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RENEWABLE ENERGY SYSTEMS

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Outline

Climate change may be one of the greatest threats facing the planet

Energy Trilemma solves world climate problems

Input of Europe when solving Energy Trilemma

New development and new energy challenges

Renewable energy systems

Intensification of oil Products Biodegradation Process by Use of Solar Energy

Environmental Issues Facing Our Planet

Population

Climate Change

Loss of Biodiversity

The Phosphorus and Nitrogen Cycles

Water

Ocean Acidification

Pollution

Ozone Layer Depletion

Over Fishing

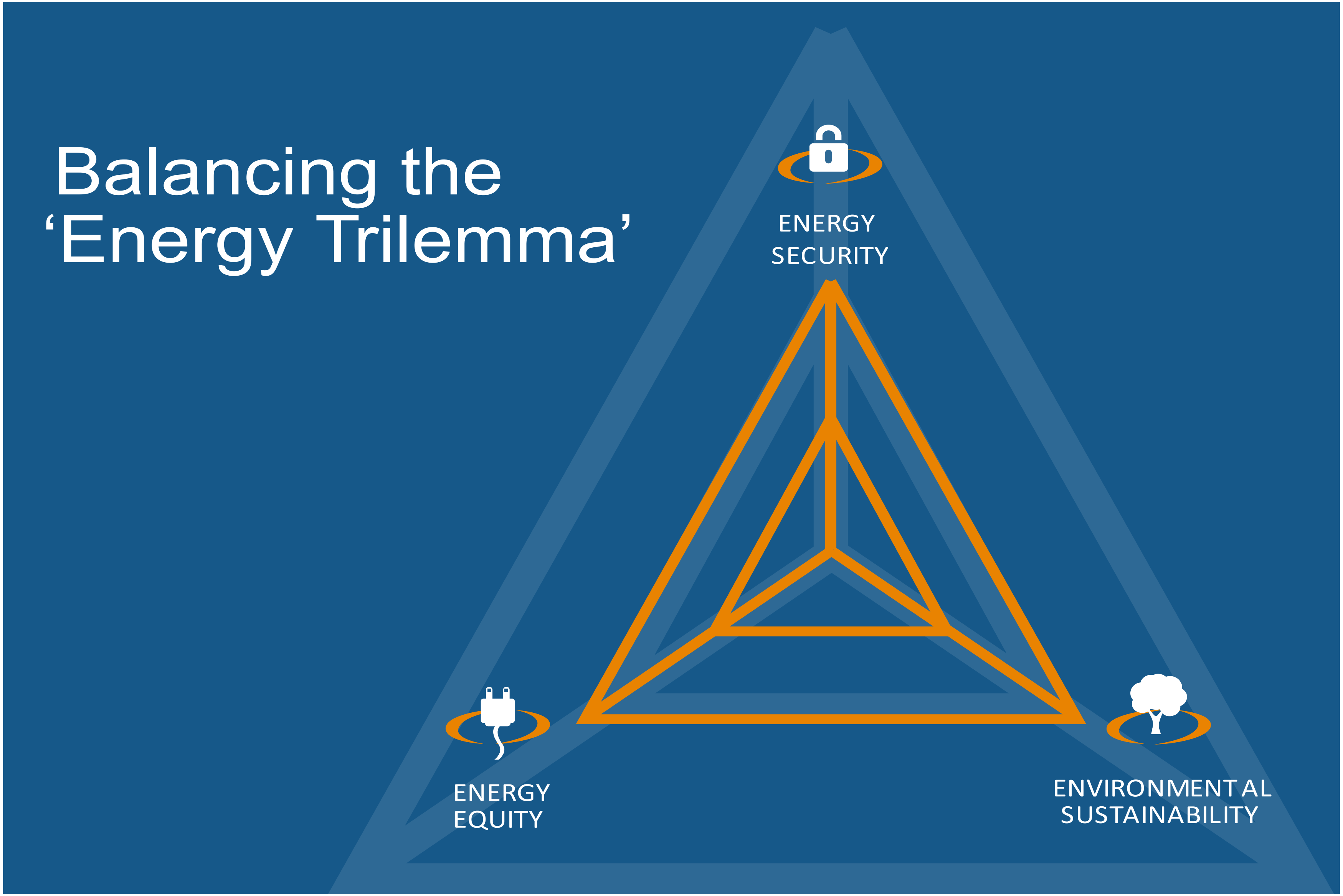
Deforestation

Energy Trilemma solves world climate problems

World Energy Council (WEC) determined that in order to solve world energy trilemma it is necessary to seek for:

- energy security
- to overcome energy poverty, including energy availability and affordability
- environmental sustainability, increasing efficiency of energy supply and consumption and using renewable energy sources with the lowest emissions

Energy Trilemma



The 2015 United Nations Climate Change Conference

Paris - 30 November - 12 December, 2015

Prior to conference:

146 coutries, having 87% world carbon emision, presented their commitments to reduce CO2 emission

