Dear Friend

Please note that this non-commercial CD – that you have just opened, - is one of a set of three companion CD's on renewable energy technologies.
It is intended solely for the use by students, workers, research and production engineers and technicians, and for political decision-makers at all levels – concerned with the development of production capability.
The material and information contained in these three CD's – does not intend nor imply any infringement of any of the copyrights of any of the authors quoted.
[For bona fide groups in developing countries a fourth CD is available on request].

Indeed – the purpose of these compendium CD's is to bring these authors to a wider public and as a token of grateful thanks for their efforts.

These CD's may be freely copied on a non-commercial basis – however only as exact 100% - 1:=>1: digital disk copies, with the same and identical title written on the

CD-upper surface. This is to ensure “droit-moral” rights of all contributors and authors.

Long experience in so-called developing countries as a political-economic and technical adviser [choice of technology adviser] especially in South-East Asia – Mainly in Viet Nam and Thailand and also in Malaysia, The Philippines and New Zealand during the 1980’s, followed by similar activity mainly in Cuba and the Caribbean area; - Has demonstrated a serious requirement, due to lack of access of alternative real-information or know-how, for a series of “hands-on handbook-type” of information material – clearly demonstrating different renewable energy possibilities, - basically suitable for local and de-central construction and use.

This is the case not only in developing countries – even in developed countries much highly relevant information is no longer available, accessible or obtainable. Many specialists today, would perhaps claim that most information is readily available over the Internet system. This is a truth with very much modification. Indeed much material can be found available on the Internet, but most of what is

really required and certainly most of what is absolutely necessary to develop de-central production capability, is in reality, still non-available, non-accessible, nor indeed in any way obtainable. Therefore it is my wish and intention that the material available on these three or four CD's should be of benefit to readers and friends at all levels.

As my friends in S.E. Asia would agree "Right work does indeed give right thinking".

It has also been my great fortune to have studied under, worked with and been inspired by several of these influential pioneers in several different fields. Dating from my first acquaintance in 1965 with the pioneering works of the Danish Prof. Poul la Cour during my studies at the Peoples College in Askov – site of the world's first modern wind turbine testing station established in 1895.
[I have also attended lectures/seminars with Prof. Victor Papanek from UNESCO etc. who should be mentioned along with his influential book "Design for the Real World"].

Likewise I have in turn received with grateful thanks many inputs, help and assistance from several of my own previous students, - and friends and co-workers in different countries and at different times.

Once again – should I have omitted to note credits to specific authors – this I regret as it has not been any intention of mine to omit any of those hard workers – whose dedicated efforts have advanced the whole status of renewable de-central energy technology. I am merely in the role of adviser and an assistant in a continuing process.

It may be noticed that there is some duplication of certain material in the different compendiums. Each compendium was originally produced as a photocopied selection of material and as an independent volume for use in a different situation, that should however also be seen and considered in a wider de-central renewable energy context.

The contents of the three CD's are as follows:

1: Wind Energy.

A: Compendium in Wind Turbine Blade Theory and Praxis.
Based on Experience from the 4th. Period of Wind Electrical Power Generation [The 4th. Period was the decade of the re-discovery of wind electrical power generation - 1968 – 1978].

B: Compendium in Low-cost Windmills.

C: Compendium on Sail Windmills.

D: Compendium in Horizontal Wind-Rotors for Water Pumping and Electrical Power Generation. [Horizontal rotor – vertical axis wind turbines]

2: Solar and Water Power.

A: Compendium in Solar Cookers, Food Dryers and Solar Thermal, etc.

B: Compendium in Small Hydro.

C: Compendium in Hydraulic Ram-Pumps.

3: Integrated Farming System and Agricultural Energy Systems.
A: Compendium in the Integrated Farming System. – Vols. I. and II.

B: Tubular Plastic Bio-Digesters in Tanzania, Viet Nam, Zimbabwe and China.

C: Kompostering og Landbrugs Energi-relevant Kilde-materiale. [Compost and other relevant background information material concerning agricultural energy issues].

Some short extra comments should perhaps be added to the different compendiums:

1A: This compendium is based on experience in Thailand and on a series of lectures and many advisory visits concerning renewable energy and specifically wind energy and production possibilities to different Universities and Ministerial Institutions in Cuba during the early and late 1990's, - during the difficult so-called "special period".

1B: Inspired by the home-built and low-cost "scrap-heap salvage-parts" work of millwright Hugh Piggott from Scotland - www.scoraigwind.co.uk and the beautiful designs by Danish architect and millwright Claus Nybroe – see: www.windmission.dk

1C: This compendium was made for a Finnish development project in Namibia. However it should be noted that following a 10-day technology investigation course in Central Finland in December 2001 and following a study-visit to Crete in 2002 – an additional extra CD should be ready for issue in 2003 - based on the study and construction of sail windmills. Those who are interested may request copies.

1D: The compendium on Wind Rotors is based on discussions in the 1980's in Indonesia with Bill Featherstone - an old fitter friend from Melbourne Australia and following many visits and discussions in Finland.

2A: The Finnish NGO – TEP/TFL - Technology for Life have been the inspiration for the now totally revised and greatly enlarged edition of this compendium, originally made for use by a local women's group in Havana Cuba.

2B: Suggested by friends in Finland for their use in projects in Nepal and Bolivia.

2C: This compendium is based upon a request for technical information material, from the energy adviser of the energy office in South West Jutland Denmark – his homemade and successful experimental result can be seen in the colour photographs.

3A: I have had the good fortune to have both studied under and worked with Prof. George Chan from Mauritius, the main modern proponent of the idea and thinking behind the "Integrated Farming System" founded on the centuries-old farming systems from the Guangzhou delta in South China combined with modern technological inputs. This compendium is further expanded and elaborated upon during studies under Frands Dolberg from the University of Aarhus in Denmark.

3B: The low-cost plastic tube biogas digester was first popularised by Prof. George Chan and is based on the original "red mud plastic" model from Taiwan. This has later been modified and widely disseminated by Prof. Preston from the University of Oxford at the University of Cali in Columbia and later at the UTA – University of Tropical Agriculture - Agricultural University of HCM-City in Viet Nam
The field-studies and papers done by several student groups from the University of Aarhus following inspiration from Frands Dolberg c/o [jbk@ps.au.dk] and also perhaps inspired by Prof. Janice Jiggins – in investigating womens' absolutely essential and necessary social role in the de-central introduction and dissemination of technology, are highly relevant in any process and should be studied carefully.

3C: This compendium, although now slightly enlarged, is based upon a background information file folder originally requested by a member of the Environmental Committee of the Danish Parliament. It consists of press-clippings and articles on different forms of agricultural energy and waste-disposal or treatment problems and issues. The articles are mainly in Danish and neither does it pretend to be exhaustive nor fully covering all the relevant issues. Some articles in German and English are included. Several groups in different countries have since requested photocopies of this file folder and so it is therefore included here. There is much valuable and interesting material and drawings to be found here, - so please do not be put off by any initial language barrier. The introduction to this compendium file is now written in English.

NB 1:

The contents of the above mentioned fourth CD - CD-4: - solely available to bona fide groups in developing countries or after a direct special request. This CD consists

of different essential and near-unavailable files in the following 5 main file groups – as follows:

a: Bio-energy.

b: Electrical generators and electrical power generation.

c: Solar power – both solar thermal and PV.

d: Wind energy.

e: Three important energy-related papers from a Danish Ministry of Energy and DANIDA - publicly financed international conference at the Danish Technical University in Copenhagen 1991.

NB 2:

Before opening the different main compendium files, - kindly read through the following additional files 02 – 10 - for a "more complete understanding of the issues".

02: "The Danish Model" – paper by John Furze. - "Acrobat Reader Document"

03: “Electrifying the Developing World” - paper by Percy S. Mistry.

04: Lecture notes for graduate students in “development studies” – Univ. of Aarhus 2000.

05: Suggested further reading and additional book-title list for graduate students.

06: Lecture notes and further reading for graduate students in “Approaches to Development Studies” – Univ. of Aarhus 2002.

07: Suggested book-title purchase-list for the Danish State Library in Aarhus.

08: “The Environmental Aspects of Renewable Energy Production”. A paper by Amanda Delgado, Tomas Hubalek, Ewa Mazurek and Sine Nissen four students of Environmental Studies [Group 1] – Univ. of Aarhus 2000.

09: “FOT” - Future Oriented Training Program.

10: University program for RE-studies.

NB 3:
Some may possibly regret the non-inclusion of a compendium on PV solar cells. However it is my belief - that the most satisfactory solution for rural de-central power supply, - is the establishment of a - 110/120 VDC micro-grid system supplied by suitable wind turbines [in all possible sizes and shapes], combined with back-up “non-refined plant-oil” small diesel-generators [perhaps Lister or Elsbett-type “BHKW - Blockheizkraftwerk” – CHP micro-diesel units] or perhaps Stirling engines, etc. and not the present popular and highly promoted approach taken with the massive introduction of some sort of apparently simple SHS technology [Solar Homes Systems]. This was the highly practical - demonstrated approach to de-central energy and power supply at the beginning of the 1900’s, as suggested and practiced in many Danish rural electrification projects by Prof. Poul La Cour, the

famous pioneer of wind electrical power generation. Precious time has indeed been wasted since then!

Several previous energy technologies, some of which were first introduced and widespread during the late 18th. and 19th. Century, are now being re-considered in the light of new materials, technologies and modern control systems, - such as Stirling engines, gasifiers, and even advanced steam engines with teflon components.

It is often claimed that many areas of the planet have low average wind speeds – this is unfortunately in many cases correct. It is therefore very important that every specific site should be carefully evaluated, measured and analysed as to the possible use of the most efficient or effective form of the various different renewable energy supply inputs.

However please note that there are certain recently developed wind turbine models and wind rotors producing usable electrical and mechanical power under

lower wind regimes than previously thought realistic. These wind turbines and the usable power that they are able to produce, are of course operating neither as "efficiently" nor as productively as a wind turbine operating in a high wind speed zone. However this obtainable and usable power is in many cases more totally cost effective than electrical energy produced by the sole use of PV cells.

Likewise the difficult question of energy batteries, compressed air, flywheels etc. or "storage systems" – [the wind in many situations, unfortunately can be a variable resource or a non-constant availability resource], is undergoing rapid change at the present time. Certain very large and also micro floppy-disk-sized new systems involving hydrogen fuel cells [and similar] are now under advanced pre-production development testing.

For those who have a need to obtain a further and deeper knowledge of PV solar cells, etc. - kindly consult – among others - the different selections in the different files found under "Solar" and "Electrical systems" in the main file "Extra files" on the CD's. Likewise as mentioned above – a special section will be found on CD-4.

I may otherwise suggest and recommend the following further sources – among the vast amounts of the many - often not quite so helpful titles, reports and material:

A: Practical Photovoltaics: Richard J. Komp available from – mail.order@cat.org.uk
B: SolarAnlagen: Bo Hanus + many other titles, material, etc. – www.conrad.com
C: Consult the several relevant and other titles in the catalogue – www.oekobuch.de
D: Solarstrom in 12 V. Anlagen [available in German, English & Spanish]: Verlag Einfalle statt Abfalle Hagebuttenstr. 23, 24113 Kiel Germany.
E: Consult the very good site and information list from – www.tecsol.fr

F: For small-scale solar-cell low-cost system design consult: - RAP microsystems GmbH, Schlachthofstr. 4, 38885 Wernigerode Germany.
G: For combined micro-grid systems, etc - www.synergypowercorp.com

Solar cells do indeed have a very important and vital role to play – but for real power purposes [and this means the ability to power de-central machinery or

household-type machinery, etc.], other than for short-term house or street lighting or in certain high-cost/difficult situations etc. - other forms of power generation must, or should be, first considered. However provided that these alternative possibilities can in any way be considered a possible option, under the given circumstances or under the given site-specific conditions.

With these three or four CD's – It is my earnest hope that there should be material, links and further contacts available to everyone – to enable and assist correct decisions to be taken and carried out - by those, to whom it may concern.

With best wishes and greetings to all from John Furze – October 2000, July 2001, April 2002, July 2002 and Dec. 2002.

furze@post.tele.dk - Ebeltoft / Aarhus - Denmark.

Lecture – 25 Feb. 2000 – Approaches to Development
University of Aarhus Denmark
John Furze TCP – Trans Caribbean & Pacific Consultants
E-mail: furze@post.tele.dk

Introduction:

- **Who I am – 41 years in development issues – Interested in renewable energy since Askov in 1965. Freja in 1974 - Tunø/Tvind project in 1975.**

"Appropriate [!] Technology, should be neither a second best, nor an outmoded technology, but a solution that fits best the local requirements.
A successful innovation policy, would probably include some of the following 4 elements:
A: Reviving an old technology
B: Adaptation of a current technology
C: Inventing new technologies

D: Improving a traditional technology"
M.M. Hoda. AT Development Unit, Gandhi Institute of Studies, Varanasi, India
Quoted in Jéquier - OECD Paris 1976 [74]

"Absence of any awareness of alternatives makes for absolute acceptance of established theoretical tenets and removes any possibility of questioning them"
Robin Horton – African Traditional Thought and Western Science – quoted in David Dickson 74 -"Alternative [!] Technology and the Politics of Technical Change"

- **Choice of Technology**

Lack of material => "Financing Renewable Energy Projects" - Jenniy Gregory "Many technical books" – Mini grids only for utilities? – Top down giving the impression of being basis controlled.

Example of : - "Financing Renewable Energy Projects" – Jenniy Gregory and Semida Silveira - IT Books London 1997.

- **Wrong approach – misleading/incorrect information**
- **My own series of Compendium – handbooks precisely because there is no ready access to required technical information.**

Total integrated system approach –

- **Important for Women – 4 serious examples**
- **example of DANIDA-woman,**
- **example of Architect and Biogas exam-project,**
- **example of wind measurement - concerning project in the Pacific,**
- **example of compost sorting factory near HCM-City**

Know about RAPS – SHS why is this not so good – HRAPS, – Stand Alone, – Who is Elsbett, - What is Orbital, - AET – [Advanced Engine Technologies], - Downwind Flapping Blades, - Marlec, - Floppy's, - Cool Power, - Ericsson and Sterling, - Michel-

Banki, - Nepal, - Ghosh-ULOG - Maria Telkes, - Reed-bed systems, - Hydraulic Ram systems, Ornat-turbines, - Low-cost Digesters – Bundschuh - BTG, Mono-pole, etc.

Inspiration from:

- **Victor Papanak – Design for the Real World 1973**
- **La Cour – Tidskrift for Vind-Elektrisitet 1904-1916 - etc.**
- **Stanley A. Hetzler – Applied Measures for Promoting Technological Growth**
- **Peter Senge – The Fifth Discipline – Management for chaos**
- **Hugh Stretton – Capitalism Socialism and the Environment**
- **Books from Handels Højskole – Danish Social Science Research Council in Cph.**

- **Stay in SE Asia, S. Pacific and Caribbean.**

Energy:

- **How much energy a human – app: 75 W on a continuous basis. However up to app: 1.5 kW and even 2 kW for a few seconds – Bicycling Science and Pedal Power – [75 W => 1/10 HK - 1 HK = 750 W] 75 W = 1/13 kW**

  Household app. 3500 kWh/year – Freja 1974
  Nørgård – Family 4 persons – 2452 kWh/year – domestic and service sector
  Each person in household of 4 . => 35W/h Domestic sector + 35W/h for Service sector. NB: not including industrial sector.

- **Home-built Dynamo from NZ.– 8 amps, 14 volts, at 234 rpm for 12 volt battery charging – 112 W**

- Foot –operated machines – American Village Institute
- Oxtrike – Dr. Stuart Wilson. – Oxford.

- Presentation of watches – different models

Strom aus der Sonne – Bernhard Krieg

- Battery watch – 36.000 DM/kWh - 144 Th/DK
- Calculator – 9.000 DM/kWh - 36 Th/DK
- Battery-light – 220 DM/kWh – 880 DK
- 50W load – 3,5 kms from net – and connected – 17,5 DM/kWh - 70 DK
- 50W load – PV – 10,7 DM/kWh - 42,8 DK
- Diesel Generator for 1 kW load - 2,2 – 250 DM/kWh
- 300 kW-max PV – power-station - 2 DM/kWh
  [VOH-Brædstrup – app. 5 DK/kWh]
- El-power-station – 0,23 DM/kWh

Structure of Lecture /Presentation

- **Cecil Mistry [World Bank] – paper – my paper the Danish Model**
- **Wind**
- **Solar – Thermo [cookers] and PV**
- **Biomass – and "Transport"**
- **Water**
- **Building and Construction**
- **"Loose-ends"**
- **Scenarios**

Wind Energy:
Most important knowledge for all Danish civil servants – not only concerning national, but also international and development issues.

- **1724-1792 – Smeaton - 1759- in UK**
- **Vogt and Irminger – La Cour**

- Prize competion in NL – 1894 – for wind generated electricity
- “Nebraska-1890’s” – turbine design 5-10 years before time !!
- Scientific Period – Stanton from UK, - Riabouchinsky from Russia, - Eiffel from France. – 1900’s
- 1905-1910 – UK, - Germany, Russia.
- Niels Hansen/Knud Lykkegård – series production and export of wind electrical plants – Somalia, South America etc.
- 1920’s – Soviet, Germany [Betz – 1919-26]
- Vinding/Jensen – Agricco wind turbine – 40 kW induction generator
- Savonius - Finland – 20’s
- Darrius - France – 30’s
- Jacobs – USA – 30’s
- Putnam – USA – 40’s
- Hütter – Germany – 30’s – 60’s
- FL-Smidth – Denmark – 1940-45
- Juul – Denmark – 1947 Vester Egesborg. – 1952 Bogø, - Gedser 1957-1967 and from 1977 – 1979 under DEFU and NASA [Juul died in 1969] 40’s – 60’s

- Golding – UK – 50's
- 4th. Period 1968 – 1978 - USA // Freja 1974 Södergård/Johansen 1976
  Claus Nybroe/Carl Herforth 1976 – Juul => Riisager 1975 – Herborg.
- Take-off Period 1980 =>

Sol Energy:

- PV Sol-Cells

- Edmund Becquerel – PV effect 1839
- Charles Fritts - USA - selenium – solar cell – 1880's
- Bruno Lange - Germany - copper oxide cell - 1931
- Bell Telephones – silicon cell 1954.
- Power stations – Carissa Plains CA – 16.5 MW – Germany etc.

- Solar cooling

- **Michael Faraday – silver chloride 1824**
- **Servel – Electrolux - Sweden-USA**
- **Ice machines etc.**

- **Solar Ponds**

- **Israel – Ornat Turbines – 2500 sq.m. – 5 MW turbo generator**
- **Organic-cycle turbines - Turboden Italy**

- **Solar Engines**

- **Augustin Mouchet – France 1860**
- **Abel Pifre – France – 1880**
- **John Ericsson – 1866-1870 [Hot-air engine 1872] – parabolic trough 1884-1889 - USA**
- **Aubrey Eneas 1899 – 6000 ltr/min from 5 meters - USA**

- Charles Tellier - low temperature ammonia pushing a diaphragm – 1500 ltr/hr - France – 1880's
- Willsie/Boyle – 1892 – 1908 low temperature sulphur dioxide 24 hr operation gas engine - stopped due to success of coal producer gas engines.
  $ 164 / hp - conventional power plant $ 90 / hp
  $ 0.45 kW/h - -------------------- $ 1.54 kW/h
  payback-time 2 years.
- Frank Shuman 1907 - Sun Power Company USA / UK – 1910 – water into steam. 15000 ltr/min lift over 10 meters. – New design from - V to)
  Meadi – solar project Egypt – 5 collectors, - each 68 meters long. – 4.40 meters wide – 24 hr operation.
  Price twice conventional plant $ 8200. - 30000 ltrs/min.
- Luz – plant 194 MW. - To supply all of Los Angeles with power - 1% of the Mojave desert or 1/3 of Edwards Air Force Base – plan to develop to 675 MW
- Sterling-engine technology.

- Solar Cookers

- **Horace de Saussure – France - 1767**
- **Sir John Herschel – UK – 1830’s**
- **Bombay – 1880’s**
- **Samuel P. Langley – USA – 1881**
- **Maria Telkes – USA – 1930’s – 70’s**
- **India – Ghosh – ULOG – Switzerland, - cooker**
- **USA – France – Finland etc.**
- **Note from Ladahk-project – “If Ladahk’s saw more Westerners using solar cookers – a change would be more likely”**
- **Solar Cookers International – www.accessone.com/~sbcn - infoseek etc.**

Biomass Energy and Biogas – Transport:

Gasifiers and the DEA – 5 finger approach to Biomass de-central CHP – systems

Eg: Cuba – 4 times total energy requirements from bagasse waste

50 – 70 tons cane/ha => 150 t/ha.
Dry matter [cosecha-paja] and bagasse with 70 tons of cane => residuals will give about 6.7 tons of oil equivalent pr. ha/year

- **Stirling engines**
- **Gasifiers**
- **Fluid-bed systems**
- **Plastic-component steam engines**
- **Organic-cycle turbines**
- **Gas-turbines**

- **Imbert – system gasifiers – WW II, – Brazil, - Phillipines**
- **Harry La Fontaine – Tom Reed – gasifier cooker**
- **India – BTG**

- **Agriculture –**
- **Quick rotation crops – elephant grass – willows, - albizia, leucaena**

- **Aquatic weeds – water hyacinth – lemna/duck-weed etc. – [water treatment]**

- **Biogas –**
- **Problem at text books cite Ram Bux Singh from India – inverted cylinder model**
- **Development in China – dug-out dome systems**
- **Taiwan – low-cost plastic bag systems – George Chan**
- **South Africa and Soviet – redundant tank system**
- **DK and NL – factory type approach – vast operation experience in the operation of large systems.**
- **Realization that the low-cost approach is better. –**
- **Bundschuh in Germany – Preston in Colombia – VN and Africa.**
- **BTG – Costa Rica**
- **John Fry / Soviet approach in DK and Europe ??**

- **Alcohol production -**
- **Additive for diesel engines – 20-50%**

- **Substitute for petrol - increase compression – pay attention to plastics in fuel lines etc.**

- **Elsbett engines – efficiency 40% [normal petrol engine 26%]**
- **Cuba Biomass conference paper from GTZ – Nepal / Mali**
- **Proton – Palm oil**
- **WW, Mercedes, Lada, KAMAZ etc. – Mercedes 190 => under 4 ltr/100 km**
- **Elsbett BHKW – "Blok Heisse Kraft Werke" 180 kW – 41% el, 51% heat**
- **Orbital engine technology – Australia - two stroke engines – 25-30% fuel reduction**
- **Advanced Engine Technologies – radial engines – reduced number of moving parts – 50% fuel reduction**

- **Stirling engines**
- **James Stirling – Scottish priest about 200 years ago – burning occurs outside the cylinder. – similar to Ericsson engine**
- **Philips – for refrigeration compressors**

- **DTU – advanced – high rotational speed 35 kW CPH unit for 20-30 houses, using straw or wood-chip boiler. – 1½ kg wood/hr/house – total heat/power**
- **Solar-powered Stirling engine – 25 kW – space program.**

- **Transport**
- **Bicycle and pedal technology –**
- **Home-built generator from NZ – rewinding generators and alternators - Abfälle – Hugh Piggott -**
- **Oxtrike**
- **Chinese influence and old European steam plough - Rodale – agricultural plough / winch – 500 kg – pulling power**
- **Pedal operated tools from – American Village Institute**

- **Sail**
- **Fast fishing boats – Guatemala – Costa Rica. – instead of outboard motors – could use 2nd hand small diesel engines as in Thailand.**
- **Sail-freight – from DEA, - Univ of Southhampton, Hamburg and DDR.**

- **Sol-hybrid car**

Water:

- **Supply – end use – treatment /disposal , medium**

- **Small-scale hydro – Pelton wheel, Michel/Banki turbine – vast literature available from IT-books – example from Nepal**

- **Pumping – wind, solar, - deep pumping requires electrical motor pump**

- **Hydraulic ram pump – 250 year old technology – many firms very old. – f.ex. - Vulcan Rams in Somerset UK - in production since 1774**
- **High Lifter – USA, Glockemann-Peck – Australia**

- **Taps, shower-heads – 50% reduction in water consumption.**

- **Toilets – compost toilets, vacuum toilets etc. - urine separation toilets – problem with faeces contamination - urinal**
- **Siphon-systems**
- **Reed-bed systems – Jørgen Løjstrup in nature /oil treatment etc., greenhouse type systems – Jesper Saxgren – Kolding – not pyramid**
- **Tony Andersen – Vesterbro - Copenhagen**
- **Flowforms**
- **Ecological engineering – water treatment following George Chan – South China Dyke-pond system – Jarna – Sweden.**

- **Water for air conditioning – Hassan Fathy – "Natural Energy" and "Architecture for the Poor" - Iraq type air vents, Danish Aqua wall**

- **Wave power – UK – Japan – DEA – 5 finger approach - Risø**
- **2 main interesting types – offshore in connection with foundations for offshore MW wind turbines – Mono-pole construction – rotor blades, or bigger construction.**

- Coastal zone barrier protection – Bølgehøvl – Wave Plane, Wave Dragon – possibly in conjunction with smaller wind turbines [dangers of visual impact]

Construction:

- Old and new type methods of construction
- Hassan Fathy – renewed interest in Adobe
- Vernacular construction
- Straw-bale construction – Alice Reite/Rolf Jacobsen - Norway
- Ken Kern – USA – Owner-built home – etc. series of books
- Alice Reite and Frederica Miller – Levende Hus
- Harald Røstvik – sol
- Field Engineering – Peter Stern and Engineering in Emergencies - Jan Davis and Robert Lambert

Loose ends:

- Cool power – more efficiency in electrical motors – in electronic components

etc.

- **Floppy's – new forms for hydrogen/brint fuel-cells – 200 W from Materials research division at Risø.**
- **New simpler and cheaper forms of sol-cells**
- **Artificial burrs - Papanek**
- **Ørkenbille - water-system for desert areas**

New thinking – choice of technology ! –
FOT – Future Oriented Technology training program – see La Cour 1904.

Scenario's:
A:

- **Small town – app. 5000 pop. – isolated, - road / track**
- **Farming, some small hand-manufacture**
- **Semi-arid dry-land area / low rain**

- River flows app ½ year
- Fields higher than river
- Adequate – deep wells – year-round supply
- Low wind speed area
- Energy, construction and transport – suggest solutions

B:

- Smaller city – app. 200 – 300 Th - Province capital
- Tropical area
- Good rain and sun
- Road and river communications – 500 kms to capital and export harbour
- Moderate-Low wind speed – inland area
- Large local trade and mono-culture agro-export
- Small local production – metal industry and agro industry
- Suggest energy, power and transport

C:

- Refugee-camp for ½ million refugees in Eastern Europe / CIS – following war type situation – now quiet. – reasonable communications
- Continental climate
- Urgent need for hospital
- Urgent need for transport
- Urgent need for construction
- Lack of all material needs – plenty of local refugee manpower
- Suggest energy, power, construction and transport, => future possibilities / opportunities

D:

- Refugee-camp for ½ million refugees in Africa
- As above.
- 1: - Arid area 2: - Tropical area

To: Students and future colleagues
From: John Furze - 29 March 2003

Dear Students

Following from our short but useful afternoon last Thursday - and following from further discussions with several students after the lecture and during the "break" - some further information as requested:

Technology is EASY - is SIMPLE - and is ENABLING - and the raw construction material – [or usable "scrap" material or components] are often to be found almost everywhere.

The wheel has indeed already been invented - as was shown by my illustration/example of two near-identical low-cost wind-diesel de-central micro-grid power supply systems from 1907 and 2001.

However as I have emphasized, - "the correct approach" combined with the knowledge of "where to obtain relevant and applicable combinations of

“knowledge”” - is the KEY to understanding how to open the door [as indeed as in all cases and as in all walks of life].

