Renewable Energies for people's basic needs

Building the future

UNESCO

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UNESCO Programme on Renewable Energies

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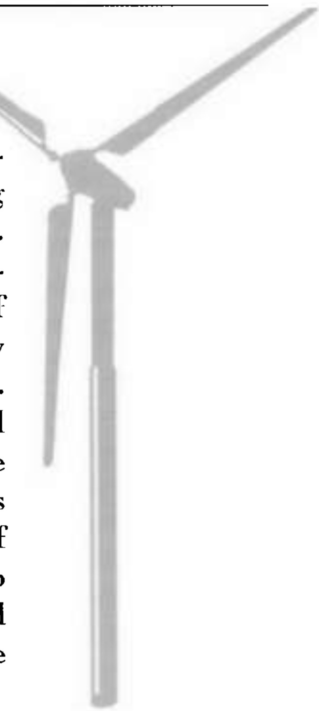
"The best energy
is the one that we do not produce"

1. Introduction



In every development process, there is a pressing need to increase the availability of qualified human resources. Developing countries tend to experience a crucial lack in precisely this area. In most countries, education in science and technology is receiving increasing attention, which indicates that development of the teaching process is considered an essential task. High quality science teaching is the best way to initiate scientific vocations. Science and technology help form values in the intellectual level and stimulate creative capabilities. Thus, they are indispensable tools for the perception of nature and the environment, as well as for understanding the contemporary world. The rational use of scientific and technological progress can contribute powerfully to solving development problems, particularly those of hunger and disease. Increasingly, science is becoming a direct productive force that underpins economic growth and social progress.

The role of training in the scientific field is apparent at three levels: for upper echelon staff and researchers, for mid-level technicians and for qualified workers. In recent years, important achievements have been accomplished in this regard, particularly in developing countries. Much work has been done in order to ensure a higher priority for the scientific teaching process, both to improve its quality and to direct it more towards solving problems related to everyday life. Developing countries are confronted with many difficulties in developing science education. It is costly to teach in these countries and there is a lack of equipment and laboratory materials. Moreover, they often lack capacity for local production.

A diversified training programme is needed to meet increasing demands for qualified personnel in the developing countries. This training should consider the latest developments in science and technology. It must strengthen competence and technical polyvalence, in such a way as to produce a technical staff of high quality in judgment and decision making. Both of these qualities are necessary for project planning and management, and for being able to identify the most appropriate application and utilisation formula for local conditions.

In light of its cost and important role in the economy, recent growth in energy consumption has led all countries to formulate and execute various strategies in three interrelated areas to:

a) **improve the efficiency of energy use;**
b) **increase energy conservation and;**
c) **explore and develop new and renewable sources of energy.**

At the same time, growing awareness of the role that renewable energies can play in the global energy system, especially for the supply of energy in rural areas, most countries are showing increased interest in creating appropriate training programmes related to these energy sources.

The training needs which are important in the short term as well as in the mid term can be explained by the fact that, the desire of using renewable energies combined with the decrease in equipment costs stimulates the countries to conduct research on new equipment and on the utilisation of renewable energies. For example, in the field of solar photovoltaic, the number of applications (rural electrification, solar pumping (mainly during dry seasons), electrification of health care centers and schools, conservation of medicines, clinic refrigerators, telecommunications, etc.) is ever increasing.


UNESCO Sumer school on solar electricity

It is evident that all programmes using renewable energy equipment depend upon the availability of specialists of various levels, who are able to use and properly maintain the supplied and installed equipment. Again, this underlines the crucial need for the training of specialised personnel. Several countries have strongly confirmed their interest in training staff and specialists who will be able to rationally utilise renewable energies.

In order to be effective, training in the field of renewable energy must be ensured along four distinct axes: researchers, decision makers (engineers, economists, administrators, etc.), local maintenance technicians and users. It should concentrate on the following elements:

- progressive reinforcement of research centres and the development of qualified personnel;
- establishing better coordination between energy needs and the choice of appropriate equipment;
- creating maintenance teams capable of interacting with the rural population in order to solve technical problems they might encounter and to provide them with necessary information on operating installed equipment;
- raising the user's awareness on how to use this equipment effectively.

Following the identification of training candidates, every effort should be made to minimise the duration of training, especially for decision makers and those engaged in field activities.

2. Training needs

2.1. Why renewable energies?

The goal of education and training is to prepare a population for its future. In order to meet actual training and education needs, one must first examine societal needs for the first part of the 21st century, that is, for the period 2000 to 2030.

Energy is vital and essential for any society, but has two contradictory aspects. Firstly, it reflects the standard of living and the progress status of a nation. It also presents growing awareness concerning the level of risks that a given nation would face in attempting to satisfy its energy needs. The first half of the 21st century will certainly see rapid progress[1] in both the level of energy consumption and in the diversification of energy production methods, which can be linked to several factors:

- Population growth especially in Asia, Latin America and Africa will lead to overall increases in energy consumption[2].
- Ecological risks associated with some energy sources are becoming increasingly evident and worrisome. Two examples include the Earth surface warming due to the greenhouse effect caused by gas emissions[3] and the uncertainty surrounding methods for long-term storage of nuclear residues.
- The need for humanity to follow a very strong policy of energy economy in the North[4] as well as in the South.
- The need to strengthen diversification of energy resources[5] and, more importantly, the growing need to use renewable energies in the future.

2.1.1. The necessity for renewable energy

It is the last point of the proceeding section that is of greatest concern. The preceding constrains lead to inevitable changes in energy strategies and this requires a long-term obligation to move toward an energy flux, rather than continuing to rapidly deplete fossil fuel stocks.

A scenario method has been used to quantify and elaborate the evolution of energy trends. A scenario is not based on foretelling; it is a theoretical model that should demonstrate good internal coherence. With the help of several scenarios, one can explore the entire field of possibilities. Working from an accurate assessment of the current situation, scenarios can describe future

1 Rapid, means here. "in some decades" It is the required time for a new energy source to be part of the energy system, even when a voluntary policy is continuously practiced.

2 Quantitatively, the future population growth is estimated with a good precision contrary to the development level. The scenarios for the future on this subject must take into consideration more realistic hypotheses

3 The content of CO_2 in the atmosphere has increased by 50% since the beginning of the industrial era The human activities (combustion of carbon, oil, and gas, the change in leaving habits) are mainly responsible According to the "Intergovernmental Panel on Climate Change "(1996),"the earth surface temperature in average increased globally by 0 3 to 0 6 °C since the beginning of the 19th century.... Analysis of a group of elements suggests that, there is a perceptible influence of man on the global climate." This climate change evolution will continue with very serious consequences. We mention, as an example the more or less realistic figures: a warming-up of 2 °C and the increase of ocean's level by 50 cm by the year 2100.

