FP7 ICT ADVISORY GROUP

Working Group on "ICT and Sustainability (including Energy and Environment)"

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1. INTRODUCTION

Sustainable development is key for our future. At the 2007 Spring European Council, Heads of State and government adopted an energy and climate package to guide the EU towards a competitive and secure energy supply while promoting energy savings and climate-friendly energy sources. Concrete targets in the package are:

- Reduction of GHG emissions in the order of 20% by 2020 compared to 1990
- 20% for renewable energy sources by 2020 compared to the present 6,5%
- Saving 20% of the EU's energy consumption compared to projections for 2020

On 23rd January 2008, the European Commission agreed on a far-reaching package of concrete measures that are proposed to deliver the European Council's commitments. The measures demonstrate that the targets agreed last year to fight climate change and reduce the energy-intensity of our society are technologically and economically possible and provide a unique business opportunity for thousands of European companies.

In December 2007, representatives of over 180 countries at the United Nations Climate Change Conference adopted the "Bali Roadmap" which charts the course for a new negotiating process to be concluded by 2009 that will ultimately lead to a post-2012 (post-Kyoto) international agreement on climate change. The EU is playing a leading role and has the best opportunity to reap the benefits.

This global political and societal context has profound consequences for practically all European citizens, and ICT has an important role to play into it. Next generation ICT will have to support the targets for lower carbon emissions not only with **new ultra low power consumption ICT devices and equipments** but mainly through **advanced ICT monitoring and control services and solutions enabling to improve energy efficiency across the economy** (e.g. smart buildings, smart grids, manufacturing, transport). Furthermore, ICT plays a vital role in gathering data on **climate change** (e.g. earth-observation systems); in modelling the climatic phenomena and in providing the necessary simulation and visualisation tools to be integrated into decision support systems. ICT is also vital for **disaster** preparedness (monitoring, detection and prediction) aimed at both mitigating the negative effects of climate change and providing solutions for disaster relief.

ICT makes **substitution and/or dematerialisation** possible; therefore it enhances energy and material efficiency and reduces transport demand by substituting products by on-line services (e.g. newspapers, films); by moving business into the Internet (e.g. banking, real state) and by the adoption of new ways of working (tele-working, flexi-work and virtual meetings enhanced by video-conferencing and tele-presence tools).

There is no doubt that a large number of the solutions to fight climate change will be made possible only by ICT. If Europe takes the lead in developing new ICT-based solutions, this will foster the competitiveness of the European industry and create business opportunities in a number of sustainability related areas, promoting the creation of jobs and stimulating innovation. However, such positive developments will not happen if the relevant drivers of change are not properly stimulated.

In 1961, in his farewell speech, US president Eisenhower identified the dynamic set of drivers that characterised the American society at the time as the Military Industrial Complex. The term covered the close cooperation between the Military's needs (and the corresponding big budgets) and the innovative companies who worked closely with universities to develop hitherto unseen solutions to the military problems. The result was a strong US industry and military that still remains today.

Presently Europe is in a unique position to create the same dynamic exchanges between large state budgets, innovative companies and top-class universities with a focus on climate and energy issues (instead of military issues) and thus create a European Climate Industrial Complex.

This report addresses the most important **topics** that are expected **to drive ICT progress in the context of Climate Change** and its corresponding **Energy Targets**. Research is presented from an application point of view because even recognising that concepts (e.g. systems robustness or control algorithms) are generic to any application, the technologies needed for implementing these concepts are different for each application domain as user requirements change. Application Research is a combination of technology, content and business models stimulating new cross-disciplinary research approaches.

Covering the needs of the market in the sense of sustainable products – even if the customer does not use explicit the denomination "sustainability" or "sustainable" – can save working places and enhance the competitiveness of Europe in an international context. For this to happen we need to learn from the lessons of the past. For example, the American car industry missed the development of the fuel market and continued manufacturing gas guzzlers, and the European car industry underestimated Toyota's hybrid engine development. There are also some positive examples, like eco-food, high efficient lamps and solar energy..

The report starts with the ICT sector showing the way by reducing its own energy consumption and by investing in innovative software/services for sustainable development; the following chapter sees ICT as an enabler for energy efficiency in other market segments; next chapter is on ICT for understanding climate change and the last is on disaster preparedness for both mitigating the negative effects of climate change and providing solutions for disaster relief. The report ends with a chapter on actions beyond research and technological development.