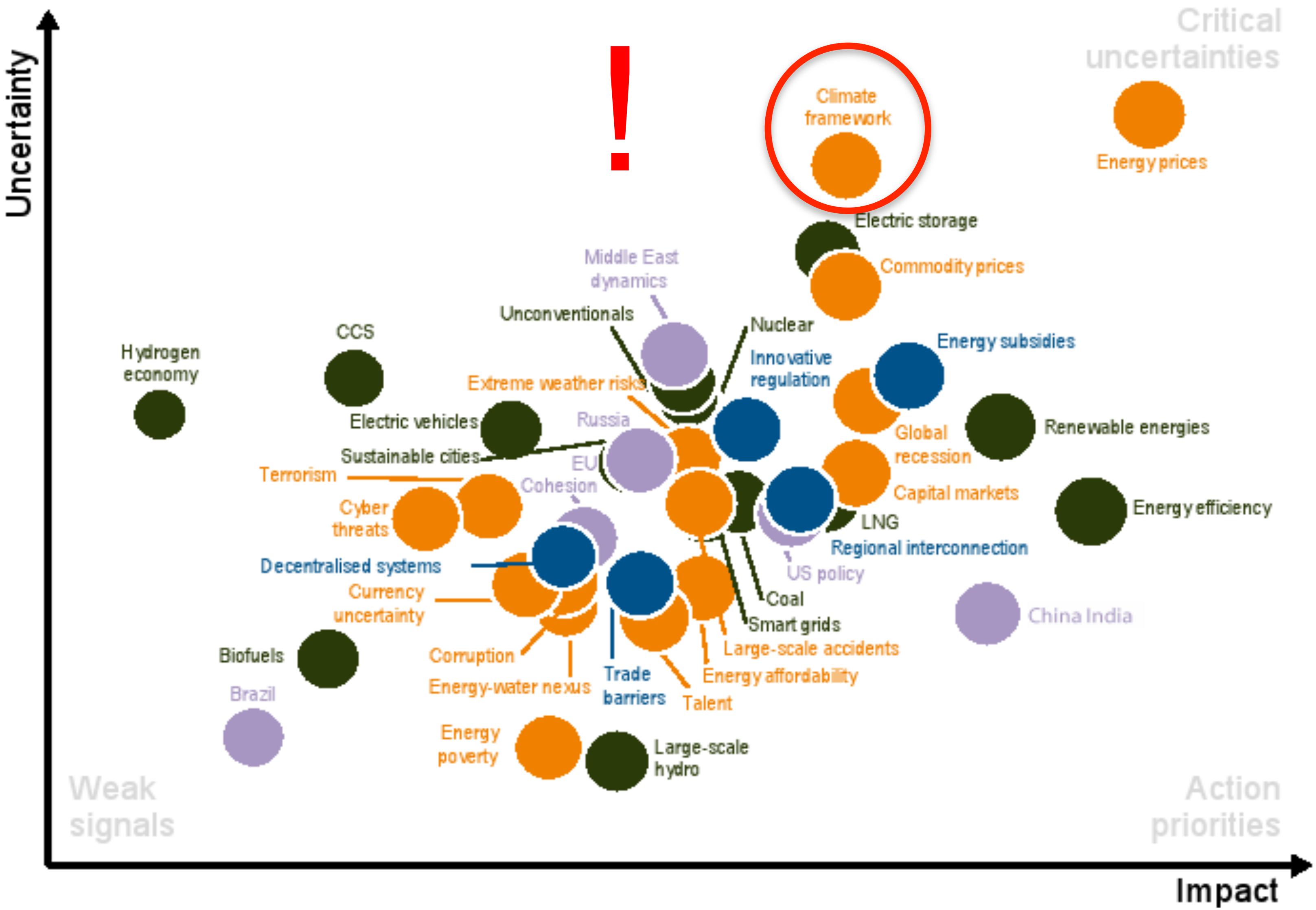
It is intended to provide finansial support and to help developing countries to decrease climate change effect and give 100 billion dollars annually up to 2020

EU will decrease CO2 emission by 40% until 2030 in comparison with 1990

But in agreement there is no information about creation of CO2 market

2015 12 12 – 196 countries in Paris conference agreed to decrease carbon emissions and fossil fuels, the expected key result was an agreement to set a goal of limiting global warming to less than 2 degrees Celsius (°C) compared to pre-industrial levels