4 In France from 1950 to 1986: More than 12% energy economy in the car industry, 20% in energy necessary for wheat production, 50% of energy needs for new housing This appreciated decrease in "energy intensity" was stopped in 1986 due to the decrease of oil prices.

5 This trend will not go by itself In the 19th century carbon was dominating while for the 20th century it is oil. Fossil fuels accumulated during hundreds of million of years are being burned today at such a rate that they will be largely depleted in few centuries. For example, oil crises in 1973 and 1979 have been overcome due to major discoveries (the North Sea, Alaska, Siberia). However, the likely absence of such discoveries in the future will affect the energy situation if the oil share in the energy balance stays as it is

levels of consumption and the relative importance of various production methods. Comparison was made for three scenarios, developed by the World Energy Council, the "Centre National de Recherche Scientifique" (France) and Shell Oil Company. These three models – each being more or less optional – share a common conclusion: a massive increase of the contribution of renewable energy during the 21st century both in absolute value and in market share.

2.1.2. Renewable energy credibility

There is no guarantee that any one of the above-mentioned scenarios will actually be followed. However, it is clear that issues related to future sustainable energy will depend on four conditions: technical credibility, economic credibility, ecological credibility and political credibility. Unless all four of these conditions are satisfied, the massive growth in the contribution of renewable energy during the 21st century will not happen.

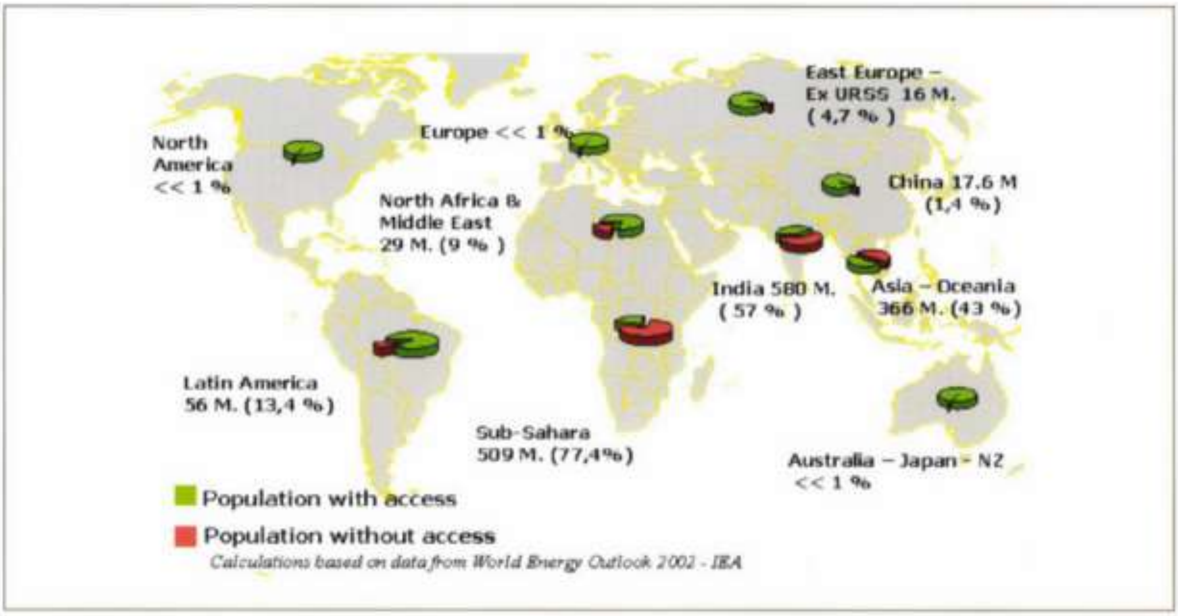


Fig 1. Needs in term of Electricity Access

2.1.3. Technical credibility

The following facts can be briefly mentionned[1]:

Heat production: (i) Wood has always been, and will continue to be, used widely for producing heat, with the exception of regions where there is a risk of desertification; improving domestic stoves in arid zones remains an essential need. (ii) District heating by geothermal energy is now functioning in several localities and contributes to solving the damaging problem of corrosion. (iii) Use of direct solar energy in buildings is an old practice that now has a new youthfulness, particularly with the regulation of bioclimatic housing, with anticipated progress in 'intelligent windows' and transparent insulating material. (iv) Solar crop drying and solar water heaters, as well as a variety of equipment for space heating with solar collectors, are being utilised more widely.

1. For more details, refer to the following EU documents:
• Renewable energies in Europe, Int. J. of Solar Energy No 1-4 (1994).
• T.Wrixon, A.M.E. Rooney, W.Plaz, Renewable energy 2000 (Springer - Verlag, 1993).

Electricity production: (i) Hydroelectricity continues to be a major resource. However, installations in many important sites are suffering from three factors: modest local consumption, the need to protect natural sites, and the shortage of financial capabilities. Still, small water heads are increasingly being exploited, especially in China. (ii) Wind generators are being commercially distributed, either to supply electricity in long networks or to satisfy the needs for specific local applications. (iii) Some thermal power plants that burn organic residues are operational. (iv) Diverse types of solar thermal power plants are the subject of research; prototypes are being constructed and, in some cases, are already operational. (v) Stand-alone photovoltaic systems are commercially marketed for rural electrification in developing countries. These supply electricity to isolated houses and have various professional applications. (vi) Grid-connected photovoltaic systems are the subject of numerous demonstrations, either in the form of central stations or integrated to building façades and roofs. (vii) Research on photovoltaic lanterns indicates a considerable level of technical progress.

Fuel production: (i) Alcohol extracted from sugar cane has been largely used in Brazil. (ii) Green fuels, designed to partially replace gasoline, show a promising career start.

While being far short of an exhaustive presentation, these examples demonstrate several techniques of the practical use of renewable energy, which have been tested at the operational level and provided satisfactory results. Some are still in the research and development phase and show a reasonable, or even significant, level of progress.

The application possibilities for such techniques are extremely diverse. On the one hand, this is an advantage as specific applications would satisfy specific needs. On the other, it has a disadvantage as the distribution is impractical and requires numerous micro-decisions.

2.1.4. Economic credibility

Discussion of this factor will be limited to the known facts concerning the most important cases.

