UNEP e-Learning Course on

Insurance Risk Management for Renewable Energy Projects

- Module 2 -

Renewable Energy Technologies, Policy, Investments Trends and Risks

Overview

The training is organized in 6 modules and fits into a 2 day training schedule:

Module	Main Content	Length of Module
1 – Climate Change	Briefing, policy frameworks and business impact	2 hours
2– Renewable Energy Technologies and Risks	**Renewable Energy technologies policy, investment trends and risks**	**3 hours**
3 – Underwriting Guidelines and Policy	Underwriting information, guidelines, risk evaluation, coverage evaluation	5 hours
4 – Claims Handling and Policy	Claims information, management, reserving, legal and payment	2 hours
5 – Intermediaries and Networks	Project development, information and consultation	1 hour
6 – Case study	Renewable Energy case study, risk assessment, impact and suitability of instruments	3 hours
Total		16 hours

Module 2 Contents

Lesson Objectives	
Renewable Energy Technologies	**To understand renewable energy technologies and market trends.**
Risk Consideration	**To present the main physical and financial risk features for RETs.**
Insurance Consideration	**To present the main insurance products offered for RETs and the main underwriting issues.**

Introduction

Renewable Energy (RE) is a cornerstone of a sustainable energy supply for the future. RE is available through a number of technologies. Those technologies have improved significantly in the last 20 years. However on a global scale, the percentage of energy produced with renewable sources is still low. Excluding large hydro, renewable energies comprise approximately 5% of the global energy supply (IEA 2007).

Due to the fact that most RE technologies are dependent upon vastly available natural resources such as the sun, wind, and water their potential is unlimited in terms of “fuel” supply. An insignificant portion (less than 0.01%) of global solar direct radiation would be sufficient to address one year of global electricity consumption.

More than 60 countries, states, and communities have set targets to achieve a higher share of RE in the local energy mix. In most cases, ambitious growth goals have been set with deadlines between the years 2010 and 2025. Focused promotion policies to enhance implementation and usage of renewable power generation have been set to reach the goals. The most common policies are the feed-in laws, e.g. establishing attractive production tariffs for RE suppliers.

Global RE capacity grew at rates of 15 to 30 % annually during the period between 2002 and 2006. Still, RE production costs are significantly higher than for traditional fossil fuels or nuclear energy. Most technologies used to generate renewable energies have been tested and there is a reliable operational knowledge basis. However, there are still many financial and physical risks, real or potential, that need to be overcome. Barriers, especially for small-scale RE installations, in the early financing stage may prevent potential projects from being realized. Investors are increasingly seeking insurance covers in order to proceed with the financing of a project.

Insurance can lower the cost of capital and increase liquidity by reducing the financial impact of risk events. Insurance covers can be offered to prevent losses from delays or damage during the fabrication, transport, construction, and operational stages of an RE project. This can be due to technical failures, human errors or forces of nature. Underwriting these events requires a sufficient degree of knowledge regarding the likelihood (frequency) and the severity of possible losses triggered by these events. Most RE projects do not have the necessary statistical data for measuring the needed probability distributions and correlations between random events. A reliable information base regarding the construction processes, operating conditions, loss factors, supply information, control measures and further detailed operational experience is essential. Only with this information at hand, can insurance underwriters adequately understand and price an RE project.

This section presents the rationale beyond the emergence of RETs. Many countries and jurisdictions have implemented promotion policies to enhance implementation and usage of renewable power generation. Installed capacity and investments have grown significantly in the last years.

Section 2 - Renewable Energy Risks

This section explains the physical, operational and financial risks implied with a certain RE technology. Based on technologies' characteristics and risk considerations, a risk analysis methodology is provided for the most common RE technologies: wind, hydro, photovoltaic, solar thermal, biomass, biogas and geothermal.

Section 3 - Insurance Offerings

This section presents the current insurance offerings for RETs. Insurance offers financial protection from delays or damage during the fabrication, transport, construction, and operational stages of an RE project. A reliable information base is required to underwrite the different RE related risks.

Renewable Energy Technologies

As of today, finite fossil energy carriers constitute the majority of our energy supply. Fossil fuels (oil, gas, and coal) still account for up to 80% of global energy supplies and are mostly used in commercial activities. However, accelerated usage and lower fossil fuel reserves combined with the negative impact of greenhouse gas (GHG) on the climate may result in changes in the future energy trends. The new patterns of energy supply and demand will be driven by four factors: changes in the global climate, excessive use of finite fossil fuels, risks associated with energy technologies, and growth of energy demand.

Factors	**Description**
Climate Change	Changes in the global climate due to global warming accelerate the need to switch to GHG-neutral energy sources (see Module 1).
Finite Energy Resources	Finite energy resources – especially fossil energy sources (oil, gas and coal) are excessively consumed. Global reserves for fossil energy continue to be depleted, reaching the point where production will start to decline (Peak Oil). Also, fossil energy sources are the main contributors of greenhouse gas emissions, which accelerate climate change.
Risks Associated with New and Existing Energy Technologies	There are risks associated with using new energy technologies. For example, nuclear technologies are high-risk installations and potentially prone to events such as environmental pollution, heating of natural water and destruction of biodiversity, nuclear accidents, geopolitical conflicts, etc. There is an ongoing analysis and comparison of the risks/costs versus the benefits of nuclear energy. Sections 2 and 3 will give a closer look at the physical and financial risks of RET.
Growing Demand	There are large differences in energy consumption between industrialized countries and developing countries. This is the global challenge of emerging and developing countries. It is assumed that global energy demand will grow by 50% in the next 20 years (from 2008), with more than 2/3 of the growth credited to emerging countries (particularly China and India).
Peak Oil	Peak oil is the point in time when the maximum rate of global fossil energy production (e.g. petroleum extraction) is reached. After reaching this point, the rate of production starts to decline. An exact determination of the point in time depends on various factors such as: future estimated demand, the availability of alternative energy sources, the development of cheaper extraction technologies, access to known and not yet detected fossil reserves, and the economic situation in the world. It is not clear if peak oil already has been reached or is still at some point in the future.

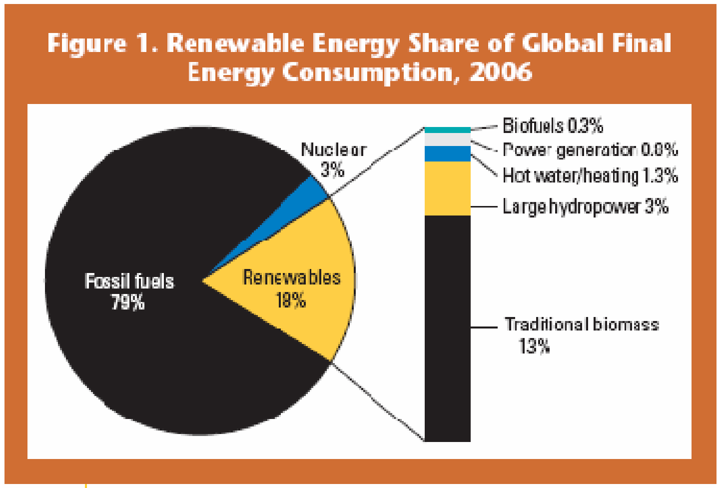
RE is an alternative energy source to fossil and nuclear energy. As of 2007, RE supplied approximately 18% of the world's final energy consumption.

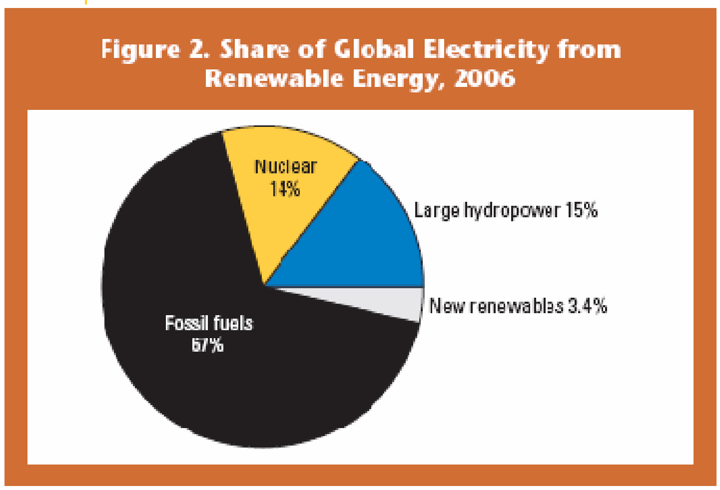
Renewable Energy	Renewable energy (RE) is generated from natural energy sources which are renewable – e.g. are naturally replenished. They include energy power derived from the sun (solar thermal, photovoltaic), the wind, the water (hydro, tidal and wave power), or the earth (geothermal, biomass, biofuels). It can replace conventional fuels in three sectors: power generation, hot water and space heating and transport fuels.
Sustainable Energy	Sustainable energy refers to the energy generated from clean sources and clean technologies. It is produced to meet the needs of the present generation without compromising the ability of future generations to meet theirs. Sustainable energy includes: Renewable energy; Implementation of energy efficiency measures in existing energy installations.
Renewable Energy Technology	Renewable Energy Technologies (RET) turn natural energy into electricity or heat. The main RETs are: - Hydro (large and small hydro); - Biomass; - Geothermal; - Wind (onshore & offshore); - Solar Photovoltaic (PV); - Solar Thermal; - Ocean (tidal/wave energy).