Biggest uncertainty is due to absence of world climate system



Source: World Energy Council, 2015: World Energy Issues Monitor

Trilemma and Energy accessibility

Energy Trilemma Profile, 2014

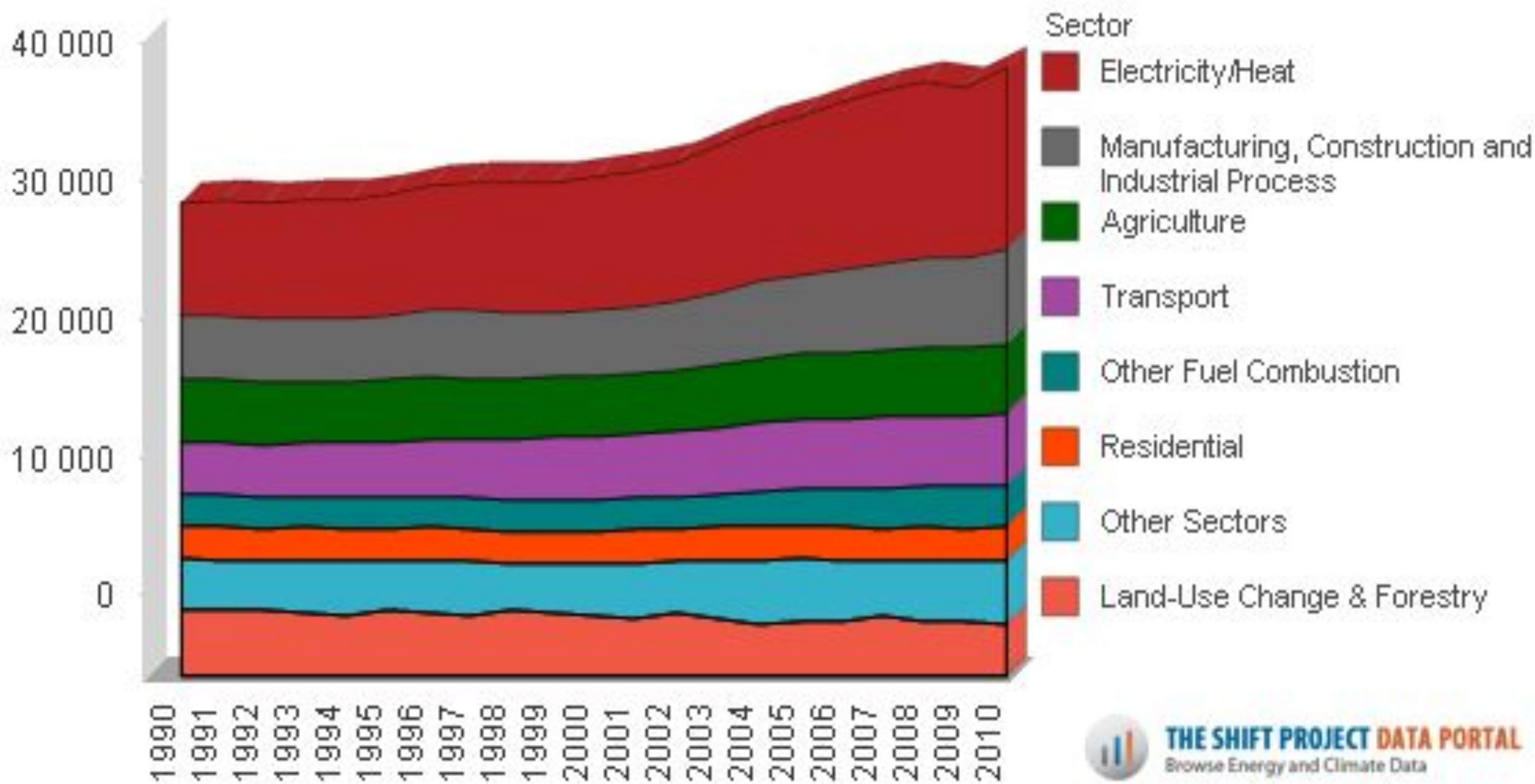
Asia | Europe | South America and the Caribean

Energy accessibility for inhabitants, %	89,5	99,9	98,1

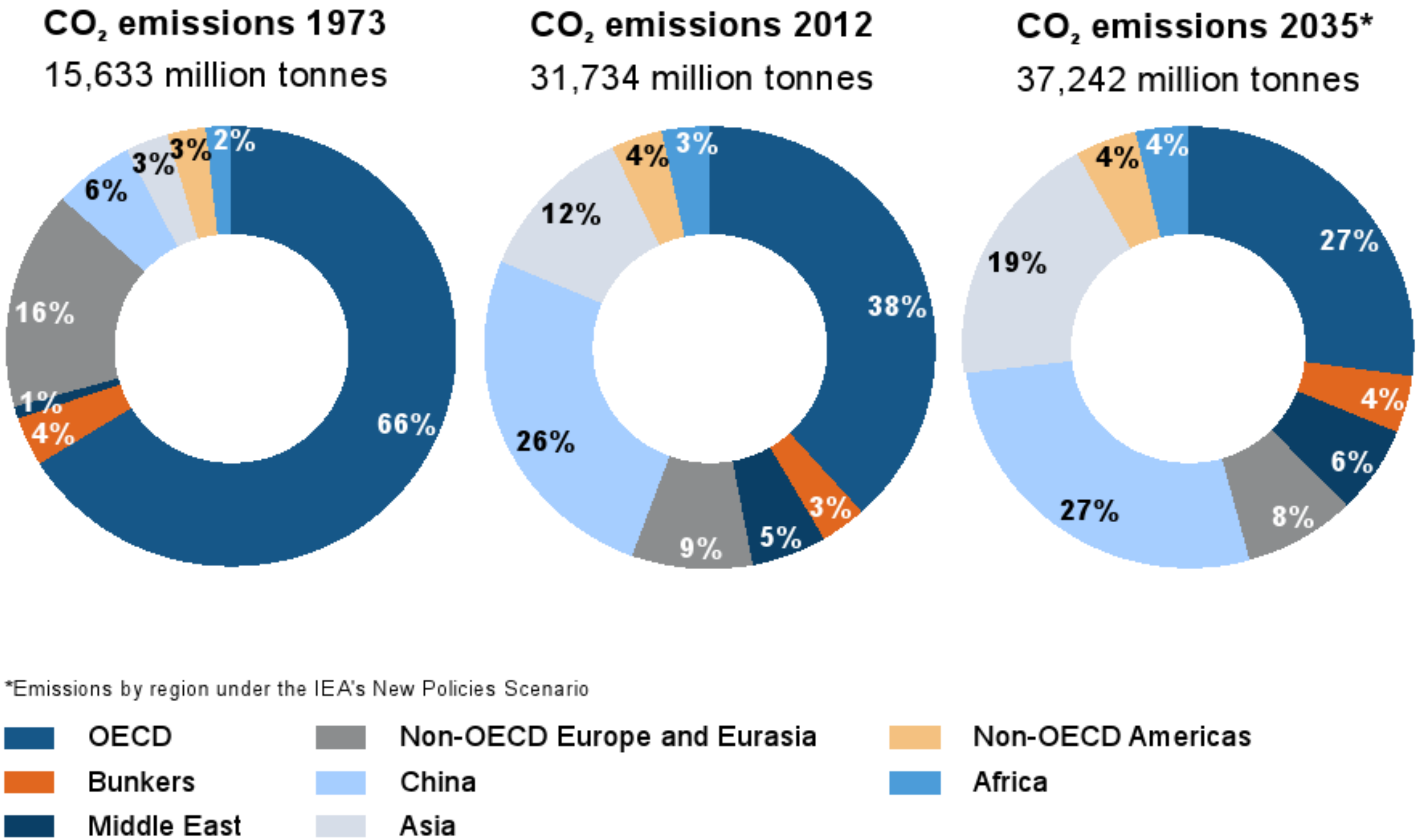
Middle East and North Africa | North America | Sub-Saharian