- Use of geothermal and solar heat by different techniques is competitive today within certain contexts, including wood.
- Hydro-electricity is an example of a successful renewable energies case. Its economic characteristics, which include an important initial investment followed by small operating expenses, can be found in many other cases.
- Wind generators connected to the grid have been shown to supply electricity at a competitive cost in the USA and in Europe, particularly in regions privileged by high wind speeds.
- Stand-alone photovoltaic systems allow for the 'micro-electrification' of isolated rural zones in developing countries (modular power around 5 kW). In fact, they outperform both grid extension and diesels systems.
- The best solar thermal power plants are 1.5 to 2 times more expensive than conventional ones, and photovoltaic power plants are 5 to 7 times more expensive when connected to a grid. However, the possibility of improvement in both cases is very high.
- Certain 'green fuels' are almost competitive.

These examples demonstrate that there is an actual niche of competitiveness, which will increase in the medium term as a function of research results and market growth.

2.1.5. Ecological credibility

All the above-mentioned techniques produce more energy than is necessary for their manufacture and installation. For example, photovoltaic systems have an energy return period of two to four years, compared to a lifespan of at least 20 years. In addition, most of these techniques are ecologically benign (dams that retain water reserves of extended surfaces are an exception). The associated social costs of renewable energy are extremely small. As demonstrated by field inquiries in Great Britain, wind generators are very well accepted by the local population. Intensive agricultural of 'energy plants', that produce green fuels, would be criticised due to certain agricultural methods. However, there is greater acceptance of modern methods that allow the localization of additives (pesticides and fertilizers) under the roots of plants (a technique which needs further development).

In most cases, the ecological balance of renewable sources of energy is better than all other sources of energy. It is important to recall that an active policy of energy economy is beneficial for the whole planet, from both the economical and ecological points of view. "The best energy is that which we do not produce."

The role of energy economy is an important consideration, and the synergy between energy economy and renewable energy is evident in various applications such as solar space heating of houses and solar rural electrification.

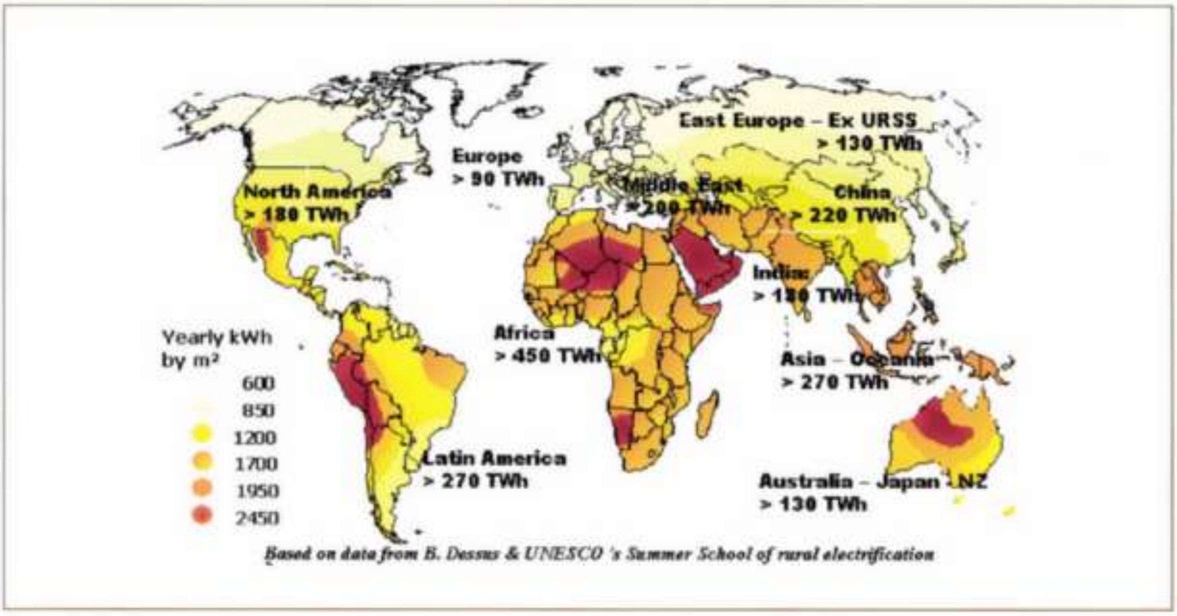


Fig 2. Solar Energy reserves (yearly) > 2130 TWh forecast 2020

At this point, it is important to introduce the concept of the social cost of energy. This reflects the actual cost paid for the consumption of energy, not only by consumers but also by citizens in general. In reality, the costs of classical energy sources are currently under-estimated, as they do not include important 'external' costs, related to factors such as environment protection, research subventions or the need to transmit a heritage unburdened or negatively influenced by present consumption to future generations. This problem is treated, for example in reference[1]. Increasingly, specialists are recommending the internalization of external costs. This would lead to the formal improvement of the competitiveness of renewable energies, which, in general, have a limited ecological impact.

1. O. Hohmeyer, R.L.Ottinger, Social costs of energy (springer - verlag - 1994).

2.1.6. Political credibility

In reality, all of the above will depend on the political will of energy decision makers, both within individual countries and at the global level. A brief analysis of the current situation regarding this issue is useful.

Over the past 20 years, many major countries have shown a firm and constant will to develop renewable energies. State and private credits granted to renewable energies in these countries have increased on a regular basis. In addition, the European Union has a dynamic policy of research and development. Some other countries, in which public opinion is strongly against nuclear energy, are now at the forefront of the movement to utilise renewable energies. A smaller number of countries are more reluctant, but still active. Among developing countries, India, Brazil, China, Morocco and others are active in some aspects; in 1993 the World Bank started financing renewable energy in these countries.

Nothing guarantees the permanence of a constant dynamic policy in favour of renewable energy. However, it is generally safe to presume that renewable energies will become more valued for their two favourable characteristics:

- Flexibility – the possibility of creating local energy sources, hopefully to complete the large central grids.
- Responsiveness – the possibility of meeting the increasing preoccupations related to sustainable development and environmental protection. The plan of implementation resulting from the World Summit on Sustainable Development (Johannesburg, 2002) and concerns on climate fragility expressed at Earth Summit (Rio de Janeiro, 1992) highlight the major role that renewable energies can play in both issues.

Admittedly, one of the principal obstacles facing the widespread use of these technologies is the lack of information. The Programme aims precisely at improving knowledge on intrinsic merits that renewable energy possesses. Increased awareness of these merits should lead to a growing interest of use and applications of renewable energies at worldwide level.

2.1.7. Job creation

Comparing all sources of energy production shows that renewable energy sources constitute one of the most important reservoirs for job creation[1]. For example, 198,852 jobs were created in the construction sector for the solar photovoltaic production of 1 TWh/year output. For the same energy produced, this represents higher job creation growth than other sources such as gas, coal, oil and nuclear (see Fig. 3).