RETs are converting the energy potential of the sun, wind, water, and the earth into the electricity, heat, or movement. The same energy conversion principles apply as for traditional fossil energies:

RET	**Energy conversion principles applied**
Wind Power	The wind's kinetic energy is turned into electricity using wind turbines.
Hydro Power Tidal/Wave	Dam/Storage: Gravitational energy of water is turned into kinetic energy and then transformed into electricity using turbines. River/Tidal/Wave: Kinetic energy of water is turned into electricity using turbines.
Photovoltaic (PV)	Solar radiation energy is turned into electricity using solar cells.
Solar thermal	Solar radiation energy is turned into heat with the help of solar thermal collectors.
Biomass Biogas	Energy from chemical and thermal processes derived from biomass or biogas is turned into heat, movement or electricity with the help of combustion, gasification, or liquefaction.

Geothermal	Heat energy from the earth is turned into heat or electricity with the help of hydrothermal systems.





Source: REN21, Global Status Report 2007 - http://www.ren21.net

RE is not always GHG emission free. However the GHG balance for renewable energy technologies is neutral during their lifetime.

GHG neutral energy	Energy generation from wind, photovoltaic systems and water is GHG emission free. However, what has to be taken into account is the GHG required to manufacture and transport the required installations. Biomass and fuels are not GHG emission free when converted into energy. However, in their lifetime their GHG emissions balance is neutral. Example: GHG emissions produced when burning wood equals the GHG absorbed during the lifetime of the tree.

RE can be produced in order to support a local need, such as the generation of electricity or heat in off-grid areas. This is the traditional usage of biomass in developing countries.

Grid-connected vs. Off-grid	Grid-connected technologies are part of the larger electricity or thermal grid or network. Typical grid RETs are: Large windfarms, large hydro. Off-grid or stand-alone technologies are single installations where production and consumption stay at the same location without any transmission/feed-in to an electricity or thermal network. Typical off-grid RETs are: Solar home systems (e.g. thermal or PV on rooftops), small wind turbines, village-scale mini-grid and mini and micro hydro.

Figure 3 –

Common Existing Applications of Renewable Energy in Rural (Off-Grid) Areas

Energy Services	Renewable Energy Applications	Conventional Fuels
Cooking (homes, commercial stoves and ovens)	• biomass direct combustion (fuel wood, crop wastes, forest wastes, dung, charcoal, and other forms) • biogas from household-scale digester • solar cookers	LPG, kerosene
Lighting and other small electric needs (homes, schools, street lighting, telecom, hand tools, vaccine storage)	• hydropower (pico-scale, micro-scale, small-scale) • biogas from household-scale digester • small-scale biomass gasifier with gas engine • village-scale mini-grids and solar/wind hybrid systems • solar home systems	candles, kerosene, batteries, central battery recharging, diesel generators
Process motive power (small industry)	• small hydro with electric motor • biomass power generation and electric motor • biomass gasification with gas engine	diesel engines and generators
Water pumping (agriculture and drinking)	• mechanical wind pumps • solar PV pumps	diesel pumps
Heating and cooling (crop drying and other agricultural processing, hot water)	• biomass direct combustion • biogas from small- and medium-scale digesters • solar crop dryers • solar water heaters • ice making for food preservation	LPG, kerosene, diesel generators

Source: REN21, Global Status Report 2007 - http://www.ren21.net

Legislation and Policy Making

With regards to legislation and policy making, all the relevant factors in the economic, social and ecological environment that contribute to the goal of achieving a sustainable energy supply should be taken into account. There are underlying guidelines for a political agenda on a country, state, or community level. The following is a list of factors that are typically mentioned in the political discussions.

Guidelines for sustainable energy supply	Relevance
Equality of access	Energy resources and services should be accessible for all.
Protection of resources	Sufficient energy resources should be available for future generations.
Compatibility with environment, climate and health	Energy related emissions and waste should not exceed the regeneration capability of the environment.
Social compatibility	People affected by certain energy supply options should be able to participate in the decision making process.
Low risk and error tolerance	Unavoidable risks and hazards in the generation and use of energy should be minimized.
Comprehensive economic efficiency	Energy should be provided at acceptable costs, taking into account the production as well as the external and social costs.
Availability and security of supply	Energy supply should be adequately diversified and steadily available.
International co-operation	Ensure a peaceful co-operation and eliminate potential resource conflicts between states.

RE policies have been introduced in about 70 countries worldwide with a strong emergence since 1998. Most policies are directed to enhance the share of RE of the total energy produced. However it is difficult to compare policies due to different measurement scales.

There are three methodologies for measuring the share of primary energy from renewables.

Measurement method	Description
IEA method (International Energy Agency)	Energy = Total fuel consumed + Energy value of electricity from renewable energy. The measurement is based on the input energy in fossil, nuclear and biomass power plants but on output energy in wind, solar and hydro.
BP method (British Petroleum)	Energy = Equivalent fossil energy to produce one unit of renewable electricity. Used in BP's yearly Review of World Energy. Also used by UNEP in the World Energy Assessment.
EC method (European Commission)	Energy = Final energy used at the point of end-use as electricity, heat or fuel. Used in the EU statistics and for setting the EU targets.

Measurement unit	Description
MW installed	1 Megawatt equals 1 million watts. Typically small-scale installations are considered to be up to 10 MW.
GW installed	1 Gigawatt equals 1 billion watts. As of 2007, Global energy supply was of 4300 GW, with RE counting for 240 GW (without large hydro). The famous Chinese Three Gorges Dam is projected to supply 22 GW.
kilowatt hour (kWh)	1 kilo Watt hour equals one thousand watts provided during 1 hour. Energy tariffs are normally accounted in monetary unit per kilowatt hour (kWh).

Policy targets vary from country to country. They usually aim to make a country or region reach a given share of renewable energy in the energy portfolio, typically between 5 and 30%, by a given year; usually 2010 to 2012 or 2025.

The following tables provide some additional information about the detailed goals for different countries regarding the share of primary and final energy, the share of electricity produced and other RE targets.

Figure 4 -

Share of Primary and Final Energy from Renewables, Existing in 2006 and Targets

	Primary energy (IEA method)		Final energy (EC method)	
Country/region	**Existing share (2006)**	**Future target**	**Existing share (2005–06)**	**Future target**
World	13%	—	18%	—
EU-25/EU-27	6.5%	12% by 2010	8.5%	20% by 2020
Selected EU Countries				
Austria	20%	—	23%	34% by 2020
Czech Republic	4.1%	8–10% by 2020	6.1%	13% by 2020
Denmark	15%	30% by 2025	17%	30% by 2020
France	6.0%	7% by 2010	10%	23% by 2020
Germany	5.6%	4% by 2010	5.8%	18% by 2020
Italy	6.5%	—	5.2%	17% by 2020
Latvia	36%	6% by 2010	35%	42% by 2020
Lithuania	8.8%	12% by 2010	15%	23% by 2020
Netherlands	2.7%	—	2.4%	14% by 2020
Poland	4.6%	14% by 2020	7.2%	15% by 2020
Spain	6.5%	12.1% by 2010	8.7%	20% by 2020
Sweden	28%	—	40%	49% by 2020
United Kingdom	1.7%	—	1.3%	15% by 2020
Other Developed/OECD Countries				
Canada	16%	—	20%	—
Japan	3.2%	—	3.2%	—
Korea	0.5%	5% by 2011	0.6%	—
Mexico	9.4%	—	9.3%	—
United States	4.8%	—	5.3%	—
Developing Countries				
Argentina	8.2%	—	—	—
Brazil	43%	—	—	—
China*	8%	15% by 2020	—	—
Egypt	4.2%	14% by 2020	—	—
India	31%	—	—	—
Indonesia	3%	15% by 2025	—	—
Jordan	1.1%	10% by 2020	—	—
Kenya	81%	—	—	—
Mali	—	15% by 2020	—	—
Morocco*	4.3%	10% by 2010	—	—
Senegal	40%	15% by 2025	—	—
South Africa	11%	—	—	—
Thailand*	4%	8% by 2011	—	—

Note: Not all countries with primary energy targets are included in table;

Source: REN21, Global Status Report 2007 - http://www.ren21.net

Figure 5 -

Share of Electricity from Renewables, Existing in 2006 and Targets

Country/region	Existing share (2006)	Future target
World	18%	—
EU-25	14%	21% by 2010
Selected EU Countries		
Austria	62%	78% by 2010
Belgium	2.8%	6.0% by 2010
Czech Republic	4.2%	8.0% by 2010
Denmark	26%	29% by 2010
Finland	29%	31.5% by 2010
France	10.9%	21% by 2010
Germany	11.5%	12.5% by 2010
Greece	13%	20.1% by 2010
Hungary	4.4%	3.6% by 2010
Ireland	10%	13.2% by 2010
Italy	16%	25% by 2010
Luxembourg	6.9%	5.7% by 2010
Netherlands	8.2%	9.0% by 2010
Poland	2.6%	7.5% by 2010
Portugal	32%	45% by 2010
Slovak Republic	14%	31% by 2010
Spain	19%	29.4% by 2010
Sweden	49%	60% by 2010
United Kingdom	4.1%	10% by 2010