It has been a major challenge for this Working Group to address specific issues of different industries in the proper form. The reader of this paper has to consider that a group of ICT specialist in spite of their broadly based background and experiences never may be so precise like the specialist of the corresponding area. This document is also an appeal to all specialist to look for a **cross industrial approach**.

2. THE ICT SECTOR

The consumption of ICT components, devices and systems can still be significantly reduced with further progress in semiconductor technologies, including the use of new materials, bio-inspired systems and systems able to capture and consume natural energy.

2.1. Lower power consumption ICT

Today, ICT components, devices and systems represent **2% of global CO_2 emissions**. It is absolutely necessary to invest important efforts and resources in research for reducing their energy consumption. This will be **crucial for the competitiveness of the ICT industry**.

2.1.1. Energy efficiency in battery operated devices

In the domain of portable devices, which form a main sector of the embedded system market, **battery lifetime**, i.e., the optimal use of the available energy is a critical parameter for the economic success of a product. In the end, physical constraints of power dissipation put a limit on the power density of highly integrated high-performance circuits. Research in innovative **system level methods and tools for energy and power optimization**, up to the algorithmic level, are clearly needed.

In practice, all systems can be classified in 3 major categories, depending on their energy use:

a) W (1 to hundreds of W)-consuming applications, which are normally grid connected.

b) mW applications, which are normally high performance, battery-powered nomadic systems (e.g. GSM, GPS, MP3 etc)

c) µW applications which are fuelling themselves with energy scavenged from the environment (thermal, kinetic, vibrational etc) as they cannot be fed by a battery (e.g. sensor networks).

European companies are well positioned in the market of embedded systems. Research efforts in this area will strengthen their position.

2.1.2. Reduce energy consumption in ICT systems

Energy scavenging has an important potential for increasing energy efficiency by substituting batteries, and research in this domain is badly needed.

More than the half of the required energy in data processing centres and telecommunication switching stations is used in cooling the equipment. Punctual water cooling of processors may scavenge so much energy that it could be enough – after transformation in cooling energy - for cooling the rest of the equipment with more diffuse heat development. In modern data processing centres **water cooling systems** have already been introduced but research is needed for telecommunication switching stations.

Important aspects are:

1. Architecture of equipment
2. Energy scavenging technology

3. Use of the recaptured energy, in situ or in neighbouring plants or buildings
4. GaN for efficient power (power electronics) for switching, motor control, ADC, etc.

Local storage will be needed and a new scaling law for storage is badly needed based upon **nano-technology** (increasing dramatically the active surface for chemical reaction/volume ratio). This could boost the efficiency of batteries and super-capacitors substantially (now limited to about 250 Wh/kg) and is a crucial factor of the smart grid vision, in order to keep a grid stability and reliable access to electricity (e.g. 2 days average consumption storage as a buffer at residential users).

Advances in **Photonics** are leading to new lighting techniques (e.g. light-emitting diode LEDs), the adoption of which could save 30% of today's consumption by 2015 and up to 50% by 2025. By adding sensing and actuation capabilities to energy efficient bulbs, so that they automatically adjust to the environment (e.g. to natural light, people's presence) further improvements are possible. Initial research in organic light emitting diodes (OLEDs) resulted in promising achievements.

2.1.3. Reduce power density of chips

Power consumption of Chips has not been addressed directly by this WG as it is developed in particular in the research agendas of the European Technology Platform ENIAC on nano-electronics[1].

2.2. Technology Obsolescence Management

A number of embedded ICT systems, e.g. a control system aboard an airplane, have a lifetime of half a century or more. During this lifetime, many generations of new hardware and software devices appear on the market and make the original equipment obsolete. **"Composable" architectures** made up of "pluggable" modules with well-specified interfaces facilitate a gradual replacement of outdated devices by newer technology without a complete redesign, implementation and re-certification of the legacy system. Research efforts in this area are needed.