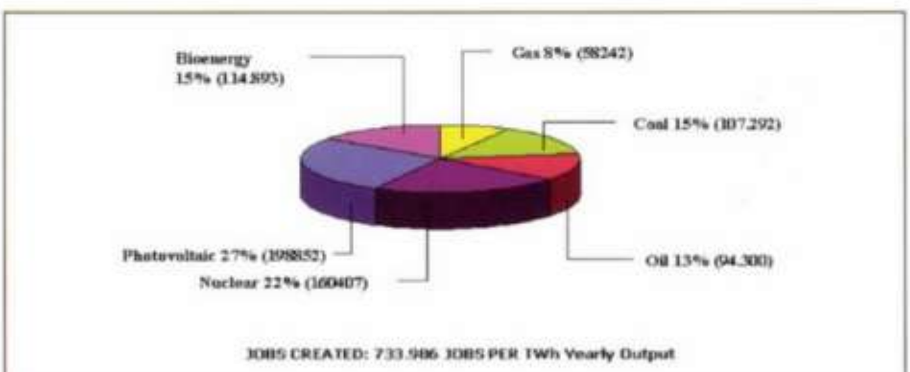


Fig. 3: Job Creation for Energy production[1]

1. J. Percebois, Vol. 2, Summer School "Solar Electricity for Rural and Isolated Zones", Ellipse/UNESCO, 1993.

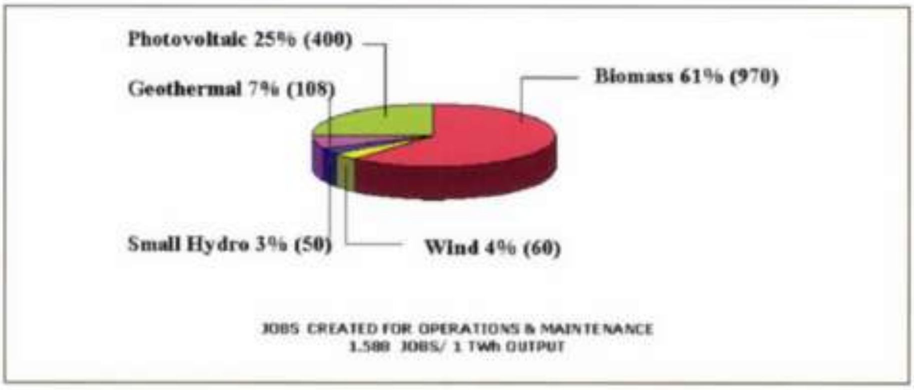


Fig 4. Manpower needs for electricity generation from renewable energies [1]

Comparing jobs created by the different forms of energy (see Fig. 4), it is clear that biomass and photovoltaic generate the highest number of jobs. As these resources are particularly abundant in developing countries concerned by the rural electrification, it is possible to imagine the total number of jobs to be created-even if only 10% of the non-electrified population were to acquire access to electricity produced by renewable energies. Apart from jobs creation, the use of renewable energies will help to improve the local economy and ensure a better quality of life. Keeping in mind that almost two-thirds of the world's population lives without access to energy services - and considering that this situation will certainly not change in the coming decades - renewable energy sources probably constitute the only real solution to improved living conditions for this population.

Fig 5. Direct Jobs Operation & Maintenance Created by RE Electrification[2]

1. J. Percebois, Vol. 2, Summer School "Solar Electricity for Rural and Isolated Zones", Ellipse/UNESCO, 1993.
2. Osman Benchikh calculations, UNESCO programme on renewable energies

The jobs created - even if a minimum of energy produced by the renewable energies is given per capita - will certainly help to improve the local economy of this already affected population and, thereby, decrease their poverty.

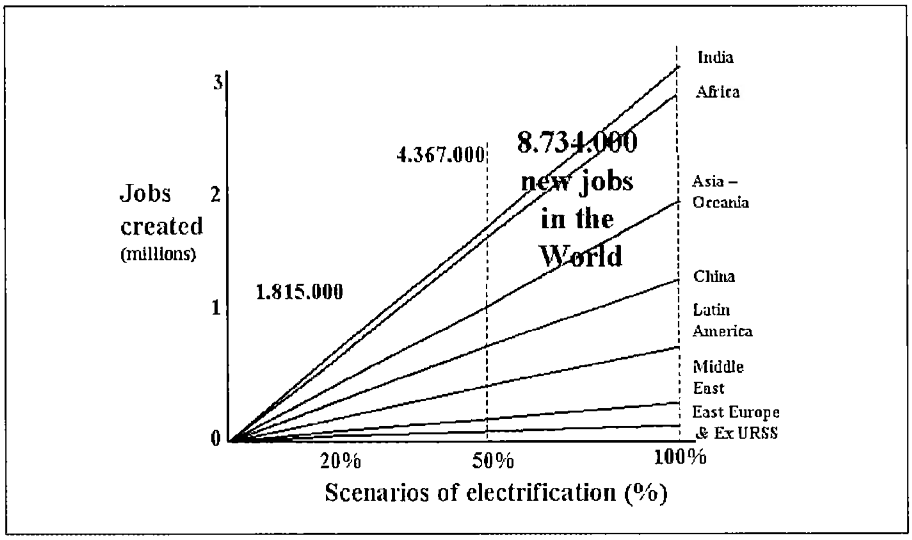


Fig 6. Direct Jobs for Operation & Maintenance Created by RE Electrification[1]

3. Training on renewable energy

3.1. Current situation

Education in the area of renewable energy is certainly a field where almost everything still needs to be done. The current lack of ambitious educational programmes can be explained by two principal factors:

- the multi-disciplinary and diverse nature of the subject, and
- general non-recognition of renewable energies as a major component of the energy issue.

Specialisation in this field assumes a general knowledge of diversified technologies and their adaptation to different contexts and different fields of applications. At present, no specific, degree-granting university training and education programmes exist in the field of renewable energy. Another problem is lack of information on the topic in general. Both of these issues must be adequately addressed.

1. Calculations made by Osman Benchikh, UNESCO

The following figures gives an overview on discrepancies that can be seen regarding the distribution of solar energy potential and repartition of education and research centers.