1: The most interesting Finnish technology “inventor” with extensive experience as a “missionary” in Africa - that I mentioned several times concerning “development-technology” such as - water-carriers, “tree-saving wood-branch cutters”, very efficient old-container or metal-shed “charcoal-burners”, and valuable wood distillates, etc:
Pauli Rantanen – Mail: pauli.rantanen@eko.inet.fi - or to information secretary: Freija Ozcan - PL 100, 01301 Vantaa Finland Tel: + 358 [0]9 47 66 43 47

2: The charcoal process “waste-product” - wood distillate and very economical - “wood fuel gelly” for refugee situations (and camping - no Finnish motor-cyclist ever travels without his tiny “Tasku Keitin-Pieni Ihme” - from Falco minor Oy, Lahti !!!) - is called “TASKU NUOTIO - Sinol-poittogeeli/Sinol-brannvatskan” - further information can be supplied if required.

3: Please copy and make full use of the 12 CD’s and the 2 diskettes supplied: -

Not only will you find all the relevant "development documents" on the five Human-Info/United Nation's CD's and other CD's - but also - and especially on my four CD's all the relevant and necessary technical information required for "local and hand-made community, village and small-town" RE-related "equipment or devices" - making/construction and production and with the "enabling potential" leading to further industrial development of own national RE-technology - based on experience from many countries and many places.

NB1: CD-3 - concerning "The Integrated Farming System and Low-cost Agricultural Energy Systems" - is most relevant for an understanding of the inter-relationships between water supply, use and re-cycling, combined with the potential in other "waste-processes" etc etc..

NB2: Keep a good eye on the most interesting future developments from www.TINYTECHINDIA.com

in addition to the exceedingly useful discussion board from: www.otherpower.com

4: If in need of further assistance and/or if perhaps I am not available - please do not hesitate to contact two of my close colleagues and friends from the University of Jyvaskyla and from the TEP/TFL - Technology for Life in Finland.
Hannu Virtanen - hvirtane@cc.jyu.fi and Ari Lampinen - ala@cc.jyu.fi

5: Several students have requested my address and telephone number – these are as follows: -

John Furze - Holme Bygade 12, Holme nr. Ebeltoft, 8400 Ebeltoft DK
Tel/Fax: + 45 86 10 07 86
Mail: furze@post.tele.dk

6: Should any students have further queries, need assistance or help or wish to discuss further with me - kindly get in touch.

With greetings and best wishes - John Furze.

To: Prof. Salter - University of Edinburgh Scotland
Cc: Klaus Elsbett, Risto Isomaki
From: John Furze - 24 Feb 2007

Dear Prof Salter

I previously wrote a mail to you on 21 June 2004 - with regard to your good work concerning "spray turbines".
Unfortunately - my mail may have possibly been lost among the many mails you must have received following from your presentation in Crete in 2002.

In my previous mail - I mentioned the pioneering work done by the famous diesel engine and cold-pressed natural plant-oil-fueled diesel engine expert - Prof. Ludwig Elsbett - to whom I once had the great honour to be personally introduced by an old mutual friend - Ulrich Jochimsen from Flensburg [who recently received the German State medal - "BundesVerdienstKreuz" - for his services to society].

I am aware that it may have been a considerable surprise for you to learn that your very interesting work had in fact been pre-dated several years before - by previous pioneering work done, patented and published in magazines, articles, etc.

Likewise I can inform you that a recent best-seller-novel by a good friend and colleague from Finland - Risto Isomaki - and soon to be issued in Germany and several other countries - mentions and describes the wind rotor-type spray systems of Prof. Elsbett.

For your information I enclose a file including a copy of the original 1991 patent from Prof. Ludwig Elsbett. Herein you will note that the first page is taken from a 1995 magazine article - [in my own library].

You will also note that the last page of the file illustrates the suction-type operation principle of the Enfield-Andreau wind turbine - an interesting and more-or-less successful French-British design from the 1950's [and likewise fully described in my previous mail from 2004] - which I consider rather interesting in this context. Likewise I can also inform you that certain Chinese researchers following exchange of information are at present working on rather similar models.

As the present climate-situation and energy-situation is becoming more and more clear even to the highest circles in the United States of America - there is considerably more interest concerning such ideas as introducing moisture into the atmosphere and especially in arid zones.

I have recently returned from S. Asia - where several possible projects are now being considered - I truly believe it is necessary for all to consider how these ideas can be possibly jointly pushed forward for the benefit of all.

Therefore please consider this mail - as a message from friendly and cooperative colleagues

With best wishes - yours faithfully - John Furze

24 Feb. 2007 - Holme Bygade 12, 8400 Ebeltoft DENMARK

Dear Friends:

Please note that this non-commercial digital library you have just opened – is solely intended for the constructive & productive study & use by students, experimenters, production workers, research & production engineers & technicians, teachers, lecturers & professors, farmers, homesteaders, peasants & fishers, women's groups & other local groups, all working people everywhere & all other good folk & for political & administrative decision makers at all levels – concerned with the development of production potential & real development in all countries – everywhere.

The material contained in this extensive library – does not intend nor in any way imply any infringement of any of the copyrights of any authors quoted or included. Indeed the sole purpose of this library is to make available their work & their pioneer efforts to a wider public – & to those who really need & who can utilize this material the most.

This library has been developed from a series of 4 written compendiums originally specially made as lecture notes & reference files for my students, friends & colleagues in many different countries. Many requests were made for these original compendiums to be transferred onto digital media in the form of CD's. The original material filling 4 CD's has now been expanded into this comprehensive library - for the benefit of all.

This library would not have come into existence without previous great inspiration from many of my own teachers & with great encouragement from some of my very best students & younger colleagues & especially from dear friends & colleagues in Finland.

Likewise the library owes a great debt to many young masters students & many other friends & colleagues especially from Viet Nam, Cuba, Pakistan, Thailand, Eastern Siberia in Russia, Iran, Denmark, Germany, Mauritius, Burkina Faso & Cameroon. And likewise with great help from many other dear friends, colleagues & other progressives from the UK & USA. My deepest respect, regards & thanks to all these special students, friends & colleagues - from whom I have learnt & shared so much.

Notes concerning - CD reproduction quality, etc:

1: It is suggested & recommended that only good quality CD's - of at least - 700 MB [80 minutes] capacity be used in any copying process.

A: Several CD's contain slightly over 700Mb [however just under 80 minutes]
B: The United Nation's "Human Info" - CD's contain "compressed files".

2: Please note that in order to satisfactory access the above mentioned 5 United Nation's – "Human Info" CD's - it is advisable to first copy or "burn" each "CD-file" directly onto a 700 Mb new & blank CD. Thereafter it will be necessary to individually install these CD's - "individually install start/run program" on the computer hard disk. Likewise it is also advisable to install the original Netscape or MS Explorer browser programs included on these CD's - [if necessary onto a separate and distinct browser file – that is separate from the computer's normal standard browser program] in order to avoid possible or difficult & unnecessary read-out problems.

3: Certain files on these CD's were made during the 1980's - much effort has been spent in editing & revision in an attempt to make certain vital files more accessible. However you will note that many files may still retain different "formatting" etc symbols. However these original & un-revised files can be read with MS WordPad. The image files on these CD's - can be accessed using a mix of different programs such as Kodak Imaging – both these programs are found as add-ons included with the MS Windows program. In addition other good image reader programs such as Corel Photo House & QuickTime can be used. You may find that some image programs produce a different or better result on some illustrations than others. The revised files are formatted either as MS-Word, WordPerfect, Adobe Reader Ver's. 4, 5 or 7 [PDF], or as a Text-file.

4: The two CD's from the University of Tropical Agriculture in HCM City, Viet Nam – require a browser such as Opera, Netscape or MS Explorer. Video files can be viewed using Opera, QuickTime Movie Player or MS Video Player.

5: Many files in the library are of poor quality – this I regret - however this is often due to the careless reproduction & the condition of some of the digital material available to me. As mentioned above wherever possible considerable lengthy & often expensive efforts have been made in attempts to trace certain other copies & to attempt to rectify some of these defects. Other friends can further assist where or whenever a possible file may be found in a good or better condition – suitable for digital retrieval – thereby enabling better utilization by others now & in our difficult common joint future progress

With my thanks, my best wishes & my greetings to all.

John Furze – Denmark 2004-2005.

Subject: your spray turbines
From: Risto Isomäki <risto.isomaki@luukku.com>
Date: Mon, 19 Mar 2007 20:14:37 +0200 (EET)
To: s.salter@ed.ac.uk
CC: furze@mail.dk

From:
Risto Isomäki,
Secretary,
Coalition for Environment and Development (Finland)

Dear Professor Salter,

I am a Finnish science and science fiction writer and an environmental activist. I have been advising the Center Party of Finland (our prime minister's party) in issues related to global warming, environment and energy. I have also been involved with various renewable energy and agroforestry projects in South Asia (India, Pakistan, Bangladesh, Nepal) and in Southern and Eastern Africa, Brazil and Mexico for about 22 years.

John Furze, a British-Danish renewable energy consultant with whom I have been doing a lot of work related to India and Pakistan, told me that he has been in correspondence with you concerning your spray turbines. He said that you are now working also with another type of concept besides the Darrieus rotor. John said that he had also informed you about the somewhat similar proposal by Ludwig, Klaus and Gunther Elsbett.

I think that the Elsbetts were the first to propose some aspects of the idea. But you have definitely carried the work much further and I think you were the first to propose wind-powered spray turbines, the Elsbetts spoke about sprinklers fuelled by vegetable oil. To my knowledge you were also the first one to propose something like this as a way to combat rising sea levels. In any case I think that what you and the Elsbetts have suggested might be - together with the revitalization of the traditional water harvesting technologies - the cheapest and the best way to solve the sweet water crises which is now a steadily growing threat for litterally billions of people, especially if the global warming leads to a much increased evaporation of moisture from the soils and surface waters.

However, I am writing this to enquire, whether you already have produced any small prototypes of your spray turbines, and whether it would be possible to buy or loan one of them for a little bit different kind of experiments in Finland and Russia (and, possibly, in Sweden).

This may sound a little bit far-fetched but I think that it might be possible to utilise similar or almost similar wind-powered turbines also for making extra snowfall or supercooled water. This would most probably require that the noozle is heated so that the water does not freeze before it gets into the air in the form of fine mist, just like in your own and in the Elsbetts' vision. When salty sea-water is sprayed into the air as fine mist, when the temperatures are far below zero, snow flakes will be created. However, when the same is done with fresh water, with no condensation nuclei for the freezing process, all the tiny water droplets become supercooled water which only freezes when it hits something or drops down, after which it becomes ice. (This scenario applies if the temperature is below the freezing point of water but above minus 45 Celsius.)

I would be very interested in finding out, whether a wind-powered spray turbine could be used to make a large amount of supercooled water or snow, which could then be spread over very large areas by the wind. I have asked many inventors and companies in Finland whether they could make a spray turbine for such experiments, but they have been very hesitant to promise that they can make one!

My interest, here, is related to the melting of the West Siberian permafrost area and the floating ices in the Arctic Ocean and around Antarctica. According to the Russian researchers the whole West Siberian permafrost area has already started to melt, and the melting can no longer stop by itself, because the reflectivity of the area has been permanently reduced. The whole one million square kilometre permafrost region is now dotted with innumerable round meltwater lakes, and the dark swamp water of course absorbs sunlight efficiently, unlike the snow and ice which reflect most of the sunlight directly back to space before it is converted to heat radiation. Each of the lakes grows a little bit larger, every year, so the reflectivity of the area is being reduced further, continuously. Some of the lakes no longer freeze even during the peak of the winter because too much methane is bubbling up from the decomposing peat below. According to Euan Nisbet the region may already be producing as much greenhouse gases as the United States of America, if the climate warming potential of methane is calculated according to a very short temporal perspective. If the decomposition of the peat accelerates further and if the other permafrost areas in the arctic regions also start to erupt, we will be in a lot of trouble. The melting of the floating ices around Antarctica and in the Arctic ocean could be even more dangerous, because it now threatens to reduce the albedo of the whole planet by a few percentage points.

However, I think that it might still be possible to halt the melting of the permafrost region by surrounding it by a few thousand wind- or gravity-powered spray turbines - spraying a lot of fresh water into the air in the form of a fine mist - at the eastern edge of the Ural Mountains and at the western edge of the Central Siberian Plateau.

During the mid-winter it is good if there is not much snow on top of the permafrost because snow is a very good insulalor and the permafrost freezes deeper if there is no or only a little snow. However, if a lot of supercooled water would rain over the permafrost during spring when the sun begins to shine, again, this might be able to halt the melting of the region. The spray turning into supercooled water could be sprayed into the air during the nights when the temperatures are far below the freezing point of water. The supercooled water would freeze and create a reflecting layer on top of the swamp. In a way the process would mean collecting "cool" from large areas of surrounding air and transporting and storing it in the form of ice to exactly where it is needed.

There are hundreds of rivers and innumerable thousands of small brooks that are running from the Urals or from the Central Siberian Plateau towards the West Siberian permafrost region, so there should be more than enough fresh water streaming towards the right direction.

I know that it will take some effort to convince the Russians that something like this should be done, but we have already started, tentatively, discussions about the issue. Also, I have mentioned the idea in a novel ("Sands of Sarasvati") which will most probably also be published in Russian, soon, and which might help a bit in raising the issue. In any case I do not know any other means through which it might still be possible to halt the warming of the West Siberian permafrost.

However, it is not really possible to discuss the issue seriously with the government of Russia unless we can organize a very convincing proof-of-concept type of demonstration, first.

If we could use one of your prototypes in such a demonstration, this would most probably also promote your own ideas about producing rain in the world's dry areas with a similar method.

Yours sincerely,

Risto Isomäki

Proposal for a Training - Study Course in Renewable Energy.
For students with a minimum of 3 – 4 semesters prior study.

A: First Semester - Code word – HRAPS – Hybrid remote area power supply (as opposed to SHS – Solar Homes Systems):

- Renewable energy in general – but specializing in wind energy
- Hands-on micro wind turbines
- Aerodynamics and system dynamics
- Electricity and electronics – generator theory – rewinding etc.
- Small Hydro – motors as generators
- Solar – PV and thermal
- Markets, political issues, negotiations and agreements, etc.

B: Second Semester – Code word – Hands on training:

- Hands-on training with small – medium wind turbines 4–10 kW and 55–150 kW
- Erection, - elementary and advanced maintenance
- Remote monitoring and control
- Re-programming, etc.
- Theory and practice of AC- DC grids for national and local (micro) grid systems
- Electronics for switching gear / voltage transformation, etc.

NB: During this semester the students will study, work together and be integrated at the lab, shop floor and site as joint study groups with participants in a worker / tradesman job-retraining program.

C: Third Semester – Code word – Advanced/further specialized study:

- Advanced design and maintenance parameters
- Stress – vibration – destruction testing programs
- Computer analysis – further wind turbine programming
- Machine and mechanical engineering production
- Logistics – purchase, supply, delivery, maintenance
- Business, entrepreneurship and market relations
- Etc.

NB: This semester will be terminated by an exam in the form of a written project, as previously accepted and discussed jointly by faculty and students. The project will be orally presented and discussed before students and faculty prior to being finally reviewed and marked by outside censors
This project therefore has a time-frame of 3 semesters or 1½ years of study. As the students are expected to have at least 1½ - 2½ years of prior studies, this will result in a total study time of about 4 - 4½ years. It is expected that the students will either continue for further study in another perhaps related field, continue with a special research project in a special field of interest, or will leave the faculty with a high qualification level, attractive for possible job opportunities or self-employment.

To: Hans Erik Jensen
Statsbibliotek Århus

From: John Furze

Dear Hans Erik Jensen,

Thanks for a good meeting last week, as you requested, may I make the following suggestions for purchases for a special section or field of **" Energy -Environment - Development ".**
Of course, as you know this is **the** Danish speciality and a more complete understanding of the available different option-possibilities will in the future be an absolute requirement for everyone, - in most fields of work and study.

I have given much thought to this selection, and most of these titles are already in my own library.
Titles headed by **- "A".** are an absolute necessity, - don´t leave home without.
Titles headed by - **"B".** are a necessity in any larger library. -- There is no ranking order.

I have divided the selections into 6 areas:
1: "Background" - more comprensive broader texts.
2: Solar.
3: Wind.
4: Bio-energy.
5: Bio-gas.
6: Hydraulic-rams.

1: " Background "

A-1: Permaculture, Bill Mollison 1990, Island Press Washington DC. 1-55963-048-5
Copy available from Tony Andersen, Permakulturgruppen i Danmark, Istedgade 79, 1650 Kbh. V. Fax: 33 25 71 79 **[app: 350 Dkr]**

A-2: Energy from Nature, Catalogue from Rainbow Power Company, nr.1 Alternative Way, Ninbin NSW Australia. Fax: 61 66 891 109 **[app: $10]**

A-3: Solar Living Source Book, - [new edition every year] 0-930031-68-7
Chelsea Green Pub. Company PO-box 428 White River Junction Vermont 05001
Also- Real Goods Trading Corp. 966 Mazzoni St. Ukiah California 95482-3471
[app: $20]

A-4: Guide Book for Rural - Cottage and Small and Medium Scale Industries,
CeCeCo, 9-29 Matsugamoto-Cho Ibaraki, Osaka 567 Japan
Att: T. Kagawa, Managing Director **[app: $10]**

B-1: Design for the Real World, Victor Papanek 1971/1985 0-500-27358-8
Thames and Hudson, 30 Bloomsbury St. London WC1B 3QP **[app: £10-17]**

B-2: The Green Imperative, Victor Papanek 1995 0-500-27846-6
Thames and Hudson **[app: £15]**

B-3: Radical Technology, Godfrey Boyle and Peter Harper UK/USA 1976
UK - Wildwood House Ltd. London
USA - Pantheon Books, Random House Inc. New York 0-394-73093-3

B-4: Renewable Energy, Godfrey Boyle 1996 0-19-856452-X (hard cover)
Oxford University Press, Walton Street Oxford OX2 6DP
[The Open University Course-book] - [paper-back app: £20]

B-5: Appropriate Technology Sourcebook, Ken Darrow 1976/1993
(1976 edition from Volunteers in Asia Inc. Box 4543 Stanford California 94305)
1993 edition --- ISBN **“** 0917704177 **“** - available from:
IT-Bookshop 103-105 Southhampton Row London WC1B 4HH
Fax: 44 171 436 2013 **[app: £20]**

B-6: Biological Paths to Self-Reliance, Russel E. Anderson 1979 0-442-20329-2
Van Nostrand Reinhold Pub. 135 West 50th. Street New York NY 10020 USA

B-7: Field Engineering, Peter Stern (F. Longland) 1983/1993 0-903031-87-6
Intermediate Technology Publications Ltd, 103-105 Southhampton Row
London WC1B 4HH Fax: 44 171 436 2013 **[app: £25]**

B-8: Owner-built Homestead, **Barbara** and Ken Kern 1977 0-684-14926-5
Schribner Publishing. New York USA

B-9: Owner-built Home, Ken Kern 1972/1975 0-684-14218-X
Schribner Publishing, New York USA

B-10: Appraisal of Projects, ODA- Her Majesty´s Stationery Office London
1988 0-11-580256-8
HMSO PO-box 276 London SW8 5DT Tel. orders: 44 171 622 3316 **[app: £13]**

B-11: Field Directors Handbook, OXFAM 1985/1990 0-85598-073-7
OXFAM / Oxford University Press, Oxford UK **[app: £20]**

Plus: A years subscription to Home Power Journal, PO-box 520 Ashland OR 97520 USA
Fax: 916 475 0830 **[6 issues by air-mail to Europe -- app: $35-40]**

2: Solar

B-1: Solenergi. / The Sunshine Revolution, Harald Røstvik 1991/--
82-91052-01-8 / 82-91052-03-04
Sun-Lab Forlag, Steingaten 87, 4024 Stavanger Norway Fax: 47 51 52 40 62

3: Wind

A-1: Wind Power for Home and Business, Paul Gipe 1993 0-930031-64-4 (paper-b.)
Chelsea Green Pub. Company, PO-box 130, Route 113, Post Mills,
Vermont 05058-0130 USA **[NB: check address - see - 1:A-3] - [UK app: £25]**

A-2: How to build a Cretan Sail Windpump, R.D. Mann 1983/1992 0-903031-66-3
IT Publications Ltd. (see above) - maybe now out of print, - **[app: £7]**

A-3: Windpower Workshop, Hugh Piggott 1997 1-898049-13-0
CAT Publications, Machynlleth, Powys SY20 9AZ Wales UK.
- orders: Biblios, Star Rd., W. Sussex, RH13 8LD UK Tel: 01403 710 971
[app: £8]

A-4: The Home-built Dynamo, A.T. Forbes 1987 0-9597749-0-4
Forbes Publishing, PO-box 3919, Auckland, New Zealand

A-5: A Handbook on the use of Trees as an Indicator of Wind Power Potential,
E.W. Hewson, J.E. Wade, and others. 1979
NTIS, 5285 Port Royal Rd. Springfield Va 22161 USA.

A-6: Siting handbook for Small Wind Energy Conversion Systems,
NTIS, 5285 Port Royal Rd. Springfield Va 22161 USA **[app: $48]**

4: BioEnergy

A-1: Handbook of BioMass Gasifier Engine Systems, T.B. Reed
BioMass Energy Foundation, 1810 Smith Rd. Golden CO 80401 USA
Fax: 303 278 0560 **[app: $25]**

B-1: Construction of Simplified Wood Gas Generator, Harry LaFontaine 1989
BioMass Energy Foundation. **[app. $10]**

B-2: Global Collaboration on Sustainable Energy Development, Meyer, Nielsen 1991
Physics Laboratory 3, DTU Denmark 87-502-0721-0

B-3: BioEnergy for Development, Woods, Hall 1994 92-5-103449-4
FAO Environment and Energy Paper nr. 13, 1994
FAO, Viale delle Terme di Caracalla, 00100 Rome, Italy

5: BioGas Energy

A-1: Evaluation of the Impact on Womens Lives of the Introduction of Low-cost
Polyethylene Bio-digesters in Viet Nam, Mette L. Lauridsen 1996.
Institute of Political Science Univ. of Aarhus, 1996.
[a term paper - e-mail: <IDE@ps.au.dk>]

A-2: The Impact of Low-cost Polyethylene Tube Bio-digesters on Small Farms in
Viet Nam, Bui Xuan An 1996
Swedish University of Agricultural Sciences, Uppsala Sweden

A-3: Tubular Plastic Bio-digester, T.E. Simalenga and Bo Gohl 1996
FARMESA- SIDA- FAO, Harare, Zimbabwe
[Bo Gohl - e-mail <fspzim@harare.iafrica.com>]

B-1: Running a Biogas Programme, David Fulford 1988 0-946688-49-4
IT Publications (see above). **[app: £13]**

6: Hydraulic Ram Pumps

A-1: Hydraulic Ram Pumps, T.D. Jeffery, et al. UK 1992 1-85339-172-7
University of Warwick, Dept. of Engineering Fax: 203 418 992
IT Publications (see above). **[app: £13]**

In addition the list of the main titles which played a vital role in the resurgence of the renewable energy industry, - in the “ 4th. period “, and still not in any way “ dated “.

a: Other Homes and Garbage, Leckie et al. 1975 0-87156-141-7
Sierra Club Books, 530 Bush St. San Francisco CA 94108 USA

b: Energy, Environment and Building, Philip Steadman and The Academy of Natural Sciences of Philadelphia 1975 0-521-20694-4 (h-c) 0-521-09926-9 (p-b)
Cambridge Univ. Press, Trumpington St. Cambridge CB2 1RP, UK

c: Energy Primer, Portola Institute 1974/ -- 0-914774-00-X
Portola Inst. 558 Santa Cruz Ave. Menlo Park CA 94025, USA

d: Public Works, Walter Szykita (ed.) 1974/ --
Links Publishing, - New York and London.

e: Practical Building of Methane Power Plants, L.John Fry 1974 0-9600984-1-0
John Fry Publishing, 1223 N. Nopal St. Santa Barbara CA 93103 USA.

f: Homemade Windmills of Nebraska, Erwin Barbour USA 1898
Reprinted by: Farallones Institute, 15290 Coleman Valley Rd. Occidental CA 95465

g: Sol og Vind, Carl Herforth and Claus Nybroe 1976 87-87498-48-0
Informations Forlag, Copenhagen Denmark.

Plus the basic scientific texts for wind-energy:

a: Power from the Wind, P.C. Putnam 1948
Van Nostrand-Rheinhold, 450 West 33rd. St. New York, NY 10001 USA

b: The Generation of Electricity by Wind Power, E.W. Golding London 1955
Spon Publishing London UK
Philosophical Library, New York USA 1955

c: Wind-Powered Machines, Y. Shefter USSR 1972
Mashinostroyeniye Press Moscow, USSR
NB: --- [also available in a copy from NTIS- USA]

d: Aerogie - Windenergienutzung, Gerd Otto DDR 1989 3-910142-00-1
Aerogie-Verlag Postfach 8517, 1184 Berlin (E) - (Fließstraße 20 Berlin 1183)

e: The Theory of Wing-Sections, Ira H. Abbott and Albert E. Von Doenhoff 1959
Dover Publishers, New York USA

With best wishes

John Furze

Århus, - April 1998. Jens Munks Vej 7, 1. 8200 Århus N.
Tel/Fax/Voice: 86 10 07 86 <furze@post.tele.dk>

A: PRE-PROJECT DESIGN PARAMETERS.

Capitalism, Socialism and the Environment. Hugh Stretton,
Cambridge UK 1976. 0-521-29025-5 [DK 1978 87-17-02280-0] *

Applied Measures for Promoting Technological Growth.
Stanley A. Hetzler, RKP UK/USA 1973 0-7100-7502-2 *

The 5th. Discipline. Peter M. Senge, Doubleday USA 1990 0-385-26094-6 *

The 5th. Discipline - Fieldbook. P.M. Senge, Brealey Pub. UK 1994/97 1-85788-060-9 *

Technological Innovation and Organizational Change. F. Borum, P. Kristensen, DK 1989/90 87-7034-252-0 *

Appropriate Technology. Nicholas Jéquier [ed.] OECD Paris 1976[74] 92-64-11492-0 *

Liquidation or Consolidation of Indigenous Technology. Jens Müller,
Aalborg University Press DK 1980 87-7307-079-3

Design for the Real World. Victor Papanek, UK/USA 1971//85/92 0-500-27358-8 *
The Green Imperative - Ecology & Ethics in Design. V. Papanek, UK 1995 0-500-27846-6 *

Appraisal of Projects. HMSO London UK 1988 0-11-580256-8 *

Field Directors Handbook. OXFAM UK 1985/90 0-85598-073-7 *

Horizont Rundt. Haldor Topsøe, DK 1992 87-12-02318-3 *

The Economies of Rich and Poor Countries. May Volkov, Chris Jecchinis,
Lev Klochkovsky, Progress Moscow USSR 1990 5-01-001918-3

Economic Growth and Environmental Decay. Barkley, Seckler, USA 1972 0-15-518795-3

TANSTAAFL - Economic Strategy for Environmental Crisis. Edwin G. Dolan,
USA 1971 0-03-086315-5

Environmental ECOnomics. Turner,Pearce,Bateman, Harv.-Wheatsheaf Pub. UK 94 0-7450-1083-0 *

Bureaucrats in Power. Mikhail Lemeshev, Progress Moscow USSR 1990 5-01-002013

Dansk Vindmølle Industri. Peter Karnøe, DK 1991 87-593-0255-0 *

Forsøgsmøllen. H. C. Hansen, Dansk Udsyn Forlag DK 1981

Permaculture. Bill Mollison, Australia/USA 1990 1-55963-048-5 *

Herbicides in War. Arthur H. Westing, SIPRI Sweden 1984 0-85066-365-6

A: Extra Titles of Interest:

01: Owner-built Homestead. Barbara & K. Kern Schribner Pub. NY USA 1977 0-684-14926-5

02: Owner-built Home. Ken Kern NY USA 1972/1975 0-684-14223-6 / 0-684-14218-X

03: Levende Hus. F. Miller, A. Reite Teknologisk Institutt Oslo 1993 82-567-0659-7
[book, - video also available. (trans. - houses as living / responding entities)].