2.3. Intelligent Recycling

Up to now, products from ICT manufacturers are being thrown away without recycling at the end of their lifetime. This happens despite of regulation and the fact that most of these devices contain very rare elements that are not easy to substitute. We therefore need to develop **methods to re-use the hardware** components once the lifetime of the device ends, in which they were originally used. This will also have a clear impact on the functional decomposition of the hardware into chips units. Research will be necessary as to how this can be done in an efficient way without compromising the product's quality. Of equal importance is software recycling: huge amounts of person power are invested into developing, but also testing and verifying software in a given hardware environment. Up to now, it has been the case that when the hardware changes, the whole cycle has to start all over again. To become more

[1] http://www.eniac.eu/web/SRA/local_index.php

efficient here, strategies, techniques and tools need to be developed that will allow for the recycling of software in a more rational way than is possible at present time.

2.4. Complexity and Robustness

Huge amounts of designer's and user's time are being invested because today's ICT systems are still being designed to paradigms that were developed for low complexity systems. This is not only true for "large" systems; it is also a problem for perceptively simple products like cell phones – which also contain programs with a million lines of code or more. If we cannot manage complexity in a satisfactory way, as a consequence, we will not be able to assure robustness of system behaviour in all possible usage contexts, either. Achieving robustness by being able to **handle complexity, e.g. through self-organizing,** dynamically schedulable and reconfigurable sub-systems, should be one of the most urgent questions to be addressed by ICT research.

2.5. Innovative software/services for Sustainable Development

Even if the demand it is not there, the ICT community has to invest in solutions for sustainable development. Concrete examples are:

The incorporation of resources consumption parameters (e.g. energy) into existing software tools. For instance, **system design tools** allowing to understand the resources consumption of a potential product before its materialisation. These tools have to be at system level considering both software and hardware and not only addressing the production phase but the complete **product life-cycle** that is, manufacturing, distribution, use and end-of-life treatment. This will allow engineers developing more efficient systems without compromising on other parameters (e.g. costs, flexibility, and interoperability). **Enterprise Management Systems** is another example. These systems may be extended to cover "emissions controlling" in addition to the well known "cost controlling" features.

New software tools and/or services will have to be developed to handle the new sustainability requirements. Here it is necessary to consider the energy consumption impact in the design of new software, bearing in mind that current software development is having from generation to generation a higher usage of energy.

It is to be noted that there is a wide variety of future and actual incentive systems in the form of regulations, cap-and-trade systems, taxes, tariffs, market pressure, etc. Each of those and their combination across country and industry boundaries will lead to new business models. These business models will require specific **ICT support, e.g. emissions controlling.**

The carbon footprint of products will be an important buying decision criterion. **ICT will make it possible to generate a carbon profile** of products including the supply chain. Customers need trustworthy information. An impartial service provider could offer this information on the base of data from the manufacturer, its suppliers and estimations.

[*section already appears above*]

3. ICT TRANSFORMING THE WAY TO MANAGE, USE AND SAVE RESOURCES

ICT has already reached all industries and therefore potentials for increasing resources efficiency and for making services and products more appropriate for contributing to more sustainability in the society by means of ICT are present in all industries.

This chapter sees ICT as an enabler for sustainable development in other market segments fundamentally through improved monitoring and control systems.

Monitoring and measuring is the first step (only what is measured can be managed). Aggregation of the measured data and its analysis targeting optimization and intelligent decision support is the second. Finally, control is the implementation of optimization strategies and decision taking processes in the underlying infrastructure.

Some keywords for working areas are:

1. Issues of processor and power system management
2. System robustness self-configuration
3. Management of complexity of distributed ICT
4. Zero-maintenance, high-availability networked systems etc

The specific research challenges are in the accuracy of the data measurements, real-time monitoring, the heterogeneous sensing and control equipment, complexity and scalability.

Sectors with considerable resources saving potential via **Monitoring and Control** are: buildings; the energy sector; traveling, transport and logistics; manufacturing; and water management.

3.1. Cities and Buildings

The use of ICT (homeworking/teleworking, mobile work, traffic management etc),can have a huge impact on the overall city management. There are already some examples like in London where ICT applications are helping to reduce and monitor flow of traffic.

Buildings (both public, residential and commercial/industrial buildings) offer one of the major sources for reduction in electricity consumption by better **monitoring in real-time** of the ambient environment through autonomous wireless sensor networks, through smart HVAC systems coupling electronically to weather conditions, to sensor networks and to the presence of people in different rooms, by use of integrated PV (tiles, cladding) in buildings, by using smart glasses (including selective thermally enhancing/shielding nano-particles), by using smart light control systems in combination with energy efficient solid state light sources (LEDs / OLEDs), by using more sophisticated and efficient building energy management systems, and/or by using more context aware technologies. The government and public authorities could and should play **a first-adopter role** and act as a role model (demonstrator effect) in view of the large amount of buildings they occupy.