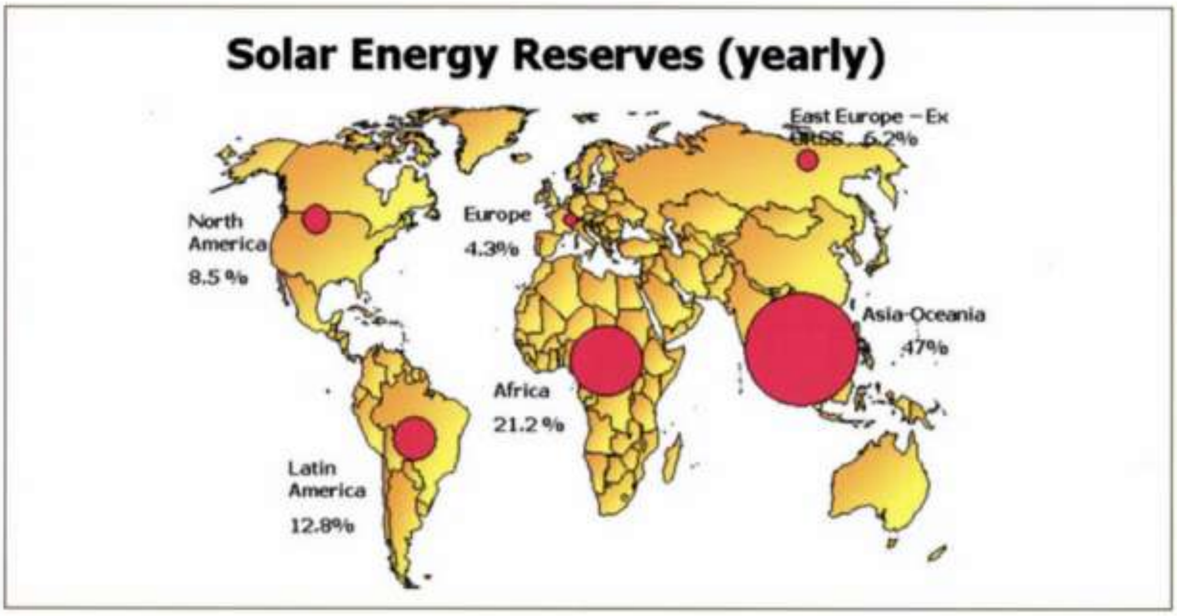


Fig 7. Potential of the solar photovoltaic in the regions (solar cell output x 10%)[1]

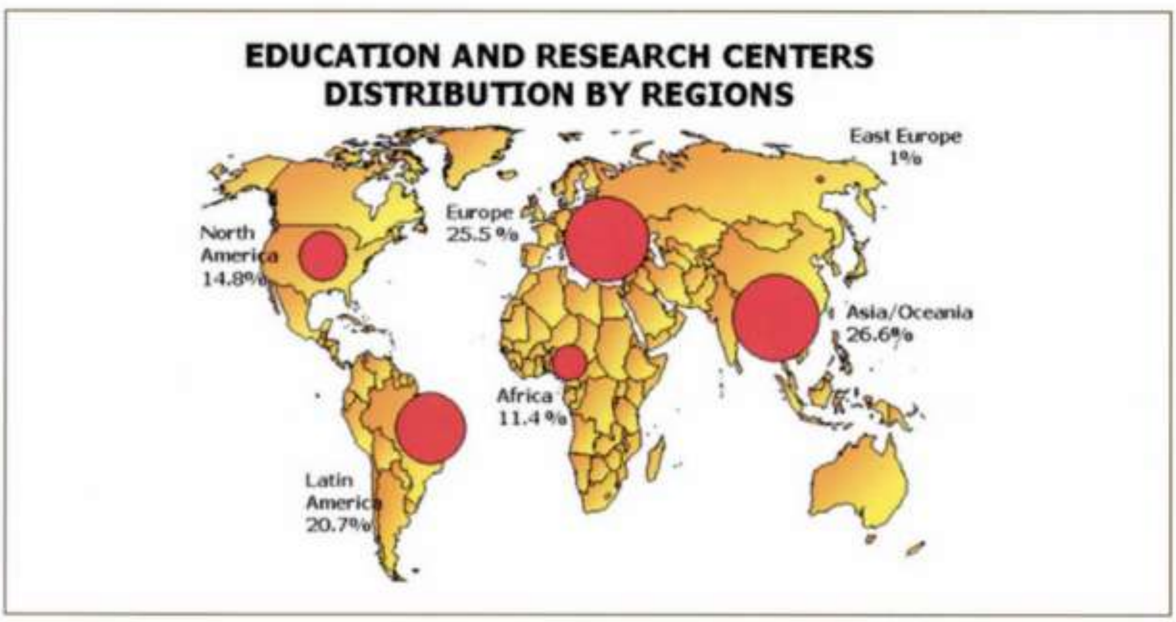


Fig 8. Distribution of training and research centers by region[2]

1. J. Percebois, Vol. 2, Summer School "Solar Electricity for Rural and Isolated Zones", Ellipse/UNESCO, 1993.
2. Osman Benchikh calculations based on data from UNESCO directory of renewable energy information sources and research centres.

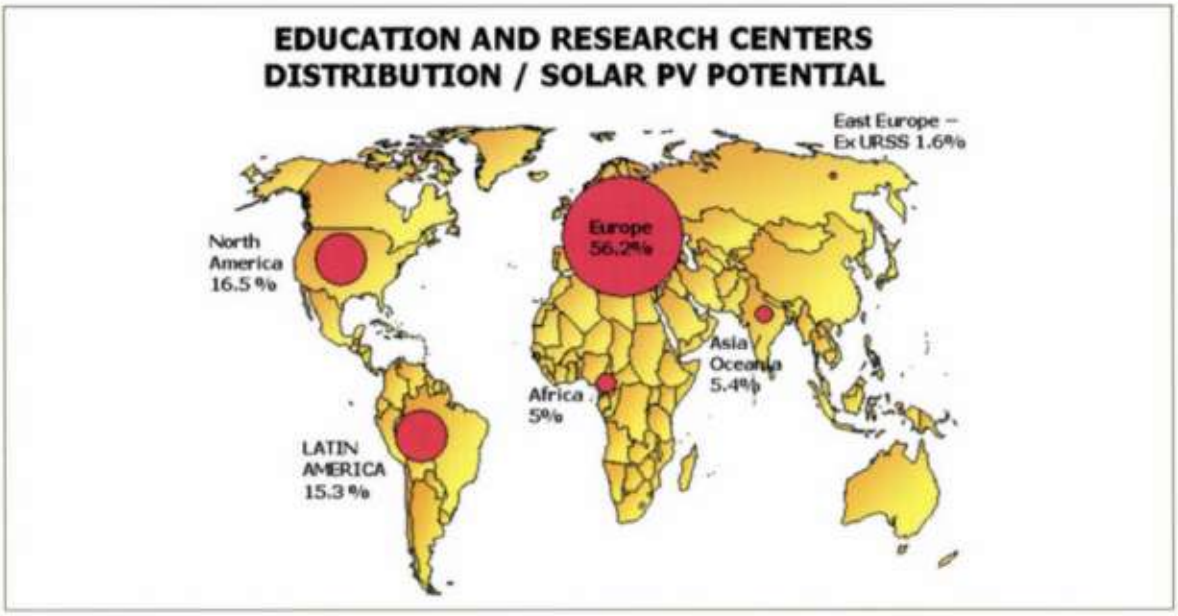


Fig 9. Distribution of training and research centers compared to photovoltaic potential[1]

The above figures highlight another issue, the poor distribution of research and training centres. In many cases, the regions favoured by a high potential of solar energy and confronted by a deficit in electricity - mainly rural - are those that have the smallest number of specialised training centres.