Energy accessibility for inhabitants, %	93,9	99,7	36,9

CO2 emissions in the world by sectors, MtCO2

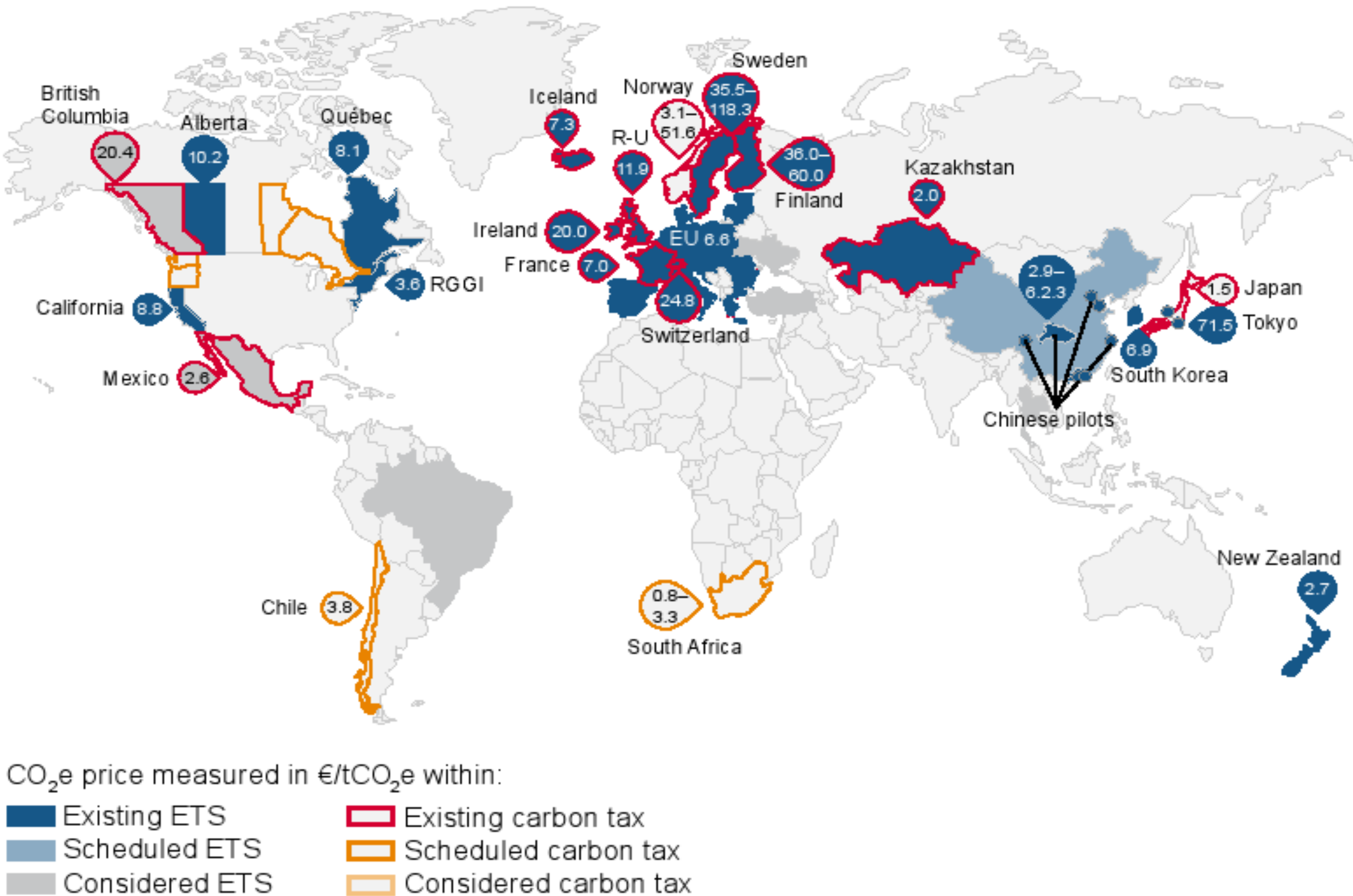


CO2 emissions changes by regions



Source: International Energy Agency (IEA), 2014: Key World Energy Statistics

Carbon pricing in the world, 2014



Source: CDC, 2015: Climate Research; World Bank, Ecofys, 2014: State and trends of carbon pricing

Input of Europe solving Energy Trilemma

- Every country increasing Energy sector has to show how Energy Trilemma may be solved

- It is easier for developed countries to solve Energy Trilemma challenges:

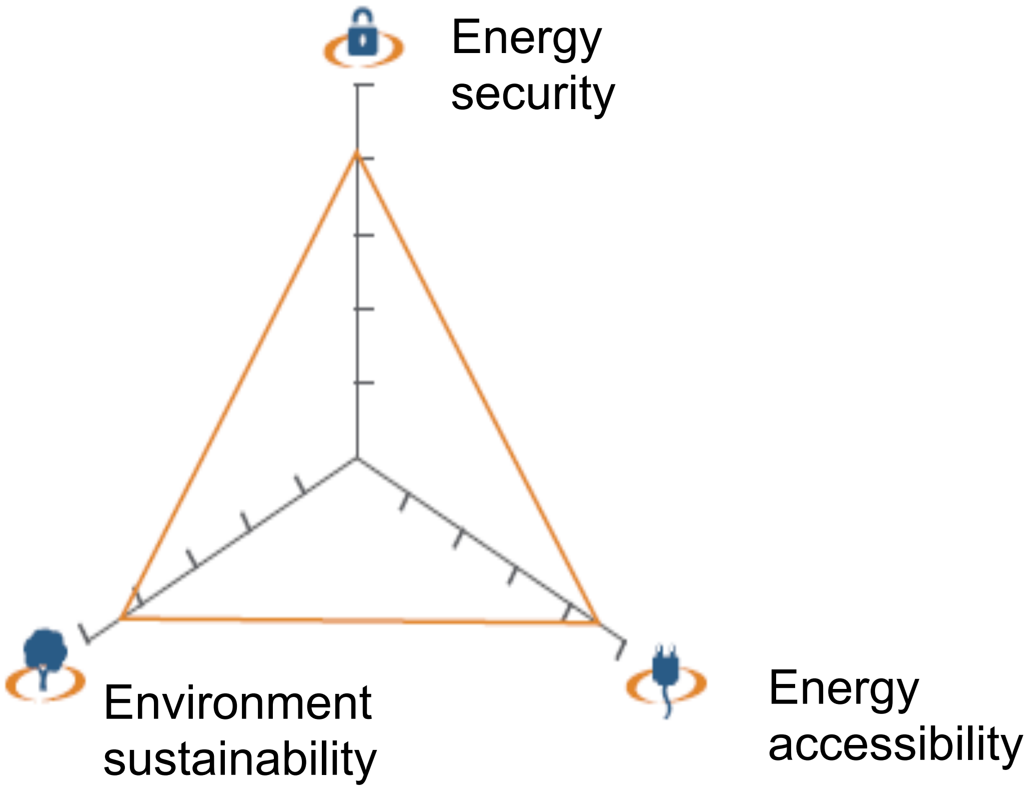
    High level of GDP

    Political and economical stability and maturity of society

    Governments have clear aim to decrease CO_2 emissions, to increase renewable energy and to ensure energy security

Energy Trilemma in Europe

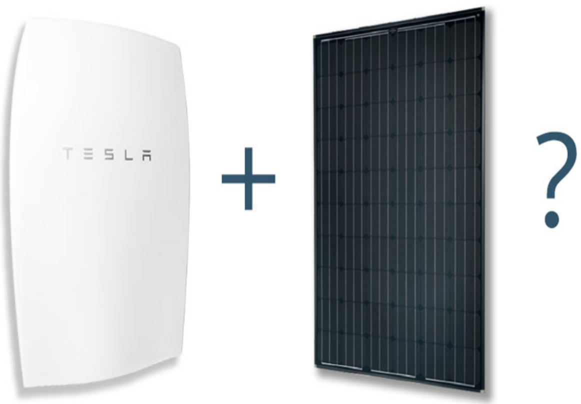
Trilemma profile and illustrative countries: 'Pack Leaders'



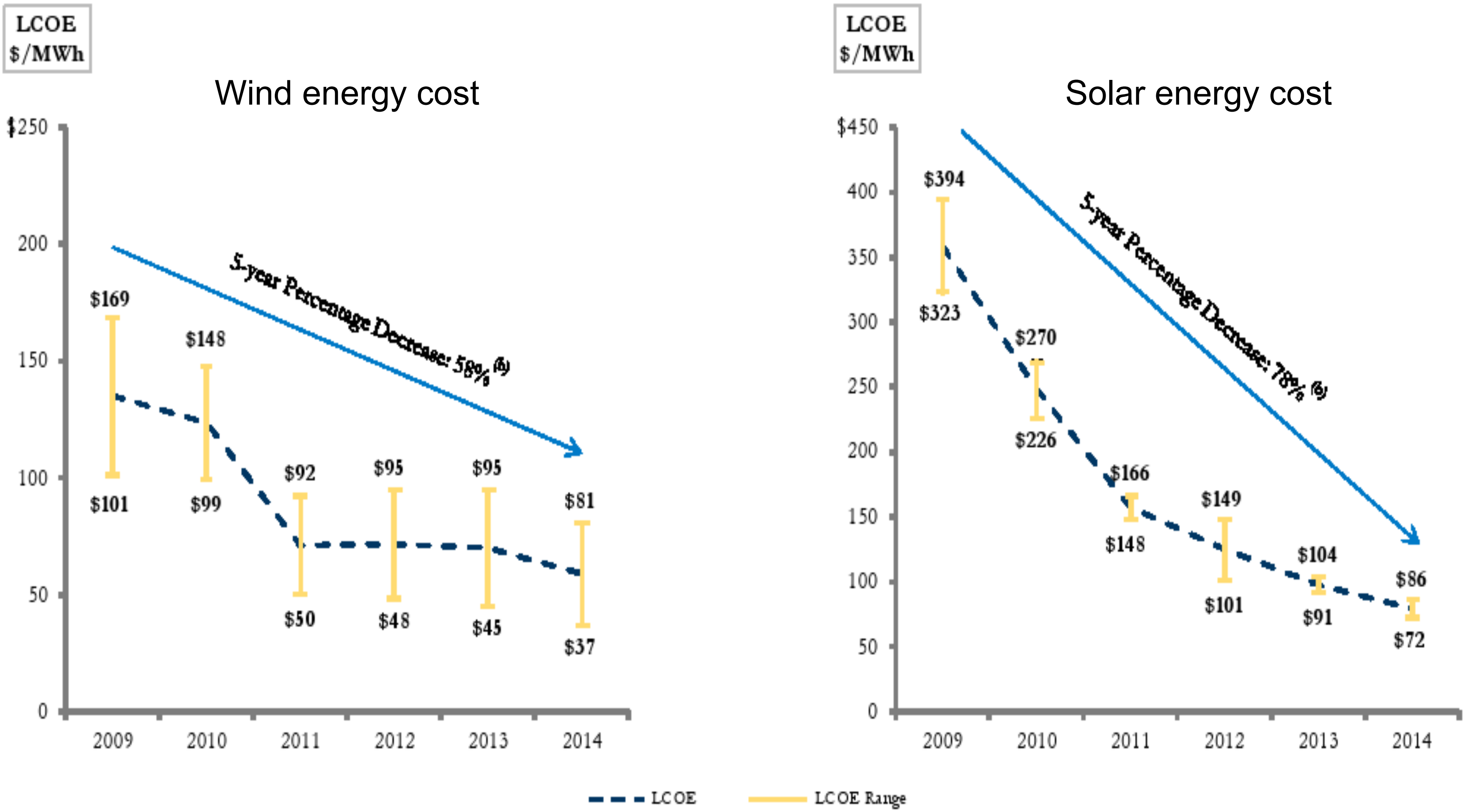
	Index Rank	Balance Score
Austria	4	AAB
Denmark	2	AAA
France	10	AAB
Germany	11	ABB
Netherlands	12	ABB
New Zealand	8	AAB
Spain	9	AAA
Sweden	3	AAA
Switzerland	1	AAA
United Kingdom	5	AAA