Today, facility management systems are proprietary and isolated systems. To reach the full potential, research is necessary to integrate the various types of facility systems with other enterprise system to provide combined data analysis. Little work has been done in this area so far.

3.2. The energy sector

ICT will play a key role in the transformation of the electricity sector that is triggered by market liberalisation, the increasing use of renewable energies, increasing prices and decentralised energy generation (and co-generation) systems. Distribution of electrical energy follows today the broadcasting model (from few centralised power plants to millions of users) while in the future it will be closer to a community based model (from thousands of de-centralised power systems to millions of users).

Re-organizing demand and supply will be possible if the industry can make use of Internet economy patterns that have been used over the last ten years in many other industries, but are yet unused in the utility sector. New business models and pricing mechanisms will be a key element in the transformation of these markets. All of this will be possible on the basis of the extensive roll-out of electronic metering devices and new software for practically all business processes in the industry ranging from pricing and billing and asset management to new customer services.

The future energy sector will be marked by a series of needs that will induce profound changes. Some of these challenges include:

a The need to avoid expensive and carbon-intensive consumption peaks (**peak shaving**).

b The need to distribute energy consumption more equally over the hours of a day (**load shedding**).

c The energy production of wind and sun depends on the weather and it is therefore not controllable. **New paradigms that better integrate the use of these fluctuating sources** must be developed.

d The overall energy consumption should be reduced. In order to leverage the market power and competence of utility companies one must find **new business models allowing earning money with saving instead of consuming**.

e **De-centralised energy systems (including combined heat and power)** must become active parts of load balancing processes.

All these points require **extensive research in new ICT enabled solutions**. For instance, an ICT enabled electricity grid will improve planning and coordination around power generation from renewable plants depending on wind or sun. Weather forecast is today so good, that quite good estimations of electricity generation from wind, solar panels and photovoltaic plants can be made three days in advance. Such predictions must now be translated into market instruments like options or other derivatives to create adequate incentives for market users to adapt to the fluctuations. It is well conceivable, for instance to offer a better price for electricity on a windy or sunny day and thus create an incentive to use this carbon neutral energy at a certain time. Intelligent dishwashers or washing machines will be programmed for running with the cheapest energy rates.

Smart metering is a very efficient way for monitoring energy consumption on an individual level. But Smart Metering also opens up completely new ways of aggregating real time consumption data and defining much more dynamic prices schemes. It is a key element of new ways of coordinating the overall ensemble of consumers in a way that, for instance avoids the expensive and carbon-intensive peaks, which still are a daily reality in today's grid. These meters provide new research challenges in networked embedded system design and electronics integration.

New **highly distributed business processes** will need to be established to accommodate these market evolutions. The traditional static customer process will increasingly be superseded by a very dynamic, decentralized and market-oriented process where a growing number of providers and consumers interact. Such an infrastructure is expected to be pervasive, ubiquitous and service-oriented. A new generation of affordable ICT infrastructure has to be developed to support these changed, complex business processes and enable the efficient functioning of the deregulated energy market for the benefit of European citizens and businesses. The architecture of such distributed system landscapes has to be designed, standards must be created and widely supported, and comprehensive and reliable IT applications will need to be implemented.

ICT will make it possible for future distributed energy systems to be self-managing, self-sustaining and robust, and will enable dynamic reorganization and coordination of services markets. Therefore, the Internet-based infrastructure will be tightly coupled with the energy domain, and used to support the development of new mechanisms for trade based on supply and demand in the electricity market. Different models and scenarios for a highly distributed information-based energy infrastructure will emerge. Transaction platforms will provide services such as electronic marketplaces, facilitating the commercial activity associated with the buying and selling electricity and its derivatives, not only for utility companies but also for decentralized consumers and producers.

Decision and policy makers will be able to base their decisions on real-world, real-time data. In combination with future Energy Management Systems (EMS) and "smart appliances", households, public authorities and companies will be able to react to market fluctuations by increasing or decreasing consumption or production, thus directly contributing to increased energy efficiency.