04: Natural Energy & Vernacular Architecture. H. Fathy Chicago USA 1986 0-226-23918-7

05: Shelter & Employment. UNCHS/ILO Geneva 1995 92-2-108523-6

06: Other Homes & Garbage. Leckie et al. USA 1975 0-87156-141-7

07: Radical Technology. Boyle, Harper UK/USA 1976 0-394-73093-3

08: Energy Primer. Portola Institute USA 1974 0-914774-00-X

09: Technological Self-Sufficiency. R. Clarke UK 1976 0-571-10835-0

10: The Power Guide. Hulscher, Fraenkel UK/NL 1994 1-85339-192-1

11: The Home-built Dynamo. A.T. Forbes Forbes Pub. Box 3919 Auck. NZ 1987 0-9597749-0-4

12: Eco-Tech. Robert S. de Ropp Delacorte Press NY USA 1975 0-440-02233-9

13: Freja 1974//75//77 Denmark 1974//75//77 87-418-4071-2 & 87-87555-028

14: Self-Sufficiency. J. Seymour UK 1973//76 0-571-09954-8 & 0-571-11095-9

15: Whole Earth Catalog. USA 1968//71//74//80//1994 394-73951-5 & 0-06-251059-2

16: Liklik Buk. Melanesian Council of Churches PNG 1977 0-86-935-0244

17: People's Workbook. EDA South Africa 1981 0-620-05355-0

18: Food. S. Szeczelkun Unicorn Press Brighton/Seattle UK/USA 1972 0-85659-006-1

19: Hydroponic Food Production. H.M. Resh Woodbridge Press USA 1978 0-912800-54-2

20: Organic Gardening under Glass. G. Abraham Rodale Press USA 1975 0-87857-104-3

21: Ferment. B. Mollison Australia 1993 0-908228-06-6

22: Sustainable Agricultural Systems. Edwards USA 1990 0-935734-21-X

23: Organic Farming. N. Lampkin UK 1990 0-85236-191-2

24: Fruit Biology. V. Kolesnikov Mir Pub. Moscow USSR 1966

25: Making Aquatic Weeds Useful. Acad. of Science. USA 1976 Lib. of Congress nr. 76-53285

26: Compendium in the Integrated Farming System - Vols. 1 & 2. Furze 1996/97

+ Agricultural & Machinery Catalogue. CeCeCo Ibaraki City Japan
+ Book Catalogue. Intermediate Technology 105 Southampton Rd. London UK

B: ENERGY. #

Solar:

A: Solenergi. / Sunshine Revolution [book, - video also available]. - Harald N. Røstvik, Stavanger, Norway/USA 1991 82-91052-01-8 / 82-91052-03-04 / Video - 82-91052-02-6
B: Pratical Photovoltaics. R.J. Komp, Aatec Pub. Ann Arbor Mich. USA 1981/82 0-937948-02-0
C: Strom aus der Sonne. Bernhard Krieg, Elektor Verlag Aachen Germany 1992 3-928051-05-9
D: Sol.tech.3-7723-7792-0/Sol.anlag.3-7723-4452-6/Sol.energ.3-7723-7932-X B.Hanus, De. 96/97
E: Thermische Solarnergie. Müller, Germany [De.] 1997 3-7723-4622-7
F: Compendium in Solar-cookers & Food-dryers. J. Furze 1996
1: SolEnergiCenter Denmark Tel: +45 43 50 43 50 E-mail - www.solenergi.dk
2: EDRC-Univ. of Cape Town S. Africa E-mails - edrc@engfac.uct.ac.za cha@engfac.uct.ac.za

Wind:

A: Forsøgsmøllen Rapport 1-4. Poul La Cour, Denmark 1900/1903
B: Wind Power for Home & Business. Paul Gipe, USA 1993 0-930031-64-4
C: Wind Power Plants. Hau, Germany 1997/98 3-540-57064-0
D: Windgeneratoren Technik. Hanus, Germany 1997 3-7723-4712-6
E: Wind-turbine Blade Design and Praxis. J. Furze, 1993/94
F: Compendium in Low-cost Wind-mills. J. Furze, 1993/95

Bio-Mass Energy and Fiber Technology:

1: a: Danish Energy Agency. b: Prof. H. Carlsen Danish Technical University .
c: S. Houmøller E-mail - houmoller@dk-teknik.dk d: Bio-Raf, Bornholm Denmark.
2: Prof. H. Stassen, BTG University of Twente Netherlands.
3: Huub J. Gijzen, IHE Delft University Netherlands. [University Cali Columbia]
4: Prof. T. Reed, Bio-Mass Energy Foundation Golden Co. USA. E-m. ReedTB@Compuserve.com
5: Prof. J.R. Moreira, NEGAWATT São Paulo Brazil.
6: Dr. A. Borroto, CEMA University of Cienfuegos Cuba.
7: Dr. P.R. Rogue, CETA University Santa Clara Cuba. E-mail - ceta@ucentral.quantum.inf.cu
8: Prof. R.H. Williams, Center for Energy & Environmental Studies, Princeton University USA.
A: Biological Paths to Self-Reliance. R. E. Anderson, Sweden/USA 1979 0-442-20329-2
B: Energie aus Bio-Mass. Flaig, Mohr. Germany 1994 3-540-57227-9
C: Bioenergy for Development. Woods, Hall. FAO-Rome 1994 92-5-103449-4

Bio-Gas Energy. - [Digesters]:

For Large Systems: - Danish Energy Agency. Copenhagen DK Fax: + 45 3311 4743
For Medium-size Systems: - "Danish Bio-Energi" Issue nr. 28/1996 p.10. - nr. 30/96 p.12. & nr. 32/97 p.10. E-mail - biopress@post4.tele.dk
- Prof. H. Stassen, BTG University of Twente Netherlands.
For Small Low-cost Units: - Prof. Zhong, Guangzhou Inst. of Geography China.
[Plastic-bag digesters, & Integrated Farming]. - University of Agriculture & Forestry, Thu Duc HCM City Viet Nam, <http//ourworld.compuserve.com/homepages/utaf> <100013.3330@compuserve.com>
- Dr. Bo Göhl FSP: E-mail - fspzim@harare.iafrica.com
- Dr. E. Murgueitio: E-mail - cipav@cali.cetcol.net.co
- Prof. Preston: E-mail - thomas.preston%sarec%ifs.plants@ox.ac.uk
- F. Dolberg: E-mail - frands@po.ia.dk
- Prof. G. Chan: E-mail - 100075.3511@compuserve.com

Wave Power:

1: Power from the Waves. D. Ross Oxford University Press UK 1997
2: Erik Skaarup, Wave Plane Int. Cph. Denmark Tel: + 45 3917 9833 / Univ.of Cork Ireland.
See: "Energi & Planlægning" June 1997 page 10. E-mail - sunmedia@dk-online.dk

Water-treatment Water-pumping - etc.:

1: Prof. Thomas L. Crisman, University of Florida Gainesville Florida USA
2: Prof. P. D. Jenssen, Agricultural University of Norway E-mail - petter.jenssen@itf.nlh.no
3: Beth Josephson, Center for Rest. of Waters Falmouth Ma. USA E-mail - bjosephs@mbl.edu
4: Angus Marland, Watershed Systems Ltd. Edinburgh Scotland Fax: +44 [0]31 662 46 78
5: Alexander Gudimov, Murmansk Marine Biological Inst. Russia E-mail - vladimd@fifo.hsf.no
6: François Gigon, NATURA Les Reussilles Switzerland Fax: +41 [0]32 97 42 25
7: Carl Etnier, Stensund Ecological Center Trosa Sweden Fax: +46 15 65 32 22
8: Prof. Ülo Mander, Institute of Geography Univ. of Tartu Estonia E-mail - ylo@math.ut.ee
A: Field Engineering. F. Longland - [P. Stern, ed.], UK 1936//93 0-903031-68-X
B: Mini HydroPower, T. Jiandong et al. UNESCO/John Wiley & Sons UK 1996 0-471-96264-3
C: Compendium in Hydraulic Ram-pumps. J. Furze, 1995

NB: It should be noted that a comprehensive multimedia6 program on renewable energy on 3 CD's, is issued by the Danish Technological Institute. E-mail - infove@dti.dk
- The Danish branch organization for heat and ventilation: CD - "Multi-Sol", showing mounting/assembly work processes for solar-collectors. http://www.vvsu.dk
- During 1998, a CD on access to wind-energy info. - should be issued under a common EU project, with as the coordinating Danish partner; - Handelshøjskole in Århus DK.
- A CD with a database on Renewable Energy is available from UNESCO-Publishing Paris.
- An energy/development CD-library is available from Belgium. E-mail - humanity@innet.be http://www.oneworld.org/globalprojects/humcdrom

Plus:

- Rainbow Power Company Catalogue, Ninbin NSW 2480 Australia. Fax: + 61 66 89 11 09.
- Catalogue from Real Goods Co. Ukiah CA 95482-3471 USA. Fax: + 1 707 468 94 86 E-mail - realgood@well.sf.ca.us
- Home Power Journal, Post-box 520 Ashland OR 97520 USA. Fax: + 1 916 475 3179.

Proposal for Immigrant/Refugee - Education and Training Program:
based upon the FOT-concept -- *Future Orientated Technology.*

Today there is a clear demand from the general public and from the Danish political side of the need to strengthen the possibilities of immigrants and refugees to be able to support themselves economically, and thereby remove them from a semi-permanent situation of passive social support. Likewise there is in these groups a need to strengthen their abilities and compentance to become independent entrepreneurs. This is an absolute necessity with regard to the realities of the present day situation, whether their future lies in Denmark, - in their previous homeland following possible self-chosen return or deportation, or in a completely different country.

With a following possible permanent residence in Denmark, a completed **FOT** course would enable a previous participant to immediately enter on an equal basis in almost every work-place, or give a good background for further future studies or training.

The **FOT** training program will be carried-out in the participants own maternal language; - Arabic, Tamil, Bosnisk etc. and Danish and especially English [All participants in each course, as far as possible, - the same ethnic background].

The **FOT** concept is based on three main factors:
a: Education / Basic science knowledge
b: " Research "
c: Production
The **FOT** concept is derived from what may also be called:
A: " The Danish Model " - as exemplified in the work of Prof. La Cour from Askov in the 1900's.
Likewise the studies made by certain Danish authors in the 1980's and 90's - Borum and Christiansen 1989, and Karnøe 1991.
B: " The Learning Organization " - Senge 1990 and Papanak in the 1960's.

Nobody can with any certainty know exactly what specific kind of special knowledge, technology or organizational form will be most applicable in the future, but some pattern indications are already clearly evident.
Who, ten years ago inside the educational or research field could expect that one of the most demanded spheres of knowledge today, is that of gasification technology. - Necessary knowledge in the field of de-centralized combined heat and power systems.
[the wind turbine industry or the trade of bicycle mechanic, could also be mentioned].

It is necessary to be able to work today to fullfill the demands and needs of the future.

The educational / training course process will be regarded as though it was on a normal Danish working place, with a complete, busy and intense working day, and with compulsory overtime.
It is proposed that the schedule should be composed of four blocks of four weeks each, plus one block of two weeks: - In all app. **775 hours**
If a further element of Danish language teaching is desired as an integrated part of the course, then the process in all will be of 5½ months duration - app. **950 hours**, with two hours of Danish pr. day.

All blocks will include the three elements of:
Education - " Research " - Production.

Objectives:

Access to local de-central energy is one of the most important factors for local development.

Local production of certain types of renewable energy equipment, for home/household use, the turist industry, or industrial use; - with limited use/supply of capital resources, opens the possibility for personel gain, and likewise for the establishment of local job-creation. This has been the Danish experience, and this has been the experiences of other countries such as Nepal or Turkey.
The most important factor in the production of energy equipment [or energy transfer equipment] is **" know-how "**, and the knowledge of knowing where or from whom further knowledge is to be found.

There are therefore three main aims with a course in the **FOT - concept.**
1: Should a participant return to his or her home country; - knowledge of **FOT** will enable him or her, to establish themselves as an independant entrepreneur in a socially benificial enterprise.
2: Should a participant remain in Denmark, knowledge of the possibilities given by the **FOT** concept, for socially benificial private and personal gain, will result in a private transfer of these de-central renewable energy technologies. [participant's knowledge will be transfered to members of their families or friends in their former homelands]. This will not only be benefical on a local-global basis but will also ease pressure on the need for possible future family immigration to Denmark.
3: A basic deeper knowledge of **FOT** will ensure that every participant is suited to proceed further in the Danish educational system, either as a participant in further labour-market qualification [SID - AMU training], or adult-apprenticeship training, or in further preparatory education in preparation for more further advanced studies.

It is selv-evident, that should an immigrant or refugee present himself, to a machine-shop, a building site or a factory, and he can demonstrate that not only can he use his hands, but in addition has a comprehensive theoretical/technical-practical knowledge; - this person is considerably more interesting from a job-related viewpoint for the enterprise in question, than otherwise.

The aim is therefore: From passive social welfare-relief to future oriented participation.

<u>Note:</u>
During the whole course process, there will be compulsory overtime; three evenings pr. week of two hours pr. evening.
This overtime will be used for the following subjects:
Entrepreneurship, IT-knowledge and accounting [each participant will receive their own notebook-PC], information search, library use, etc.
Following successful course completion, each participant will be allowed to purchase the PC at a very considerable discount.
Therefore following the course: The participant will be fully equiped for entrepreneurship in one of several rapidly increasing and gainfull enterprise sectors.

The course will be suitable for a group of 15 - 20 participants, - giving 4 - 5 work teams or study groups of 4 - 5 persons each.

Block 1: Carpentry - wood working
Metal working
Glass-fiber
Electricity - Electronics

Block 2: Gasifier technology for motors
Water and water-saving technology
Hydraulic-ram pumps, biological water treatment systems
Material-economic building construction

Block 3: Solar water heating, solar cookers, solar dryers
Low wind-speed wind turbines, sail wind mills
12 Volts wind generators, low speed generators, rewinding technologies and steering systems

Block 4: Course in Permaculture and design: 1 week
Pratical training at a solar collector factory: 2 weeks
Preparation for " examen - test ".

Block 5: Apprenticeship - exam: 2 weeks.

Alternative course with Danish language teaching 5½ months.

Block 1: Wood working
Metal working
Glass-fiber

Block 2: Electricity - Electronics
Gasifiers

Block 3: Water and water-saving
Material-economic building construction
Solar water-heating collectors, solar cookers

Block 4: Low wind-speed wind turbines
Low-speed generators

Block 5: Course in Permaculture and design: 1 week
Pratical training at a solar collector factory: 2 weeks
Preparation for examen

Block 6: Exam: 2 weeks

John Furze - Holme Bygade 12, 8400 Ebeltoft, Denmark
Tel/Fax: + 45 86 10 07 86 E-mail: furze@mail.dk

Relevant “hands-on” Renewable Energy Litterature - Wind, Solar & Liquid bio-fuels:
Possibly a usefull selection among many other good sources & titles & as added help-material to the subjects discussed on - http://www.otherpower.com “The Discussion Board”

Wind Energy -

A: Hands-on & background texts.

1: “Wind Power” - Paul Gipe - James & James Science Publishers Ltd. London, UK - 2004. ISBN:1-902916-54-9.
This is a very thorough and absolutely essential book.

2: “The Wind Power Book” - Jack Park - Cheshire Books, Palo Alto Ca. USA - 1981. ISBN:0-917352-06-8.
Jack Park has written other very useful books on wind energy - however this title is the book of choice.

3: “The Home-built, Wind-generated Electricity Handbook” - Michael A. Hackleman - Earthmind Press, Mariposa, Ca. USA - 1975. ISBN: 0-915238-05-5.
An essential and thorough book.

4: “The Homemade Windmills of Nebraska” - Erwin Hinckley Bardour - Nebraska - USA - 1899 - [reprinted by The Fallones Institute - Occidental, Ca.- USA - 1976]

5: “A Field Guide to American Windmills” - T. Lindsay Baker - University of Oklahoma Press - USA - 1985 - ISBN: 0-8061-1901-2.

6: “Windpower Workshop” - Hugh Piggott - Centre for Alternative Technology, Machynlleth, Wales, UK - 1997. - ISBN: 1-898049-13-0. - [http://www.cat.org.uk]
Plus: - The yearly editions of “How to build a wind turbine” - available from the author. [http://www.scoraigwind.com]

B1: Hands-on construction texts - Sail windmills & “American-type” farm windmills:

1: “Constructional Manual for a Cretan Windmill” - Niek van de Ven - Steering committee for wind energy in developing countries, Amersfoort, The Netherlands - 1977.

2: “Technical Report 1990 - WOT Diever 450"

3: “Constructional Manual for 12 PU350, 12 PU500 Windmills”

4: “ Technical Report 1982"- Niek van de Ven - TOOL/WOT -

Obtainable from WOT - Twente University of Technology, P.O. Box 217 - 7500

AE - Enschede, - The Netherlands.

NB: When ordering these books/manuals - insist upon - and ensure that the copy process of both the text and the drawings is as good as absolutely possible and that the photographs in "Cretan Windmill" are as good and as clear as possible !!!

The last title can also possibly still be obtained from The Regional Wind Energy Test Station, Institute of Engineering & Rural Technology, Allahabad, India.

Otherwise these three good books can only be accessed by borrowing from libraries or purchasing AND QUALITY CONTROL - by good contacts or friends in The Netherlands itself.

During the late 1970's-1980's - the "Australian Council of Churches" published a book-report concerning low-cost house construction and windmill irrigation projects near Saighanchi, Afghanistan. I have previously seen a copy of this book and note that a full set of drawings for the 12PU500 windmill are included with the text. Perhaps a good friend in Australia can find & recover a copy of this very good report & thereby make all of this usefull information available to others.

Likewise "The World's Council of Churches" in Geneva, Switzerland published in the late 1970's-1980's - the 80 page book "Pompe Eolienne - Sahores" [Sahores Windmill Pump - in French] - by Jean Sahores. After many attempts a hard-copy of this book is still untraceable. All the relevant archives in Geneva have been "cleaned-out" in connection with an office re-construction. If any friends discover an original hard-copy or can obtain a good & clear photocopy taken from an original hard-copy edition - kindly let me know.

5: "The Gaudgaon Village Sailwing Windmill" - William W. Smith III - VITA Publications , Arlington Virginia ,- USA - 1982.

6: "DIY Plan nr. 5 Sail Windmill [Cretan] - parts 1 & 2" - Centre for Alternative Technology, Machynlleth, Wales, UK - 1977. [http://www.cat.org.uk]

7: "How to build a Cretan Sail Windpump" - R.D. Mann - Intermediate Technology Publications, London, - UK. - 1983/1992 - ISBN: 0-903031-66-3.
This is a very comprehensive work - although possibly complicated as perhaps it deviates too far from the simpler models in Crete.

8: "Low-cost Windmill for Developing Nations" - Hartmut Bossel - VITA Publications USA - 1970/1977.
This is a classic text - well-suited for small metal workshops.

9: "WaterPumping Windmill Book" - Gary Hirshberg & The New Alchemy Institute. - Brick House Publishing, Andover Mass. - USA - 1982. - ISBN: 0-931790-23-9.
This is a very good and comprehensive book - based on previous work done by Marcus Sherman with the so-called Madurai wind pumps in India. [http://www.fuzzylu.com/greencenter/publist.htm]
Illustrations and a good short description of this NAI windmill will also be found in:

“Technological Self-sufficiency” - Robin Clarke - Faber & Faber Ltd. London, - UK - 1976 - ISBN: 0-571-11057-6

However those who are seriously interested in building a “Cretan-type” windmill - and who require further assistance or information - f.ex. photographs of the various necessary constructional details of the actual models on site in Crete, - which often considerably differ from those described in the available litterature, or with regard to other different litterature etc.- should write a letter and send by postal-mail to the following address in Denmark:
Danmarks Vindkrafthistoriske Samling: - For the personal attention of - John Furze. - Smed Hansensvej 11, Lem - 6940, Vest Jutland, Denmark.

Much wind energy technological information is deposited or archived with the DVS. This material will be available for all serious students to freely consult - “for the benefit of all” - in addition to the vast quantities of other material & know-how.

B2: Hands-on construction texts - low-cost small wind turbines under 1 kW.

1: “Windkraft - ganz einfach”, “Windkraft - ja bitte”, “Windkraft - echt stark” - Christian Kuhtz, - Oekobuch Verlag, Staufen - Germany [http://www.oekobuch.de].
These three low-priced booklets are full of drawings, photographs etc on every page - for the construction of cheap and simple wind turbines - they can easily be fully understood by all & are therefore very highly recommended.

2: Read the posts & the present & previous archives at [http://www.otherpower.com] - learn & then consult other colleagues & friends on the discussion board & through the links

B3: Hands-on construction texts - simple small wind turbines under 20 kW.

1: “The Penryn Windmill Book” - Patrick Arnoldi - Penryn Farm Peterborough, Ontario - Canada. - [http://www.windmillconstruction.com]
This book is a gold-mine of practical experience and good ideas.

2: “Windenergie - Praxis” - Horst Crome - Oekobuch Verlag, Freiburg - Germany. - 1987 ISBN: 3-922964-40-0
Unfortunately this book is now very hard to obtain, except from libraries in Germany - a later similar book by the same author is below.

3: “Handbuch Windenergie-Technik” - Horst Crome - Oekobuch Verlag, Staufen - Germany - 2004 - ISBN: 3-922964-78-8. [http://www.oekobuch.de].
These two books by Prof. Crome from the Technical University of Bremen, Germany - are very descriptive, lavishly illustrated and can be fully understood without too much difficulty by non-German readers - and although they badly need to be translated into English - they are however very highly recommended indeed.
The technology described in these books - as practiced by local cooperative working construction-groups & by his own students - is based on inspiration from the former Danish Agricco 20-40 kW induction generator - grid-connected wind turbines [with aerofoil blades] from 1919. These models

from 1919 were also produced under licence in both Germany and The Netherlands.

4: “Maine-built Windmills” - Everet Russell - Home Power Magazine # 79 Oct-Nov 2000, - USA - 2000 [http://www.homepower.com]

The famous book by Professor Poul La Cour & Jacob Bjerre - “Landlige Elektricitetsvaerker” - [in Danish] Copenhagen, Denmark - 1907. - should finally be mentioned for the record. This book fully describes the complete construction and installation etc of small automatic 5-20 kW de-central wind-diesel power systems for small farms and communities [with full battery and Hydrogen-gas back-up for energy storage]. This book had a great infulence on the development of de-central wind-energy power-generation systems in several European countries in the 1920's-1940's.

A full description in English together with diagrams - of the “La Cour” automatic wind-energy control systems, was published in the book - “Windmills & Wind Motors” - F.E. Powell - Camelot Press, New York - USA - 1910 - presently available as a reprint from Lindsay Publications - [http://www.lindsaybks.com]

C: Hands-on construction texts for horizontal rotors:

1: “Wind and Windspinners” - Michael Hackleman - Earthmind/Peace Press Publication, Mariposa Ca. - USA - 1974/1977.

2: “Savonius Rotor Construction” - Jozef A. Kozlowski - VITA Publications - Arlington Virginia, - USA - 1977 - ISBN: 0-86619-062-7
Several of the minor errors and faults in Hackleman’s comprehensive good book are covered & rectified by Kozlowski.

3: “Der Savonius Rotor - Eine Bauanleitung” - Heinz Schulz - Oekobuch Verlag, Staufen, Germany - 1989/1999 - ISBN: 3-922964-48-6. [http://www.oekobuch.de].
This book by the former director of the State Agricultural-technology Research Institute of Bavaria - packed with fully detailed construction drawings is absolutely essential for those contemplating the construction of large and powerful horizontal-rotors & is very highly recommended.

Solar Energy:

A1: Solar Thermal - background etc:

1: “Golden Thread” - Ken Butti & John Perlin - Cheshire Books - Van Nostrand Publishing - New York - USA - 1980 - ISBN: 0-442-24005-8.& - 0-917352-07-6.
This book - based on an article originally published in “The CoEvolution Quarterly # Fall 1977" - should be in all libraries everywhere.

2: “Solar Living Sourcebook” - Real Goods Company - Chelsea Book Publishing, Vermont - USA. - ISBN: 0-930031-68-7 [http://www.realgoods.com].

3: “Energy from Nature” - Rainbow Power Company - Nimbin - Australia
[http://www.rpc.com.au].

A2: Solar Thermal - hands-on:

1: “Solar Homes & Sun Heating” - George Daniels - Harper & Row Publishers - New York - USA - 1976 - ISBN: 0-06-010937-8.

2: “Passive Solar Water Heaters” - Daniel K. Reif - Brick House Publishing, Andover Mass. - USA 1983 - ISBN: 0-931790-39-5.

3: “Sunshine to Dollars” - Steven E. Harris - USA 2003
[http://www.KnowledgePublications.com].

4: “Thermische Solarenergie” - Friedrich Udo Muller - Franzis-Verlag, Feldkirchen - Germany - 1997. - ISBN: 3-7723-4622-7. - [http://www.amazon.de]

5: “Solaranlagen” - Heinz Ladener & Frank Spate - Oekobuch Verlag Staufen - Germany - 8th fully revised edition 2003. - ISBN: 3-922964-94-X.

6: “Solaranlagen Selbstbau” - Armin Themessl & Werner Weiss - Oekobuch Verlag, Staufen - Germany & Arbeitsgemeinschaft Erneurbare Energie, Gliesdorf - Austria.
ISBN: 3-922964-73-7 [Germany], &: 3-901425-09-8 [Austria].
[http://www.oekobuch.de, & http://www.aae.at]
This book is the fully-illustrated course-notes for the very successfull home-owners self-build solar-thermal construction courses in Austria and other countries and is very highly recommended.

7: “Solarwarme Optimal Nutzen” - Wagner & Co.- Colbe - Germany
- ISBN: 3-923129-36-X. - [http://www.wagner-solartechnik.de]
This is a good comprehensive construction & installation manual from Wagner Solartechnik & is also very highly recommended.

8: “Manuel pour la conception, le dimensionnment et la realization des installations collectives” - Download from ADEME [Agence de l’Environnement et de la Maitrise de l’Energie - France April 2002. - [http://www.tecsol.fr/st_fr/manuelSol.htm]

9: “Home Power Magazine” - [http://www.homepower.com].

A3 Photovoltaics -for experimental use:

1: “Practical Photovoltaics” - Richard J. Komp - Aatec Publications - Ann Arbour Mich., USA. - ISBN: 0-937948-02-0. - [http://www.bookstep.ie/bks/showbk2.php?bookid=578]

2: “Strom aus der Sonne” - Bernhard Krieg - Elektor Verlag, Aachen, - Germany 1992.-
ISBN: 3-928051-05-9. - [http://www.amazon.de]

3: Home-made “Fruit-Jam” & Titanium oxide solar cell - [http://www.solideas.com/]

4: “Homemade Solar Cells” - [http://www.fuelless.com]

:5 “Home Power Magazine” - has many good & thorough articles concerning medium & larger PV systems - likewise consult among others - [http://www.solarenergy.org]

Liquid biofuel technology & conversion systems for diesel engines - [not including various forms of alcohol fuels - such as ethanol or methanol nor algae-technologies etc.]:

1: “From the Fryer to the Fuel Tank” - Joshua Tickell - [http://www.JoshuaTickell.com] ISBN: 0-9707227-0-2.

2: “Mecanique des Fleurs” - Reseau Petales - C/O Roule Ma Fleur,- Fraissinet de Lozere, 48220 France - [roulemafleur@free.fr]

3: “Pflanzenol als kraftstoff” - Barbara Eder & Franz Eder - Oekobuch Verlag, Staufen - Germany - 2004. - ISBN: 3-936896-05-4. - [http://www.oekobuch.de]

4: “Die Energie Insel” - Wolf Rudiger Weiss - Germany Available from [http://www.conrad.com]

5: “Handbook of Agricultural Energy Potential of Developing Countries” - James A. Duke - CRC Press, Boca Raton, Florida - USA - 1987 - ISBN: 0-8493-3640-6

6: “Biological Paths to Self-Reliance” - Russel E. Anderson - Van Nostrand Reinhold Publishers - New York - USA - 1979 - ISBN: 0-442-20329-2

7: “Energy Plant Species” - N. El Bassam - James & James Science Publishers, London - UK - 1998 - ISBN: 1-873936-75-3.