Country/region	Existing share (2006)	Future target
Other Developed/OECD Countries		
Australia	7.9%	—
Canada	59%	—
Israel	—	5% by 2016
Japan*	0.4%	1.63% by 2014
Korea	1.0%	7% by 2010
Mexico	16%	—
New Zealand	65%	90% by 2025
Switzerland	52%	—
United States	9.2%	—
Developing Countries		
Argentina*	1.3%	8% by 2016
Brazil*	5%	—
China	17%	—
Egypt	15%	20% by 2020
India	4%	—
Malaysia	—	5% by 2005
Morocco	10%	20% by 2012
Nigeria	—	7% by 2025
Pakistan	—	10% by 2015
Thailand	7%	—

Note: Not all countries with electricity targets are included in table;

Source: REN21, Global Status Report 2007 - http://www.ren21.net

Figure 6 – Other national renewable energy targets

Country	Target(s)
Australia	9.5 TWh of electricity annually by 2010 (RPS)
Brazil	3.3 GW added by 2006 from wind, biomass, small hydro
Canada	3.5% to 15% of electricity in 4 provinces (RPS); other types of targets in 5 provinces
China	300 GW hydro, 30 GW wind, 30 GW biomass, 1.8 GW PV, 300 million square meters solar hot water by 2020
Croatia	400 MW by 2010, excluding large hydropower
Dominican Republic	500 MW wind power capacity by 2015
India	10% of added electric power capacity during 2003–2012 (expected 10 GW). 10.5 GW total wind power existing by 2012; other long-term goals to 2032
Italy	3 GW of solar PV by 2016
Iran	500 MW of electricity output by 2010
Korea	1.3 GW of grid-connected solar PV by 2011, including 100,000 solar homes
Mexico	4 GW added by 2014
Morocco	1 GW wind power by 2012 and 400,000 square meters solar hot water added by 2015
New Zealand	30 PJ of added capacity (including heat and transport fuels) by 2012
Norway	7 TWh from heat and wind by 2010
Philippines	4.7 GW total existing capacity by 2013
Singapore	50,000 square meters (~35 MWth) solar hot water by 2012
South Africa	10 TWh added final energy by 2013
Switzerland	3.5 TWh from electricity and heat by 2010
Spain	500 MW solar power by 2010
Tunisia	500,000 square meters solar hot water by 2009 and 300 MW added wind by 2011
Turkey	2% of electricity from wind by 2010
Uganda	100 MW small hydro and 45 GW geothermal by 2017; other rural electricity and productive-uses targets
United States	5% to 30% (typical) of electricity in 26 states and District of Columbia (RPS)

Note: Countries on this list may also have primary energy or electricity targets.

Source: REN21, Global Status Report 2007 - http://www.ren21.net

Most countries with RE targets have also promotion policies focused on enhancing implementation and usage of renewable power generation. The most common policies are the feed-in laws which guarantee feed-in tariffs.

Promotion Policy	**Description**
Feed-In Laws	They enact feed-in tariffs for RE which should attract innovation and investment into these technologies. Most renewable energy tariffs are higher than the market prices of traditional fossil or nuclear energy. Thus, they are subsidized by public institutions (local government, donor agencies etc). They are implemented using decreasing tariffs over time; they have minimum and maximum limits and maximum support periods which may differ according to the customer segments (households, industry, etc).
Renewable Portfolio Standard (RPS) or Quota Policy	An RPS sets RE quotas for a specific country, state or county. Most RPSs require RE power shares to be in the range of 5 to 20% with target dates between 2010 and 2025.
Public Subsidies	There are many forms of public subsidies including loans, investment subsidies and rebates, tax incentives and credits, sales and value-added tax exemptions, direct production payments, and direct public investment and financing.
Tradable RE certificates	Green power certificates are issued and voluntarily traded. Certificates can be issued in combination with a quota policy in order to enable the quota to be met. They are also used in order to prove that the energy provided originates from renewable sources.
Net metering	Net metering (also net billing) is used to allow excess power produced with small-scale renewable energy installations to be sold back to the electricity grid e.g. rooftop solar PV installations.
Public mandates	Some countries mandate usage of certain renewable technologies in new construction building. For example, Spain enacted a national building code that requires a minimum level of solar hot water and PV in new constructions and in renovated buildings. Sometimes these mandates are accompanied by capital grants and subsidies.

Figure 7 –

Renewable Energy Promotion Policies

Country	Feed-in tariff	Renewable portfolio standard	Capital subsidies, grants, or rebates	Investment or other tax credits	Sales tax, energy tax, excise tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Public competitive bidding
Developed and transition countries										
Australia		✓	✓			✓			✓	
Austria	✓		✓	✓		✓			✓	
Belgium		✓	✓		✓	✓		✓		
Canada	(*)	(*)	✓	✓	✓			(*)	✓	(*)
Croatia	✓			✓					✓	
Cyprus	✓		✓							
Czech Republic	✓		✓	✓	✓	✓		✓		
Denmark	✓				✓	✓		✓	✓	✓
Estonia	✓				✓					
Finland			✓		✓	✓	✓			
France	✓		✓	✓	✓	✓			✓	✓
Germany	✓		✓	✓	✓				✓	
Greece	✓		✓	✓						
Hungary	✓				✓	✓			✓	
Ireland	✓		✓	✓		✓				✓
Italy	✓	✓	✓	✓		✓		✓		
Israel	✓									
Japan	(*)	✓	✓			✓		✓	✓	
Korea	✓		✓	✓	✓				✓	
Latvia	✓								✓	✓
Lithuania	✓		✓	✓					✓	
Luxembourg	✓		✓	✓						
Malta	✓				✓					
Netherlands	✓		✓	✓		✓	✓			
New Zealand			✓						✓	
Norway			✓	✓		✓				✓
Poland		✓	✓		✓				✓	✓
Portugal	✓		✓	✓	✓					
Romania					✓					
Russia			✓			✓				
Slovak Republic	✓			✓					✓	
Slovenia	✓								✓	
Spain	✓		✓	✓					✓	
Sweden		✓	✓	✓	✓	✓	✓			
Switzerland	✓									
United Kingdom		✓	✓		✓	✓				
United States	(*)	(*)	✓	✓	(*)	(*)	✓	(*)	(*)	(*)
Developing countries										
Algeria	✓			✓	✓	✓				
Argentina	✓		✓	(*)	✓		✓			
Brazil	✓								✓	✓

Renewable Energy Promotion Policies *continued*

Country	Feed-in tariff	Renewable portfolio standard	Capital subsidies, grants, or rebates	Investment excise, or other tax credits	Sales tax, energy tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Public competitive bidding
Cambodia			✓							
Chile			✓							
China	✓		✓	✓	✓				✓	✓
Costa Rica	✓									
Ecuador	✓			✓						
Guatemala				✓	✓					
Honduras				✓	✓					
India	(*)	(*)	✓	✓	✓		✓		✓	✓
Indonesia	✓									
Mexico				✓				✓		
Morocco				✓						
Nicaragua	✓			✓	✓					
Panama							✓			
Philippines			✓	✓	✓				✓	
South Africa			✓							
Sri Lanka	✓									
Thailand	✓		✓					✓	✓	
Tunisia			✓	✓						
Turkey	✓		✓							
Uganda	✓								✓	

Note: Entries with an asterisk (*) mean that some states/provinces within these countries have state/province-level policies but there is no national-level policy. Only enacted policies are included in table; however, for some policies shown, implementing regulations may not yet be developed or effective, leading to lack of implementation or impacts. Policies known to be discontinued have been omitted. Many feed-in policies are limited in scope or technology. Some policies shown may apply to other markets beside power generation, for example solar hot water and biofuels. *Source:* All available policy references, including the IEA online Global Renewable Energy Policies and Measures database and submissions from report contributors.

Source: REN21, Global Status Report 2007 - http://www.ren21.net

Installed capacity

Global RE capacity grew at rates of 15 to 30% annually in the period between 2002 and 2006. Most growth has happened in grid-connected solar PV with a 60% annual growth rate. Biofuels (biodiesel and ethanol) also had significant growth rates.

Regarding power generation, large hydro is still the predominant and lowest-cost energy technology. In 2006, large hydro accounted for 15% of global electricity production; 19% down from the previous decade.

Excluding large hydro, global installed capacity of RETs was 207 GW in 2006. This is equivalent to 5% of total 4300 GW installed capacity. Small hydro and wind power account for three quarters of the renewable energy capacity.

Wind power capacity had increased more than any other renewable technology in 2007, with 21 GW added in 2007 an annual growth of 28%. Most of the growth was concentrated in five countries, United States, Germany, India, Spain and China, which accounted for two thirds of the added capacity.

Biomass is employed for power and heating. Overall, 45 GW of biomass power capacity existed in 2006. Usually biomass is used in district-heating systems. In developing countries, biomass is applied in small-scale power and heat production installations using agricultural waste.

Geothermal installations provide around 10 GW worldwide. These installations are especially common in countries with strong volcanic activities. Iceland gets 25% of its power from geothermal installations. As of 2008, over 2 million geothermal heating pumps have been installed worldwide.