This application domain requires highly interdisciplinary research aiming at:

- Closely linking ICT to energy management
- Creating new architectures and business models for electronically based decentralized energy markets
- Developing service architectures, service delivery and trading platforms, methods and tools to support the networked enterprise
- Understanding and managing the complexity of critical infrastructures including investigating the security, safety and risk-management of it.

Next Generation **Energy Management Systems and Grid Control Systems** will create transparency about the resources consumed, take informed decisions considering external variables and act consequently. An example could be the combination of an EMS with a washing machine, where the user tells the machine that proper clothes are needed in 2 days and the machine decides when to start the washing taking into account the whether forecast (the availability of zero emission energy) and the evolution of the energy market prices. In a study published by the German Federal Ministry of Economy BMWi, the potential of such practices has been identified as one of the contributions to an improved future energy system.

3.3. Travelling, Transport and Logistics

Between 1990 and 2005 the CO_2 emissions from transport in the EU grew by 32% and the contribution of transport to the total CO_2 emissions grew from 21% in 1990 to 27% in 2005. In this sector the development is running in the wrong direction. Therefore it is necessary to develop a strategy that takes into account the:

a) environmental impact (CO_2 emissions, soil consumption for streets and highways construction).

b) economic impact: at current oil prices, it becomes economically prohibitive to operate alongside the same approaches as in the past: new attitudes and approaches are needed and ICT can play a major role in this conversion: the energy issue becomes a matter of innovation (and opportunities) in a competitive economic landscape.

c) Geo-political impact (too much dependence on oil and a limited number of - sometimes less stable – suppliers).

Research is needed to:

1. Incorporate energy efficiency parameters into **traffic control**, street lighting, **navigation systems** and **fleet management** (cargo, planes, and trains) systems.
2. **Embedded systems** to reduce fossil fuel in the transport sector (hybrid cars, new generation of engine management, new fuel mixes…)

Furthermore, a big potential is related to the substitution of travelling by video and audio conferences and by tele-working. The estimated potential for CO2 emission reductions is between 20 and 30% of individual transportation (Results from a study of WWF and ETNO European Telecommunication's Network Association). Although video and audio conference is not new, the acceptance is low (e.g. lack of body language feedback and lack of direct eye-contact). **Research on the acceptance of virtual communication solutions** is needed.

3.4. Manufacturing

The manufacturing domain is moving towards the increase of open networked embedded devices (NEDs) that can optimise processes at local level in a global cooperation/coordination (EU SOCRADES project – www.socrades.eu). As such it is possible to build and deploy more efficient approaches that will optimise/save energy and resources. Autonomous wireless sensor & actuator networks can play an important role in this context. The base technology and methodologies are known, but **crossing industry boundaries** in today's complex manufacturing scenarios creates, from and ICT perspective, a completely new set of research challenges.

3.5. Water management

Water is crucial for human well-being, for agriculture and for the economy in general. The European Commission has recognised the challenge of water scarcity and droughts needs to be addressed (http://ec.europa.eu/environment/water/quantity/scarcity_en.htm). Not only the affordable access to potable water is necessary, it is also necessary the collect sewage in a non-contaminant way. There are only a few activities about water management by means of ICT or with ICT support. Australia and China seam to be pioneering this area. Research is required for:

Estimation/prediction of water resources: Remote sensing of rain, soil moisture (important for infiltration of rain) and run-off in combination with rain forecast to predict water availability and the risk of floods. Research is in the development of sensors and in modelling water resources.

Water distribution grid: Water distribution needs to be replaced by new systems preventing leaks and evaporation. Knowing it cannot simply be replaced over night, the challenge is to gradually evolve from the current infrastructure to the next generation one. ICT plays an important role in the monitoring, analysis, decision support and control of water infrastructure. **Sewage pipelines** are a risk for human health and the environment because of leakage. Similar to the potable water the current infrastructure has to be gradually replaced. Autonomous wireless sensor and actuator networks can play an important role in this context.

4. ICT FOR UNDERSTANDING CLIMATE CHANGE

ICT tools are vital in gathering data on today's climate (e.g. earth-observation systems) and past climatic phenomena; in modelling (the hydrologic and hydro-geologic cycles) and the climate change and in providing the necessary simulation and visualisation tools to be integrated into decision support systems.