8: “Edible Nuts of the World” - Edwin A. Menninger - Horticultural Books Inc. - Stuart, Florida - USA - 1977 - ISBN: 0-9600046-4-5

9: “The book of Edible Nuts” - Frederic Rosengarten Jr. - Walker Publishing Company, New York - USA - 1984 - ISBN: 0-8027-0769-9

All these books are highly recommended - plus consult - [http://www.journeytoforever.org], “Home Power Magazine” & other sources - etc.

Hvorfor ! [Know Why].

1: Progress for a Small Planet. Barbara Ward 1979.

2: Alternative Technology and the Politics of Technical Change. David Dickson 1974.

3: The Green Imperative. Victor Papanek 1995.

4: Design for the Real World. Victor Papanek 1971 / 1984.

5: Capitalism, Socialism and the Environment. Hugh Stretton 1976. [DK 1978].

6: Soft Energy Paths. Amory B. Lovins 1977.

7: Gaviotas - A Village to Reinvent the World. Alan Weisman 1998.

Hvorfor => Hvordan ! [Know How].

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CHAPTER 1. INTRODUCTION

In last decade energy production from renewable energy sources has become increasingly important on the political agenda and the renewable energy sources have been awakened from a sleeping beauty position. The comeback of energy from renewable sources should be considered as a consequence of the bigger awareness about environmental deterioration world wide caused by issues such as global warming and air pollution.

Renewable energy production is considered as cleaner and more sustainable energy, and therefore often seen as a solution to the environmental problems caused by conventional energy sources (coal, oil, gas). However, in a truly sustainable development also the adverse environmental impacts from renewable energy sources have to be taken into account.

It is therefore our intention to make a holistic analysis of the impacts from renewable energy sources. By holistic we mean an analysis that includes descriptions of the benefits, the adverse environmental impacts as well as solutions and mitigations to the impacts. We have chosen to emphasise the adverse environmental impacts, because in our opinion they are often overlooked on the political agenda. It is our goal with this project to contribute to a more balanced public debate.

Environmental impacts in our project should be understood in a broad sense. By this we mean that we take into consideration the physical, chemical and ecological impacts on the environment as well as socio-economic activities.

For the purpose of our project we define renewable energy sources as ”*the term used to cover those energy flows that occur naturally and repeatedly in the environment and can be harnessed for human benefit. The ultimate source of most of this energies are mainly the sun, also the gravity and the earth's rotation”* (Godfrey, 1996).

We have focused on four types of renewable energy: wind power, hydropower, solar energy and biomass, because we consider these to be the most important sources that are also technologically well established.

The context in our project is the European Union because there we are witnessing a change from oil, gas and coal as energy production back to renewable energy sources, due to increased awareness about the environment. We think that the EU constitutes a natural choice for our investigations because of the united political framework.

The project start with a brief historical outline and a sketch of the current energy situation in which we have included analysis of global warming and the sustainability concept used in the EU. This is followed by a study of the future situation.

Chapter 3 consists of analysis of wind-, hydro-, solar- and biomass-power including a discussion of benefits, adverse environmental impacts and mitigations/solutions to these impacts.

In the last chapter there is an outline of the general benefits and impediments from renewable energy sources followed by a ranking and a comparison.

CHAPTER 2

2.1. A brief history of energy use.

The use of energy sources other than the human body has characterised human cultures for thousands of years, utilising traditional sources such as wood, biomass, animal power and wind as objects for transport, production and for human comfort (Boyle,1996).

The change to the present intensity of fossil and nuclear fuel use began with and was an intimate part of the Industrial Revolution. Technical inventions such as the steam engine and later on the development of electricity and the internal combustion engine provided transport and growth bases for industrial production. First coal and later oil and gas was introduced to the market, and by mid twentieth century the spread of distribution networks for electricity further increased the industrial production. Since the 1950´s the industrial countries have relied heavily on use of fossil fuels, especially oil, for production, manufacturing, communication, construction, foodgrowing and processing and many other activities (Boyle,1996).

The electricity and energy production in the twentieth century has been almost completely dominated by fossil fuels and to a lesser extent nuclear power and hydropower[1]. The rate of energy consumption has multiplied by a factor 30, so that world energy demand in 1980 was 8730 million tonnes of oil equivalent (Houghton, 1997).

Up until the 1970´s renewable energy was considered as minor declining energy source, while huge oil and gas fields were continuously discovered, distribution networks were improved and prices for oil were low. To sum up cheap, convenient and abundant energy supply encouraged

[1] Hydropower generation has been the only renewable energy source that have been used on a large scale since mid twentieth century. Overall it is estimated that it has contributed about 20% of the electricity production although in some countries the percentage is much higher (Eg. Norway, with 99%)

an optimistic-passive political approach in Europe using huge amounts of oil/coal produced energy and neglecting renewable energy sources. (IEA, 1998). In this type of policy and practise the environmental impacts from energy production were not given many considerations.

Only the oilcrises in 1973-74 and 1979 changed this approach. Then suddenly the vulnerability to oil-supply disruptions were realised in the European Governments and more attention was paid to make research and development within the renewable energy sector, in order to secure a diversity of sources and thereby higher energy security. However, as oil supply was re-established and the price once again stabilised in the beginning of the 1980´s, interest diminished and once again renewable energy sources had low priority on the political agenda in governments and in international policy and investments decreased significantly (IEA, 1998a).

Recently concerns about pollution from fossil fuel-based power generation have become the driving force in rehabilitation of renewable energy power generation and this has caused a significant change in growth rates in energy use.

2.2. The current situation in energy supply

The total world consumption of primary energy, in all of its forms, was in 1997 estimated approximately 9.6 billion tonnes of oil equivalent (toe) per year (Brown et al., 1999). As mentioned above and according to table 2.1., there is a possibility to see an obvious change during the twentieth century in energy supply.

Table 2.1. Total energy supply from different energy sources

	1900		1997	
Energy Source	**Total** (mtoe)	**Share** (%)	**Total** (mtoe)	**Share** (%)
Coal	501	55	2122	22
Oil	18	2	2940	30
Natural gas	9	1	2173	23

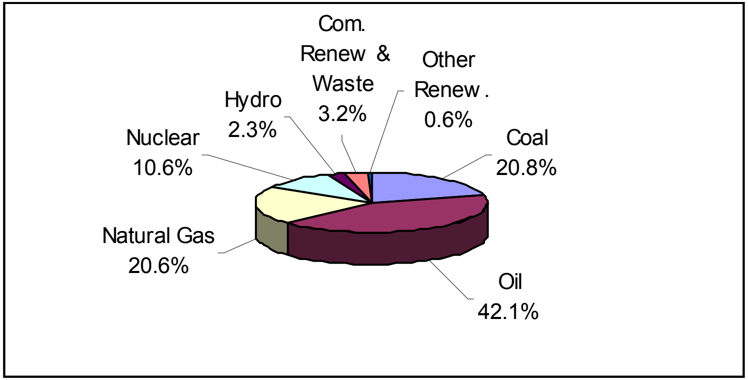
Nuclear	0	0	579	6
Renewables	383	42	1833	19
Total	911	100	9647	100

Source: Brown et al., 1999

Nowadays the main energy sources are fossil fuels. Oil, coal and natural gas provide 75% of energy worldwide and the higher share is in most industrial countries. The most important energy source in the world is oil (about 30% of total energy supply), followed by natural gas (23%), which emerged as an environmentally preferred energy source for many uses. The former the most important world energy source - coal - has maintained an important role in power generation and holds a 22% share of total energy use. Nuclear power is much less used (around 6%). Use of renewable energy sources (biomass, hydro, wind, solar, and geothermal energy) accounts for about 19% worldwide. But this share is first of all caused by using of biomass in the form of traditional fuel in developing countries. In the industrialised countries there is a much smaller share of renewables (Brown, 1999).

The higher emphasis on using fossil fuel, which is seen in industrialised countries, is demonstrated by the Figure 2.1. This figure expresses energy supply by the source in all the OECD countries, but it applies also very similar fuel shares to the European OECD countries.

Figure 2.1. Estimated energy supply by sources in the OECD in 1997.



Source: IEA,1998.

The use of different energy sources varies enormously from country to country within Europe, and has changed rapidly over the past few decades. The present differences can be showed on examples such states as United Kingdom (dependence on coal), Norway (most of electricity is from waterpower) and France (a large extent of nuclear power).

These differences are also in using of renewable energy sources (RES). The use of renewable energy sources is depended on resource availabilities (suitable conditions and location for the certain type of renewable energy source), on energy prices, and in particular on national energy policies, which are connected to specific measures taken in promotion of RES in national level (IEA, 1998). With reference to the various renewable energy sources, biomass/wastes and hydropower are the main RES in the EU. Biomass/wastes is the most important RES in the EU, especially in producing heat. The use of this source is predominantly in the form of firewood consumption in households, although wood waste burned in industry as well as municipal solid waste incineration contributes significantly. Hydro- power is the second largest renewable energy source in the EU, but it is the biggest producer of electricity. Wind-power has also started to play an important role for a few last years, especially in some countries such as Denmark, Germany, Spain and the Netherlands (Boyle, 1996; IEA, 1998).

Renewable constitutes a growing percentage of energy production also because of increased awareness about global warming.

In the late 1980s the atmospheric scientists were the first in make sound the alarms about greenhouse warming and the climate change (Hempel, 1996). After the first alarm, and with still not total agreement in the scientific community, nowadays we can say that the increase of the average temperature on the Earth's surface is real. The increase of the most concentrated of the gases, the carbon dioxide, is due to human activities such as the burning of fossil fuels and deforestation. Therefore the consequence of using fossil fuel as the main energy supply is the climate change.

"The basic principle of global warming can be understood by considering the radiation energy from the sun, which warms the Earth's surface and the thermal radiation form the Earth and the atmosphere which is radiated out to space. On average this two-radiation streams must balance. If the balance is disrupted (for instance by an increase in atmospheric carbon dioxide) it can be restored by an increase in the Earth's surface temperature". (Houghton, 1997).

The natural greenhouse effect, due to the greenhouse gases (such as; H_2O, CO_2, CH_4, N_2O) keep the Earth about 35 °C warmer that it would be without them, and therefore the Earth's average temperature is 15°C. However the increase of human emitted greenhouse gases (such as CH_4, CO_2, N_2O, CFC´s) has changed the incoming solar radiation and the outgoing heat radiation. The consequence is the enhancement of the greenhouse effect (Kuemmel, 1997).

Still there are important disagreements at the greenhouse debate between scientists; but there is also scientist consensus for major claims about global warming as:

<u>At global level:</u>

- At projected emission rates, concentration of greenhouse gases will be doubled by the year 2050.
- This will result in a 1-4°5 C rise in mean global surface temperature.
- It will cause a rise in sea level of up to 2 meters in the next 100-200 years.

- Warming oceans surface can accelerate evaporation rates that could amplify greenhouse effect.

At regional level:

- Warming at the poles will be higher than at the equator.
- Total precipitation will increase, and also regional droughts
- It can change regional vegetation and therefore the balance in ecosystems
- The Antarctic ice sheet can melt in a few centuries. (Hempel, 1996).

Human use of fossil fuel produces nearly 7 billion tons of greenhouse gases every year. In the pre-industrial era the concentration of CO_2 was 280 ppm but the current concentration has increased until 350 ppm (Boyle, 1996), and the increase of global mean surface temperature is from 0.3 C to 0.6 C in the last 100 years (Houghton, et al 1990). The consequence of using fossil fuel is not only the global warming but also acid rain, and damage of the seas by the transport of oil. All this environmental damage enlarge the interest in expanding the use of renewable energy sources.

As a result the interest in renewable energies has grown during the last years, renewable energy has been seen as a possibility to solve the environmental problems of the use of fossil and nuclear fuels. (Boyle, 1996).

2.3. Towards Sustainability

The host of environmental problems we are witnessing today--such as the continued relentless deterioration of the natural environment and the global warming have caused increased focus on the environmental policies in the European Union. The environmental problems were first recognised in the 1970´s but the first many years of environmental policy was rather incidental and not very effectual (Hildebrand, 1992). In the beginning of the 1990´s it became generally recognised that new measures had to be taken in order to improve the green policies. Ideas and principles were adopted from the international environmental agenda such as the work of the World Commission on Environment and Development (The Brundtland Commission, 1987), and the United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro 1992. One of the most important adopted principles was the concept of **sustainable development**. (Fifth Environmental Action Programme, Towards Sustainability,1992)

Today the Brundtland commissions definition is often used to delimit the concept sustainable development: *"It is development which meets the needs of the present without* *compromising the ability of future generations to meet their own needs*" (Fifth Environmental Action Programme, Towards sustainability, 1992). It basically means that where the overall goal is continued economic and social development, this should not worsen the environment or restrict future generations need for resources. The sustainability concept breaks with the former development concept understood strictly as economic growth. One could say that it encourage a more holistic thinking, including the environment in economic thinking and vice versa. It also favours integration of environmental considerations into different sectors such as industry, energy and agriculture. (Fifth Environmental Action Programme; Towards sustainability, 1992)

In the European Union the idea of sustainable growth as a guideline to institutional and organisational decision-making was introduced in the 1992 Maastricht Treaty (§2) and later same year, the Fifth Action Programme proposed a number of actions to improve the environment through a sustainable approach. The programme paid special attention improvements in the sustainable management of natural resources and reduction in the consumption of non-renewable energy. (Fifth Environmental Action Programme: Towards sustainability, 1992)

While The Action Programmes are not legally binding it is still our clear opinion that it operates as background for many directives on the environment. (e.g. the IPPC directive).

In our opinion the sustainability approach, and the holistic thinking as informed basis for decision making as well as the integration principle, including among others the energy sector in the environmental considerations, are important aspects of European policies today. Renewable energy types in this framework are considered more sustainable than conventional energy production, and therefore encouraged by politicians.

As a result renewables have a favourable position. And they should have- in our opinion! But it is important to recognise that the concept of sustainability is by no means transparent. There is an ongoing discussion on the accurate meaning of the term-e.g. how much does the future generations need to meet their demands? As there are no clear definition the criteria for sustainable development could be bent by different interest groups.

While we recognise the weaknesses and the possibility for political manipulation we still think that sustainable development is more than a simple catchfrase. The introduction of the concept in the European Treaty is one example. However it should not be used as a opportunity to rest and take no further actions. Therefore renewable energy sources should be scrutinized for adverse environmental impacts and mitigations should be found in order to obtain true sustainability.

2.4. Future scenarios

The world consumption of energy in 1997 was about 9.6 billion tones of oil equivalent per year (toe) (Brown et al., 1999). Current knowledge of proven recoverable reserves indicates that known reserves of fossil fuels will meet demand for the period up to 2020 and substantially beyond. Around mid-century, if demand continues to expand, oil and gas production will come under increasing pressure. Further exploration will be stimulated which will lead to the exploitation of more sources, although increased difficulty of extraction can be expected to lead to a rise in price. As far as coal is concerned, there are operating mines with resources for production for well over a hundred years.

At current rates of use, reserves of oil and gas are likely to be available for 100 years and of coal for more than 1.000 years (Houghton, 1997).

The energy sector is dominated by our consumption of non-renewable fossil sources of energy and emission from using and consuming them burdens the atmosphere and the environment in general. Consideration of the global environment calls on us to use renewable energy and to use all energy efficiently, while utilisation of fossil fuels is to be reduced. At the same time, this will contribute to lower energy costs. Less use of fossil fuels will also make the energy supply system more robust by reducing the vulnerability in a situation in which world market prices for energy rise as it happened during the oil crisis in seventies (IEA, 1997).

All tendencies point in the same direction – cross-border environmental problems are becoming tomorrow’s challenge in energy matters. At the same time energy market is developing at full speed. Today's plans should be made for an energy future in which the traditional resources of energy will be under growing pressure from the aspects of environment and supply. A lot of attention and effort will be put to develop and to utilise renewable energy resource because they offer substantial environmental benefits compared with conventional energy technologies. But a host of players are involved in the future of renewable energy. These include government decision-makers (devising and implementing policies and encouraging technology transfer), private industry and utilities (developing and using renewables), financial institutions (funding appropriate projects), universities and national laboratories (undertaking effective, goal oriented research and development – D&R) and the public at large (creating a demand trough expression of informed opinion). Each market sector, and in some cases each renewable energy technology itself, has a set of key organisations, institution and industrial interests which determine, or at least influence, the pace at which a new technology moves in the market place (OECD/IEA, 1997).

Most recently, renewable energy received important backing from the Kyoto UN Climate Change Conference in December 1997. The greenhouse gas emissions reduction targets of the Protocol imply that, once the Protocol is ratified, developed countries will pay particular attention to renewable energy because of it's great potential for reducing global greenhouse gas emissions (IEA, 1999).

There are about 6 billion people on our planet today. World population is assumed to grow from about 6 billion now to 12 billion in 2100, with more than 90 per cent of this growth in the developing countries (Houghton, 1997). Together with growth of population energy demand can be expected to increase. But it is very difficult to estimate future energy demand next century and how it can be met. Any attempts are involved with dubious accuracy. No one really knows how human beings will behave or what political, institutional or technical changes may occur. But there are few estimations made by World Energy Council (WEC), International Energy Agency (IEA), United Nations and European Commission.

The World Energy Council is an international non-governmental organisation with representation from all parts of the energy industry and from over 90 countries (Houghton, 1997). The Council has developed two energy scenarios for the period to 2020, each representing different assumptions in terms of economic development, energy efficiencies, technology transfer and the financing of development round the world. These scenarios (Table 1.2.) take into account likely population growth and energy sources and a realistic view of the rate of technical change.

The business-as-usual scenario assumed continuation of existing trends (e.g. low fossil fuel price increases, steady increases in energy efficiency, modest increases in penetration of renewables, etc). Under these assumptions, the new renewables (biomass, geothermal, small-scale hydro, solar and wind) are expected to grow at an increasing annual rate. This ranges from 3 % per annum in 1990-2000 to 4,8 % per annum in 2010-2020. Large-scale hydro grows at steady rate of 2,5 %. All renewables together would comprise about 25 % of the global electricity production predicted for that year and about 21 % of the expected world energy demand in 2020 (IEA, 1998).

Table 1.2. : Some characteristics of the WEC scenarios out to the year 2100.

		Business-as usual scenario		**Ecologically driven scenario**	
	1990	**2050**	**2100**	**2050**	**2100**
Global energy demand (Gtoe)	8,8	27	42	15	20

Fossil fuels (% of primary energy)	77	58	40	58	15
Nuclear (% of primary energy)	5	14	29	8	11
New renewables (% of primary energy)	2	15	24	20	50
Annual CO_2 emissions from fossil fuels (Gt carbon)	6,0	14,9	16,6	7,3	2,5

Source: Houghton, 1997.

The ecologically driven scenario assumed faster and more extensive penetration of renewables caused by greater cost reductions for renewables, enhanced environmental concerns, and higher cost of fossil fuels, etc. The growth is assumed from 6,5 % in 1990-2000 to 7,8 % in

2010-2020. All renewables together would comprise about 45 % of the total, global electricity output for that year and about 30 % of the predicted world energy demand in 2020 (IEA, 1998).

The IEA assumption suggested that within OECD countries utility of new renewable sources (excluding large-scale hydropower and “traditional” biomass use) could rise substantially to 2010 with an average growth rate between 7 % and 8,6 % per annum. “New” renewables will still only contribute around 2 % to OECD electricity supply by 2010. OECD electricity supply from hydro power is expected to decline from 16 % to 14 % by 2010 due mainly to lack of sites where exploitation would be acceptable to the public. A significant increase in using biomass is expected to stem from increased use of industrial and municipal waste for energy production. But significant changes in government policies or technological break-throughs would be necessary to significantly increase this share of renewables in energy supply (IEA, 1997).

CHAPTER 3.

3.1. WIND ENERGY

3.1.1. Introduction

Wind energy was one of the first non-animal energy sources to be exploited by early civilisations. The static exploitation of wind energy by means of windmills is thought to have been going on for about 4000 years.

Windmills were traditionally used for milling grains, grinding spices, grinding dyes and paintstuffs, paper making and sawing wood. ‘Modern windmills’ tend to be called wind turbine, partly because of their functional similarity to the steam or gas turbines that are used to generate electricity, partly to distinguish them from their traditional forebears. They are also sometimes referred to as wind energy conversion energy systems (WECS) and those used to generate electricity are sometimes described as wind generators or aerogenerators (Boyle, 1996).

The variety of machines that has been devised or proposed to harness wind energy is considerable and includes many unusual devices. There are various types of machines that have been proposed over the years. Apart from few innovative designs, modern wind turbines come in two basic configurations – horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT) (www.risoe.dk/vea-wind/history.htm-24/05/2000). Today only a very small fraction of wind turbines of VAWT type is in operation. The HAWT turbines can roughly be classified in five technical characteristics. First, the rotor can be placed upwind or downwind. Second, the number of blades can be any number from one and up. Third, the output regulation provides that the generator does not produce more power than designed for. Fourth, the hub can be connected to the rotor in two ways. It can either be a rigid bolted connection or a hinged connection – as so-called teetering hub. Fifth, the rotational speed of the rotor can be either fixed relative to the frequency of the grid or it can be variable and the frequency can be controlled by power electronics. For machines not connected to a grid (e.g. water pumping wind roses) variations in the rational speed is less important (www.risoe.dk/vea-wind/history.htm-24/05/2000).

The majority of modern wind turbines are electricity generating devices. They range from small turbines that produce a few tens of hundreds of watts of power to relatively large turbines that produce 1 megawatts (MW) or more. Wind turbines with lower power ratings, below approximately 100 kilowatts (kW), are usually referred to as 'small scale'. Wind turbines between approximately 100 kW and 700 kW power ratings are called 'medium scale' and wind turbines above approximately 700 kW are referred to as ‘large scale’ (Boyle, 1996). Currently, medium scale wind turbines are the most viable commercially, although both small- and large-scale machines may become more viable with improvements in technology and in the means of manufacture. Larger than 1 MW, multi-megawatt wind turbines have also been built but these have almost been research prototypes.

The vast majority of wind turbines produced at the present time are horizontal axis turbines with three blades, 15 – 30 m in diameter, producing 50 – 350 kW of electricity (www.iclei.org/efacts/wind.htm-08/05/2000). These turbines are often grouped together to form “wind farms”, which is defined as a cohesive group consisting of 8 or more single turbines, or to form “clusters”, which is defined as 4–7 wind turbines (Tangestue, 1996). Fewer wind turbines can either be in the form of a single turbine or in the form of arrangements in pairs or threes. Wind farms and clusters usually provide power to an electrical grid but wind turbine technology can be grouped also in other types of applications (www.risoe.dk/vea-wind/history.htm-24/05/2000).

3.1.2. Benefits

Environmental advantages of wind power utilisation are almost obvious. First of all, wind power has none of the greenhouse gas and acid gas emissions, which result from the combustion of fossil fuels such as coal, oil and natural gas, the traditional sources of electrical power. Similarly, wind power does not result in the risk of radioactive problems associated with nuclear power plants.

Second, electricity from wind turbines has no liabilities related to decommissioning of obsolete plants. Today, most metal parts of wind turbines can be recycled. In a very near future other parts, such as electronics and blades, will be recycled almost in 100 %(www.risoe.dk/vea-wind/history.htm-24/05/2000).

The use of wind energy reduces dependency on conventional fossil and nuclear fuels what improve security of energy supplies. In the longer term, it would maintain cost-effective, environmentally sustainable energy supplies. The cost of wind energy equipment fell steadily between the early 1980s and the early 1990s. The technology is continually being improved to make it both cheaper and more reliable, so it can be expected that wind energy will tend to become more economically competitive over the coming decades (IEA, 1998-Appendix D).

Additionally, wind turbines do not require water supplies, unlike many conventional (and some renewables) energy sources.

3.1.3. Adverse Environmental Impacts

Wind energy development has both positive and negative environmental and social-economic impact although those impacts are principally local in nature and scale. The scale of its future implementation will rely on successfully maximising the positive impact whilst keeping the negative impacts to the minimum. The main environmental impacts that have been identified for wind energy projects are ecological impacts and involved with that noise emissions (it also can be qualified as social problem), life cycle emissions, bird strike and disturbance. As social-economic impact we can regard visual intrusion, moving shadows, land use, electromagnetic interference, and accidents.

3.1.3.1. Noise emissions

The dominant source of noise is from the operation of the turbines although noise also appears from turbine manufacture, transportation and construction. Operation of the turbines emits two major types of noise: aerodynamic and mechanical (IEA, 1998-AppendixD).

Aerodynamic noise is generated by the passage of air over the moving blades. The result of that is described as a “swishing sound”. It is affected by the shape of the blades, the interaction of the air flow with the blades and the tower, the shape of the blade trailing edge, the tip shape, whether or not the blade is operating in stall conditions, and turbulent wind conditions. The “swishing sound” is made up of a wide range of frequencies. It is thought that a number of processes are involved in aerodynamic noise: discrete frequency noise due to the rotation of the blades, broad band noise due to the variety of blade self-induced mechanism and noise due to the turbulent inflow of the wind. The primary discrete frequency of a turbine is well below of threshold of hearing and higher harmonics are generally less significant (IEA, 1998-Appendix D).

Aerodynamic noise will tend to increase with the speed of the rotation of the blade trough the air. For this reason, some turbines are designed to be operated at lower rotation speeds when wind speeds are low. Noise nuisance is usually bigger problem in light winds than at higher wind speeds, when the background wind noise tends to mask wind turbine noise. Operating at lower rotation speed will help to minimise any aerodynamic noise problem in low wind condition (Boyle, 1996).

Mechanical noise can be generated by all of the moving parts in the nacelle, (e.g. the generators, fans and auxiliaries), but the major source of the noise is usually gearbox. The noise levels depend on the quality of construction. Such noise comprises many distinct tones that contrast with natural sounds. The noise is emitted directly and via the rest of the structure, including the tower, with the latter mechanism being dominant in some cases (IEA, 1998-Appendix D).

Whilst the total noise is due to the sum of mechanical and aerodynamic noise, most complaints about wind turbines seem to relate to mechanically generated noise, specifically when the noise has a strong tonal component. However, fieldwork indicates that, where machines emit noise within their design specification, there are not any problem at nearby houses. To date, many of the complaints associated with the noise from wind turbines have been attributed either to lack of appreciation at the design stage of the importance of the designing for low noise or else to defects in components or manufacture. These problems have generally occurred where wind farms have been constructed rapidly and not subjected to extensive commissioning tests (IEA, 1998-Appendix D). Modern turbines should not suffer from these problems. Noise can also be a problem for certain topographies, for example when wind turbines are situated on the top of the hill with dwellings on the lee side. Such dwellings have reduced background noise levels and so they will be subject to greater perceived noise increments from the turbines (IEA, 1998).

The potential impact of a noise source depends upon a number of factors which include: the level of emissions relative to the background noise, the nature of the noise (tonal and broad band content), site characteristic (topography) and meteorological conditions. These factors affect together propagation, the number of people exposed to the noise source, individual tolerance of noise in general and attitude towards the development. Therefore, the impact of noise is extremely site specific (IEA, 1998-Appendix D). In cases of inappropriate siting, impacts have occurred and these have resulted in considerable public opposition.

The noise generated from wind turbines is much less than that from other industrial activities and as such, it does not normally come into the regime covered by national regulations. As a comparison, there is a Table 3.1.

Table 3.1. Noise of different activities compared with wind turbines

Source/Activity	**Noise level in decibels (dB)**
Threshold of pain	140
Jet aircraft at 250 m	105
Pneumatic drill at 7 m	95
Truck at 40 km/h (30 mph)at 100 m	65
Busy general office	60

Car at 64 km/h (40 mph)	55
Wind farm at 350 m	**35-45**
Quiet bedroom	20
Rural night-time background	20-40
Threshold of hearing	0

Source: (Boyle, 1996).

The basic processes involved in noise dispersion have been evaluated, and sounds level can be estimated using simple equations or more complex models. Such work has shown that large noise increments are likely to affect only isolated properties sited close to the developments. Noise increments at distances of 1,5 km are generally less than 2 dB, even for a large wind farm. Experience has shown that there is unlikely to be a significant noise problem for residential properties located further than 350-400 m from the nearest turbine (IEA, 1998-Appendix D). In general, wind turbines are not especially noisy compared with other machines of similar power rating (Table 3.1.1). However, there have been incidents that wind turbine noise has been cited as a nuisance.