UNESCO summer school on solar electricity for rural and remote area

1. Osman Benchikh calculations, UNESCO programme on renewable energies

3.2. Training needs

General aspects of the needs for training are analysed from two angles:

- What should be the focus for the educational process? It is evident that current needs are the actual prospects of the market.
- What courses should be taught?

In only a few years, figures have passed from 1.5 to 5.6 jobs per installed megawatt—a sign of a more advanced industry. This brings to mind an indication from the World Watch Research Institute regarding the manpower needed to build a piece of equipment producing 1000 GWh annually:

Sector	No. of persons required
Nuclear	100
Coal	116
Solar thermal	248
Wind generation	542

These numbers will certainly decrease in the future. However, renewable energies will remain an important source for job creation compared to classical energy sources.

Production, use and application of renewable energy systems require diversified know-how.
The man power needs vary according to the different project stages and the systems components. This can be summarized as follows:

- meteorologists and analysts for the identification of sites and appropriate programs;
- metal workers with good competence in hydraulics for the assembly of wind rotors and towers or assembly of solar collectors;
- plumbers and tube workers for the installation of solar heaters;
- electricians for photovoltaic and wind energy systems;
- carpenters and building craftsmen for the integration of solar systems in buildings and power plants;
- architects for the urban planning and buildings design;
- engineers and designers in several sectors: civil engineering, power electronics, electric engineering, process control, quality control, chemistry etc.

The various competencies mentioned above needs an appropriate training and all needs training sessions based upon their original background. For instance, engineers, designers and architects do have sufficient basic knowledge. However a radical change in their usual behavior is necessary. They are used to work with conventional systems that can be used anywhere and in any environment. Contrary, the renewable energy technologies depend on the site and climate as they also interact with consumers. They do not offer universal solutions (except for some applications, such as calculators and solar lighting kits). This constitutes one of the principal barriers to their widespread use. In general, they require more work than conventional systems for their design, adaptation, and use. This implies the creation of more jobs in order to get durable and efficient systems.

Solar for land irrigation in Mali

3.3. Specific training aspects[1]

In order to improve training of researchers, engineers and technicians, several specific considerations should be taken into account. This is also true for the information required by decision makers, local elected representatives, consultants and the general public. The following develops some of these considerations with a focus on the training of technicians. This is the most important and necessary action for the success of a renewable energy programme. Thus, it will be presented first.

3.3.1. Training for technicians

Technicians play a major role in all aspects of renewable energy projects, participating at the levels of laboratory work, test centres, industrial production of components, commercial distribution, and system assembly, as well as installation, operation and maintenance. The success of renewable energy projects will not be achieved unless each step is realised successfully by competent technicians.

Thus, the most important requirement is the availability of competent technicians to ensure the installation, repair and maintenance of systems. If one considers the example of rural electrification, its development will be achieved through local networks of installers and repair technicians. First of all, system design, sizing and optimisation should be performed based on the precise needs of either individuals or the village community. These systems then need to be installed. They also need to be operated, maintained and repaired when needed, in order to ensure the best quality of service.

Past experience reveals that, even if photovoltaic modules are of an extraordinary quality, they are subject to failures. These are most often caused by defects in classical components (switches, batteries, power conditioning, connections, etc.). If one can rectify them in due time, such problems would be without consequences. It is regrettable to neglect these aspects of after-sales service.

1. O. Benchikh, UNESCO,"Renewable Energy Education and Training Program

Training platform Solar water pumping system

A very similar situation occurs in the solar thermal field. The large-scale development of solar heaters use will depend upon qualified installers, who will also have to ensure the repair and maintenance of these systems. There are very precise needs for training technicians in specialties such the installation, repair and maintenance of PV systems and solar water heaters.

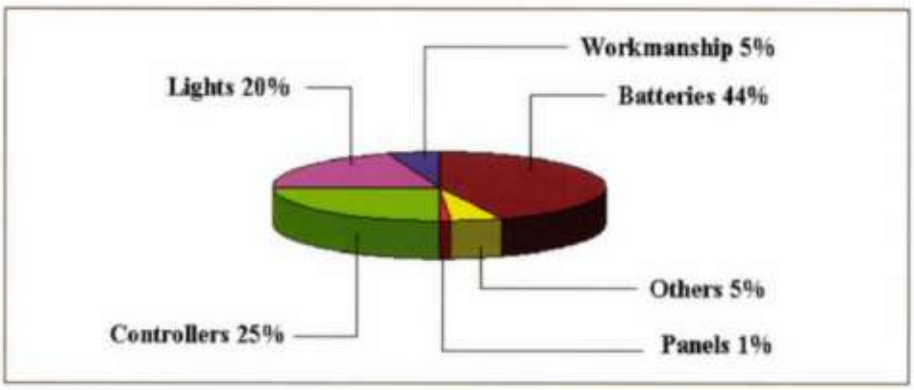


Fig 10. Contribution of components to systems fault (average in Africa)

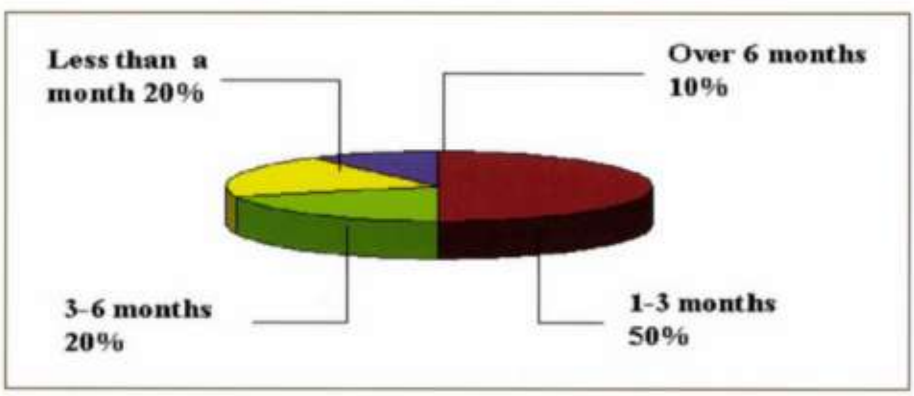


Fig 11. Time taken to repair a fault (average in Africa)

Training platform for solar lighting systems (UNESCO)

Technical education institutes are logically the best places to carry out this training. Therefore, institutes should work in close relations with the solar testing centres, particularly where it is possible to use their technical facilities to support training and education.