New development and new energy challenges

- Renewable energy development
  - technology of solar energy
  - progress of wind energy technologies
- Microenergetics / micronets, producing users
- Progress in electrical cars technologies

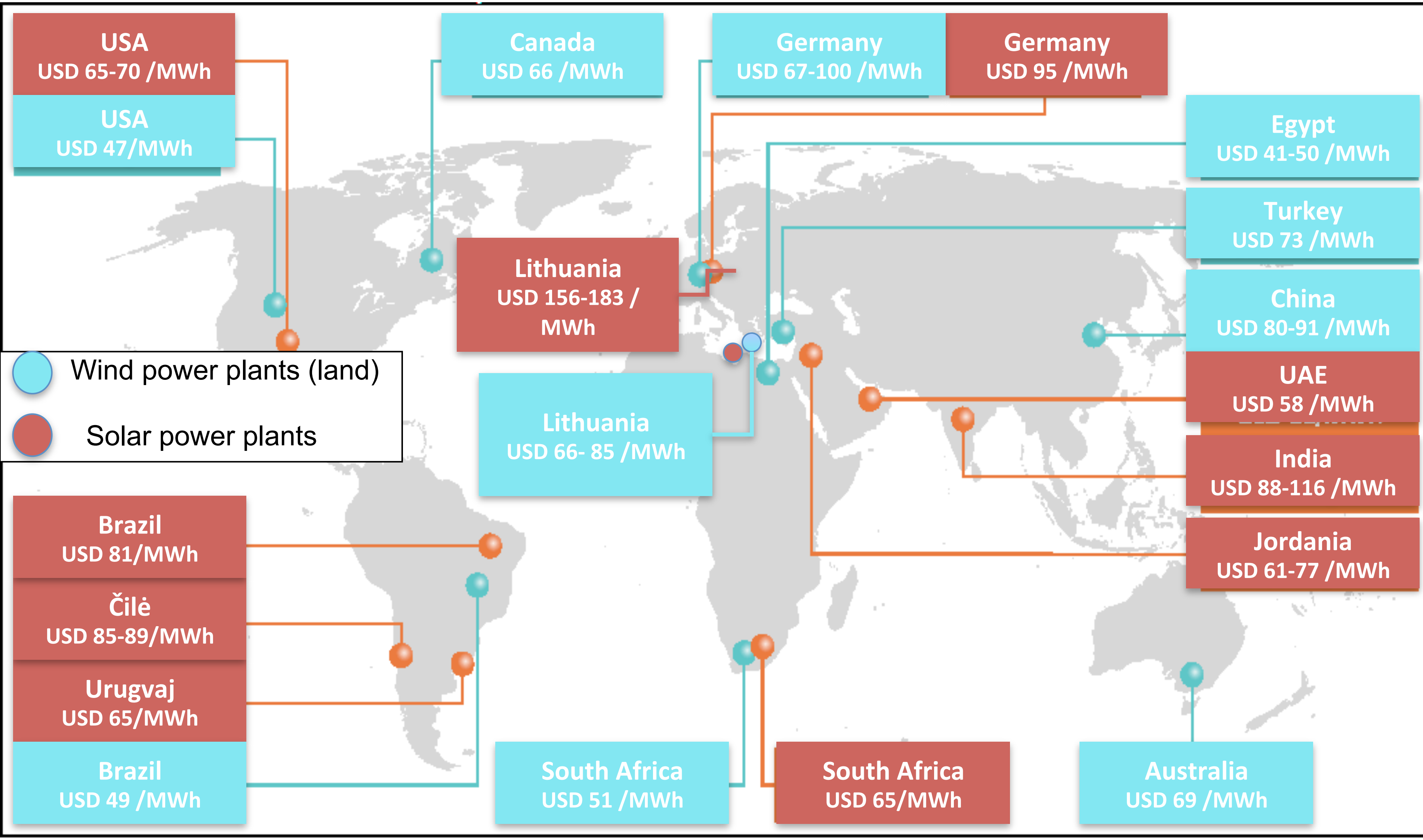


Comparative Decrease of solar and wind power manufacturing cost within 5 years