3.1.3.2. Life cycle emissions

Although wind turbines produce no atmospheric pollutants during operation, there are emissions involved in other part of the life cycle. The most significant are those associated with the processing and manufacture of materials and components for the wind turbine. The total emissions from these stages have been calculated for a range of different wind turbines within the UK, German and Greek and values from the German and UK assessments are shown in Table 3.2.

Table 3.2. The total emissions from processing and manufacture of materials and components for the wind turbine.

Emission	German data[2]			UK data[3]		
	Tonnes per turbine	Tonnes per MW	G/kWh	Tonnes per turbine	Tonnes per MW	G/kWh
CO_2	69	276	6,46	190	475	9,1
SO_2	0,16	0,6	0,015	1,8	4,5	0,087
NO_x	0,22	0,9	0,020	0,8	2,0	0,036
Particulates	0,05	0,2	0,005			
CH_4	0,22	0,9	0,020			
N_2O		0,003	6,7			

Source: (IEA, 1998-Appendix D).

[2] These values are derived from the specific examples (ISET, 1995) for a 250 kW rated machine with a 20 year lifetime, based on German emissions data.
[3] Tese values are derived from the specific examples (Eyre, 1995) for a 400 kW rated machine with a 20 year lifetime, based on UK emissions data.

Both sets of values include the emissions arising from the manufacture and construction of turbines, foundations, power conditioning components, transformers and the generator and the grid connections. The life cycle emissions are around two orders of magnitude lower than those from conventional coal fired power generation.

The exact emission values will vary according to the individual turbine and power rating chosen, and the capacity factor which is assumed. Table 3.1.2 represents typical life cycle emissions. But there is some variation between machines of different design, in general the weights of components for a machine of typical commercial size are broadly consistent. The main differences in the emission values thus arise from the differences in generating mixes and fuel characteristics in the countries considered rather than variations in turbine manufacture (IEA, 1998-Appendix D).

3.1.3.3. Bird strike and disturbance

The impact of wind turbines on birds can be divided into: direct impact including risk of collision and effect on the breeding success, indirect impact including effect caused by disturbance from the wind turbine (noise and visual disturbance) (www.risoe.dk/vea-wind/history.htm-24/05/2000). The disturbance effects of wind turbines fall into three categories: disturbance to breeding birds, disturbance to staging and foraging birds, disturbing impacts on migration/flying birds.

The major potential impacts on birds are behavioural disturbance (e.g. from construction activities, from the physical presence of the turbines) and collision with rotating turbine blades. The effect of disturbance on bird population is thought to be very small and most attention has focused on the effects of bird strike. However, despite recent concerns, there is little evidence that win turbines pose a substantial threat to bird life. UK studies concluded that there is little reason to expect collisions for resident bird species in good visibility conditions. Indeed, the Royal Society for the Protection of Birds reported that there was no measurable impact from the large (3 MW) experimental wind turbine in the Orkney Islands on their nature (IEA, 1998-Appendix D). In conditions of poor visibility (e.g. bad weather and night time), there would be low number of species around typical wind farm locations. There have been concerns regarding migratory species, due to unfamiliarity with the turbine sites, but is thought most birds fly well above the heights of even the largest turbines (IEA, 1998-Appendix D).

More extensive studies, in area with a high density of water birds in Europe (in Netherlands), have also found similar results. The mortality was less than one victim per turbine per season. A three-year monitoring study in UK, at the wind farm also reported the similar level of bird strike per turbine. Such studies indicate that the numbers of birds killed are comparable to that from other human activities, in particular from road transport (IEA, 1998-Appendix D).

Isolated examples have been reported of significant damages on specific species such as The Tarifa wind farm in the Cadiz Region of Southern Spain occupying hills above the Strait of Gibraltar or The Altamont and Solano wind farms in California. The wind farm in Spain is sited on a major migratory route across the Mediterranean Sea and there will be very high numbers of migratory birds at certain time of the year. This has influence on possible high mortalities, especially on certain species, such as storks and raptors. In California the most severely affected species were raptors. These birds tend to use the open lattice towers as perches for sighting prey and because of their selective concentration on the prey during hunting (IEA, 1998-Appendix D).

The above examples are exceptional cases. The experience of these two sites should teach us the importance of assessing projects prior to development. This is particularly important where there are rare raptor or other threatened species (IEA, 1998-Appendix D).

Other flying species can be affected including bats (their sophisticated sensory systems should prevent collisions), non-vertebrate species (may be less possible for them because of their size) (IEA, 1998- Appendix D).

If not properly prepared, wind farms sited in coastal zones can disturb breeding and resting birds. Typically, an effect has been recorded within 250-800 m, with the highest sensitivity for geese and waders. Professional knowledge of birds and wind turbines in a planning process of wind farms can solve this problem (www.risoe.dk/vea-wind/history.htm-24/05/2000).

Overall, the risk of collision between turbine blades and birds is minimal both for migrating birds and for birds from local habitats. However, in ecologically sensitive areas or areas designated for their ornithological value, developments should be carefully examined (IEA, 1998-Appendix D).

3.1.3.4. Visual impact

The other main impact of wind farms is on visual amenity, with the main visual impact coming from the physical presence of wind turbines. Visual intrusion and noise are very close connected and extremely site specific. They depend on a number of factors such as: the physical size of the turbine, the distance from the turbine to the receptor, the numbers and design of the turbines, the layout of the wind farm, indigenous population density within the zone of visual influence, the number of visitors, the landscape type and availability of alternative unspoiled areas, etc. There have been understandable concerns over the potential visual impact of siting developments in designated areas of scenic importance (e.g. National Parks) and it is clear that such sites should be avoided. The predominantly rural, open space character of wind resource area could be significantly altered by a wind energy development. In analysing the effects on visual amenity it is necessary to distinguish between the actual visible image and human responses to it. The burden of the visual image of the turbines falls on observers in the line of sight of the wind farm. Beyond 20 km, the turbines will not be visible to the human eye. In practice, there are very small or negligible effects on visual amenity beyond 12 km. Between 6-12 km, the towers are indistinct and the rotor movement will be visible only in good conditions. Therefore, the visual amenity effects are generally concentrated within 6 km of the wind farm. Wind farms located on a ridge or in the open countryside may be visible from most directions. For turbines sited on a hillside, the wind farm is likely to be obscured from at last one direction. In all cases, vegetation and buildings will reduce visibility further (IEA, 1998-Appendix D).

It is clear that attitudes to wind energy are likely to affect aesthetic judgements about visual amenity. Some surveys indicate that public attitudes to the visual impact of wind farm may not be negative and there is evidence that there is only minority who believes that wind turbines spoil the scenery in a typical location. Deployment experience has shown reduced perception of visual amenity impacts where the local community can see the benefits of the scheme, either from directly using wind energy or from seeing existing fossil fuel station displaced. Conversely, it is thought that the visual burden is greater if the turbines are still, as the observer does not perceive their usefulness. There are indications that the public is more hostile to other similar structures which offer fewer environmental benefits or which cause irreversible changes in land use (IEA, 1998-Appendix D).

In summary, visual impacts are only normally important for residents and tourists up to a distance of about 10-km, with the main effects on amenity being concentrated within a few kilometres of the wind farm.

3.1.3.5. Moving shadows

Wind turbines can also produce a “shadow flicker” effect from the sunlight streaming past the rotating turbine blades. This will have a visual impact-affecting amenity. The precise effect in a given situation would depend on topography, siting, the number of generators in the immediate area and the proximity and size of population (e.g. resident, visiting or otherwise present) which would potentially be affected.

There have been concerns over the possible stroboscopic effects of the flicker and the potential danger to epileptics. However, this latter impact is extremely unlikely and stroboscopic effects are minimised by keeping rotation rates below 50 r.p.m. for three-bladed machines and 75 r.p.m. for two-bladed machines. The flicker effect has only a short potential duration each day and depends on a number of other criteria (e.g. distance-effect would be minimal at distances greater than 300 m) (IEA, 1998-Appendix D). Therefore, this is unlikely to have significant impact unless buildings are within this range.

3.1.3.6. Land use

The amount of land occupied by wind machines at a particular site depends upon their number and spacing. Individual wind farm turbines are separated by 5-10 diameters, in order to reduce interaction effects. The total area of the wind farm can thus be considerable. The level of impact depends on whether the land can be used between turbines. There are numerous examples of agricultural practices continuing in wind farm areas and evidence suggests that neither wild nor domesticated animals will be affected. Additionally, at the end of the operational lifetime, the foundation can be reused and the site restored to its original condition at low expense.

The land used for the siting of wind farms may lead to the loss of natural habitats or agricultural land. The importance of this loss depends on the agricultural, forestry or recreational value of the land. In less intensively farmed land (e.g. upland pasture or forests) or non-agricultural areas, there may be impacts on unmanaged ecosystems. The long-term loss of the land (from e.g.

turbines, ancillary buildings and access tracks) and the temporary construction activities could affect terrestrial ecosystems. Construction activities have the greatest potential effects. However, these are generally small and reversible, with rapid recolonisation of the disrupted land from the surrounding system after work has finished (IEA, 1998-Appendix D). The only exceptions are where access road lead to increased intrusion and where there are very fragile ecosystems. Construction activities could also lead to erosion of exposed soils after removal of vegetation and this erosion could have water quality impacts and thus implication for aquatic life (ECC, 1994). For areas of recreational importance, they may be some loss in amenity. This is most likely to result from the effects of visual intrusion of the turbines on recreational activities (e.g. hiking, etc.). However, in some cases, this can be seen as a recreational benefit.

Land use may have more important effects in areas of archaeological importance or high conservation value but permission for siting on such land is likely to be controlled.

3.1.3.7. Electromagnetic interference

Wind turbines sometimes give rise to interference with microwave communications links and also with television transmission, due to the metal rotors reflecting radio waves. This affects all forms of electromagnetic communications to a greater or lesser extent depending on frequency and location of the turbine. Microwave interference will only occur if the turbine is directly in the line of transmitter and receiver station and may be easily avoided with careful siting. Interference with radio and television frequencies can occur at distances of up to 2-3 km around the turbine and be more difficult to control. The magnitude of impact depends on factors such as a distance between wind turbines and transmitter, the existing reception conditions of the area, the number of residence affected, and the location of airports, emergency services and other agencies relying on radio communications (ECC, 1994).

3.1.3.8. Accidents

Any incremental development may give the reason to occupational and public accidents. Occupational accidents can occur at all stages of the wind fuel cycle but recent studies indicate that the greatest area of impacts will arise from manufacturing, construction and transportation phases (EIA 1998-Appendix D). Accidents involving the public are extremely unlikely. There is a very small risk of an accident if part or all of turbine blade detaches from the turbine whilst operating. At high turbine speeds, this could result in the blade being projected over significant distances. In practice, this would be unlikely to reach nearby houses (if sited properly to minimise other impacts), unless detachment occurred as a result of overspeeding. Under such conditions, it is possible that a blade fragment could travel 700 or 800 m (EIA, 1998-Appendix D). However, such an event is extremely unlikely. There is no known occurrence of injury to a member of the public due to the operation of wind turbines (EIA, 1998-Appendix D).

3.1.4. Solutions

The public concern is rooted in the fact that environmental advantages of wind power is on a global or national level, whereas, the environmental disadvantages of wind power is on local or neighbourhood level, associated with the presence and operation of wind turbines (www.risoe.dk/vea-wind/history.htm-24/05/2000). Then, the mitigations should be taken at local level.

The UK government's recently released planning guidelines for renewable energy projects. And this is the main stage at which the most of adverse impact can be solved. The appearance of a wind farm should be simple and logical to avoid visual confusion while at the same time underlining the character of the man-made element. The evaluation of the visual expression of the wind farm is subjective. But it can be based on commonly known and accepted architectural design principles such an order and repetition visualised in lines, perspectives and space in an overall landscape composition (Tangestue, 1996). Additionally, the visual impact of turbines can be mitigated by tree planting or similar screening close to the observer (IEA, 1998-Appendix D). Furthermore, the selection of certain colours, structures and layout of turbines can help to minimise intrusiveness. Provided care is taken in site selection and turbine layout, and careful planning conditions are enforced, the true visual impacts of wind energy schemes are generally small and extremely localised. What is important, they are also reversible and opposition to such schemes can be further reduced by involvement of the local community, at the planning stage and trough participation.

Through proper planning, also the effects of moving shadows and electromagnetic interference can easily be predicted and avoid. Furthermore, the effect of moving shadows can be alleviated by installation of blinds (IEA, 1998-Appendix D).

The proper sites of the wind farm must not be ignored. It should be avoided to site wind farm in high visible value, important natural scenery or high historical or archaeological value areas. Existing planning regulations will in most cases have a strong influence on the deployment of wind turbines in sensitive areas. It can mitigate remarkably the environmental impact on birds, partly noise problem, erosion, etc. The examples, where sites have been inappropriately chosen (the Tarifa wind farm in Southern Spain, Alamont and Solano in California), only proved how important the planning stage is.

The adverse impact involved with land use can be easily solved. The area actually occupied by wind farms is relatively small comparing to the area used for biomass. The level of impact depends on whether the land between turbines can be used (e.g. for different types of agricultural production). There are a lot of examples of agricultural use the land between wind turbines. Secondly, the wind farms can be sited offshore. However, there is visual impact of that. But the visual consequence of locating wind turbines offshore are different from those related to locating them on land. Characterised by the obstructed view, offshore turbines can be seen over great distances, depending on the visibility and light conditions. At the same time, it is difficult to estimate distances across the water. From a long distance, even large wind turbines will seem small in relation to the open great field of vision created by the sky and open sea (Tangestue, 1996). However, there are not a lot of residents or visitors who can be disturbed by visual impact of offshore wind turbines.

The nuisance caused by turbine noise should be mitigated at the design stage. Wind turbine manufacturers have lessened the mechanical noise of larger wind turbines by isolating the gearbox from the nacelles and installing sound deadening insulation. The aerodynamical noise of wind turbines of all sized was cut by sharpening the trailing edges of the blades and employing new tip shapes. These new quieter wind turbines can be good neighbours when sited with care (Gipe, 1993).

3.1.5. Conclusion

Wind energy is being considered as a viable alternative energy source, with the objective of reducing the harmful effects of conventional electric power generation. Wind energy is thought as clean and safe. Wind turbines do not produce green house gases. Wind energy has no liabilities related to decommissioning of obsolete plants. The energy invested in the production of a typical wind turbine has a “pay-back” time of less than half a year of operation (www.risoe.dk/vea-wind/history.htm-24/05/2000).

On one hand, in many countries the public in general favours renewable energy sources such as wind power. On the other hand, deploying a wind farm in a local community sometimes raises local resistance due to the neighbours uncertainty and negative expectations about the wind turbines. The public concern is often about environmental effects of wind energy and is rooted in the fact the environmental advantages of wind power is on a global or national scale, while, the environmental burdens of wind power is on a local scale (as it was said earlier). In conclusion, the adverse impact of wind energy cannot be classified as high environmental impact, compared to other energy sources. In industrialised countries public acceptance of wind power is often the most important planning restriction and consequently also political issue (www.risoe.dk/vea-wind/history.htm-24/05/2000). Environmental regulations continue to transform the planning and operation of electric utilities, wind power is becoming increasingly attractive.

3.2. HYDROPOWER

3.2.1. Introduction

In this part we shall first give a brief description of the energy source, its different technologies and benefits. Thereafter we analyse the adverse environmental impacts in detail and present solutions and mitigations to some of the problems. The chapter ends with some considerations about the sustainability of large hydropower schemes.

Hydropower is an ancient technology that has been used as a natural source of energy for many hundreds of years. It has made a substantial contribution to the worlds electricity supply since the 1940´s. Construction of large-scale hydroschemes began after the II world war, and today it is a well-established and mature technology, which is deployed extensively world-wide. It is also the only renewable energy source that have up until now been used on a major scale for electricity production. The World Energy Council estimates that the installed large-scale hydro capacity in 1990 equalled about 20% of the worlds installed electric generating capacity (a production of 2200 TWh). 97% of the hydrogenerated electricity is produced by large-scale hydro schemes (IEA, 1998-Appendix F).

It is estimated that the technical exploitable hydroelectric potential might be as high as 10000-20000 TWh annually, or about 10 times the current production. However a number of different practicalities such as how accessible the water resources are, whether they are economic viable and how acceptable they are from an environmental point of view influence this technical assessment, and in reality the potential is lower. In Europe most suitable sites for large hydropower schemes are already developed, whereas there is a potential for small schemes.(IEA, 1998-Appendix F)

3.2.1.1. Different types of hydroelectric schemes

Hydropower schemes use the kinetic energy in running or falling water to produce electricity. Water from a river is allowed to flow through turbines that transfer it into electricity. The power generated is proportional to both the volume of water and the vertical distance through which it falls (the head)[4]. Most hydro schemes do have a structure, e.g. a dam that redirects stores or otherwise concentrates the energy in flowing water. (IEA, 1998, appendix E).

The size of our project does not allow a full scale technical description of different hydropower schemes. The following brief outline of different types of hydroplants is included to give the most basic background knowledge.

In this project we have chosen to distinguish between low, medium and high heads, because the head does have a large say in the electricity output.[5]

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[4] The power output can be calculated from this formula: P (kW)=10nQH. (P=Power, expressed in kW=kilo Watt. n=efficiency expressed as a fraction. Q=the number of cubic metres per second. H=the effective head). (Renewable energy, 1996)

[5] Other important factors in classification are the effective head of water, the capacity, the turbine used and the location and type of dam. (Boyle, 1996)

- **Low heads** (run-of-the-river schemes); (head below 10 meters). Run-of-the-river schemes do not have significant waterstorage capacity and therefore use of the water flowing in the river. Typically they include a low level diversion weir (a small dam) which raises water sufficiently to make of small head. (Figure 3.1.)
- **Medium heads**. Often a large dam is constructed to store water and to provide sufficient head for the turbine. These water storage schemes enable the power station to generate at times of peak power demand, and allow water level to rise again during off peak time. Medium heads are best suited for larger gently graded rivers. (Figure 3.2.)
- **High heads**: (head more than 100 meters). Here the entire reservoir is well above the outflow, and the water flows through a long penstock—often tunnelled through a mountain—to reach the

turbine. High head schemes have a smaller volume flow, because of the increased pressure from the water. High heads are often placed in mountain streams. (Boyle, 1996)(Figure 3.3.)

Figure 3.1 Figure 3.2. Figure 3.3.

Source: Boyle, 1996

Different scales.

Usually there is made a distinction between large-scale hydro and small-scale hydro (e.g. below 10 MW). But there is no definite definition. However, a general distinction is that large hydroschemes tend to involve large dams and storage reservoirs (medium heads) whereas small hydro schemes tend to be run-of-river and highhead schemes. (IEA,1998, Appendix E)

In this project the emphasis is very much placed on environmental burdens resulting from large hydroschemes because they produce by far the largest amount of energy, and have the most significant negative impacts on the surrounding environment. Smaller hydro schemes do have similar impacts as large hydroschemes but on a much smaller and more local scale.

3.2.2. Environmental benefits

The most important factor on today's political agenda is that hydropower schemes produce electricity without the atmospheric emissions associated with conventional power stations.

Furthermore there are no wastes from hydro energy production. Hydropower schemes are also extremely reliable and efficient, and have great flexibility, meaning that they can produce electricity at peak hours and store it in the dam at low demand. Thereby they reduce the need for conventional peak power plants, and improve the overall environmental performance. (IEA, 1998, Appendix F).

Hydropower dams can beside electricity production be used for irrigation of agricultural land and water supply. They can also be used as floodregulation, to prevent large disasters following floods. Dams also provide opportunities for navigation and recreational use. This includes popular waterbased activities such as fishing, water-sports and waterfowl hunting (www.ornl.gov.08/5 2000).

Hydropower, however, may also be considered the *infant terrible* of renewable energy sources. When the large hydroschemes were first constructed in the 1940-50´s it was done without due considerations of adverse environmental impacts and the environmental cost of the cheap and reliable electricity production were discounted.
Because of the time spend, the adverse environmental impacts are well understood today. In fact a number of non-governmental organisations oppose further constructions, and in some parts of the world (including Europe) there are strong oppositions towards existing and planned large hydro schemes.

3.2.3. Adverse environmental impacts

The impacts from dams are potentially large. However it has to be mentioned that in any discussion on hydro projects it is impossible to produce of definitive list on environmental impacts, for different reasons, e.g.: the before mentioned different types of schemes, the wide range in the size of the schemes (from 100 Watts to 12.000 MW), and variations in location, geomorphology, topography, population density, flora, fauna, temperature etc.

Not one hydropower scheme has got the same environmental impacts and the benefits depend on the site (EIA, 1998, Appendix F). This project therefore discusses the general impacts from large hydroschemes, and it is important to emphasise that for most schemes only some of the implications are likely to be relevant. It should be further mentioned that “modern schemes” (including a more thorough evaluation of environmental considerations) have less impact than “older schemes.” (EIA, 1998, Appendix F).

3.2.3.1. Physical/Chemical impacts

Dams are very large civil engineering projects and therefore they have significant environmental impacts during construction. They also result in permanent changes in the physical and structural conditions of the river, such as changes in discharge and current and altering of natural periodicity. (IEA,1998, Appendix F). ambuilding often results in flooding of areas, eg fertile valleys, gorges, marshlands with subsequent loss of habitats, adapted species, agricultural land, recreational valuable land as well as places of conservational and cultural/archeological interest.

3.2.3.2. Construction Impacts

Hydropower schemes are often placed in formerly remote areas with limited access. The engineering projects therefore often include a considerable development of the area, including construction of a new infrastructure (roads), transmission lines, housing for employees, transport, quarries to abstract material for building of dam and clearing of forest. Noise from the worksite, emission of dust and disposals from construction may affect water quality downstream-thereby influencing the aquatic species in the river.(IEA,1998,Appendix F)

3.2.3.3. Visual intrusion

Large dams are impressive constructions and can be an awesome sight. However if placed in areas of natural beauty they can have significant effects on the visual landscape. Again the actual impacts will be site-specific, depending on the topography and from how far it influences the vision. (IEA,1998, Appendix F). It should be added that how much emphasis different persons place on the visual intrusion as an environmental impact may be a question of personal taste and opinion.

3.2.3.4. Impacts from development/operation

Impoundments of rivers result in some permanent changes in the riversystems. The connectivity between upstream and downstream is obstructed, resulting in changes in discharge and currents as well as natural periodicity eg. spring floods and seasonal variations in flow (Allan,1995). The regulation of freeflowing rivers brings about fundamental change in their structure and functions and affects waterquality in a numbers of ways, as will be outlined in the following section

3.2.3.5. Water quality

Hydroschemes often decrease the amount of water in the natural riverbed. It means that natural ripples, pools and runs are destroyed. It also means that there is a possibility for higher pollution concentrations, thereby causing deteriortion in waterquality and habitat availability with a deleterous effect on different aquatic species, e.g. fish (IEA,1998). Also it has been a problem, especially when using long penstocks for diverting the water, that the riverbed dried out completely in periods. Today generally there is a ten percent requirement, meaning that there should always be at least ten percent of the natural flow in the river bed. However the situation is not ideal while some aquatic species are dependent on seasonal variations for breeding and hatching.

Change in flow regime: As hydropower schemes often are used to peakhour production of electricity, the change in discharge varies considerably, causing rapid rises and falls in waterlevel. These flow variations (often on a daily basis) are considered highly deleterous to aquatic organisms. Flow regulations affects especially larval fish in nursery habitats and stress other populations. Benthic populations downstream may be wiped out or dislodged in periods with high releases. Species well adapted to stress factors survive while more sentitive organisms dissappear causing a reduction in species diversity. (Vehanen et al. 1999).

Also strong water level fluctuations may increase erosion, causing more nutrient-rich and turbid water quality which again can result in eutropication of rivers as well as dams.

3.2.3.6. Sedimentation

Impoundments of big hydroschemes often result in a changed level of suspended solids in the water. Sediments normally flowing in the river settles in the impoundments, where as the discharge from the hydroplant lacks sediment. The lack of sediments and high speed of water released downstream can cause erosion. Increased amount of suspended solids and thereby larger turbidity in the dams affect a number of fish and other aquatic species, especially in spawning areas. Also the amount of fish species is likely to decrease. Downstream from the hydropower scheme decrease in suspended solids can cause reduced nutrient supply, (reduced amount of fish) which again influence on natural ecosystems. Agriculture can be affected in areas where it has been dependent on nutrients from sediments dumped by periodic floods (IEA,1998, Appendix F).

3.2.3.7. Eutrophication

Increased amount of suspended solids in the water also means increased amounts of nutrients in the dams.[6] An abundance of nutrients (especially nitrogen and phospor) stimulates a heavy growth of algae and other aquatic plants. Increased photosynthetic production leads to an increased regeneration of nutrients and organic compounds, stimulating even further growth. Phytoplancton concentrates in upper layers of the water, resulting in a murky green cast. The turbidity does not allow the light to penetrate very deep into the water, and restricts biological

[6] Nutrients can come from the riversystem (downfall from trees, outwash from banks etc) but may also be a result of agricultural practices in the surrounding area, with excess fertilizer washed out into reservoir. In this project we have chosen to focus primarily on the naturally occurring nutrients as agriculture contributes with a great number of implications that are not directly related to impoundments and hydropower schemes.

production. Dead materials sink to the bottom as sediment, where bacterias decompose it. These activities result in a depletion of oxygen supply on the bottom and deep water. (Smith, 1998).

In an eutropicated dam it is possible to talk about a “vicious circle”, because when the oxygen is low in the bottom more nutrients are released, which cause increased algae growth, which again hamper submerged plants and give unclear water. Thereby the piscivor fish is hampered and the coarse fish is promoted. Coarse fish eat zooplankton and if there is little zooplankton the algae growth increases further. A highly euthropicated dam therefore have few species thriving, and the large fish species, attractive for human consumption, tense to disappear.(Smith, 1998).

3.2.3.8. Thermal stratification

Large deep dams, if the water is kept in them long enough, tend to develop lake features such as thermal stratification in the summer period: A temperature gradient in the water collum creating two isolated water masses—the *epilimnion*—a warm and light surface layer, the *hypolimnion*—a cold and dense bottom layer. These layers are seperated by the *thermocline.* The thermocline act as a barrier between the epi-and hypolimnion, and prevents contact between top and bottom layer, with very little cirkulation taking place. Lake features such as these change the living conditions for aquatic animals dramatically, and usually results in a change from riverine species to lake species (Leo Smith, 1998)

The lack of oxygen in the deep layers may result in anaerobic conditions close to the bottom of the dam. Few animals thrive in this climate and also there is a great risk for outwash of heavymetals such as iron and manganese, which affects water quality in a negative direction. Also the decomposing matters on the bottom of dams can release greenhouse gases, such as ammonia and carbondioxide. Worldwide there is an increasing focus on this problem especially from very large dams, because it curb the advantage for hydropower over conventional energy. However greenhouse gas emissions are small compared to coal and oil electricity production (IEA,1998,Appendix F).

The thermal stratification also influences on downstream conditions. If the waterintake in the turbines comes from the bottom layers of the dam, where aeration level is low—deoxygenated water can travel a long way before it becomes sufficiently reoxygenated, and the living conditions downstream will be very poor. However it should be mentioned that simple techniques for aeration of water exist, and that this problem therefore can be solved without too great environmental and economic cost. If the water on the other hand is taken from the warm surface layer, with plenty of oxygen, downstream life will also be affected, because organisms that favour colder water with less oxygen will be replaced with organisms adapted to warmer water.

3.2.3.9. Local climate

A large waterbody, such as a dam will influence on the local climate: Increased evaporation cause higher humidity in the area around the reservoir. The cloud cover may be affected negatively in warmer regions, and in temperate areas fogs forms over dams when the temperature comes close to freezing (IEA, 1998, Appendix F). Also temperature may increase, because of the waters ability to even out temperatures. In a Swedish study it has been proven that temperatures around dams could be up to about 4 degrees warmer at night than surrounding areas. (Sundborg, 1977)

3.2.3.10. Ecological impacts

A natural river basin contains many ecosystems; found in headwaters and catchment landscapes, channels from headwaters to the sea, riparian areas, floodplains, wetlands, and estuaries.