Grid-connected solar PV provides around 8 GW worldwide and has been growing at the highest rate of all RETs. Germany accounts for 50% of the global market. This translates into 1.5 million households with rooftop solar PV power injected into the electricity grid. The solar thermal power market had remained stagnant until 2004 and new commercial scale developments have been emerging.

In the transport sector, production of fuel ethanol reached 39 billion liters in 2006, increasing by 18% from 2005. The leading producer countries are the United States, Brazil, and some of the larger countries in Europe. Biodiesel has grown by 50% in 2006, to over 6 billion liters. Half of this amount is produced in Germany. In Asia there has been an aggressive expansion of palm oil plantations in order to produce bio diesel.

The following table provides some typical characteristics and costs of renewable energies. The costs are significantly higher than the traditional wholesale power generation, which is in the range of 4 to 8 cents per kilowatt-hour (kWh).

Figure 9 –

Status of Renewables Technologies—Characteristics and Cost

Technology	Typical Characteristics	Typical Energy Costs (U.S. cents/kilowatt-hour)
Power Generation		
Large hydro	*Plant size:* 10 megawatts (MW)–18,000 MW	3–4
Small hydro	*Plant size:* 1–10 MW	4–7
On-shore wind	*Turbine size:* 1–3 MW *Blade diameter:* 60–100 meters	5–8
Off-shore wind	*Turbine size:* 1.5–5 MW *Blade diameter:* 70–125 meters	8–12
Biomass power	*Plant size:* 1–20 MW	5–12
Geothermal power	*Plant size:* 1–100 MW *Type:* binary, single- and double-flash, natural steam	4–7
Solar PV (module)	*Cell type and efficiency:* single-crystal 17%; polycrystalline 15%; amorphous silicon 10%; thin film 9-12%	—
Rooftop solar PV	*Peak capacity:* 2–5 kilowatts-peak	20–80*
Concentrating solar thermal power (CSP)	*Plant size:* 50–500 MW (trough), 10-20 MW (tower); *Types:* trough, tower, dish	12–18†
Hot Water/Heating		
Biomass heat	*Plant size:* 1–20 MW	1–6
Solar hot water/heating	*Size:* 2–5 m² (household); 20–200 m² (medium/multi-family); 0.5–2 MWth (large/district heating); *Types:* evacuated tube, flat-plate	2–20 (household) 1–15 (medium) 1–8 (large)
Geothermal heating/cooling	*Plant capacity:* 1–10 MW; *Types:* heat pumps, direct use, chillers	0.5–2
Biofuels		
Ethanol	*Feedstocks:* sugar cane, sugar beets, corn, cassava, sorghum, wheat (and cellulose in the future)	25–30 cents/liter (sugar) 40–50 cents/liter (corn) (gasoline equivalent)
Biodiesel	*Feedstocks:* soy, rapeseed, mustard seed, palm, jatropha, or waste vegetable oils	40–80 cents/liter (diesel equivalent)
Rural (off-grid) Energy		
Mini-hydro	*Plant capacity:* 100–1,000 kilowatts (kW)	5–10
Micro-hydro	*Plant capacity:* 1–100 kW	7–20
Pico-hydro	*Plant capacity:* 0.1–1 kW	20–40
Biogas digester	*Digester size:* 6–8 cubic meters	n/a
Biomass gasifier	*Size:* 20–5,000 kW	8–12
Small wind turbine	*Turbine size:* 3–100 kW	15–25
Household wind turbine	*Turbine size:* 0.1–3 kW	15–35
Village-scale mini-grid	*System size:* 10–1,000 kW	25–100
Solar home system	*System size:* 20–100 watts	40–60

Source: REN21, Global Status Report 2007 - http://www.ren21.net

The table below gives an assessment of the main renewable energy indicators at the global level and for the top 5 countries (in terms of renewable energy capacity).

Figure 10 -

Selected Indicators	2005	2006	2007 (estimated)
Investment in new renewable capacity (annual)	$40	55	71 billion
Renewables power capacity (existing, excl. large hydro)	182	207	240 GW
Renewables power capacity (existing, incl. large hydro)	930	970	1,010 GW
Wind power capacity (existing)	59	74	95 GW
Grid-connected solar PV capacity (existing)	3.5	5.1	7.8 GW
Solar PV production (annual)	1.8	2.5	3.8 GW
Solar hot water capacity (existing)	88	105	128 GWth
Ethanol production (annual)	33	39	46 billion liters
Biodiesel production (annual)	3.9	6	8 billion liters
Countries with policy targets	52		66
States/provinces/countries with feed-in policies	41		46
States/provinces/countries with RPS policies	38		44
States/provinces/countries with biofuels mandates	38		53

Top Five Countries	#1	#2	#3	#4	#5
Annual amounts for 2006					
New capacity investment	Germany	China	United States	Spain	Japan
Wind power added	United States	Germany	India	Spain	China
Solar PV added (grid-tied)	Germany	Japan	United States	Spain	South Korea
Solar hot water added	China	Germany	Turkey	India	Austria
Ethanol production	United States	Brazil	China	Germany	Spain
Biodiesel production	Germany	United States	France	Italy	Czech Republic
Existing capacity as of 2006					
Renewables power capacity	China	Germany	United States	Spain	India
Small hydro	China	Japan	United States	Italy	Brazil
Wind power	Germany	Spain/United States		India	Denmark
Biomass power	United States	Brazil	Philippines	Germany/Sweden/Finland	
Geothermal power	United States	Philippines	Mexico	Indonesia/Italy	
Solar PV (grid-connected)	Germany	Japan	United States	Spain	Netherlands/Italy
Solar hot water	China	Turkey	Germany	Japan	Israel

Source: REN21, Global Status Report 2007 - http://www.ren21.net

Investment flows and trends as of 2007

In 2007, more than USD 70 billion were invested in new RE capacity worldwide. Germany with more than USD 14 billion, China with USD 12 billion, and the United States with USD 10 billion were the leading investors.

Wind power is the most dominant investment category (47%), with solar PV (30%) and solar hot water (9%) following and small shares for small hydro, biomass and geothermal. For large hydropower an additional USD 15 to 20 billion were invested.

In addition to capacity investments, USD 10 billion were invested into solar PV production and equipment plants as well as more than USD 4 billion in biodiesel production plants.

Total investment in sustainable energy reached record levels in the year 2007 with USD 204.9 billion. The largest amount of this investment was allocated to renewable energy (excluding large hydro) with USD 197.7 billion in 2007. Energy efficiency investment (USD 7.5 billion in 2007) accounts for 3.7% of total investments in sustainable energy.

Private and public institutions provide sources of financing. Private sources are mainly mainstream banks and institutional lenders and – with growing appetite – also venture capital investors. Venture capital funding for Solar PV and biofuels exceeded USD 3 billion in 2006, with most capital provided by the United States.

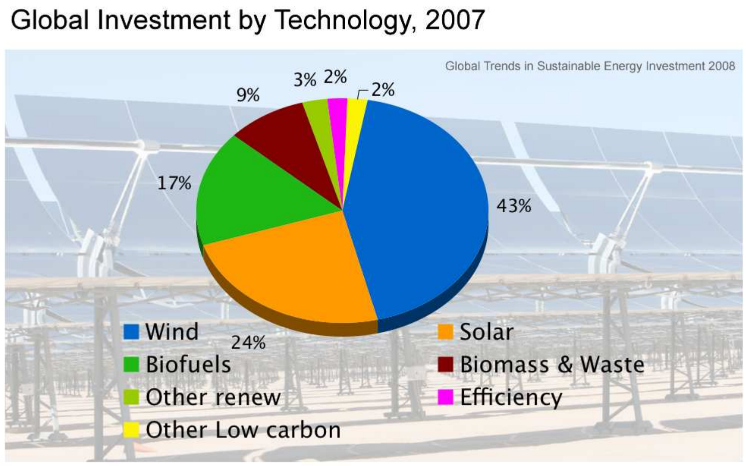
Public finance flows into developing countries reached approximately USD 700 million between 2005 and 2007. The three largest funds were the KfW Entwicklungsbank from Germany, the World Bank Group and the Global Environment Facility (GEF). Further public financing is provided by several agencies and governments within the framework of development assistance projects with sizes ranging from USD 5 to 25 million in average.

Market capitalization of the 140 publicly traded companies in the RE industry exceeded USD 100 billion in 2007. Overall there were several high-profile IPOs especially in the solar PV area. Altogether clean-energy companies invested about USD 10 billion in 2006 double the figure from 2005. Most of the capital was raised in Europe, pre-dominantly on the London Alternative Investment Market (AIM).

Most investments were made in manufacturing plants of wind turbines and components, solar PV (conventional, thin-film) and solar thermal power components, and in biofuel production plants.