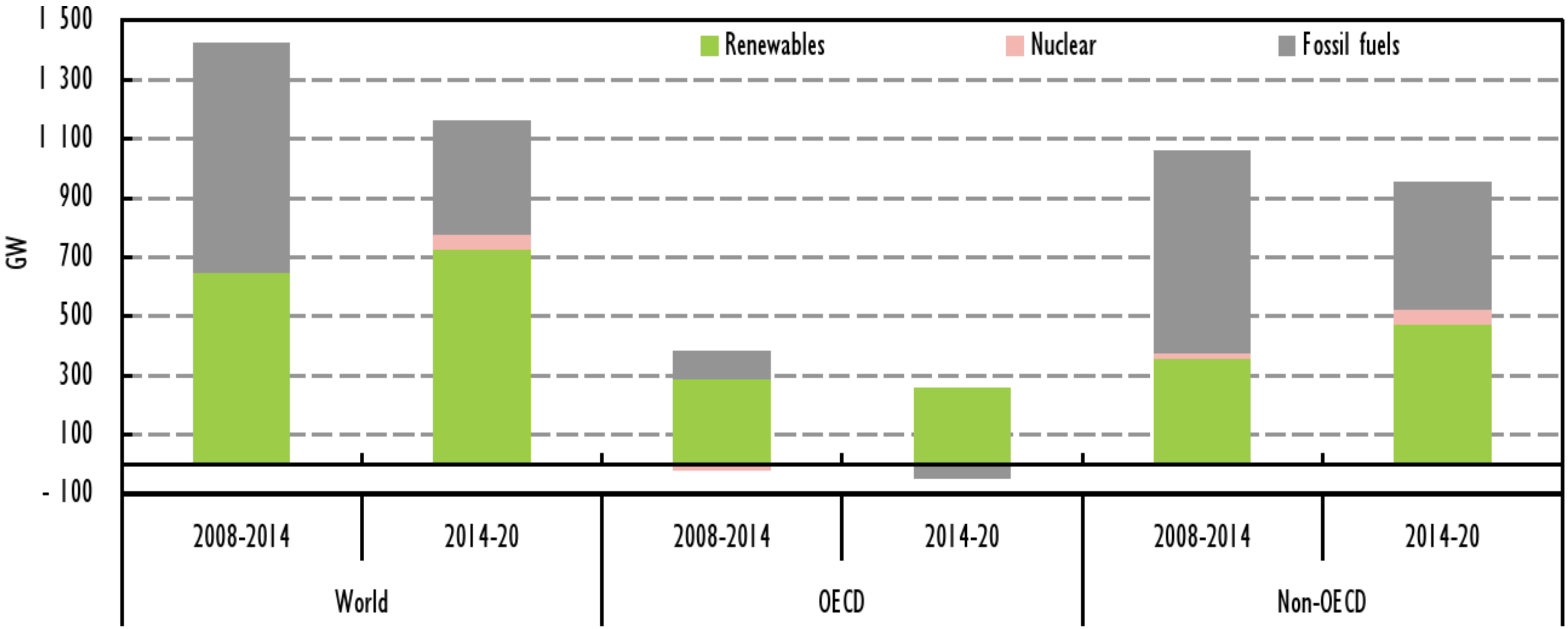
Source: Lazard's Levelized Cost Of Energy Analysis—version 8.0

Wind and solar power manufacturing cost 2015-2019



Source: Medium -Term Renewable Energy Market Report 2015_IEA; http://www.regula.lt

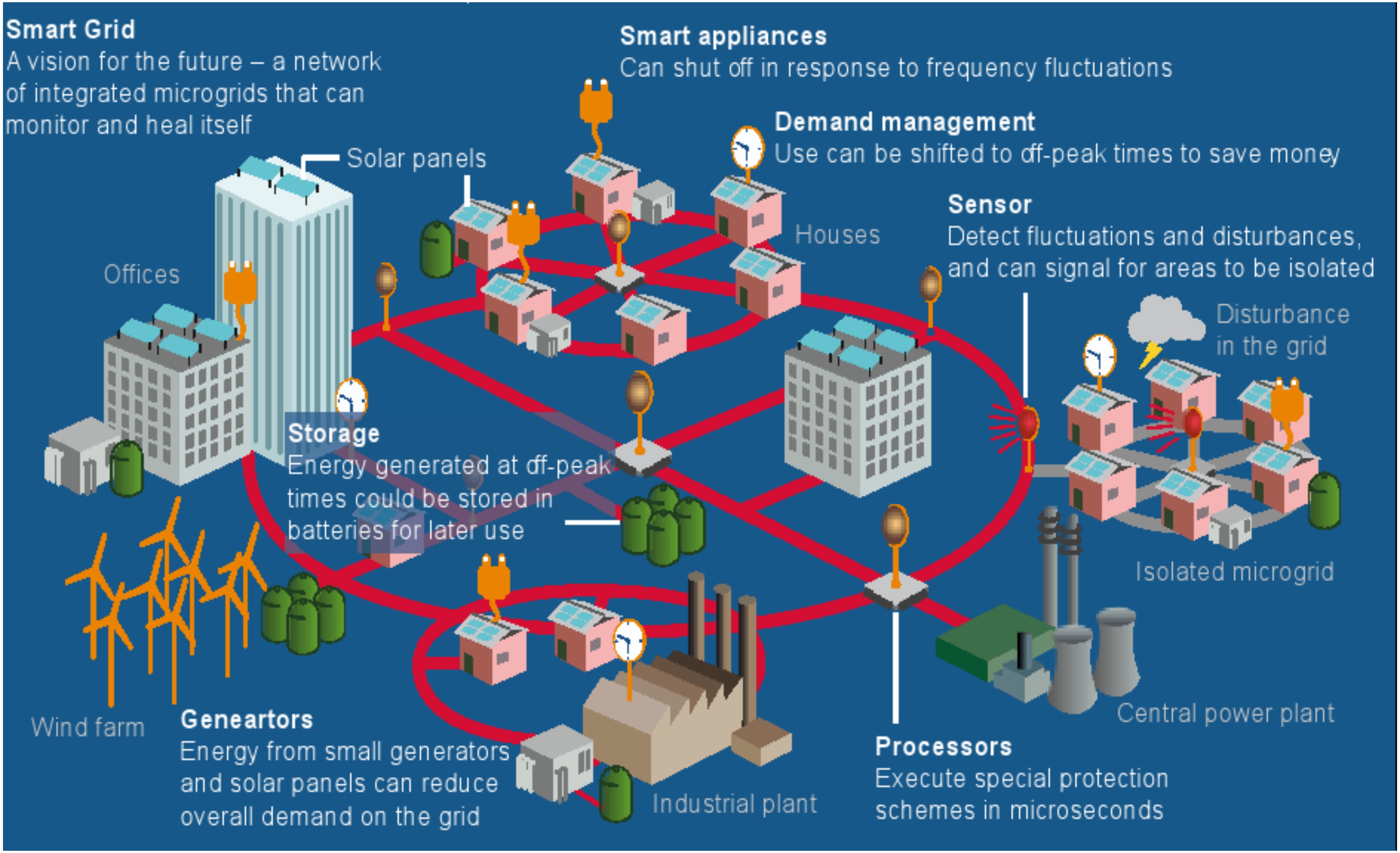
Perspective of new power manufacturing in the world within 2014 -2020