The current state of knowledge indicates that impacts of dams on ecosystems are profound, complex and varied. As the natural distribution and flow timing is altered, it results in the physical and chemical changes discussed above. Changes in sedimentation, nutrient regimes, water temperature, flow and flooding in general affects ecosystems negatively (Http://www.dams.org 12.5.2000).

In the dam, the ecology of the flooded area of the empoundment is permanently effected, and this result in new habitats which attract other fauna—such as waterbird and fish species, adapted to lakes. Generally in dams there are a change in species from riparian to reservoir. While some species may thrive in dams, biodiversity often is diminished.

Downstream from dams changes in the amount of water, the current speed and temperature changes, and lack of nutrients generally have impact on numerous species including aquatic communities of plants, invertebrates and fish as well at benthic communities. If the hydroschemes produce peakhour electricity and thereby change the flow several times every 24 hours, the riverian species are stressed even more and tense to be replaced by a few "survivor"species. Also the bankvegetation may be disturbed as well as the natural ripples and pools in the river, resulting in loss and change of habitats which again mean decrease in the biodiversity.(IEA, 1998-Appendix F).

In the deltas, estuaries and wetlands the reductions of annual floodings result in a lack of nutrients with a negative effect on the natural productivity and species diversity. (Http://www.dams.org 12.5.2000)

In warmer regions dams create favourable ecological environments for parasitic/waterborne diseases, such as the malaria mosquito. Many dams also witness an abundance of aquatic weeds, such as waterlily, which thrive in the shallow warm conditions. When covering entire dams they cause increased sedimentation and blocks the light in the dam.

To sum up briefly the reduction of habitats and the impacts from changed physical and chemical conditions contribute to a decrease in biodiversity, with some species becoming extinct or endangered.

<u>3.2.3.11. Fish Migration</u>

One of the adverse impacts from large-scale hydroschemes that has been researched intensively is the influence of dams on migratory fish species (such as salmon and sea trout). This is because often there is very large economic and recreational interest connected to healthy fish populations.

The large dams create obstructions to the fish migratory patterns. Salmons for example must be able to migrate upstream from the ocean to reproduce in fresh water. Despite different mitigation measures such as fish ladders the presence of hydroelectric dams essentially has changed the migration pattern of fish. (http://www.ornl.gov/ORNLReview/rev26-34/text/hydmain.html 08.05.2000)

In many rivers in Europe and other parts of the world the different salmon populations have suffered and some places have become extinct. You do not have to look very far to find an example: When Lange Tange was constructed in 1924 on the Gudenå-system, the salmon disappeared. The fish simply could not pass the turbines. Later mitigations measures such as a fish ladder has not improved the situation remarkably. Because only 1% of the water flows into the fishladder, the fish cannot find it. A breeding and restocking program was initiated, but still today the situation is not well. The young salmon migrating down stream are easy prey in Lake Tange (personal communication,2000).

Breeding and restocking has been used widely in Europe, but although a mitigation measure it has some problems of its own. A salmon is not just a salmon: It is now recognized that every population of fish consists of many subpopulations, (stocks), coming from specific watersheds. The multiple stocks are important both to fishproduction and the genetic diversity of the species. Breeding have a tendency to favour one specific stock- e.g the largest and most beautiful. This may outcompete smaller natural species, but it may not be the most successful in breeding, and it become very vulnerable to diseases (http://www.ornl.gov/ORNLReview/rev26-34/text/hydmain.html, 08.05.2000).

Also the smaller fish species are damaged by the pressures encountered in turbines, and spillways. In some hydroschemes the small fish and animals suffer a very high mortality percentage in the turbines. Further it should be mentioned that the physical changes in the river systems also limit the amounts of habitats, e.g the amount of gravel patches used for spawning, the availability for cover, gives unfavourable conditions for hatching the eggs—all contributing to the decline in number and species.

3.2.3.12. Adverse socioeconomic impacts

It is difficult to put a definite value on an untouched river system, however some features could be mentioned. The natural ecosystems do perform functions such as flood control and storm protection, yield products such as wildlife, fisheries and forest resources. Also one could include the aesthetic and cultural importance to many people.(Http://www.dams.org, 12.5.2000)

It must be made clear the all the above mentioned (physical, chemical and ecological) changes affect human population in one way or another. But the effects are of course not only detrimental.

Developments that large hydroschemes sometimes initiates—that is jobs, houses, infrastructure, agricultural land etc. are often counted as positive indicators. It depends of course on what value you put on ecosystems and untouched rivers qua socioeconomic development of an area.

Should focus continue to be kept on the adverse socioeconomic impacts it is worth mentioning that the local inhabitants, that is the people living where the empoundment are made and in the surrounding areas, often suffer. In Europe as well as in other parts of the world, dams are often made in remote areas, far from major cities. Often local (ethnic) communities are affected. We have found a case from northern part of Norway, where the Saami people opposed a major hydroscheme. It should be seen as an attempt to explore a world wide trend with indigenous people or poor rural communities being negatively affected by resettlement and flooding of their native or agricultural land getting little or no economic compensation.

The case concern the Alta/Kautokeino river in the northern part of Norway (Finnmark) where the Norwegian Water Resources and Electricity board, in the 1970´s proposed a hydroproject that included flooding of a little village with Saami inhabitants. The Saami people primarily lived from reindeer pastoralism. Following the proposal a government made report concluded that the proposed dam would have “catastrophic” consequences for the Saamish way of living. (Robert Paine, 1985) The project was then revised and reduced but not given up by the Authories (the Norwegian parliament).

“The Saami Action group” was formed in the village in 1979 out of frustrations and disgust for the failure of the Norwegian government to consider their rights and distinctive way of living. However the Norwegian government failed to recognise it as a Samish demand for respect for their rights and culture. The government just saw a Norwegian opposition movement (The

Norwegian government persistently employed the idea of a single nation, and did not recognise the Saami as an indigenous population). The Saami Action Group reacted by raising a tent (a lavvo) on the lawn outside the Parliament building, and delivered speeches, in order to gain public attention and support for their case. The symbolic effects were enormous. The Norwegian public supported the activists and began to question the Government agenda. The non violent action, gave the Saami population public attention, media attention and a voice to speak against the Norwegian government, despite minority status.(Paine, 1985)
In the end the action could not prevent the empoundment of the river. The opposition could not stand the centralised, capital focused Government (Paine, 1985).

Other local people may not have the resources to form effective resistance groups, or they might experience that their local opposition does not withhold the national interest pressure.

This aspect elucidates the fact that most of the adverse impacts from renewable energy sources are local whereas the benefits are national or global.

Often the local population are affected so badly because there are no proper funding for resettlement and there has not been sufficient contact between developers/constructors and the local population. I shall come back to this discussion in the "mitigation section".

Flooding of lands does not only include agricultural land but also areas of cultural heritage and sometimes-religious features as well as geological interest. Areas of invaluable interest have been lost.

Another potential risk for people living close or downstream from a dam is the risk of a dam failure. Dams are not build to last forever and some have been constructed with errors. A large dam failure can cause a major flood with disastrous consequences—flooding, drowning and wash away of agricultural land are some.

Modern practices include routine surveillance and maintenance of dams to monitor the dam safety and therefore the risk of catastrophic failures involving loss of life is today extremely rare. But it could still happen: 0.6 of the dams world wide have failed (IEA, 1998-Appendix F).

Tourism can have both positive and negative impacts. When pristine land is flooded and dammed interesting landscapes of outstanding scenic beauty and biodiversity (an attraction to some more biological minded tourists) are wiped out. On the other hand formation of a large empoundments may create new possibilities, such as watersports, sailing, swimming, fishing.

Tourists may contribute to further environmental deterioration through disturbance, noise, pollution etc, but they may also push restoration of lakes and habitats in order to find a more enjoyable environment. (Smith, 1998)

3.2.3.13. Summary of adverse environmental impacts

When discussing environmental impacts from hydropower the scale is important to consider: It is often stated that small scale-hydro (below 10 MW) only have few potential negative impacts: Disturbance and emissions during construction, some modifications of local habitats due to change in water flow, and disruptions of fish movements all on a small, local scale. (EIA, 1998-Appendix E). However some critics are also extremely sceptical about small-scale hydro schemes, because potentially they do the same to smaller streams as large hydroschemes do to big rivers (Http://www.dams.org, 12.5.2000).

The most serious adverse impacts come from the empoundments of large shallow dams, which flood large areas of land. The impacts here causing loss of land, population resettlement, and a large number of physical and chemical disturbances (discussed above) resulting in changed habitats and poor water quality-decreasing the amount of species and natural ecosystems (IEA,1998).

3.2.4. Solutions

As the adverse environmental impacts from hydropower schemes have been well documented for some time now, a number of mitigation measures and solutions have been invented, reducing the adverse impacts remarkably.

Today one widely used method to assess impacts from large constructions such a dams is Environmental Impact Assessments[7] (EIA) in which an investigation of potential impacts is carried out prior to construction by the relevant authorities in cooperation with the developer and the

[7] EIA´s, refers to the evaluation of the effects likely to arise from a major projects significantly affecting the natural and man-made environment. If is carried out prior to construction so that decicionmakers can decide whether the proposal should be approved or dismissed. The EIA should supply decisionmakers with an indication of the consequences of their actions. If carried out correctly both proponents and the population at large should benefit, because the unacceptable projects would be abandoned or mitigations to the environmental effects would be incorporated to make the proposals acceptable. As such the EIA is a political tool, with the intention of giving full knowledge og consequences. EIA´s does not always prevent projects with significant adverse environmental impacts from being implemented. In EU EIA´s are now implemented in the legal system, and a standard procedure has been set up. (Wood, 1995)

public. We would like to use the EIA framework for our discussion of mitigations and solutions, because in our opinion it has the most holistic approach. Following steps must be accomplished (http://www.dams.org, 12.5.2000):

1. Measures to avoid anticipated adverse effects.

2. Incorporation of mitigation measures into a new or existing operating scheme, in order to eliminate, offset or reduce ecosystem impacts.

3. Measures that compensate for adverse effects that cannot be avoided or mitigated.

4. Decommission of the dam and restoration of the riverine ecosystem

Ad.1. Measures to avoid adverse effects include careful site selection. Impacts from hydro schemes are highly site-specific (local, depending on climate, geomorphology etc.). So sites situated in areas with natural beauty, endangered species or cultural importance should be avoided.

The design of the dam can be made to minimise impacts. For example turbines with lower mortality in the rotors could be used. Another possibility is to choose run-of-rivers schemes, because they do not include flooding of large areas (IEA, 1993)

Improved planning of projects, better information and communication between developers, decisionmakers and local population may also improve the hydroschemes as well as sufficient knowledge about the site and the ecosystems. (http://www.dams.org 12.5.2000)

Ad.2. Mitigation measures include usage of Environmental Flow Release. It means that hydroschemes does not just release the "10% minimum flow" during operation, but follows the seasonal variations more closely in order to improve conditions for ecosystems downstream. (http://www.dams.org, 12.5.2000). A further improval would result if peakhour production were limited, as this is very hazardous to the aquatic life. This is of course problematic because peak hour production is one of the advantages from hydropower. However if hydropower was combined with other types of renewable energy instead of conventional (oil,coal) the adverse impacts would be smaller.

In order to make the hydroschemes less visible in the landscape, different amelioration techniques such the choice of building materials, height and shape of the dam and connected buildings and replanting of vegetation around the construction site can be employed. Replanting of vegetation on the banks of the dam also reduce soil erosion and thereby help reducing the outwash of sediments into the dams.

Mitigation measures also include some of the technical solutions previously mentioned, such as fish-ladders, double gratings to prevent fish from entering turbines combined with artificial breeding and restocking programmes. (www.ornl.gov/ORNLReview/rev26-34/text/

/hydmain.html, 08.05.2000)

Ad.3. Measures to compensate for damage includes for example restoration of habitats, e.g. construction of new wetlands. Also weirs and stream deflectors can be built in the stream to provide patches with rapids and shallow pools and tree trunks put strategically provide cover for the fish. (www.dams.org/wp-fe-no-finaldraft, 12.5.2000)

Compensation should also be considered in relation to the people affected by the hydroscheme. It is very important that the local people are not neglected, especially as these often are poor rural people with little political and economical power. Sufficient economic support to resettlement, and compensation from lost income should be a natural part of every proposed hydroscheme. Unfortunately it is not. We suppose that a lot of the non-governmental-organisations working against hydropower schemes spring from this fact rather than from environmental concerns.

A common practise today is retrofitting and upgrading of old hydro schemes and dams used for other purposes, e.g.for watersupply. As it has been mentioned many of the older hydroschemes built in the 40-50´s did not take environmental considerations. By reassessing these old-timers, the risk of flooding caused by dam failure is diminished, the productivity enhanced and the environment can be taken into account. Technological progress have provided less costly and more environmental friendly types of concrete regeneration, foundation treatments, geomembranes and computing tools[8] as well as before mentioned flow regulation models and all this can reduce the adverse impacts from old schemes. Retrofitting also has the advantage that it can be done

[8] Also sonic testing, electrotechniques, chemical projects, and preservation of fish have improved. (IEA,1993)

without the large impacts resulting from construction of new schemes. If the existent hydroschemes are more efficient it reduces the need for additional schemes.(IEA,1993)

Ad.4. Decommission of the dam should restorate the riverine ecosystem as good as possible. There should be sufficient money set aside for restoration.

The mitigations and solution of the adverse environmental impacts from hydropower operate on different levels. There are the technical solutions, eg. fish-ladders, habitat restoration and design on the one hand and on the other is the political awareness and will to action.
By that we mean what perception of hydroschemes exits in the mind of politicians and planners and what measurements are taken. For example if the importance of biodiversity and natural

ecosystems and their conservation is not stressed and understood, how could these be taken into consideration?

In a report made for World Commission on Dams “ *Dams, Ecosystem Functions and Environmental Restoration”* it is stressed that the important role of natural ecosystems in contributing to sustainable development should be recognised politicians and planners, as well as that of biodiversy and nature conservation. (http://www.dams.org 12.5.2000)

We think that incorporation of external costs—that of the environment, of the local population etc.—and a more holistic approach is clearly an important part of improving the adverse environmental impacts from hydro schemes. It is therefore not enough only to use technological mitigations but also to include the sustainability approach—considering the environment, people and future generations. Knowledge about the environment, and participation from different interest groups therefore should be considered an important mitigation measure.

It is important to mention that the EIA-framework has got some deficiencies. It might not work if there is lack of resources spend on EIA´s, or if the authorities lack knowledge about EIA-procedure: The framework also may be negatively affected if there is lack of communication between different stakeholders or if there is an insufficient information base for decisionmaking choices. These four aspects often result in inappropriate considerations for the environment and local people or failed plans.

However, the holistic approach, that take into consideration avoidance, mitigation, compensation and restoration as well as participation should, in our opinion, clearly have advantages above for example cost-benefit analysis, because simple cost-benefit analysis often externalise the environment. Of course economic aspects will always be an important part of major construction works, but they should not be the only one.

3.2.5. Conclusion

In this chapter the many adverse environmental impacts from hydropower schemes have been outlined. It is important to remember that the impacts vary according to scale, site, temperature, geomorhpology and technology.

Because hydropower has been used on a large scale for many years there is also an extensive knowledge about mitigations and solutions to the environmental effects. We have emphasised that the solutions should not only be of technological character, but also include knowledge and participation from different actors as well as political insights and policy aims, such as the sustainability concept.

For all the best many hydropower schemes still have considerable negative impacts on the natural environment and the local population. We therefore think that it is crucial to continue the development of mitigation measures, on the technological front and on the political scene.

3.3. SOLAR ENERGY

3.3.1. Introduction

In this chapter we will explain what is direct solar energy, what kinds of technology is developed to use solar energy and the general benefits. We will emphasise the environmental problems of solar energy, explaining at the end the possible solutions for these problems.

The solar resource: The term solar energy is usually taken to refer only to those energy technologies that derive directly from the sun's light and heat. Solar radiation is absorbed at the Earth's surface and the atmosphere at a rate of $10.3*10^{16}$ W, while current global rate of energy consumption is approximately $9*10^{12}$ W. Clearly, then, solar energy has the potential to supply all world energy demand (UN, 1992)

But many factors; technological, economic, political and others make difficult the realising even of a small factor of this potential. Although sunlight is ubiquitous and everlasting, it is low power density and intermittence make collection, conversion and storage expensive. To make the best use of solar energy is important to determinate how much solar energy is available at the system site, the latitude, angle of the sun and others. Therefore in EU the Mediterranean countries have the most potential for the exploitation of this energy source.

3.3.1.1. Types of solar energy technologies;

The four main types of solar energy technology are:

- Solar thermal heating - employs fixed solar collectors to capture the sun's heat, primarily for space[9] and water heating.
- Solar thermal electric - converts the sun's heat energy into mechanical energy in a turbine[10] and finally into electrical energy.
- Solar photovoltaic (PV) - which involves the direct conversation of light into electricity by means of specially prepared semi-conductors.

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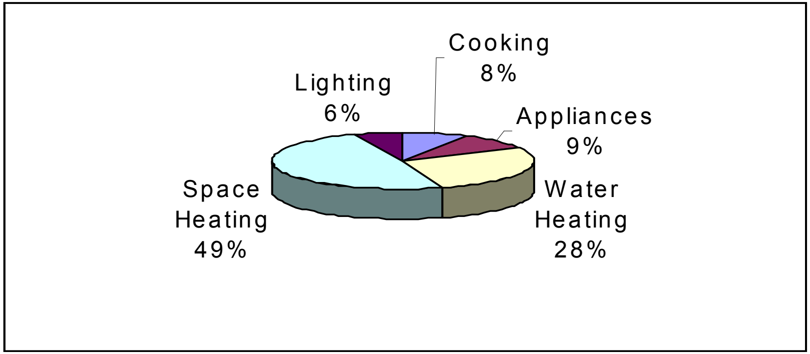
[9] It is shown in the graphics the importance of space heating in Europe.
[10] Is a steam turbine like an ordinary power plant produces electricity.

- Passive solar - which uses the form and fabric of a building to capture solar radiation and so reduce the need for artificial light, and auxiliary space heating and cooling (Boyle, 1996).

Figure 3.4. Use of space heating in the domestic use in the EU



Source: Boyle, 1996.

With this graphic we want to illustrate, the importance of solar thermal heating and passive solar systems[11].

Photovoltaic technology. Types of PV cells:

- Monocrystalline. Cells made of crystals of silicon. These are the most expensive, but the most efficient cells (~16%), with a lifetime of about 40 years.
- Polycrystalline. Also made of silicon crystals. But cheaper than monocrystallines. They have the second largest efficiency (~12%) with lifetime of 40 years.
- Thin layer:
    * Amorphous: With silicon, are the cheapest and the efficiency is lower (~5%), but shorter lifetime.

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[11] These systems do not have relevant environmental impacts.

* Gallium arsenide: with an efficiency of ~10% and cheaper than crystalline ones.

* Copper Indium Diselenide ($CuInSe_2$= CIS): Is cheaper than crystalline ones and the efficiency is around 10%

* Cadmium telluride (CdTe): Also cheaper than crystalline ones and efficiency around 10% (Scheer, 1995).

3.3.2. Benefits

The exploitation of solar energy is, just like several other sources of renewable energy, expensive as regards initial expenses and cheap in operation, in contrast to fossil fuels. Exploitation of fossil fuels often demands fewer initial expenses but, it is very expensive in operation. Another advantage of solar energy production is that the solar energy systems can be easily adapted in ordinary households (both solar heat systems as well as photovoltaic systems) (Solar Energy Committee, 1998).

Power from the sun is clean, silent, limitless, and free. At the generating phase there is no release of CO_2, SO_2 or NOx gases, which are associated with burning fossil fuel reserves. Therefore solar energy do not contribute to global warming. (www.ecocentre.org.uk/resources/facts.htm, 18/4/2000).

Besides, if the photovoltaics and solar thermal electric systems produce more than consume, then it is possible to sell the excess back into the national grid, (which means profit for the private users or for the solar energy plants).

About the land use needed for solar energy, against what can be thought, solar energy systems need less space to produce a megawatt of electricity than does coal fired power (www.ases.org/solarguide/fbext.html 24/4/2000). Recycling materials used to produce solar energy systems are cost-effective with around 20-30 years of productivity life.

Some solar energy technologies as solar thermal systems can also be used to dispose water pollutants such as agricultural and industrial wastes by solar photovoltaic water detoxification. Through UV rays from the sun, with very high frequency, most pesticides and chemical compounds are degraded and do not damage anymore (IEA, 1991)

There are experimental-desalinisation plants such as in Spain (Almeria), Italy (San Nicola) and France (Cadarach), where the lack of freshwater supply is a relevant factor for the agriculture production. At these experimental plants they are trying to make possible the seawater desalinisation through PV systems. If these experimental plants could reach a cost-effective production it would mean a high impact for the agriculture sector in many of the EU countries (Belessiotis, 1995).

There are also socioeconomic benefits from solar energy production. The introduction of solar energy could generate new jobs in nearly all sectors of industrial production and service sector. The cost of solar energy is higher not because of the cost of the primary energy, but because of labour costs. Then it means that solar energy production require more jobs, although in case of change in the energy sector from conventional energy to renewables some new jobs will occur obviously come at the expense of old ones (Scheer, 1995)

Most solar energy technologies are modular in construction and can be built up on site in a flexible way, thus minimising front-end financial risk and investment cost.

It is true that the current contribution of solar energy systems is small, but annual production of solar energy systems in EU is doubling every seven years.

3.3.3. Adverse environmental impacts from solar energy

We will divide this section in the two main solar energy systems, which have more significant negative environmental impacts. And these two systems are the most important of energy production; photovoltaic systems and solar thermal electric technology. In solar energy systems ecological impacts are at regional or local level, whilst that socioeconomic impacts are at global level.

Photovoltaic systems:

3.3.3.1. Physical/chemical impacts

The burdens of PV systems depend on the type of cell that is used, the size and type of scheme. The operational phase cause few impacts, but there are significant impacts at the production, construction and decommissioning stages.

Production stage. Wide ranges of materials, some of which are potentially toxic and hazardous, are used in the PV industry. The risk exists in case of accidental releases and emissions to soil and groundwater.

1) Crystalline silicon. It contains Trichorosilane ($SiHCl_3$), Phosphorus oxychloride ($POCl_3$) and Hydrogen Chloride (HCl). Which produces severe fire hazard, when it is exposed to heat. It is also moderate toxic for animals and plants after ingestion and inhalation.

2) Amorphous silicon. Which contains: Silene (SiH_4), Phosphine (PH_3), Diborane (B_2H_6), this compounds are easy ignited in air, and are high toxic for animals.

3) Gallium arsenide; With arsenide (As). Which is highly toxic in ecosystems.

4) CdTe. With Cadmium (heavy metal). Toxic and bioaccumulative in ecosystems.

5) CIS. With Hydrogen Selenide (SeH_2). Form explosive mixtures with air and is extremely toxic in ecosystems (IEA, 1998).

3.3.3.2. Ecological impacts:

One of the main impacts is the effect on ecosystems and land use during the construction stage of, mainly, large-scale plants. The impact on land use in natural ecosystems depends on the extension of land covered by the PV system, the type of land and the biodiversity of the area. In hot dry regions (where PV systems have more optimal production), the shade provided by solar cells can have a significant impact in ecologically sensitive areas, because this shadow changes the microclimate. The large land areas required for centralised schemes results having a significant visual impact. In small schemes this visual impact is much lower, particularly in roof mounted schemes. The noise pollution is just produced during the construction stage, derived from the building activities (Neff, 1981).

In addition, PV systems has life cycle emissions; from resource extraction, material processing and production modules. The lifetime of PV systems is taken to be 20 years, therefore every this lifetime period PV systems produce indirect emissions of gases of using the energy from burning fossil fuels.

Impacts from decommissioning of PV systems. The toxicity of cadmium, arsenic and Silene is high in ecosystems and is public health hazard, if not recycled or disposed of according to waste regulations. Also the disposal of lead-acid batteries used for storage in some PV systems, especially because this batteries have much shorter lifetime (between 2-3 years) than the PV systems. This batteries could present a hazard of soil and water contamination (Kuemmel, 1997).

3.3.3.3. Socioeconomic impacts

This technology as most of renewable energy technologies has the problem of the storage of the energy that is produced. In addition, solar energy is present in great quantities in daytime and during the summer. It is therefore necessary to be able to store and save the energy from day to night and from summer to winter (in Europe, because of the latitude, there is seasonal climate). There is a need for technological development of different storage types. (www.energy.state.md.us/HEA/ALL-ABOV/SOLAR_EN.HTM, 18/4/2000).

PV systems are still very expensive in comparison with conventional technologies. Electricity from PV systems is currently around ten times the price of conventional electricity. But the cost of conventional forms of electricity production does not take into account the costs of the environmental impacts associated with their use.

In normal operation PV energy systems, they emit no gaseous or liquid pollutants. However in the case of CIS, CdTe or Gallium Arsenide modules, which include small quantities of toxic substances, there is a risk that a fire or accident might cause small amounts of these chemicals to be released into the environment. Not only in case of accident, but also at the decommissioning stage the toxic metals can be released to the environment.

There are several occupational impacts on human health at various stages of production, installation and use of PV systems. There are both immediate effects such as accidental or toxic exposures and long-term health effects. From CdTe modules; Cadmium as airborne particle can cause damage to the respiratory system as edema or even ephysema in cronic exposures. Cadmium is also toxic to the kidneys that can injure different components of them and thereby undermine their functions. Finally the reproductive system of both males and females can be harmed, in special in males reducing sperm production. And it is considered cancerigenous (Rodricks, 1992).

Arsenic from gallium arsenide modules is toxic and carcinogenic. Low direct exposures have been reported to cause skin irritation, and higher level lead to vomiting, nausea, ulceration, and kidney damage. The effects of chronic arsenic poisoning include dermatitis, muscular paralysis, visual disturbances, kidney degeneration, edema, bone marrow injury, nervous system disorders and cancer (Neff, 1981). In addition as in other electrical equipment, there are some risks of electric shock, for the workers at the generating plant.

These kinds of PV cells that use Cd or As utilise relatively scarce minerals at the Earth's surface. Which means that large-scale deployment of those technologies could lead to resource depletion, and therefore not constitute a sustainable technology.

Solar thermal electric systems

There are different kinds of solar thermal plants, in all of them there are atmospheric emissions from; transportation, construction of material, construction phase and others. The construction phase involve also the increase of noise and traffic in the area.

Large-scale schemes can have significant environmental and visual impacts arising from construction activities and land use. The most used places for thermal systems are arid desert areas, which typically have fragile soil and plant communities, with high specialisation. Therefore the construction and operationing phases have the negative effect on soil erosion, habitat loss, and fragmentation of the ecosystem. The fragmentation of the ecosystems produces barriers to wildlife movement, which means enhance the risk of loss of fragile species and reduction of genetic variability of different populations of the same specie. This can brake the ecosystem balance.

The shade offered by the reflectors[12] from both sun and wind can change the microclimate around the scheme, due to local disruption in the thermal energy balance, with uncertain effect on vegetation (Røstvik, 1992).

The concentration of light and heat energy in this system could pose a danger to local fauna. Operational experience has shown that whilst flying insects are frequently incinerated, birds avoid the danger areas, possibly by being sensitive to air turbulence (IEA, 1998).

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[12] Mirrors that reflect the light to the central tower to concentrate the energy.

These systems, which use conventional steam to generate electricity will have a requirement for cooling water. This could place a significant strain on water sources, in arid areas[13]. But in these systems is also possible the use of cold air at night to cool the water that is heated during the day.

In addition, there may be some pollution of water sources, through thermal discharges, and accidental release of working fluids, that contain: biocides, hydrocarbons, oils, corrosion inhibitors, bactericides and others.

Socioeconomic adverse impacts from thermal electric systems.

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[13] Usually, groundwater source.

There is a significant visual impact at large-scale schemes, due to the large area occupied by the mirror system. The atmospheric requirements for these systems point to their deployment in areas of low population densities, usually in arid areas and deserts. Therefore the noise from the generating plant is unlikely to cause a disturbance to the public.