Continuing education is another important aspect to consider for technician training. It should permit technicians qualified in other disciplines to acquire, in a relatively short time, the knowledge necessary to master one of the above-mentioned specialties. Organising this type of training constitutes one way of ensuring the formation of solar technicians.

The availability of high quality, specialised literature is a necessary and complementary aspect of technician training. Technicians will benefit greatly by acquiring material such as:
• Technicians' guide or handbook that collates, in a condensed manner, the theoretical results, schematic diagrams, basic formulas, rules and practical recommendations that would be useful to solar technicians.
• Documentation on components and solar equipment, which could serve as a kind of 'user's guide', indicating suppliers, cost, performance, best ratio of quality/price, etc.

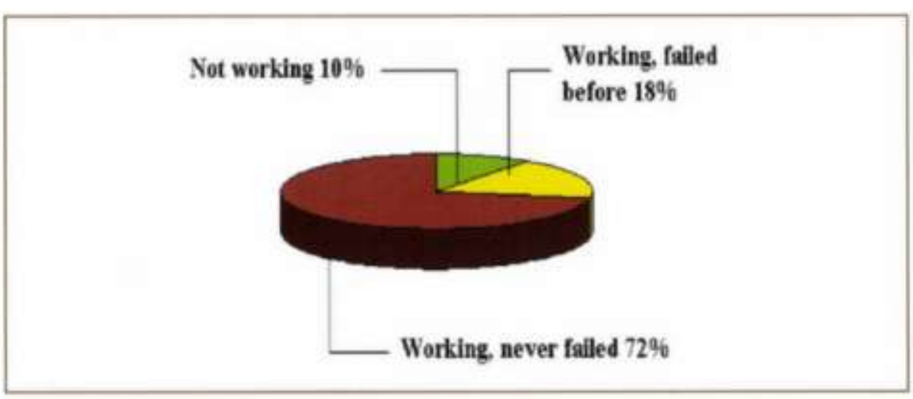


Fig 12. Fault occurencences in Solar PV intallations

3.3.2. Training for researchers

One must underline the importance of promoting a research programme in the relatively new sector of solar chemistry, which is dedicated to fuel production. It is convenient also to mention other research topics that are already well established, but should at least continue or even be amplified.

First of all, it is important to consider research on photocells and photovoltaic systems. The performance and cost of these systems still need to be improved substantially. As an outcome to the rural electrification programme and resulting market expansion, progress in this field will be accelerated. This dynamism would lead to an increase in industrial efforts and justify the reinforcement of research facilities in this sector.

Universities and schools of engineering, in the countries of the North and of the South, be called upon to take up the mission of forming tomorrow's researchers. In turn, these individuals will ensure progress in this Programme. The following actions can be adopted now to help these institutions achieve their mission:

- Reinforce theoretical and practical education in the basic disciplines, upon which the above-mentioned research depends. Within this frame, several other disciplines should be considered amongst the first rank: solid-state physics, physics of materials, molecular physics, thermo-chemistry, photochemistry, thermal sciences and thermodynamics.
- Define research topics in the field of photovoltaic (photocells, photo-chemistry, and solar fuels) for student thesis or graduate projects.
- Incorporate these research topics into a global vision of the role of renewable energies among the energy resources for the coming century (analysis of energy supply and demand, economic considerations, and environmental constraints).
- Organise cooperation programmes amongst higher education institutions, in the North and South, on research related to solar energy. This collaboration could be made through common studies of scientific projects and could lead to student exchanges.
- Create a 'think tank' (under the framework of the World Solar Summit, for example) on the training of researchers in the disciplines that would support the progress of solar energy. The task of this group would be to define the actions to be taken for training researchers, to elaborate a strategy, and to aid university departments in establishing such programmes.

3.3.3. Training of engineers

The realisation of renewable energy programmes, particularly solar rural electrification, constitutes a large industrial project for the coming decades. Industrialised countries can have an appreciable contribution in this area, which will also have a beneficial impact on job creation. This dynamism could help generate a domestic industry with the capacity to significantly contribute to these programmes.

The industrial boom foreseen in solar and wind electricity, as well as in passive architecture, requires a new generation of engineers whose work, initiatives and competence will be the best guarantee for success. There is a clear need to ensure the development and training of future engineers who will have the task of creating, organising and establishing the solar industry of the future.

The required fields of competence for engineering curricula are identical to those mentioned above for the researchers: solid-state physics, physics of materials, molecular physics, thermo-chemistry photochemistry, thermal sciences and thermodynamics. In addition, they would require expertise in power electronics, electro-technology, and fluid mechanics.

UNESCO training of trainers session

In this educational process, practical aspects should have top priority. In fact, the course contents should leave a large portion for experimental work and for projects related to real equipment and full-scale installations. There is a strong interest in establishing the training institutions for engineers near solar testing centres, a certain number which already exist.

Specialised education and training in renewable energy leading to a university degree, at the Master's level, constitutes a programme that could be proposed for both researchers and engineers working in this field. This type of education would allow planners and those who carry out renewable energy programmes to have access to complete information and know-how within a reasonable period of time (18 months).

Continuing education constitutes another important aspect for the training of engineers. In fact, this would allow engineers who specialised in other disciplines to acquire, during a minimum of time, sufficient knowledge to enable them to work efficiently in a new field. Short training courses, such as summer schools, are very responsive to this need. The annual summer school on 'solar electricity for rural and isolated zones' organised by UNESCO, presents an example of action in this direction. This initiative should be encouraged, continued, and even extended to other sectors such as biomass and wind energy, as well as other renewable energies.