4.1. Tools for simulation and visualisation

Progress in computing, communication and data handling performance provides already scientists world wide with powerful simulation and modelling tools to improve our understanding of climate change and anticipate development scenarios. However these tools are still far from being sufficient to analyse the impacts of the various factors influencing the environment today and in the future. More interactive and powerful simulation and visualisation tools with self adaptation capabilities based on experimental data and observations are needed to be able to understand, monitor, anticipate and control better climate change.

4.2 Monitoring forestation/deforestation

One of the most promising areas for reduction of CO2 emissions recognized in the GeSI study is monitoring forestation/deforestation with the target of environmentally sound forest management. Furthermore the protection of forest was included at the recent conference in Bali into the agenda for the post-Kyoto negotiations. That means, that ICT based monitoring systems will get tremendous importance in the future. For some concrete information see: Optical Remote Sensing for Forest and Biomass Change in the Context of the Kyoto Protocol:
http://www.gofc-gold.uni-jena.de/documents/jena06/RA01-01.pdfhttp://edocs.tu-berlin.de/diss/2003/coenradie_bodo.htm
http://md1.csa.com/partners/viewrecord.php?requester=gs&collection=TRD&recid=0224764CI&recid=0224764EA&q=forrest+remote+monitoring&uid=788405280&setcookie=yes
http://www.informaworld.com/smpp/content~content=a713862722~db=all

4.2. Awareness raising on climate change

There is a big gap between the knowledge about climate change and the consequences of it and the awareness of the citizens about their opportunities for reducing their own CO2 emissions by a climate-friendly way of life without renouncing quality of life. It is necessary to find a way for explaining the citizens what is happening and what are the proper measures for facing the climate change challenge in everyday life. Because ICT is well positioned in the modern society it offers a good opportunity to reach many people. Research could bring important information about how to use ICT for this issue.

5. ICT FOR DISASTER PREPAREDNESS AND DISASTER RELIEF

As a consequence of the Climate Change, various disasters are occurring in many countries and regions, beyond national borders and regardless of haves and have-nots.

Systems for disaster preparedness and relief have to provide **emergency warnings** and information to the relief teams even if the main telecommunication infrastructure is out-of-order. Normally, a large number of relief agencies and relief teams will participate (even more if a cross border disaster) which create severe pressure on requirements for interoperability. Standardisation work and agreements on the radio frequencies are paramount requirements.

During any emergency situation, the role of a reliable Decision Support System is very crucial for effective response and recovery. **Geographic Information System (GIS)** provide a versatile platform for Decision Support by furnishing multilayer geo-referenced information which includes hazard zoning, incident mapping, natural resources and critical infrastructure at risk, available resources for response, real time satellite imagery etc. GIS-based information tools allow disaster managers to quickly assess the impact of the disaster/emergency on a geographic platform and plan adequate resource mobilization in the most efficient way.

6. BEYOND RESEARCH AND TECHNOLOGICAL DEVELOPMENT

Education:
Sustainable development is a complex research area requiring knowledge in a variety of technologies and competences at systems level. This is a missing kind of curriculum at most universities and European industry is in bad need for such a profile.

International Cooperation:
Areas identified for cooperation with non-European countries are:

1. Countries exposed to dangerous climate change (floods, storms, drought, soil degradation, aridity)
2. Countries with Mega cities for traffic reduction, traffic management, integration measures (e.g. traffic management and teleworking)
3. Countries with extensive forest (Monitoring of forest/deforest)
4. US, Canada, Japan for …???

Regulation:
The regulatory framework is crucial for boosting or paralyzing developments.

- What are the key-regulatory obstacles?
- What are the key-infrastructural obstacles?
- What are the key-economic obstacles?
- Are there other significant challenges?
- What would have to be true to see adoption of the technology ?

Standardisation:
To create a pan-European standardisation initiative on specifics topics related to ICT for sustainability. A candidate example is smart energy networks.

Innovation:
To develop a European-wide incubator based within the Member States to offer entrepreneurs access to best practice, and a range of support to develop new businesses around the emerging Sustainability Infrastructure. This incubator platform could also be used by SMEs to inform potential customers on their activities and the features and qualities of its products and services.

A Final remark: In this report the word "research" is used in sense of RTD, that is, from basic research to technological developments. A single research project could cover the complete cycle but where research is not necessary but the potentials for sustainable development are important it should be discussed the possibility of demonstration projects under real conditions for showing the potentials.