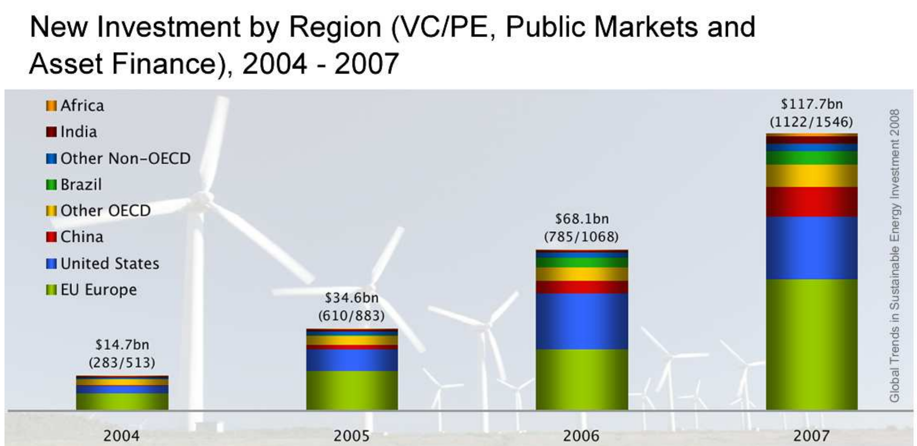
For an overview of the global investment flows and trends in sustainable energy, consult the UNEP Global Trends in Sustainable Energy Investments Report 2008 at http://sefi.unep.org/english/globaltrends.html (free download)

Figure 11 –



Source: New Energy Finance

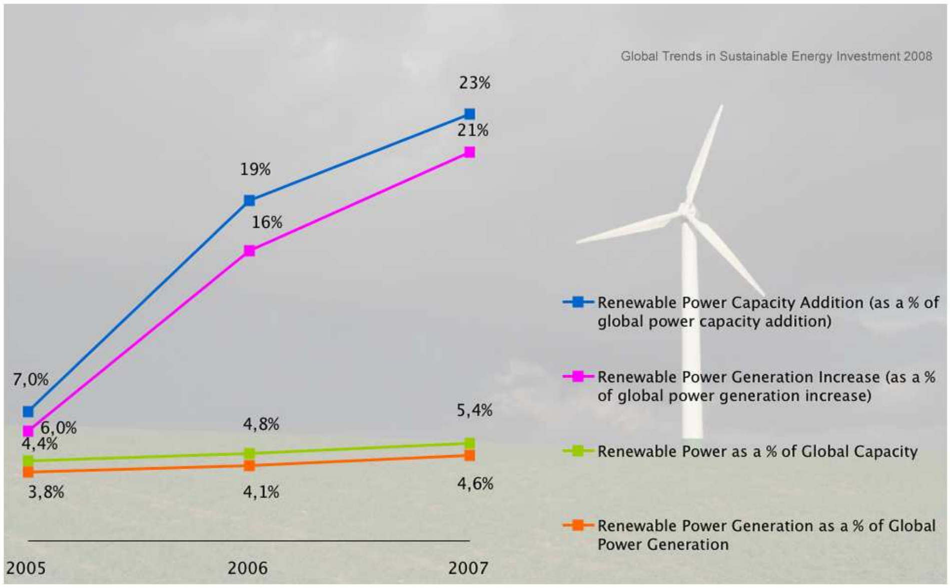
Figure 12 –



Source: SEFI, New Energy Finance

Figure 14 -

Renewable Energy Capacity as a proportion of Global Power Generation Capacity, 2005 - 2007 (GW)



Source: SEFI, New Energy Finance

2 Renewable Energy Risks

Diligent financial risk management is a key component for any investment project. In order to evaluate the attractiveness of a project a clear and reliable analysis of expected costs and projected revenues is required. Also, the appropriate understanding of all involved elements, technologies, jurisdictions, developers, and other counter-parties is essential.

For RE projects some specific considerations must be made:

RE Project Specifics	**Financial Risk assessment**
Technology maturity	Mature technologies include hydro and traditional biomass. Most of the RE technologies are still at a relatively early development stage or production process (wind, geothermal) and need to be backed up by fossil fuel power.
Size of project	Many RE projects are “small-scale projects”. Projects bundling (portfolio approach) and standardization can help make small scale projects attractive for commercial investors.
Jurisdiction of project	RE projects can be located in “risky jurisdictions” with a certain level of country political risk. Political Insurance, Export Credit Agencies Guarantees and Development Banks’ Guarantees are amongst the most adapted solutions.
Project finance requirements	The following elements are needed to ensure the profitability of an RE project: availability of long-term contracts (fuel supply), power purchase agreements with creditworthy parties, fixed price agreements, turnkey design and build contracts, experienced contractors and sponsors, insurance and/or bank guarantees.
Revenue exposure	Revenues are maximized with an optimal management of project delays, damages/losses during fabrication, transport, installation, construction and of the operational stage.

Risk transfer instruments enable the project sponsors or lenders to transfer some of the risks by using mechanisms such as insurance, reinsurance, alternative risk transfer, risk finance, contingent capital, and credit enhancement products.

The followings tables summarize the key risks and risk management considerations for the different RETs.

Wind Power

Characteristics	Description
Resource	Kinetic energy from the wind.
Sites / Areas	Onshore (coastal, hilltops) and offshore.
Field of application	Electricity generation.
Technologies	On-shore: Mature wind technology with typical turbine size between 700 kW and 3 MW. Off shore: Bigger size turbines than on-shore. Easier site location with less environmental impact but more expensive to construct.
Capacity	Per turbine: 50 W to 6MW.
Markets as of 2007	Market leaders are Germany, United States, India, and China.
Average Investment requirements	USD 1200 - 1700 per kW for onshore. USD 2200 – 3000 per kW for offshore
Investment Trends	Wind turbine suppliers are increasing their production capacity and there is a growing number of local suppliers for components in developing countries. Supply-chain bottlenecks and delays exist due to the booming demand, especially for turbine components. New manufacturers in the United States, India and China – more expansion to be expected in emerging markets. Turbines' capacities are increasing and can be of 2 MW and more.
Costs and operations	8 – 12 USD cents / kWh.

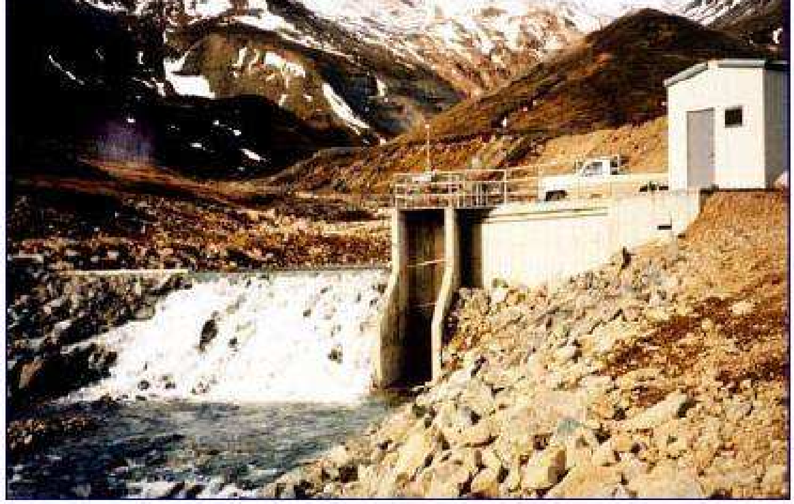
Key Risks	Risk Management Driver
Development times and up-front costs (e.g. planning permission and construction costs) Critical component failures (e.g. gear train/ box, bearings, blades etc) Wind resource variability Offshore cable laying	Make and model of turbines Manufacturing warranties from component suppliers Good wind resource data Loss control e.g. fire fighting can be difficult offshore due to height/location Development of best practice procedures

Hydro Power

Characteristics	Description
Resource	Kinetic energy from water.

Sites/Areas	High- and medium-altitude mountains, rivers and streams.
Field of application	Electricity generation. Storage.
Technologies	Large hydro is normally above 10 MW – small hydro below 10 MW. Run-of-river typically used for small hydro, has less environmental impact. Storage plants are only economical for large hydro.
Capacity	Large scale hydro and run-of-river power stations have a capacity of 10 to 18,000 MW. Small-scale hydropower stations have a capacity of 1 to 10 MW.
Markets	While the market leaders are Nordic and Alpine countries, hydro is used throughout much of the world.
Average Investment requirements	USD 1000 – 5500 per kW (large hydro). USD 2500 – 7000 per kW (small hydro).
Investment Trends	Large hydro with very prominent projects such as Three Gorges Dam in China (expected volume of 22,500 MW). Small hydro has significant potential and competitive generation costs.
Costs and operations	Large hydro: 3 to 12 USD cents per kWh. Small hydro: 6 to 14 USD cents per kWh.

Key Risks	**Risk Management Driver**
Flooding Seasonal / annual resource variability. Prolonged breakdowns due to offsite monitoring and lack of spare parts.	Long-term proven technology with low operational risks and maintenance expenses.



This small scale hydro system can provide power for a community of 800 people. (Photo courtesy Warren Gretz and NREL).

