVANCED CONTROL SYSTEMS

The complexity of production processes is rising and this fact requires new solutions for control systems. For efficient, reliable and safe control of industrial processes new control methods should be implemented. Various advanced theoretical concepts such as model based control, predictive control, adaptive control, fuzzy control, gain scheduling and various methods for on-line fault detection, estimation of degradation, etc., could together with new hardware platforms, contribute to more dynamic control and higher adaptability to the changes on shop-floor and to more efficient, reliable and safe production control.

“For efficient, reliable & safe control of industrial processes new control methods should be implemented.”



## NETWORKS

The key objective is to develop efficient IT support for highly dynamic networked systems (e.g. supply chain management). Collaborative design, identification and verification of system requirements of all involved parties, determination and specification of processes as well as relevant industrial informatics solutions are among the required key competencies. The research focus is on industrial informatics support for network configuration, partner identification & partner development, networking, capacity utilization, operation, optimisation and support for advanced decision-making.

The use of sensor networks, well-being, and working in extreme environments has long roots in the electrical engineering sector. Recent technological developments have enabled sensor miniaturization, power-efficient design and improved compatibility. Issues related to system integration, low-power sensor interface, and optimization of wireless communication channels are active research fields.

The increased availability, miniaturization, performance, enhanced data rates, and the expected convergence of future wireless communication and network technologies around mobile health systems will accelerate the deployment of networked systems and services within the next decade.

Sensor and actuator networks can be deployed in a variety of configurations and nodes can be added or removed at any time. As a result, both the network and the applications running on the nodes must be designed to dynamically determine their configuration and take the necessary steps to operate under that network configuration.



# ARCHITECTURES & PLATFORMS

Architectural concepts are needed to ensure the capability of a system to deliver an acceptable level of service despite the occurrence of transient and permanent hardware faults, design faults, imprecise specifications, and accidental operational faults. A system must be resilient with respect to unanticipated behaviour from the environment of the system or of sub-systems. In case such unanticipated behaviour occurs, the system should still exhibit some sensible behaviour, and not be completely unpredictable. Fault-handling, error-containment, and fault masking are suitable strategies to achieve these goals.

The architecture should support monitoring the functionality and performance of components for the diagnosis of faults. Reliable identification of failed subsystems can be used for the autonomous recovery of the system service in case a subsystem failure is transient, and support maintenance in case the failure is permanent. Last but not least, architectures have to be scalable to the changing field environment and interoperable with other systems and platforms in a transparent way.

## DESIGN METHODS & TOOLS

Design methods and tools are essential for rapid development and prototyping, without which it is unrealistic to attempt development of such complex systems. Ever-growing complexity of developed applications together with the distribution of R&D facilities and personal require integrated tools and methods to make development process modular yet interconnected such as:

- Establishment of an integrated tool chain to support a complete process flow of development of embedded systems and industrial informatics from user requirements, through system design, to system-on-chip production.
- System-level model-based tools and design processes that contribute, in an integrated fashion, to elevating the abstraction level for architecture exploration and product design. Models and supporting modeling theory must address the following issues: in the data view, the data model and algebras; in the usage view, the interface model and features and component models; in the structure view, the distributed system model and composed systems; in the state view, the state machine model and state transitions; and, in the process view, the process model, events, and interaction. Using structured models is a way to manage the complexity.
- Test, validation and verification tools to support compositional design that can be integrated into the complete process flow, to support concurrent verification and validation at the product level as an integral part of the design process.



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