**INTEGRATION OF RENEWABLE ENERGY**

 The rapid deployment of renewable energy technologies and their larger deployment in the near future, raise challenges and opportunities regarding their integration into energy supply systems. Energy systems are needed to meet the demands for a broad range of services (household, commerce, industry, and transportation needs

 Energy systems include an energy supply sector and the end-use technology to provide the aforementioned energy services. In the EU, the electricity supply system is mainly composed of large power units, mostly fossil fuelled and centrally controlled, with average capacities of hundreds of MW. Renewable energy sources are geographically widely distributed and if embedded in distribution networks are often closer to the customers. Locating renewable and other generators downstream in the distribution network is known as Distributed Generation. Distributed generation involves the use of small, modular electricity generation units close to the point of consumption. In the power sector, utilities have limited experience of interconnecting numerous small scale generation units to their distribution networks, and the possible level of renewables penetration depends strongly on the existing electrical infrastructure.

 Bringing on land the power produced from a large offshore wind farm is (economically) only possible where sufficient electricity grid capacity is available. In some specific locations, a new electricity infrastructure has been set up with the specific purpose of providing very high penetration levels, up to 100% electricity from renewables. Distributed electricity generation, close to the end customer, differs fundamentally from the traditional model of an energy system consisting of large power stations generating centrally controlled power. The approach is completely new, replacing the concept of economy of scale using large units by economy of numbers using many small units)3. Far from being a threat, distributed generation based on renewable energy offers opportunities.

It can

* Reduce the transmission and distribution losses as well as transmission and
* distribution costs4
* Provide customers with continuity and reliability of supply5
* Stimulate competition in supply, adjusting prices via market forces
* Be implemented in a short time due to the modular nature of Renewable Energy

**Technologies**

 In the transport sector, the use of renewable energies in the form of biofuels is just starting to develop in Europe, whereas in some countries like Brazil it already plays an important role. Also in the transport sector, the integration of renewables requires the adaptation of an infrastructure which has grown over a century of development based exclusively on fossil fuels. Besides the gradual substitution of the vehicles in circulation, it is necessary to develop a new supply chain for the production and distribution of bio-fuels.

 This will require substantial investments. However, the development of the fossil fuel based transport system also required investments that were historically subsidised by the public sector in many countries. Also in the heating sector, the full integration of renewable energies requires an adaptation of historically grown infrastructures. This process is particularly important because, in many parts of Europe, it is possible already today to have new buildings which are completely independent from fossil fuels or electricity for their heating needs. This can be achieved using state of the art renewable heating and cooling applications which are linked with energy efficiency measures and demand side management.

 A substantial economic restriction to the integration of renewable heating (solar thermal, biomass, geothermal) is given by the long lifetime of buildings. The installation of renewable heating systems is much more cost effective during the construction of a building or when the overall heating system is being refurbished. This means that there is a short window of opportunity for cost effective integration of renewable heating. If this occasion is lost, for decades that building will remain dependent on fossil fuels or electricity to cover its heating demand. For this reason, it is essential that all possible measures be taken to make sure that the available renewable heating sources are installed in all new buildings. It is also necessary to promote the use of renewable heating at the moment of the modernisation of the conventional heating system.

 The existing infrastructure and market dominance of conventional heating represents a substantial barrier to growth for renewable heating. Biomass heating can be competitive in areas where the fuel supply chain is well developed, but this is not yet the case in many areas of Europe. A solar thermal system can be a good economic investment, but in many areas of Europe most users are not aware of this and most heating installers are trained only for conventional heating systems and therefore recommend their customers to stick to the conventional heating.

 Renewable heating sources can be used also for cooling purposes. An increasingnumber of well working systems is being installed, mainly based on solar thermal and geothermal energy. The growing demand for cooling is having a dramatic impact on the electricity systems in Europe, with several countries reaching peak electricity demand insummer instead of winter. These problems can be mitigated by supporting the development and commercialisation of renewable cooling technologies . The choices of millions of citizens in their homes and offices are crucial to the future integration of renewable energies in the heating sector. Raising awareness among the general public and specific training of the professional groups involved (heating installers, building engineers, architects, managers of heat intensive buildings or devices) are therefore very important. Increasing the use of renewable energies must obviously be accompanied by energy efficiency and demand side management measures at the customers’ end. Renewable Energy development and increase of energy efficiency are strongly interdependent.

 An estimated economic potential for energy efficiency improvement of more than 18% of present energy consumption still exists today in the EU as a result of market barriers, which prevent the satisfactory diffusion of energy-efficient technology and the efficient use of energy . Special emphasis should be placed on urban areas, where a high proportion of all energy is consumed. Urban areas are characterised by a highly developed infrastructure, not always easily allowing a rapid increase of the level of renewable energy generation. The fact that electrical network infrastructures are generally over-dimensioned in urban areas, can in some cases allow a high degree of penetration of PV generators, without changing the existing cabling, transformer stations, etc. However, in general, the future energy infrastructure will have to be designed from the beginning to effectively accommodate RES to a very high level.