Solar Photovoltaic Power

Characteristics	**Description**
Resource	Direct sunlight and diffuse solar radiation.
Sites / Areas	Worldwide, on roofs and facades.
Field of application	Electricity generation.
Technologies	PV solar has three emerging technologies: Crystalline silicon, which currently is the reliable standard technology used in most PV installations (more than 90%). However, the sector must cope with a scarce availability of polysilicon feedstock (mineral used to manufacture PV cells). Thin film is a lower cost innovation compared with crystalline silicon and is less material-intensive but has lower efficiency rates. Concentrator cells have an efficiency ranging from 40 to 60% (the technology used in large solar plants which can reach a 500MW capacity is usually the most efficient); however, they need to be directed precisely towards the sun and cannot absorb reflected sunlight.
Capacity	Several Watts to several MW.
Markets	Ideal in areas with optimal sunlight and solar radiation.
Average Investment requirements	USD 5000 to 6500 per kW (installed).
Investment Trends	In 2007, solar PV production strongly grew to 3.5 – 3.8 GW up from 2.5 GW in 2006, and 1.8 GW in 2005 respectively. Half of global production is delivered by 5 producers: Sharp (Japan), Q-cells (Germany), Kyocera (Japan), Suntech (China), and Sanyo (Japan). There is strong investment in new manufacturing in Europe, Japan, China, and the United States. Thin-film solar PV only accounts for 6 to 8% of solar PV. Due to the significantly lower use of silicon in the manufacturing of solar cells, strong future growth can be expected.

Costs and operations	Typical costs of 20-40 UScents/kWh for low latitudes with solar isolation of 2500kWh/m²/year, 30-50 UScents/kWh for 1500kWh/m²/year (typical of southern Europe, and 50-80 UScents for 1000 kWh/m²/year (higher latitudes).North Africa: 40 – 55 US cents per kWh.

Key Risks	Risk Management Driver
▪ Component breakdowns (e.g. short-circuits). ▪ Weather damage. ▪ Theft/Vandalism.	▪ Performance guarantee available (e.g. up to 25 years). ▪ Standard components, with easy substitution. ▪ Maintenance.

Example of a PV grid-connected system. (Photo courtesy NREL.).

Solar Thermal

Characteristics	Description
Resource	Direct solar irradiation, with storage system.
Sites/Areas	Arid regions (Southern Europe, North Africa, Arabian Peninsula, North America).
Field of application	▪ Electricity generation. ▪ Combined heat and power generation for cold production. ▪ Water desalination. ▪ Process heat.
Technologies	There are two types of solar thermal technologies: ▪ Linear concentrators with parabolic troughs are the most mature solar thermal technologies and can be coupled with fossil fuel systems for better economics. Linear concentrators with Fresnel lenses are a current innovation, and are less expensive but also have lower efficiency. ▪ Point concentrators (using tower or single Stirling dish units) have higher efficiencies than linear concentrators but require higher capital and maintenance costs. There are two types of solar thermal installations: **Passive** The simplest systems are passive solar water heaters, also called batch or breadbox

	collectors; they are most common in regions that do not experience extensive periods of below freezing temperatures. The water in these solar collectors circulates without the aid of pumps or controls. **Active** Active solar water heaters use pumps to circulate water or an antifreeze solution through heat-absorbing solar thermal.
Capacity	Per dish: 10 kW per module. Per tower/power plant: 5 to 200 MW.
Markets	Ideal in regions with optimal sunlight and solar radiation.
Investment requirements	USD 4000-9000 per kW (installed).
Investment Trends	Resurgence of solar thermal power after years of stagnation, with several GW of production facilities in the planning stages.
Costs and operations	Solar only: 13 - 23 USD cents per kWh. Hybrid: 6 - 16 USD cents per kWh.

Key Risks	Risk Management Driver
▪ Prototypical/technology risks as project size increases ▪ Other technological risks e.g. solar towers.	▪ Good operating history and loss record. ▪ Maintenance can be neglected, especially in developing countries.

The Solar Two project in California USA uses a field of mirrors to focus solar energy onto a central boiler to produce steam and electricity. (Photo courtesy NREL).

Bioenergy

Characteristics	Description
Resource	Wood, grains, vegetation, plants containing oil, organic leftovers, bio-waste.
Sites/Areas	Worldwide, depending on availability of biomass.
Field of application	▪ Electricity generation. ▪ Heating purposes. ▪ Combined heat and power generation. ▪ Biofuels: Combustion engines.
Technologies	Solid biomass with fluidized beds or grate boilers is the most mature technology. Often used in combination with electricity and district heating. Solid biomass based on Organic rankine Cycle (ORC) is primarily used for heat recovery from several processes and is a proven technology. Liquid biomass consists of biodiesel generating electric power and is dependent on vegetable oil supply and costs. Biogas is produced by organic waste decomposing or by fermentation under anaerobic conditions in a landfill (using waste, farm waste, energy crops, also dung and manure). Biogas is used to produce heating, electricity, or gas for combustion engines.
Capacity	Biomass co-firing: 5-100MW (existing); >100MW (new plant) Biomass combustion for power: 10-100MW Biogas: <200kW-10MW

Markets	Global. Biofuels have strong market bases in United States and Brazil.
Investment requirements	Biomass co-firing: USD 120-1200 + power stating cost per kW. Biomass combustion for power (solid fuels): USD 2000-3000 per kW. Biogas (including landfill gas) digestion: USD 2300-3900 per kW
Investment Trends	New investment in biodiesel and ethanol industries. There are more than 80 ethanol plants under construction in the United States – adding to the 130 existing plants which produced 26 billion liters in 2007. Brazil continues to aggressively expand its ethanol capacity by 2012, with a total investment of more than USD 15 billion between 2006 and 2012. This should add 22 billion liters/year. Further commercial investments are to be expected in second-generation biofuels. Large-scale production facilities are planned for turning cellulose to ethanol or biodiesel.
Costs and operations	Heat: 2 - 16 USD cents per kWh. Electricity: 8 - 50 USD cents per kWh.

Key Risks	**Risk Management Driver**
Biomass/Biofuels	
Fuel supply and availability.	Long-term contracts can solve the resource problems.
Resource price variability.	Fuel handling costs.
Environmental liabilities associated with fuel handling and storage.	Emission controls.
Biogas	
Resource risks (e.g. reduction of gas quantity and quality due to changes in organic feedstock). Planning opposition associated with odor problems.	Strict safety procedures are needed, as are loss controls such as fire fighting equipment and services. High rate of wear and tear.

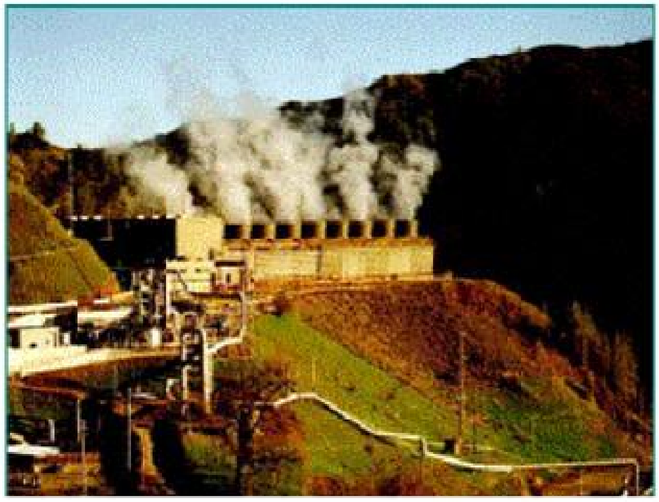
Residues from crops can be gasified and combusted to provide heat and power. (Photo courtesy Warren Gretz and NREL.).

Geothermal

Characteristics	Description
Resource	Near surface (down to 400 meters): 7 to 25 °C. Hydrothermal: 25 to 120 °C. Hot-Dry-Rock (Enhanced Geothermal System- EGS): depends on the depth.
Sites / Areas	Worldwide.
Field of application	▪ Heating and cooling. ▪ Seasonal storage of heat and cold. ▪ Ice prevention. ▪ Process heat. ▪ Electricity generation.
Technologies	Near surface (or small hydro) technologies consist of absorbing heat from the uppermost layers of the earth or from ground water. This is mostly used for private-usage heat pumps. Can be applied everywhere. Hydrothermal is a high-temperature system using hot water (above 100°C) from depths of at least 4000 meters for electricity generation. There are also low-temperature systems (40 to 100 °C) that create heat. Hot-Dry-Rock technology (Enhanced Geothermal System- EGS) uses a heat-transfer medium circulated through hot dry crystalline rock as far down as 5000 meters. Water is forced into the rock under very high pressure in order to generate a hydraulic stimulation. It is used to generate electricity and heat but is still very costly.

Capacity	Near surface (small hydro): 1 – 10 kW. Hydrothermal: 1 – 100 MW thermal. Hot-Dry-Rock: 5 – 50 MW electricity.
Markets	Global, with no geographic restrictions
Investment requirements	Geothermal heat: USD 250-2450 per kW. Geothermal power: USD 1700-15,000 per kW.
Investment Trends	Geothermal power generation adds up to roughly 10 GW worldwide. The United States is leading with 3 GW. New projects are underway. For instance, in the U.S. more than 80 geothermal projects in 12 states are currently in an advanced stage. It is expected that capacity will double to 6.3 GW. New technologies such as "Hot Dry Rock" might extend the use of geothermal power to non-volcanic areas.
Costs and operations	Heat: – 9 USD cents per kWh. Electricity: 12 – 25 USD cents per kWh.

Key Risks	Risk Management Driver
▪ Drilling expense and associated risk (e.g. blow out). ▪ Exploration risk (e.g. unexpected temperature and flow rate). ▪ Critical components failure, such as pump breakdowns. ▪ Long lead times (e.g. planning permits).	▪ Limited experience of operators and certain aspects of technology in different areas. ▪ Resource measurement data is limited. ▪ Planning approvals can be difficult. ▪ Stimulation technology is still unproven but can reduce exploration risk.