To summarize, the following recommendations can be made:

- Encourage and support the activities of solar testing centers and promote their contribution in the education and training of engineers.
- Promote the engineering teaching of the above mentioned disciplines and encourage introduction of renewable energy topics on the occasion of practical training in enterprises, graduation projects, practical work, etc.
- Organize at an international level the contribution of students of engineering schools from the North and South countries, in a thoughtful study on topics related to renewable energy projects.
- Respond to the needs related to continuing education on renewable energies. The model of summer schools programs should be reinforced and expanded.
- Set up an international advisory committee on education and training of engineers in order to elaborate a strategy in the capacity building and human resources development area.

3.3.4. Information for decision makers, locally elected members and service technicians

One of the difficulties to be overcome in promoting these programmes is convincing decision makers of the solid basis of these proposals, in order to get their support. The current context is falls far short of being favourable for such action. The current low cost of oil products and the existence of other technologies — considered, correctly or incorrectly, to be more credible — create a degree of uncertainty, scepticism and even hostility towards solar technologies amongst decision makers and experts. This difficult situation can also be linked to the lack of general knowledge on the results and successes of solar technologies in recent years. It is highly likely that the potential progress and future prospects are very poorly known.

This insufficiency of information on renewable energies is not necessarily due to the modesty of solar researchers but rather is due to the limitations of the facilities offered to them in the past. A real effort is needed to improve general knowledge outside the solar research community.
Past experience shows that the principal obstacle to the development of solar technology is the neutralism or opposition of electricity-producing and distributing companies. This is coupled to the indifference of decision makers responsible for selecting energy materials for local communities or regions. For an electricity planner, rural electrification usually means the development and the extension of the existing grid. A locally elected representative, who does not have a good knowledge of the various available technologies, may simply go back to the national electricity utility. The end result is that the safest solution is adopted either by inertia or by tradition.

Training of trainers, UNESCO Programme on renewable energies.

It is therefore necessary to convince both electricity utility staff and local representatives that the adoption of solar technologies is a bonus card for all. Decentralised solar technologies are not necessarily antagonistic to interconnected networks, but rather are complimentary to them. Certain electricity utilities hold this viewpoint, especially when the construction of new power station and electricity grid encounter financial, ecological or regulatory difficulties. They see solar technologies as being complementary to traditional solutions.

In developing countries, the concept of 'pre-electrification' would result in promoting certain solar technologies as a first step towards the construction of an interconnected network. Solar energy's best ally is the electrical engineer who understands that it is not a competitor of, but rather a tool for, the development of electricity supply. A major effort for improve general knowledge and training in this field is still needed.

Actions required for the development of general knowledge programmes oriented towards decision makers should include:

- Organising seminars, workshops or summer schools that target decision makers and experts related to other energy fields. The goal should be to inform them about possible future solar applications, including the anticipated progress and economic aspects.
- Developing presentations on the possibilities of solar technology market penetration in the form of alternative scenarios.
- Reporting on the prospects of renewable energies in scientific and economic journals.
- Organising technical visits to the most outstanding solar energy installations.
- Producing audio-visual materials that illustrate existing solar installations, as well as future prospects for these technologies.

Technical visit to a solar communication plants in Morocco, (UNESCO summer school)

3.3.5. Information to the public

Training and information activities, similar to those elaborated in the previous section, should equally be under-taken for the general public. At present, most people are unaware of most of the achievements, possibilities and prospects of solar technologies. In countries where solar programmes could be implemented, or where the population would have direct contact with solar equipment, this information programme would join that for users.

There is much work to be undertaken in the information and training of the general public, including the following:

- Publishing information, in the form of study articles and comprehensive, well documented reports, on solar energy and its prospects.
- Distribute such information and/or documentation to consumer associations.
- Produce and broadcast programmes and documentary films for television.
- Create fixed exhibitions at technology parks to allow the presentation of a wide array of solar equipment and its applications. Organise general public visits to solar test centres.
- Encourage teaching of renewable energy technologies in primary and secondary schools. Within the context of courses in physics, chemistry and technology, a scientific base on solar energy can effectively introduced into the minds of young students. In the very near future, these individuals will be the implementers of the large energy programmes, currently being launched.

3.4. General contents of teaching programmes

The overall objective of education and training programmes is to address general problems related to energy, as well as the need to conserve energy and use renewable energy sources. At the same time, the particular technology should correspond to the competence of the instructor and the desire of the learner.

In the past, most training programmes focused on a specific type of renewable energy, concentrating on a certain technology without placing it in a more general context. In addition, existing general training programmes on energy conservation were not oriented toward a specific renewable energy form or a particular application. This situation is unsatisfactory in that it does not respond to real needs.

A general training programme on renewable energies and related technology options is proposed as an example. It could be compared to a 'general store' of basic courses and 'menus' from which particular options can be selected for each target audience (researchers, engineers, technicians, decision makers, industrialists, end-users, the general public, etc).

At present, there is a scarcity of appropriate disciplines in relevant teaching programmes for each technology. It is easy to see that, if an individual would like to intensify his/her technical capabilities to solve the problems encountered, this person must select one of these particular technologies. This should be supported by the usual basic knowledge, which remains the foundation for building up the trainee's abilities, together with any other complementary knowledge that is necessary to the training.
The complementary knowledge would be acquired partially through the basic general courses mentioned above, which would help clarify the role of renewable energy in today's world. Depending on each technology option, it would also include other particular points to help trainees deal with real field problems. Sensitising trainees to the real state of the art of the systems use and manufacturing is a high priority; it will also help clarify the role and importance of the various technology options. Therefore, the proposed training programme should cover at least one or two of the technologies referred to in the following table.

Guide of technology options

Technology	Hydro electric	Wind turbines	Photo-voltaics	Solar therdyn. conv.	Solar thermal	Geo thermal	Biomass
Related disciplines							
Mechanics	••	••		•	•		
Geology	••					••	•
Atmospheric physics	•	••	•	•	•		•
Thermodynamics				••			
Thermal sciences				••	••	••	
Building engineering					••		
Chemistry			•	•	•	•	•
Chemical engineering			•	•			••
Physics of mathematics	•	•	••		•		
Electro-physics		•	••	•			
Electro-technology	•	•	•	•			
Agronomy							••
Biomass engineering							••

Each scientific education unit will select its technology options according to its field of interests. It is important to not that this does not exclude to simultaneous selection of a renewable energy option and another form of energy. In addition, sufficient time should be allocated to general knowledge. Units that currently specialise in economics or human sciences but wish to initiate training programmes on renewable energies could call upon external specialists to deliver the necessary information to the target audience.

The most important consideration is that the information be realistic and cover the use and application of renewable energies, especially in the different contexts. That is, trainees should be made aware of the potential of renewable energies to meet sustainable targets, contribute to poverty reduction and support job creation.