As occupational hazards; the accidental release of heat transfer fluids (oil and water) could form a health hazard, because of the high temperature of these fluids. The hazard could be substantial when the heat transfer medium is liquid sodium or molten salts. These systems have the potential to concentrate light to intensities, which could damage eyesight and even blindness. Under normal operating conditions this could not pose any danger to operators, but failure of the tracking system could put in danger to workers onsite.

There are general energy requirements and pollution generation associated with materials needed to tap all kinds of solar energy, primary steel, glass and cement, but also water source (for cooling water) and land. Such tracts of land should be ideally situated in areas receiving high solar radiation and not too distant from population centres[14] (www.elsevier.com/locate/apenergy, 22/4/2000).

The use of herbicides to avoid vegetation growth around the systems is an important source of pollution if it is released to soil or water courses. There is also generation of several non-recyclable at decommissioning stage such as fiberglass, glass, insulation, and toxic substances. At soil level there is soil erosion and compaction, wind diversion, and potential decrease in evaporation rate from the soil. All these imply a negative consequence on the conservation of

[14] To reduce distribution losses and expenses on installing transmission lines.

desert wildlife, that have a high level of rare endangered animals and endemic species (Røstvik, 1992).

3.3.4. Solutions

To analyse this part we will divide between photovoltaic and solar thermal electric systems, because of the differences of the impacts and therefore the solutions.

Both energy technologies have been developed over the last 22 years, therefore these technologies are still at a relatively early stage of development and the solutions are at the experimental stage (UN, 1992).

PV systems solutions: The solutions are analysed following the steps of Environmental Impact Assessment (EIA) process:

1.- Planning stage, when it is tried to avoid the adverse impacts.

2.- Construction stage, compensation and minimisation measures.

3.- Operation stage, as at the construction stage.

4.- Decommissioning stage, minimisation and compensation measures (Therivel, 1995).

At the manufacturing stage and chemical process, careful attention must be paid to plant design and good operation practise, to avoid any toxic or potential harmful chemicals in accidents or plant malfunction.

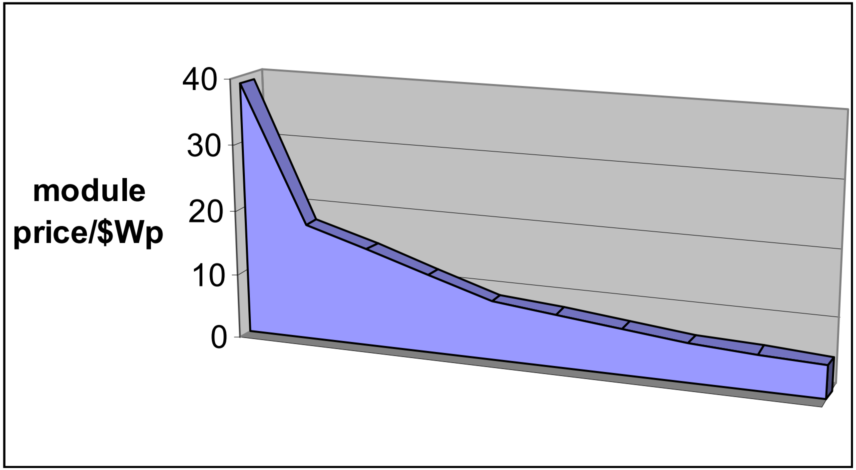
At the planning stage there must be chosen very carefully the place to establish the generating plant, avoiding natural beauty minimising the visual impact. Then are taken measures to re-establish the previous biodiversity by artificially supporting the flora and fauna if necessary. A special attention during this phase as well as during construction and operation will minimise the effects on vegetation and soil habitat. At small-scale schemes the ecological and visual impact from land use is not relevant, because the schemes are incorporated into roofs or facades of the buildings.

At operation stage to avoid accidents and spills good operating practise must be ensured. Finally, at decommissioning stage, in order to avoid uncontrolled dumping in landfills and health hazards the PV modules must be recycled (Solar Energy Committee, 1998).

The potential of direct solar energy is huge, and developments in PV technology lead to reductions in the cost of systems, these help to expand the use of PV systems, reducing the economic impediment. In order to balance the competition between conventional and solar energy,

there should be made a total assessment of the externality costs from solar and conventional energy. This would help to reach the real price of each energy, in order to make better the choice of energy supply. A recent study at the European Commission scientists has shown that, in average European Conditions, the energy payback time for PV modules is between 1-2 years. It is also estimated that a PV module will produce at least 20 times the electricity used in its production and every square metre will prevent the emission of over two tonnes of carbon dioxide (www.ases.org.solarguide/fbext.html, 22/4/2000). Over the last 20 years the price of PV systems has fallen dramatically (Figure 3.4.) and developments are constantly made them ever more efficient and reliable. In EU solar power is a fast growing market expanding about 12% a year, although are still expensive.
(www.ecocentre.org.uk/ressource.facts.htm, 18/4/2000).

Figure 3.5. Evolution of PV system prices since 1980 until 1998.



Source: Boyle, 1996.

To solve the energy storage problem in general from solar energy and from the others renewables, the investment in storage systems should be increased.

The interest on the use of hydrogen as a medium for energy storage and distribution has increased, and there are some pilot plants at Mediterranean countries, as in Spain; “Las Marinas”. Where it is produced hydrogen[15] as energy source by PV systems (Contreras, 1999). Hydrogen could be produced by the electrolysis of water, using PV or other renewable energy source. The hydrogen would be stored and transported to wherever it is needed. It would be converted back to electricity, or simply be burned to release heat (www.ases.org/solarguide/fbext.html, 24/4/2000).

Solar thermal electric solutions: The production of electricity from thermal schemes is a relatively new technology, in consequence the possible solutions or mitigations are still not

[15] Hydrogen has a higher effeciency than fossil fuels.

developed. This system is placed in deserts and arid areas, which usually are fragile ecosystems. Therefore special attention during the planning, construction and operation phases will minimise the effects on the ecosystems. At the planning stage the selection of the area to build the plant must avoid ecological sensitive areas.

At the operation stage there must be re-establish the local flora and fauna. In addition the accidental release of plant chemicals and occupational hazards on eyesight injuries will be avoided by good operating practise.

3.3.5. Conclusion

In this section we have analysed the main environmental impacts from solar energy technologies. As we have seen solar energy systems are still in an early stage of development. In the future these technologies are expected to develop increasing the efficiency of the systems and reducing the economic costs. There are different solar energy technologies, but the most relevant for energy supply are the ones that produce electricity: photovoltaic and solar thermal electric systems.

In our opinion is very important to continue investigating the possible environmental adverse impacts from the still non-experienced solar energy technologies.

3.4. BIOMASS

3.4.1. Introduction

Biomass is the general term used to include *phytomass* (plant biomass) and *zoomass* (animal biomass. Biomass therefore represents the animal and plant matter resource that is present in the biosphere (Boyle, 1996). Solar energy when intercepted by plants and converted by the process of photosynthesis into chemical energy, is fixed in the form of terrestrial and aquatic vegetation. Vegetation when grazed by animals is converted into zoomass and excreta. Energy, which is stored in biomass feedstock (in the bodies of plants and animals, or in the wastes they produce) is called "biomass energy" (Abbasi and Abbasi, 2000; http://www.seda.nsw.gov.au/ren_biomass_body.asp, 24/04/2000).

Biomass energy accounts for approximately 14 % of world energy supply and therefore it is the fourth largest energy source worldwide (Hall, 1997; Hall and Scrase, 1998). The share of biomass in the total energy supply is very different in regions and countries around the world. Most of the share is the form of traditional fuel wood, residues and dung in developing countries, where biomass energy accounts one third of primary energy consumption (http://www.iea.org/ieakyoto/docs/bionews.htm, 7/05/2000). There is a much smaller share of biomass energy supply in Europe. Presently biomass energy supplies at least 2 EJ/yr (47 Mtoe) [161] in European OECD countries that is about 4 % of total annual primary energy consumption (54,1 EJ). This figure is an underestimate since it is based on poor quality data. A significant amount of primary energy from biomass has also some industrialised states with large forest areas, such as Finland (18%), Sweden (16%), and Austria (13 %), (Hall and House, 1995a; Radetzki, 1997).

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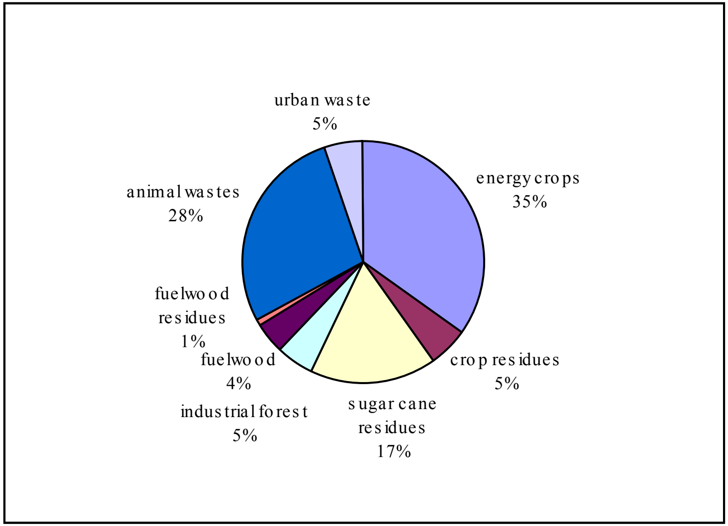
[16] EJ = 10^{18} J; Mtoe = Mt (10^{6} t) oil equivalent = 42 * 10^{15} J, since 1 t of oil equals 42 * 10^{9} J

There is an enormous untapped biomass potential, particularly in improved utilisation of existing forest and other land resources, higher plant productivity and more efficient conversion processes using advanced technologies. The higher development of large-scale energy production from biomass in the future is connected with specifically grown energy crops (such as tree plantations, sugar cane, perennial herbaceous plants and grasses and oil plants) and with better utilisation of energy from animal wastes and MSW (Hall and House, 1995b; Hall, 1997).

The Figure 3.6 represents a future scenario (Renewable Intensive Scenario) of different types biomass in the biomass energy share in 2025 (excluding most methanol and hydrogen production).

Figure 3.6. Contribution of Various Biomass Resources in 2025



Source: IEA, 1998, Appendix H, I

Note: Biomass conversion to methanol and ethanol for use in transport is omitted. 70% of biomass for methanol and ethanol production was assumed to come from energy crop plantations; the remainder to be spread across forest residues, crop residues and urban waste.

3.4.1.1. Different types of biomass sources

Although there is a wide range of potential biomass feedstock, three broad categories can be identified (IEA, 1998; ECC, 1994):

- biomass from existing uncultivated vegetation (including stands of trees, shrubs, bracken, heather etc.) and energy plantations (involve specially planted energy crops such as willows, poplars, miscanthus or sugar cane either on land brought into production for that purpose, land diverted from other agricultural production, or as catch crop planted on productive land as part of the agricultural cycle)

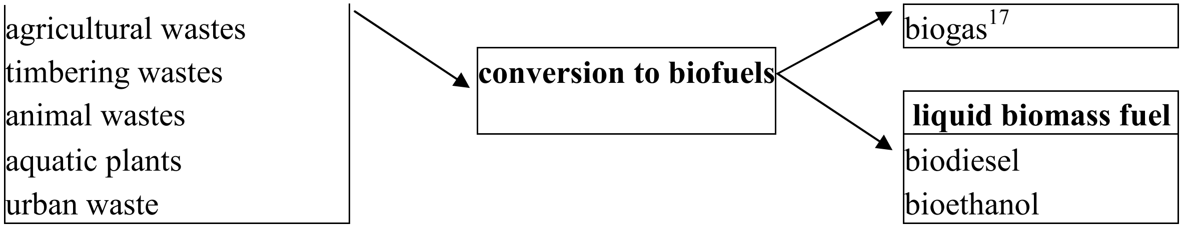
- agricultural and forestry residues and wastes (these are agricultural and forestry materials currently treated as wastes; there two main types of biomass waste-to-energy scheme: dry combustible wastes (e.g. straw, forestry wastes and dry animal waste) and wet wastes (e.g. farm slurry and green agricultural crop wastes)
- organic urban or industrial wastes (principally solid materials and sewage sludge that are currently tipped or incinerated; this source is known as municipal solid waste – MSW).

Biomass sources are also distinguished as traditional and “modern biomass” sources. Use of traditional biomass is mainly confined to developing countries and includes small-scale uses, often occurring outside the market place. “Modern biomass” refers to large-scale use of biomass to replace conventional solid, liquid and gaseous fossil fuels. It includes wood residues (for industrial use), bagasses (sugar cane residue), urban wastes and biofuels (including energy crops, crops grown for the production of ethanol and biogas production). The World Energy Council estimate of biomass usage in 1990 showed that modern biomass accounts for about 12% of total biomass use worldwide (WEC, 1993; IEA, 1998).

Biomass is a versatile energy source. This energy may be burnt directly or be converted into electricity, heat, or liquid fuels using a number of different energy processes and conversion technologies such as pyrolysis, anaerobic bacterial digestion, gasification or alcohol fermentation (Miller, 1990; Hall and House, 1995; http//www.worldenergy.org/wec-geis/mem...cations/default/current_ser/biomass.stm; 18/05/2000;).

In residential applications, biomass can be used for space heating or for cooking. Businesses and industry use biomass for several purposes including space heating, hot water heating, and figure 3.6 electricity generation. Many industrial facilities naturally produce organic waste. The expresses this basic use of biomass feedstock.

Figure 3.7. Conversion of biomass feedstock



[17] biogas is primarily a mixture of CH_4 and CO_2, together with various trace components, though it is methane that is used for energy generation.

biodiesel comprises ethyl or methyl esters of edible oil; rape-methyl ester (RME) produced from oilseed rape is the main source of biodiesel in Europe

bioethanol is produced from crops with high sugar or starch contents; sugarcane (exactly bagasse - the stem-fibre by- product of sugarcane crushing) is the world's largest source of bioethanol fermentation.

Landfill gas and waste incineration are very different from other renewable energy sources. Strictly speaking it is not a true renewable, because it is a by-product of modern civilisation and, being a waste, it ultimately represents a less sustainable resource. But efficient utilization of energy from these sources can provide the important share in future energy supply (IEA, 1998).

3.4.2. Benefits

When produced in an efficient and sustainable manner, biomass energy has numerous environmental and social benefits compared with fossil fuels. These can include a reduction of CO_2 levels, improved land management, use of surplus agricultural land in industrialised countries, waste control, nutrients recycling, job creation etc (Hall, 1997; Hall and Scrase, 1998; Johannson and Lundquist, 1999).

The most important environmental benefits of biomass energy are:

- theoretically inexhaustible fuel source, available throughout the world
- substantial greenhouse gas emission reductions:

1) a reduction of CO_2 - plants and trees take CO_2 from the air during their growth and with the conversion of biomass into electricity and heat is no (extra) CO_2 added to the atmosphere

2) a reduction of CH_4 emissions by utilization of animal wastes, thereby much more potent greenhouse gas is converted into CO_2 (a molecule of CH_4 is nearly 30 times as effective as a molecule CO_2 in trapping the earth's radiated heat (Boyle, 1996)

- a reclamation of degraded land and habitat (growing energy crops on land degraded by previous agricultural practices can help to improve soil condition and enhanced wildlife diversity)
- a reduction of air pollution (much less SO_2 is produced by biomass energy comparing coal and natural gas; abatement of pollution from transport by use of alternative fuels)

- an improving of water quality (substituting arable crops by energy plantations can result ininputs lower levels of agrochemicals and in a reduction of erosion rates; to avoid a water pollution treat, sewage sludge and agricultural wet wastes can be converted to produce biogas)
- additional provided energy from MSW and agro-industrial slurries and effluents (the level of certain agricultural/industrial waste streams are decreased, a reduction of potent environmental impacts from landfilling)
- job creation (total employment overall is expected to increase if the national energy need are providing by biomass resources)

3.4.3. Adverse Environmental Impacts

Nowadays large- scale bioenergy programs have started on a global and local scale. There are some questions, which have to be addressed for an establishment such programs. Some of these questions are also concerned to environmental issues. Because biomass energy is very diverse, its impacts are therefore management and site specific. Different approaches will be appropriate for different localities. It is essential for biomass energy developers to recognize local and national perceptions from the outset of any large- scale developments (Miller, 1990; IEA, 1998).

The environmental burdens from energy crops:

- impacts from cultivation of the energy crop (land availability, use of agrochemicals, soil erosion and visual intrusion)

- impacts from the construction of the combustion plant (emissions, noise, accidents, effects on local ecosystems, etc.)
- collection and transportation of the energy crop (noise, transport emissions, accidents, etc.)
- atmospheric emissions from combustion
- solid waste
- impacts on amenity from the site (visual intrusion, noise, etc.)

The environmental burdens from agricultural and forestry waste:

- impacts from the construction of the combustion plant (emissions, noise, accidents, land use, effects on local ecosystems, etc.)
- collection and transportation of waste (noise, transport emissions, accidents, etc.)

- impacts on agricultural and forestry practices from crop or residue removal (soil condition, runoff, etc.)
- impacts on amenity from the site (visual intrusion, odour, noise, etc.).

The environmental burdens from landfill gas operation:

- collection and transportation of MSW (noise, emissions, accidents, odour, etc.)
- impacts from the construction of the landfill site (emissions, noise, accidents, and effects on local ecosystems, etc.)
- atmospheric emissions from operation (landfill gas escape and flaring), landfill gas combustion and from engine/turbine manufacture and construction
- leakage emissions and potential contamination of soil, ground water and surface water

- impacts on amenity from the site (visual intrusion, odour, noise, etc.)

The environmental burdens from waste incineration:

- plant construction (e.g. noise, emissions, accidents, and effects on local ecosystems)
- collection and transportation of MSW (noise, transport emissions, accidents, odour)
- combustion of the waste (atmospheric emissions, including trace levels of dioxins and heavy metals)
- impacts on amenity from the incinerator (noise, visual intrusion, odour, etc.)
- transport and disposal of waste ash residues (including abatement technology residue)

For the reason of the certain extent of this project, only the main environmental burdens from biomass energy are described.

3.4.3.1. Land use (land availability)

This can be perceived as a constraint to a large-scale production of energy crops (Kocsis, 1992; Abbasi and Abbasi, 2000). But on the other hand, there are also considerable areas potentially available for biomass energy in some part of the world. For instance, large areas of agricultural land surplus in Europe could become significant biomass producing areas (Hall and House, 1995a). The land availability depends on how intensive the production of biomass is. Nowadays is preferable low input agriculture, but it can therefore result in larger extensification (more land required). Land requirements depends on energy crop yields and efficiency of conversion.

Assuming a 45% conversion efficiency to electricity and yields of 10 Odt/ha.yr [18], a 20 MW electricity facility (sufficient for 4000 households in OECD countries today) would require 7 000 ha that represents 10 % of the land within a 14 km radius of the facility (Hall, 1997). In lower latitude countries biomass yields can be considerable higher than this and because there is also lower energy demand per household, even more households could be supplied with such a facility. According to an example of larger extensification, for a 50 MW combustion plant is required 15,000 to 20,000 ha of energy crop plantation, so- called about 2 to 3% of the land within a 50-km

[18] Odt/ha = Oven dry tonnes per hectare (1 Odt = 20 * 10^9 J)

radius of the plant (IEA, 1998, Appendix H). And these facilities represent only medium - scale biomass power plants, therefore for large- scale plants is required much more land.

The land use for increased biomass production for energy would have to compete with crops, forests and urbanisation (Abbasi and Abbasi, 2000). This fact can be valid first of all for developing countries. There is a surplus of agricultural land available for biomass plantation, for instance in Europe (Hall, 1997)

A development and construction of the facilities all biomass sources also requires land (the need for infrastructure of roads, harvesting and conversion facilities, etc).

3.4.3.2. Agrochemical Use

This burden is especially connected to energy crops. It varies according to the type of crop, in particular whether it is an annual or perennial crop. For perennial woody energy crops, use of agrochemicals is generally less than with other arable crops (Abbasi and Abbasi, 2000).

Herbicides may be used to prepare ground prior to planting coppice and again in the first and second years after planting. The use of herbicides in the initial stages leads to a loss in floral diversity but, as the coppice becomes established, floral diversity should return. Herbicides could also enter surface waters through atmospheric drift, surface runoff, erosion and/or direct spills.

The use of pesticides, insecticides and fungicides is very site and type of management specific and, in many cases, their use may be considered impractical due to the low-value nature of the crop. It may be possible to develop more natural mechanisms to control pests and diseases (ECC, 1994).

3.4.3.3. Loss of soil fertility

This problem is connected to long-term soil fertility, which involves soil management related also to enhancing micro- and macrofauna in soil (Hall, 1997, Boman and Turnbull, 1998). The harvesting of crop residues for biomass energy will cause a significant nutrient loss. The actual effect of residue removal depends on the quality of the site soil (e.g. the existing nutrient status or deposition sources). The nutrients tend to concentrate in parts of plants such leaves and twings, therefore this issue is connected to a careful management of removal agricultural and forestry residues. The bigger use of fertilisers is usually on established plantations on degraded soil. However a certain amount of fertilisers is required to realise higher yields, even on good sites. Fertilisers are a major source of external energy input to biomass systems (Boman and Turnbull, 1998; Saéz, Linares and Leal, 1998). Nowadays there is seen a strategy reducing fertiliser inputs in the fields.

3.4.3.4. Soil Erosion

There is a potential erosion risk in a biomass plantation (IEA, 1998). Biomass energy production projects can exacerbate soil erosion problems (Godgil, 1993). The rate of soil erosion from managed lands depends on climate (particularly rainfall), topography, soil characteristics and the crop. The erosion risk is an important criterion in selecting the plantation species. Thus annual herbaceous crops (like sorghum) are no better in controlling erosion than other annual agricultural crops, whereas either short-rotation forestry (SRF) with replanting every 15- 20 years or perennial grass crops can provide better erosion control. It is thought that erosion will be highest in the first and second years after the crop (SRF or perennial crops) is planted and then it will reduce substantially. Over the lifetime of the energy plantation, total erosion rates are much lower than for arable land used for annual crops, but higher than for established woodland. Impacts on soil erosion thus depend very much on the type of land use that the energy crops displace (Abbasi and Abbasi, 2000).

The forestry residues act as a mat, over which machinery can operate. When this is removed, compaction damage can occur, which indirectly affects tree growth by increasing surface run-off and soil erosion and by reducing root growth. On certain soils (such as peat) there may still be residual compaction problems even when careful machinery is used.

The impacts of soil erosion and runoff of soil into streams and rivers can include increased water turbidity, stream scouring, and silting and increased concentrations of nutrients or pesticides. Most of soil removed by erosion is expected to settle in stream beds and reservoirs, where it could lead to an increased need for dredging, and to an impact on flood control measures. Soil remaining suspended in the water could increase its turbidity, it may be adverse for small clear-water streams, where suspended sediment concentrations can be a long term stress on aquatic organisms (IEA, 1998, Appendix H).

3.4.3.5. Biodiversity and alteration of habitats

The impact of energy crops on habitat and biodiversity depends not only on the previous land use and cultivation but also on the nature of the energy crop (Hall, 1997; Hall and Scrase, 1998). If the plantation displaced permanent woodlands or other environmentally sensitive habitats, then impacts are likely to be negative. The range of biological species will be much narrower in biomass plantations than in natural forests (Gadgil, 1993). Alteration of forest and wetlands will reduce many preferred habitats and mating areas of some animals. There could also be severe impacts associated with endangered species and migratory pathways.

The impact of biomass energy production on biological diversity depends on how sensitively biomass is produced. Annual crops are likely to be managed in the same way as conventional arable crops and do not offer as many opportunities for new habitats. Their impact on habitat and biodiversity is likely to be similar to conventional crops (Abbasi and Abbasi, 2000).

Exotic species are often used as they may be more productive than indigenous species, but they are generally less well adapted to local environment (Hall and House, 1995b). Monoculture plantations of fast-growing trees reduce the diversity of vegetation and the value of the areas as habitats for many wildlife species. Plantation of only one or two species with plants of similar age can be also more vulnerable to attack by pests and pathogens. Therefore pesticides are used to protect plantations. The negative effect on diversity is seen with requirements of increased energy inputs in the form of pesticides and fertilisers to maintain productivity (Pimental et al., 1981; Miller et al., 1990).

Another influence can be sometimes recorded on aquatic environment. Decreased low flows and increased suspended solids, sediments and chemical ions resulting from can adversely affect fish and aquatic life (ECC, 1994).

There is also a problem related to generation biomass energy from landfill sites. Many of the activities on landfill site can disturb local ecosystems. The land used for the site is resulted in a change of habitat for local species. The presence of methane and carbon dioxide can lead to anaerobic conditions near plant roots. This is of itself hazardous to many plants and it can stimulate the take up of toxic compounds, including heavy metals. Some of the minor emissions (e.g. ammonia and organic compounds) also have a toxic effect on plants (IEA, 1998-Appendix J).

3.4.3.6. Water impacts

Nutrient leaching from plantations can contaminate run-off and also groundwater reservoirs, thereby degrading drinking water supplies and effect water quality in receiving rivers, lakes or estuaries by causing eutrophication. There are again very big differences in nutrient leaching for planted species, much better are short-rotation forestry crops and agricultural perennial crops (Hall, 1997).

It also contributes significantly to water pollution via using pesticides and fertilisers that are inevitably needed in sustaining any intensive cultivation (Abassi, 2000). Promoting plantations can be therefore water demanding in certain areas.

Treatment of sewage sludge in digesters can reduce some environmental impacts associated with conventional disposal of sewage sludge (odours, water pollution, chemical and biological pathogens). But there may be problems with residual heavy metals on long-lived toxic chemicals in the digested sludge, that can be a potent risk to water pollution. Untreated, livestock slurries represent a potential source of pollution, especially of watercourses. Even after a primary treatment (i.e. typically, the waste is left for a minimum of four months before spreading on land) over-application of such waste can result in excess nutrients, leading to groundwater or surface water contamination (IEA, 1998, Appendix J).

The release of any leachate from the landfill site may result in contamination of the surrounding soil, surface water or ground water. It is also possible to contaminate local surface water with runoff during waste filling, particularly at elevated landfill sites. Contamination of soil and ground water is unlikely with modern designs of landfill sites. A risk of contamination only remains from an accidental discharge.

Solid waste ash from biomass combustion and waste incineration represents another risk of water contamination, because it can contain some toxic trace elements (IEA, 1998, Appendix I, J).

3.4.3.7. Air pollution

Air pollution presents one of the most monitored environmental burdens of biomass energy. There are some general similarities but also some differences between the categories of biomass feedstock. There are emissions associated with the cultivation and harvesting of the energy crop, with waste collection, waste transportation, transport of ash waste and with the manufacture and construction of the combustion plants. But one of the main sources of emissions is the actual combustion of biomass (Hall and Scrase, 1998; EIA, 1998; Boman and Turnbull, 1998). Therefore in this project, there is emphasis on emissions from biomass combustion.

Air pollution from energy crops

The CO_2 released during combustion was originally sequestered from the atmosphere by the crop during its growth. Therefore there is no net release of CO_2 into the atmosphere. The main emissions of CO_2 that contribute to its increase in the atmosphere arise therefore during the cultivation and processing of the energy crop (Boyle, 1996; Boman and Turnbull, 1998).

There are different emissions of pollutants that arise primarily from combustion. Energy crops can contain sulphur compounds absorbed from the soil during their growth but, at 0.01 to 0.1 percent their levels are very low when compared to solid fossil fuels (e.g. coal has sulphur contents ranging from of 0.5 to 5%). This leads to very low emissions of SO_2 during combustion of energy crops (Hall, and House, 1995; Hall and Scrase, 1998). Emissions of NO_X and uncontrolled emissions of particulates can be relatively much higher than SO_2 emissions. Particulate emissions from gasification are very low, as particulates must be removed from the gas before it enters the turbine. Combustion can release a wide range of organic compounds in trace concentrations (dioxin[19] hydrocarbons, toxic irritants such as acid, aldehyde, phenol and carcinogenic compounds such as benzopyrene) (Swezey, Porter and Feher, 1995).