Geothermal power plants, such as this one in the US, can be designed to produce both heat and power. (Photo courtesy Pacific Gas and Electric and NREL).

3 Insurance Offerings

Insurance provides financial protection from delays or damage during the fabrication, transport, construction, and operational stages of an RE project. These events can be due to technical failures, human errors or forces of the nature. Furthermore, the lender might want to insure the loss of income due to business interruption since it affects the balance sheet of the entire project.

Practices and principles from the engineering and energy industries are applied to identify, analyze and assess the risks in an RE project.

Insurance can lower the cost of capital and increase the liquidity by reducing the financial impact of risk events. Underwriting these events requires a sufficient degree of knowledge regarding the likelihood (frequency) and the severity of possible losses triggered by these events. Most RE projects do not have available the fully required statistical data for measuring the necessary probability distributions and correlations between random events. Underwriting restrictions exist. This means that most RE projects are arranged on a case-by-case basis and therefore entail more restrictive terms and conditions.

The pricing of insurance includes:

- The expected loss exposure;
- A charge for the risk capital employed;
- A risk premium; and
- Administrative costs.

For smaller projects and lesser-known technologies, the business acquisition, underwriting due diligence and account servicing costs can cost more than for larger projects and better known technologies.

Insurance offerings and underwriting guidelines are exposed in further details in Module 4 “Claims Handling and Policy” of the course.

Traditional insurance products available for RE projects:

Risk Transfer Product	Basic Trigger	Scope addressed
Construction All Risks (CAR)/Erection All Risks (EAR)	Physical loss and/or physical damage during the construction phase of a project.	All risks of physical loss or damage and third party liabilities including all contractors' work.
Delay in Start Up (DSU)/Advanced Loss of Profit (ALOP)	Physical loss and/or physical damage during the construction phase of a project causing a delay to project hand-over.	Loss of revenue as a result of the delay triggered by perils insured under the CAR policy.
Operating All Risks (OAR)/ Physical Damage (PD)	Sudden and unforeseen physical loss or physical damage to the plant/assets during the operational phase of a project.	All risks package.
Machinery Breakdown (MB)	Sudden and accidental mechanical or electrical breakdown necessitating repair or replacement.	Defects in material, design construction, erection or assembly.
Business Interruption (BI)	Sudden and unforeseen physical loss or physical damage to the plant/assets during the operational phase of a project, causing an interruption.	Loss of revenue as a result of an interruption in business caused by perils under the Operating All Risks Policy.
Operators Extra Expense (Geothermal)	Sudden, accidental, uncontrolled and continuous flow from the well, which cannot be controlled.	All expenses associated with controlling the well, redrilling/ seepage and pollution.
General/Third-Party Liability	Liability imposed by law and/or Express Contractual Liability for Bodily Injury or Property Damage.	Includes coverage for hull and machinery, charters liability, cargo etc.

The main coverage issues and underwriting concerns which need to be addressed are listed in the table below.

Risk Transfer Product	Coverage issues/underwriting concerns
Construction All Risks (CAR)/Erection All Risks (EAR)	Losses associated with laying cable, such as snagging, can be significant for offshore wind projects. Quality control provision for contractors.
Delay in Start Up (DSU)/ Advanced Loss of Profit (ALOP)	Cable Laying risk. Loss of transformer. Lead times for replacement of major items. Offshore wind weather windows and availability of vessels.
Operating All Risks/ Physical Damage	Explosion/fire concerns for biogas, geothermal. Increase in fire losses for wind. Lightning. Quality control and maintenance procedures.
Machinery Breakdown (MB)	Concerns over errors in design, defective materials, or workmanship for all RETs. Scope and period of equipment warranties. Wear and tear (excluded from MB).
Business Interruption (BI)	Cable/transformer losses represent large potential BI scenarios. Lead times for replacement of major items. Offshore wind/weather windows and availability of vessels. Supplier/customer exposure (e.g. biomass resource supply).
Operators Extra Expense (Geothermal)	Some geothermal projects require relatively large loss limits. Exploration risk excluded. Well depths, competencies of drilling contractors.
General/Third-Party Liability	Concern over third-party liabilities issues associated with toxic and fire/explosive perils.

With regards to the specific selected RETs, the following insurance offerings are available:

Wind Power	
Characteristics	**Description**
Overall attractiveness	Significant growth potential.
Current situation	Trend to off-shore wind farms.
Ideal operating conditions	Require right window of wind speed (between 10 and 25 m/s).
Insurance Maturity and Loss Experience	Early phase of large underwriting losses. With latest increase of projects there is more underwriting and loss experience available.
Major known loss factors	Design and material, lightning, storm, short circuit, fire.
Insurance Offerings	Used to be part of main property insurance package. As projects' sizes and numbers are increasing, specific policies are becoming available. Insured limits of up to USD 500 million have been placed. Construction phase: CAR, DSU, TPL available. Operational phase: Operating All Risk, MB, BI.

Hydro power	
Characteristics	**Description**
Overall attractiveness	Large scale is already established and has proven attraction. Small scale installations in developing countries/rural or remote areas are becoming an increasingly important leading source of RE.
Current situation	Small hydro has significant potential and competitive generation costs.
Operating conditions	Storage reservoir systems require large space. Run of river systems require sufficient river flow.
Insurance Maturity and Loss Experience	Large-scale hydro is a well-developed, long-term proven technology with low maintenance expenses and few operational risks. Small-scale hydro installations with lifetime of up to 50 years.
Major known loss factors	Flooding, seasonal/annual resource variability.
Insurance Offerings	Large hydro: All insurance packages available. Small hydro: Only few insurance offerings. Liability coverage is becoming more widely available. Small hydro might benefit from the large experience base and risk management understanding in large hydro.

Solar (PV/Thermal)	
Characteristics	**Description**
Overall attractiveness	Off grid are small-scale consumer products with low attraction for commercial insurance. Grid connected projects for solar PV start to gain traction. Some large scale projects are underway.
Current situation	Grid connected projects increase in size and value. Significant subsidies in some countries.
Ideal Operating conditions	High local sun irradiance with high amount of W per m^2.
Insurance Maturity and Loss Experience	Not yet mature. Low loss experience.
Major known loss factors	Faulty material, theft (offsite), fire exposure (thermal), technology parts (circuits, converters), climate (hail, lightning), and leakage (thermal).
Insurance Offerings	Currently very few options.

Biomass/biogas	
Characteristics	**Description**
Overall attractiveness	Biomass technologies are mature, but are still relatively costly especially in the case of organic ranking. A challenging situation exists with regards to stable fuel/biomass supply. In some countries, biofuels using sugar cane and other agricultural waste have already gained a significant share.
Current situation	Biomass generally gets less support and subsidies than wind and solar. Mature technologies can be employed at large scale (10 to 100 MW). Biofuels currently debated with regards to ethics and crop substitution (crop for food vs. crop for fuel).
Operating conditions	Key criteria include the long-term continuous supply of fuel (biomass, crop). For biogas, strict safety conditions apply.
Insurance Maturity and Loss Experience	Despite mature technologies, insurance is still lacking. Relatively low loss experience.
Major known loss factors	Faulty material, fire exposure, TPL due to emissions and pollution, prototypical technology, operational lack of experience.
Insurance Offerings	Very few as of today. Biogas: Machinery Breakdown (MB), Business Interruption (BI).

Key Terms

Term	Definition
BI	Business Interruption (BI) Sudden and unforeseen physical loss or physical damage to the plant/assets during the operational phase of a project, causing an interruption. Loss of revenue as a result of an interruption in business caused by perils under the Operating All Risks (OAR) Policy.
CAR/EAR	Construction All Risks (CAR)/Erection All Risks (EAR) Physical loss and/or physical damage during the construction phase of a project. All risks of physical loss or damage and third party liabilities including all contractors' work.
DSU/ALOP	Delay in Start Up (DSU)/Advanced Loss of Profit (ALOP) Physical loss and/or physical damage during the construction phase of a project causing a delay to project hand-over. Loss of revenue as a result of the delay triggered by perils insured under the CAR policy.
MB	Machinery Breakdown (MB) Sudden and accidental mechanical or electrical breakdown necessitating repair or replacement. Defects in material, design construction, erection or assembly.
OAR/PD	Operating All Risks/ Physical Damage Sudden and unforeseen physical loss or physical damage to the plant/assets during the operational phase of a project. All risks package.
Peak Oil	Peak oil is the point in time when the maximum rate of global fossil energy production (e.g. petroleum extraction) is reached. After reaching this point, the rate of production starts to decline. It is not clear if peak oil already has been reached or is still at some point in the future. An exact determination of the point in time depends on various factors such as: future estimated demand, the availability of alternative energy sources, the development of cheaper extraction technologies, access to known and not yet detected fossil reserves, and the state of the global economy.

RE	Renewable energy (RE) is generated from natural energy sources which are renewable – e.g. are naturally replenished. They include energy power derived from the sun (solar thermal, photovoltaic), the wind, the water (hydro, wave/tidal), or the earth (geothermal, biomass, biofuels). It replaces conventional fuels in four sectors: power generation, hot water and space heating, transport fuels, and rural (off-grid) energy.
RET	Renewable Energy Technologies (RET) enable the conversion of RE sources into electricity, heat, gravitation or movement, which might be further converted into productive use in the future.
Sustainable Energy	Sustainable energy is defined as energy that is provided to meet the needs of the present generation without compromising the ability of future generations to meet their needs. There are two components contributing to a sustainable energy situation: - Usage of renewable energies for energy production - Implementation of energy efficiency measures in existing installations

Lesson Review

Section 1 – Rationale for Renewable Energy Technologies

Renewable Energy (RE) is an alternative energy source to fossil and nuclear energy. RE is derived from the sun, water, wind, the earth (Geothermal) as well as from biomass. Due to the ongoing challenges of climate change, finite fossil energy resources, environmental risks associated with nuclear energy, and the growing energy demand, RE can offer a sustainable energy supply alternative. RE does not deplete and secures the growing demand of current consumers and future generations.

In order to convert the energy potential of the sun, wind, water and the earth into more usable energy forms such as electricity, heat, and movement, efficient technology is required. Main Renewable Energy Technologies are wind, hydro, solar (photovoltaic and solar thermal), biomass, biogas and geothermal. Some of them have been in place for centuries: wind (windmills), hydro and traditional biomass (wood).

Today, more than 60 countries and many states and communities have introduced legislation to promote policies that promote the implementation and usage of renewable energy. These policies consist mostly of feed-in tariffs which aim to attract innovation and investment into renewable energy projects. Other policies comprise quota agreements, public subsidies, renewable energy certificates, net metering and public mandates.

Between 2002 and 2005 RE capacity has grown between 15 and 30% annually. 5% (207 GW) of the global installed capacity of 4300 GW is provided by RE.

Investment flows are largely dominated by three countries: Germany, United States and China, which contributed half of the global investment volume into RET in 2007. Roughly half of the investment was for wind power, 30% for solar PV, and 9% for solar thermal. Small hydro, biomass and geothermal had smaller shares.

Section 2 – Risk Assessment

Diligent financial risk management is a cornerstone of each investment project. In order to evaluate the attractiveness of investment projects, an appropriate analysis of the technology, project size, jurisdiction, finance requirements and revenue exposure must be performed. For RE projects, some specific considerations must be made. It is essential to understand the key characteristics of each RET in advance. Section 2 lists the main fields of application, technologies in use, capacity, investment and cost considerations, as well as key risks and risk management drivers per RET.

Section 3 – Insurance Offering

Insurance provides financial protection from delays or damage during the fabrication, transport, construction, and operational stages of RE projects. In principle, RE projects follow insurance considerations from the energy and engineering business. Insurance is not (yet) available for all RET projects in all forms. This is due to the fact that not all technologies are mature in terms of construction and operational experience. This makes it difficult to evaluate for underwriting, and some of the RE projects are too small to be considered as attractive targets for insurance companies.

Each RET has ideal operating conditions and there are major known loss factors as well as underwriting issues, exclusions and restrictions. Innovative insurance solutions can be offered and are presented in Module 3 – Underwriting Guidelines and Policy.

Further Readings and Related Links

Reading	Link
UN Publications	
UNEP DTIE http://www.unep.fr	
CEO Briefing: Adaptation and Vulnerability to Climate Change: The Role of the Finance Sector. Climate Change Working Group, 2006. (Author A. Dlugolecki)	
e-Learning Course on Climate Change: Risks and Opportunities for the Finance Sector, UNEP Finance Initiative (UNEP FI), 2007.	
Financial Risk Management Instruments for Renewable Energy Projects, Summary Document, UNEP Division of Technology, Industry and Economics (DTIE) and SEFI, 2004.	
Global Trends in Sustainable Energy Investment 2008, REN21 together with UNEP Division of Technology, Industry and Economics (DTIE) and SEFI, 2008.	
Insuring for Sustainability: Why and How Leaders are doing it, Insurance Working Group, UNEP Finance Initiative (UNEP FI), 2007.	
Investing in a Climate for Change, Engaging the Finance Sector, UNEP 2008	
Risk, the environment and the role of the insurance industry, UNEP Finance Initiative Australasian Advisory Committee on Insurance, 2003.	
Scoping Study on Financial Risk Management – Instruments for Renewable Energy Projects, Reference Document, Marsh together with UNEP Division of Technology, Industry and Economics (DTIE) and SEFI, 2004.	
Survey of Insurance Availability for Renewable Energy Projects, Marsh Marine and Energy Practice, together with UNEP, 2006.	
The Role of Public Finance in Renewable Energy Sector Development, International Grid-Connected RE Policy Forum, Mexico, 2006. (Author: E. Usher)	

Further Publications	Link
Clean Development Mechanism – Exploring the Solutions through Learning-by-doing, World Business Council for Sustainable Development, 2000.	http://www.wbcsd.com
Energy and Climate Change, Facts and Trends to 2050, World Business Council for Sustainable Development, 2004.	http://www.wbcsd.com
Environmental Policy: Renewable Energy Sources in figures – national and international development, Federal Ministry for the Environment, Nature Conversation and Nuclear Safety, Berlin 2004.	http://www.bmu.de
From Risk to Opportunity: 2007, Insurers Responses to Climate Change, CERES, 2007. (Author E. Mills)	http://insurance.lbl.gov
International Energy Agency (IEA), Implications of climate change for energy industries, especially World Energy Outlook series.	http://www.iea.org
Renewable Energy Projects Handbook, World Energy Council, 2004.	http://www.worldenergy.org/publications/322.asp
Renewable Energies, Innovations for the future, Federal Ministry for the Environment, Nature Conversation and Nuclear Safety, Berlin 2006.	http://www.bmu.de
Renewables 2007, Global Status Report, Renewable Energy Policy Network REN21, 2008.	http://www.ren21.net
Stern Review on the economics of climate change. London, The Treasury, 2006.	http://www.occ.gov.uk/activities/stern.htm
Hurricanes: more intense, more frequent, more expensive: insurance in a time of changing risks, 2006.	http://www.munichre.com
Opportunities and Risks of Climate Change, 2002.	http://www.swissre.com
Pioneering Climate Solutions, 2008.	http://www.swissre.com
Reducing Greenhouse Gas Emissions – Emissions Reductions – Main Street to Wall Street – The Climate in North America, Rueschlikon Centre for Global Dialogue, 2002.	http://www.swissre.com
Reducing Greenhouse Gas Emissions – Addressing the New Business Imperative, Rueschlikon Centre for Global Dialogue, 2003.	http://www.swissre.com
Insurance Instruments for GHG Projects: Private Sector Options, UNECE Ad Hoc Group of Experts on Coal Mine Methane, Presentation by W. Diogo of Marsh Ltd in Geneva, April 2007.	http://www.marsh.com

Survey of Insurance Availability for Renewable Energy Projects, Marsh Marine and Energy Practice, together with UNEP, 2006.	http://www.marsh.com

Examination

Question 1

Which of the following statements is false?

Answers:

Renewable energy is generated from natural energy sources which are naturally replenished.	☐ Check if Correct
Sustainable energy is defined as energy that is provided to meet the needs of the present generation without compromising the ability of future generations to meet their needs.	☐ Check if Correct
Renewable energy is an alternative energy source to fossil and nuclear energy and is mostly derived from solar radiation.	☐ Check if Correct
None of the above statements is false.	☑ Check if Correct

Question 2

What is meant with “peak oil”?

Answers:

Peak oil is the point in time when the maximum rate of global fossil energy consumption is reached. After reaching this point, the rate of consumption starts to decline.	☐ Check if Correct
Peak oil is the point in time when the maximum rate of global fossil energy production is reached. After reaching this point, the rate of production starts to decline.	☑ Check if Correct
Peak oil is the point in time when the maximum oil price is reached. After reaching this point, the rate of consumption starts to decline.	☐ Check if Correct
Peak oil is the point in time when the maximum rate of fossil energy efficiency is reached. After reaching this point, the fossil energy efficiency starts to deteriorate.	☐ Check if Correct

Question 3

Which of the followings are Renewable Energy Technologies?

Answers:

Offshore Wind, Small Hydro, Photovoltaic, Biomass.	Check if Correct
Onshore Wind, Geothermal, Solar thermal, Gas thermal.	Check if Correct
Offshore Wind, Large Hydro, Heat, Photovoltaic.	Check if Correct
Small Hydro, Photovoltaic, Electricity, Solar thermal.	Check if Correct

Question 4

What are typical key risks when operating a biomass production facility?

Answers:

Fuel Supply, Price variability, Off-shore facility installation.	Check if Correct
Theft and vandalism, Fuel supply, Environmental liabilities associated with fuel handling and storage.	Check if Correct
Fuel Supply, Price variability, Flooding.	Check if Correct
Fuel Supply, Price variability, Environmental liabilities associated with fuel handling and storage.	Check if Correct

Question 5

Which of the following statements is wrong?

Answers:

Wind power experience with off-shore technology is more significant than with on-shore wind technology.	Check if Correct
Small hydro installations have a lifetime of up to 50 years.	Check if Correct
Solar Photovoltaic is not yet mature in terms of insurance offerings.	Check if Correct
The key risk with biomass technology is the stability of fuel supply.	Check if Correct