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[19] 'Dioxins' is the generic name for a family of related compounds, which includes polychlorinated-dibenzo-dioxins *(*pCDD) and polychlorinated-dibenzo-furans *(*pCDF). There are 75 different congeners of the pCDD group and 135 of pCDF, including a number of compounds which are probable carcinogens. The most toxic congener is 2,3,7,8-Tetra-Chlorinated-Dibenzo-Dioxin (TCDD).

In terms of ozone depletion all the biomass systems are ozone destructive due to relatively high emissions of N_2O during combustion and cultivation (Hall and Scrase, 1998).

There are also aldehyde emissions from burning ethanol and they can be significantly higher than for gasoline. This may prove to be a serious problem, because aldehydes are reactive species. Acetaldehyde, for example, is known irritant and possible carcinogen, and formaldehyde is a known carcinogen (IEA, 1998-Appendix H).

Air pollution from agricultural and forestry wastes

The main source of emissions in these technologies is the actual combustion of the waste or biogas. There are a number of important variables that influence emissions produced by a waste to energy scheme (e.g. the content of the waste, the type and location of the scheme, the exact method of collecting the waste).

The actual emissions arising from the combustion process are very site-specific. Emissions will depend on the exact technology and operation, plus the degree of abatement technology in place. As with energy crops, the carbon dioxide released during combustion of forestry and agricultural residues was originally sequestered from the atmosphere while the plants were growing. Therefore, the net CO_2 emissions from a forestry and agricultural waste to energy scheme include only those emissions from other life cycle stages. Other compounds present in the combustion emissions are typical of most fuels such as NOx, SO_2 and particulates (Saéz, Linares and Leal, 1998).

An example can be chosen the straw combustion. Emission levels of NO_X from straw combustion are generally higher (per kWh produced) than other fuel sources because straw is a relatively low calorific fuel and the process efficiency is relatively low (even for modern biomass plants). However, SO_2 emissions are much lower than from other fuels, due to the low sulphur content of straw. There can also be some emissions of hydrogen chloride and very small emissions of dioxins from straw combustion. These arise from the halogenated pesticides used on intensively farmed cereals.

Different emission rates are connected with wet animal wastes. When animal slurries are collected, a natural degradation occurs. This results in emissions of methane (a potent greenhouse gas). As energy recovery schemes combust this gas, they can potentially reduce methane emissions by converting the gas to carbon dioxide, whose global warming potential can be ignored because it is of a biomass origin. But there are still certain emissions of CH_4 from the combustion, because there is no 100 % efficiency in the combustion process. As the produced gas contains low sulphur concentration, there are very low emissions of SO_2 and also emissions of particulates are lower (IEA, 1998- Appendix I).

Air pollution from producing of landfill gas

For any MSW landfill site, the gas produced will consist primarily of CH_4 and CO_2. Landfill sites produce a small but highly variable yield of other gases (e.g. hydrogen, oxygen, nitrogen, ammonia and hydrogen sulphide). Gas formation depends on number of factors, such as the amount and type of waste, how the site is managed, the moisture and climate (Swezey, Porter and Feher, 1995). In addition there are around 200 minor constituents present in trace amounts, mainly organic compounds. The amounts of these minor constituents vary from site to site and with time. The most important of these pollutants include heavy metals and organic compounds such as BTX (benzene, toluene, xylene), PAH`s (poly-aromatic hydrocarbons9, organo-sulphur compounds (notably mercaptans), halocarbons (including chlorinated hydrocarbons).

There will also be extremely low levels of trace heavy metals. Whilst the high temperature of combustion destroys many of the volatile organic compounds (VOC´s), there are still be emissions of both organics (from compounds that pass through the combustion process unchanged) and new compounds formed during the combustion process. Of these, the most important will include complex organic compounds (especially dioxins) which occur in very low concentrations. These compounds are careful monitored, because they are extremely toxic and represent a high health risk (IEA, 1998- Appendix J). As landfill gas collection is not 100% efficient, there are still some residual releases of raw gas.

Air pollution from waste incineration

The most important environmental impacts from waste incineration are the emissions from the combustion of MSW. The major atmospheric emissions from waste combustion are typical for most solid fuels (CO_2, NO_X and SO_2, etc.). Emission levels are generally higher (per kWh produced) than most fuel sources, because MSW is a relatively low calorific fuel and the overall generating efficiency is low (typically ~20%). Carbon monoxide (CO) may also be produced, indicating poor combustion and that the plant is not operating optimally.

There are also other important atmospheric emissions from incineration, which are released at lower concentrations. The individual emissions of the above pollutants from any given incineration plant vary according to the specific technology and operating practices in place, exact waste composition, the pollution abatement equipment present (Swezey, Porter and Feher, 1995). These emissions include hydrogen chloride (HCl), hydrogen fluoride (HF), heavy metals (such as Cd, Hg, Pb, As, etc.) and organic compounds, including semi-volatile/volatile organic compounds (VOC´s). There are also a number of other important organic emissions, including polycyclic-aromatic hydrocarbons (PAH´s), poly-chlorinated biphenyls (PCB´s) and formaldehyde (HCHO) and the halogenated organics (dioxins). These atmospheric emissions from MSW incineration are expressed in Table 3.3.

Table 3.3: Emissions from Incineration Plant Combustion.

Flue gas composition EC 369/89	**mg/m^3**	**g/kWh**
SO_2	300	2,5
HCl	50	0,417

HF	2	0,017
NOx	350	2,92
CO	100	0,83
VOC´s	20	0,17
Total particulate matter	30	0,25
Cadmium (Cd) and mercury (Hg)	0,2	0,0017
Nickel (Ni) and arsenic (As)	1	0,0083
Total other metals, Cr,Cu,Pb,Mn	5	0,042
Dioxins (ng TEQ/m 3)	1 (ng)	8.3E-09 (g)

Source**:** IEA,1998-Appendix K

3.4.3.8. Waste from biomass energy generation

There is an environmental issue with regard to the disposal of the ash produced by biomass combustion. Ash from the combustion plant must be disposed of, either to a landfill site or by depositing it on the cultivation sites as a fertiliser. The ash content of biomass is typically much lower than for coal. The ash from plant biomass contains variable amounts of nutrients (mainly calcium, magnesium potassium and phosphorus), but it can also contain a certain concentration of heavy metals such as cadmium. This fact is caused by the presence of nutrients and different chemical compounds in soil where biomass come from. The spreading the agricultural and forestry ash on areas other than where the biomass came from can increase heavy metal loads in the topsoil and lead to environmental damage. Therefore in some areas the ash is dumped in landfills rather than returned to the forest (Löfstedt, 1996).

Much more toxic substances can be found in bottom and fly ash from incineration of MSW. The solid and liquid waste generated by the incineration process vary with individual abatement technologies and operating practices but can consist of bottom ash, dust trapped by air pollution controls and wastewater (for some specific abatement technologies). All of these can contain pollutants. The quantities of individual pollutants vary according to the individual technology and the specific waste stream (Swezey, Porter and Feher, 1985).

In general, most of the inorganic pollutants (such as heavy metals) can be present in the bottom ash stream at higher concentrations than in the raw waste (typically 3 - 4 times the level in the original waste). The bottom ash is generally disposed of to landfill. This waste is essentially an inert material, there is a small risk from accidental leakage discharge from the landfill site.

The fly ash residue (the ash collected in precipitators) has a much higher concentration of metals and needs special disposal because of its potential environment impact. Such waste is often deposited in controlled or hazardous waste landfill sites. In addition, there may be a contamination from activated carbon that is used to reduce organic emissions and some mercury vapour under strict emissions limits (activated carbon can be therefore contaminated with some metal vapour and organic compounds) and may also need special disposal.

For some plants, the abatement system will collect fly ash, scrubber products and carbon in one waste stream, which would then be treated or disposed of in hazardous waste landfill. However, some incineration processes and abatement technologies may produce liquid effluents that are controlled and treated prior to release. In addition, some flue gas cleaning systems produce potentially harmful liquid effluents (e.g. wet-scrubbing systems would need complex treatment to remove metals) (IEA, 1998 - Appendix K).

3.4.3.9. Socioeconomic impacts

The major social impacts are shifts employment and increases in health and safety problem. More occupational injuries and illnesses are associated with biomass production in agriculture and forestry than with either coal, oil or gas recovery operation (Abbasi and Abbasi, 2000). Biomass is the fuel most closely associated with energy related health problems in developing countries (burning of biomass in household cooking/heating stoves). But there are also health-related emissions from biomass combustion that can occur everywhere.

The storage of wood chips can lead to spore release which, in a confined space, can represent a health hazard (prolonged exposure can cause the disease “farmer’s lung”). Biomass from plants cannot be stored for more than six months due to the leaching of various turpentines found in the wood and to mould and mildew build-up which can cause health problems (Löfstedt, 1996).

There is a potential fire risk to local residents and natural ecosystems from this storage of biomass (wood chips as well other types of biomass are known to self- ignite during storage). Methane is a flammable gas and, therefore, its uncontrolled release incurs a risk of fires and explosions.

Some of the trace compounds from biomass combustion may represent a hazard to human health and they include a number of known or suspected carcinogens. The heavy metals, chlorinated-organic micro-pollutants and some complex PAH compounds have been linked to adverse health effects and they are persistent (they do not break down quickly in the environment and thus can accumulate in organisms). In addition, there are public health risks if landfill leachate contaminates water used as a drinking supply or an irrigation source, from the potentially toxic compounds and pathogens present. The other main public health issue concerns birds, rodents and other animals that are attracted to landfill sites (IEA, 1998, Appendix J).

Incineration of MSW and landfill sites present much bigger amenity impacts than other biomass sources. Amenity impacts can include odour from the waste, noise, and visual intrusion, wind blown litter and attraction of flies, vermin and rodents. The potential amenity impact of any incineration plant or landfill site is very site-specific. It was suggested that amenity effects become insignificant beyond a 4 miles radius from a landfill site. This illustrates the localised and site-specific nature of the impacts. As a result, the scale of the impacts will be highly dependent on whether the location is rural or urban, on the local population density, etc. (IEA, 1998- Appendix K).

One of the main constraints for many biomass schemes is the relatively high cost per unit of output, that it is caused by high capital and initial investment, high cost of raw material and for instance the smaller scale nature of most biomass projects. Therefore biomass energy is presently more expensive than fossil fuels and some other renewables, such as hydro or wind power. Criticism against biomass energy is therefore seen with the need for large subsides (Lunnan, 1997; Hall and Scrase, 1998).

From a production economics point of view, it has to be distinguish between 2 situation:

- biomass for energy as a by- product such as straw and manure (the main product is typically a food, feed or fiber product and it covers the fixed costs and the by- product only has to cover marginal cost)
- the energy crop is the main product and has to cover all costs (purpose- grown energy crops)

3.4.4. Solutions

Emissions of many pollutants (except CO_2) can be limited by various abatement techniques, also “best available technologies” (BET) are required. Known technologies can thereby mitigate most of air emissions. These include, for example, use of stack scrubbers and electrostatic precipitators, sorting of plastic to avoid PVC hazard and incineration at high temperatures to destroy dioxin.

A careful site selection is necessary to avoid large changes to local ecosystems, noise, odour and visual intrusion from plants and transportation of wastes and other operations. A planting energy biomass on degraded land or replacing monocultural food crops is preferred.

Species selected for the plantation should be fast- growing, perennial and well matched to the plantation site to provide a good erosion control and a reduction of potential water pollution.

To keep or increase biological diversity, there is a shift to polycultural strategies (e.g. mixed species in various planting configuration) and special land-use planning in which natural patches are connected via network of undisturbed corridors, thus enabling species to migrate from one habit to another. A plantation area should be aside for native flora and fauna to harbour natural predators for plantation pest control.

A natural recovery of nutrients to soil (leaving some wastes in the field, selecting a nitrogen- fixing species, intercropping the primary crop) should be preferred to keep long- term soil fertility and a good soil management.

To favour the smaller scale biomass plantation and thereby also the smaller and medium-scale biomass power plants.

Biomass cogeneration has more potential growth than biomass generation alone because cogeneration produces both heat and electricity (it results in net fuel use efficiencies of over 60 percent).

3.4.5. Conclusion

If biomass energy systems are well managed, they can form a certain part of an energy supply share, which is environmentally sound and therefore contributes to sustainable development. The possible positive effects can far outweigh different environmental negative effects, when careful planning and management is involved. Appropriate local and regional decision-making is essential for efficient long-term sustainability of biomass energy production in an environmentally and socially acceptable manner.

CHAPTER 4.

4.1. General benefits of renewable energy

In this section we will analyse some of the general benefits from renewable energies. We have identified renewable energy sources as sustainable technologies. There are several environmental benefits from using renewable energy supplies in preference to conventional sources such as coal, oil, gas and nuclear power.

Through the use of renewable energy we can achieve environmental benefits such as:

- Reduction in emissions of greenhouse effect gases (e.g. carbon dioxide), which is the most important consequence, in interest of the global climate stability. Electricity generating renewables already displace 1.500 Mt of carbon dioxide, corresponding to about 7% of current energy related carbon dioxide emissions (http://www.elsevier.com/locate/futures, 25/5/2000).

- Reduction of the emissions of acid rain gases (as nitrogen oxides, sulphur dioxide)
- Improve the state of lakes, rivers, forests and soils
- Reduction of wastes (by utilisation of waste products for energy generation)

Besides these general benefits there are also the other advantages discussed in chapter 3 connected to the specific energy types.

There are also socioeconomic benefits associated with the exploitation of renewable energy sources. Previously, environmental benefits alone have been the basis for both the governmental promotion of renewables and support by communities for their local deployment.

In the future socioeconomic benefits from renewables are expected to be of growing importance, particularly in gaining popular support for their large-scale deployment.

In Europe an increase in the energy supply from renewable energy would have an important economic benefit because renewables can contribute to a diversified and secure indigenous energy supply and to promote a stable energy cost. Inevitably, the resources we depend upon will become more expensive and will run out (of oil, gas, and coal). Furthermore, energy crisis can be avoided by increasing the use of renewable energy, decreasing the countries reliance on imported fuel.

Moreover, there is an increase in employment opportunities. It is very important because unemployment especially in rural areas is currently a key political concern in many EU countries. The investments in renewables predicted by the WEC (World Energy Council) in an ecological driven scenario would require $ 2.4 trillion (WEC, 1993). This represents a great business opportunity for industry.

Table 4.1. Direct employment created by electricity industry's technology.

Technology	Jobs (per TWh per annum)
Nuclear power	100
Coal	116
Solar Energy	450
Wind	542

Source: EUROSTAT, (European Commission, 1998).

It is also possible to enhance the national economies through the development of strong renewable energy industries thereby boosting the potential to compete in export energy markets. A reduced degree of dependence on other countries will increase the world stability, both politically and economically. This could help to achieve increased deployment through supporting renewables at all stages of their development. The increased market penetration will give feedback in the form of reduced cost (IEA, 1997).

Most renewable energy systems are modular, allowing flexibility in matching load growth and are suitable for use in decentralised energy production and consumption (off-grid utilities). It promotes the decentralisation of energy markets, by providing small, modular, rapidly deployable schemes.

Large-scale applications are relatively capital intensive (compared with technologies against which they compete) and require major investment in equipment to capture diffuse energy sources. However, after the investment has been made, the economics of renewables would improve in comparison with conventional competitors, since running cost are low compared with using conventional fuels (Boyle, 1996).

Another difference between renewables and conventional energy source, is that the lifetime of renewables is infinite, the cost of the source is free and the operational and maintaining cost of most renewables are low.

In the future (particularly when their generating costs fall) the other benefits of many renewable energy sources will become increasingly recognised. But the environmental benefits of renewable energies are still not adequately reflected in energy pricing in the majority of Europe. Otherwise, the environmental negative impacts of conventional generation are not taken into account when they are cost, thereby, currently competition between renewable energies and conventional ones is not at all equal.

4.2. Impediments and measures in the EU for renewable energy implementation

The potential of renewable energy is generally poorly exploited due to a combination of technical, socioeconomic and market impediments: as the lack of social awareness, the public acceptability, uncertainty of the effect of restructuring the energy sector and others.

Even after the use of best practice, renewables have irreducible environmental adverse impacts, others than life cycle emission. The most important ones perceived by the public are: high land use, visual impact and noise. On the other hand the damage to ecosystems, the intermittence of renewables and the storage problem are also significant. But most of the impacts are temporary and fully reversible on decommissioning the scheme (Twidell, 1986).

Unlike conventional fossil fuel technologies, renewable energy technologies (apart from biomass) generally produce no greenhouse gas or other atmospheric pollutants during their generation stage. However, emissions do arise from other stages in their life cycle:

- Resource transportation.
- Material processing
- Component manufacture
- Plant construction
- Plant operation
- Decommissioning
- Product disposal (IEA, 1997)

The adverse ecological impacts of renewable energy technologies are, in general, at local or regional level. But the socioeconomic impacts are more at global and international level. The high cost of renewable sources is partly due to the dispersed nature of renewable energy, and partly because many renewable energy technologies are not yet mature. Moreover, no monetary values are given to many of the environmental and social benefits that increased use of renewables can bring. These benefits are ignored in economic comparison of renewable energy with conventional energy sources.

In the EU these high cost has been helped over recent years by a number of policy, technological and economic factors. One of the more important, has been a political will to promote renewables since Earth Summit in 1992. Also the reduction of technology costs has been another important factor (IEA, 1998-Appendix A).

The social and institutional implementation problem is very hard to resolve. Part of the problem of transition is that renewable energy technologies are trying to establish themselves in an institutional market and industrial context on the existing types of energy technology. And renewable sources are diffuse and the technologies are smaller scale than conventional energy (www.elsevier.com/locate/futures, 22/5/2000).

The problem of resistance to change becomes very clear if we look at the international level. For example, progress on reaching international agreements concerning environmental control on emissions has been slow. There is a conflict between the impetus toward global free market competition and environmental pressures for increased regulation. The implementation process will be slow, unless the environmental advantages of renewable energy use are factored into the economic assessment, and for the moment renewable energy is expensive (Abbasi and Abbasi, 2000).

Environmental Impact Assessment (EIA) must be used to reduce the adverse environmental impacts from renewable energy. This tool is essential for choosing a correct site, for a renewable energy scheme, avoiding fragile areas. The EIA procedure has a common framework for all the Member States of the EU under a EIA directive (www.europa.eu.int, 24/4/2000). Another measure to make renewable energy more environmentally friendly is choosing the best technology available. Include the adoption of relevant, modern technical and management practices, sensitivity to environmental concerns and minimisation of any adverse impacts associated with the scheme. Finally, local involvement, in addition to public consultation, could help to improve public acceptability. Including the local community more actively in proposed schemes (Abbasi, 2000).

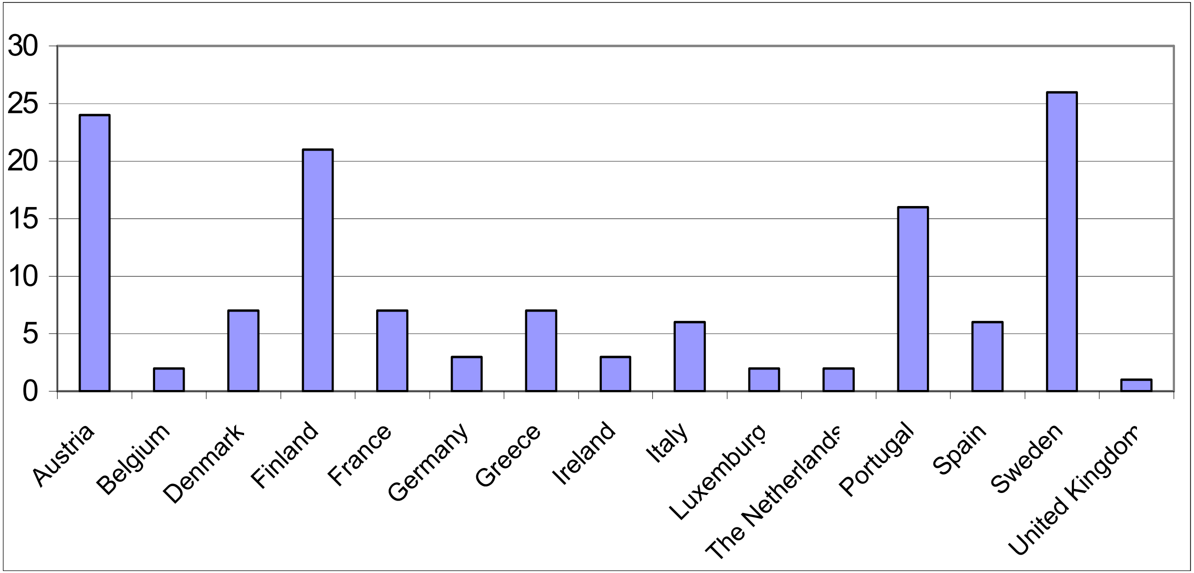
In the EU currently, there is some legislation in force that control the renewable energy deployment and use. It is the 88/349/EEC: Council recommendation of 9 June 1988 on developing the exploitation of renewable energy in the Community, with the following aim:

“The Council adopted the objective of continuing the development of new and renewable energy sources and of increasing their contribution to the total energy balance”(www.europa.eu.int/eur-lex/en/lif/dat/1988/en_388XO349.html, 4/5/2000). This recommendation brings different measures that the member states can develop if they consider it necessary. But it is just a recommendation, which advise the promotion of renewable energy, without any kind of obligation for the Member States.

The European Union identifies security of energy supply, environmental protection and the development of competitive industries as its three key aims for present and future developments in energy policy. Renewable energy technologies clearly have an important role to play in achieving these aims: they are indigenous, they generate little pollution, and they are becoming a cost-effective alternative to conventional energy technologies. Renewable energy is mainly local energy. Its development can create new businesses, bring employment and encourage economic and social cohesion in regions that otherwise lack industrial development. But, still the penetration of renewable energy sources into Europe's energy mix is still low: in 1996 renewables contributed less than 6% towards total inland energy consumption[20] (European Commission, 1998).

Figure 4.1. Percentage share of renewable energy sources consumption (1996).

[20] As we can see in the Figure 4.1. there are big differences between the use of renewable ernergy of each Member State.



Source: EUROSTAT (European Commission, 1998).

The EU has published its White Paper on Renewable Energy Sources[21]. This sets out for the first time a comprehensive strategy and action plan designed to achieve, by 2010, an ambitious but realistic goal of doubling from 6 to 12% the share of renewable energies in the total energy demand of the EU. This White Paper recognises that unless the EU succeeds in supplying a significantly higher share of its energy demand from renewables over the next decade, it will miss an important market development opportunity.

[21] Energy for the future: Renewable Sources of Energy.
¨White Paper for a Community Strategy and Action Plan”.

At the same time, it will become increasingly difficult for the EU to comply with its commitments to environmental protection and emissions reductions both at European and international level (Abbasi, 2000).

However, there are still many factors that are holding back the greater development and implementation of renewable energy technologies throughout the EU and world-wide. While several of the technologies, notably wind energy, small-scale hydro power, solar energy and energy from biomass, are often economically viable and competitive, and others are approaching viability, initial investment costs are high and investors often lack confidence in technologies that are relatively unknown. As a result, development has been limited.

The EU White Paper on Renewable Energy Sources proposed an Action Plan that aims to provide fair market opportunities for renewable energies without excessive financial burdens. It has proposed a list of priority measures and actions to overcome the obstacles preventing implementation of renewables, and to try to redress the balance in their favour. In the Renewables White Paper the Commission proposes to support a campaign for the take-off of renewables throughout the Community. The campaign proposes to promote the implementation of large-scale projects in different renewable energy sectors, and it will need close co-operation between Member States and the Commission (European Commission, 1998).

On the other hand the European Commission's proposed Fifth Framework Programme cover all the research efforts of the EU for the period 1998-2002. For energy, the programme focuses on two key areas: cleaner energy systems, and economic and efficient energy for a competitive Europe (www.europa.eu.int/en/comm/dg17.htm, 22/4/2000). The development of sustainable technologies is only part of the process of moving towards a sustainable future, that will also require social and institutional changes, including, new attitudes and expectations concerning consumption and affluence.

4.3. Comparison

In the following section we combine our analysis of the adverse impacts from renewables, in order to make a ranking. We intend this ranking as a tool for decisionmakers to make use of when deciding what energy types should be strengthened. It should be emphasized that this ranking is based on environmental impacts only and therefore does not take into consideration the economic and technologic availability of the different energy types.

Table 4.2. Comparison of renewable energy sources.

Environmental Impact

	Chemical	Physical	Ecological	Socioeconomic	Total
	emissions *leakage* *use of chemicals*	*construction* *noise* *change of landscape* *visual intrusion* *landuse*	*ecosystems* *biodiversity*	*health* *employment* *accidents*	
Solar thermal electric	L	M	L	L	L
Photovoltaics	M	H	M	M	M
Wind	L	M	L	L	L
Agricultural and					

forestry biomass	M	M	M	M	M
Landfill gas	M	M	L	M	M
Waste incineration	H	L	L	M	M
Hydropower (dams)	L	H	H	H	H
Run of the river	L	L	M	L	L

Notes: **L, M, H = Low, Medium, High.**

These are estimates intended to be indicative only and not to be used for direct comparison with non-renewable technologies.

The ranking in the table originates from our discussion from wind, hydro, biomass and solar the adverse environmental impacts. The table therefore represents our opinion. It should also be mentioned that it is an ideal construction and impacts from the different energy types varies according to scale, management, location, available technology and development.

In the table we have ranked wind power low because adverse impacts are low compared to that of hydro, biomass and PV. Aspects such as visual intrusion and noise are dependent on the perception in the neighbourhood of wind turbines.

We have categorised solar thermal electric and run of river hydropower under low environmental impacts. This is due to the smaller scale of the schemes. Compared to other renewables we consider biomass to have medium impact. This is because biomass use agrochemicals and produce atmospheric emissions during generation.

We have placed photovoltaics at the same level as biomass because these systems have a significant land use in areas with fragile ecosystems. Besides the PV life cycle includes large energy consumption when produced and emission of heavy metals.

We have ranked hydropower as having high environmental impacts. This is due to the permanent change in the chemical and physical structure of the river resulting in high impacts on the ecosystems. Large construction work and movements of local people are other significant impacts from hydropower. However, this high level of impacts is caused by the larger scale of hydropower schemes compared to other renewable energy sources. As mentioned earlier hydropower is a mature technology that has been used extensively during most of the 20th century.

From our ranking we recommend that the energy sources with low--medium impacts are used more extensively. That is windpower, solar thermal, run-of the river hydro and different types of biomass.   Large scale hydropower should preferable be downgraded.

We would like to mention that our ranking does not include the scale of energy production and it is possible solar thermal powers, windpower and biomass would have substantial impacts if they were used on a larger scale.

CHAPTER 5. CONCLUSION

Renewable energy sources have gained a strong foothold within the last decade and it is most likely that they will grow further in the future. In the current situation we are witnessing a rapid development of new more efficient and competitive technologies, especially in the fields of wind, solar and biomass. This development is a result of increased political awareness about the environment, because renewable energy sources are seen as cleaner and more sustainable. In our project we have tried to give a more balanced view of the renewables by analyzing the environmental and socioeconomic impacts. Like any other energy sources there are adverse environmental impacts from using water, wind, sun and biomass. Most of the impacts are local, small and can be mitigated. However the impacts are inclined to grow with increased scale and therefore likely to be more relevant in the future unless adequate measures are taken to minimize them.

Despite their growth renewable energy sources are facing many obstacles on the energy market, especially because there are still huge financial interests connected to conventional sources. We would like to emphasize that this project although exploring the adverse environmental impacts of renewables should be considered as a support to the use of renewable energy sources. We hope that our project can contribute to a more holistic picture of the renewables and prevent a repetition of the environmental disasters resulted by the uncritical consumption of conventional sources.

Our version of the future perspectives for renewable energy production includes a high degree of mixture of sources. The ideal situation would be an almost 100% renewable scenario where the different sources complemented each other, using the resources at hand- e.g. when there where no wind- biomass could be used etc. This however demands intensive research in storage and transportation of renewable produced energy. Even though this highly idealistic perspective is perhaps not realistic in a near future, we still encourage further research, development and political support to renewable energy sources.

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