It is predicted new power manufacturing from renewable energy in the world

Source: Medium -Term Renewable Energy Market Report 2015_IEA

Smart grid technologies – perspective for Lithuania



Number of electrical cars is increasing

BMW i3

Ford Focus EV

Kia Soul EV

Mitsubishi i-MiEV

Nissan LEAF

smart fortwo Electric Drive

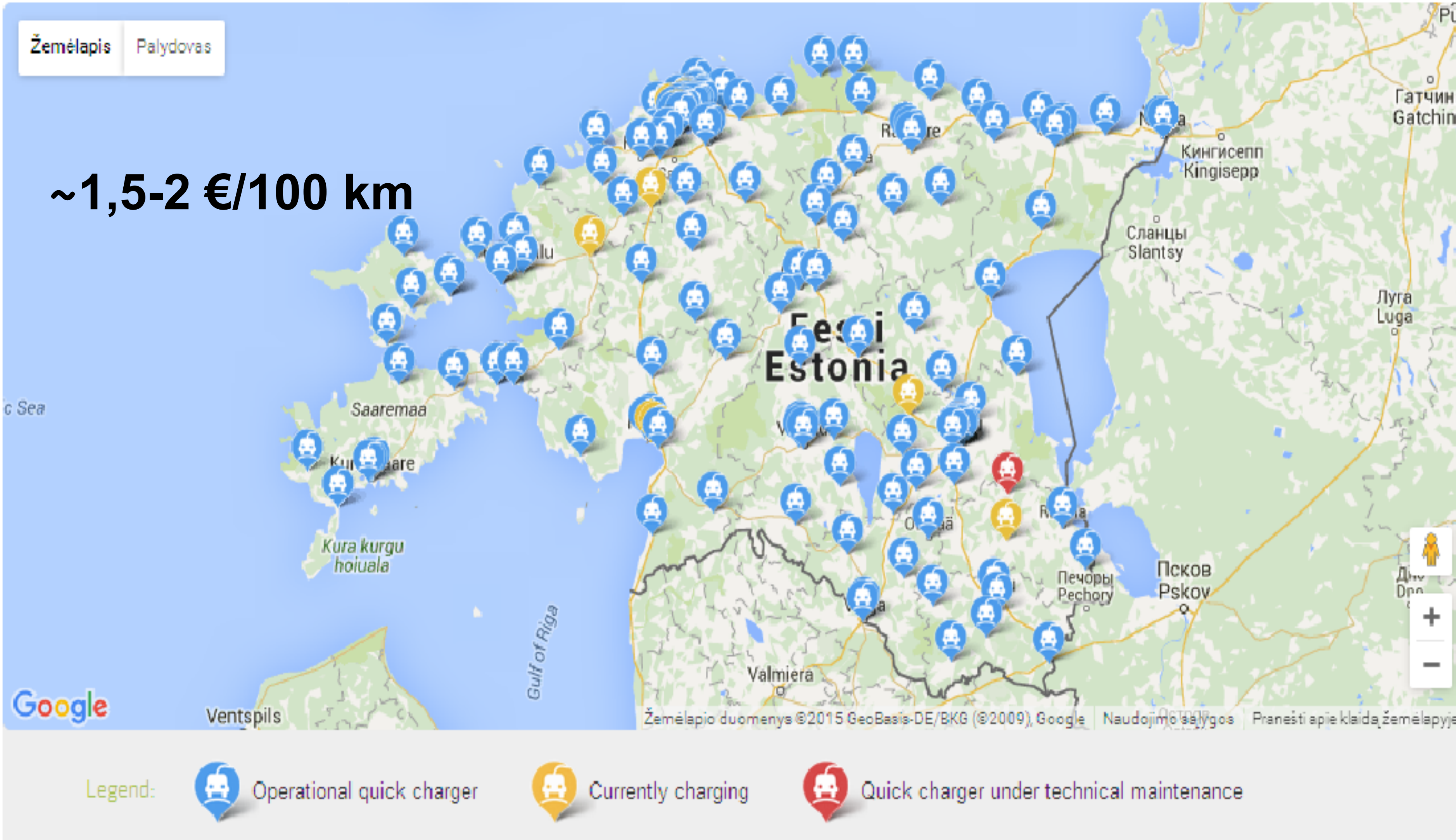
Tesla model x 90d

Renault Zoe

Opel Ampera

Estonia has developed electric car charging network (165)

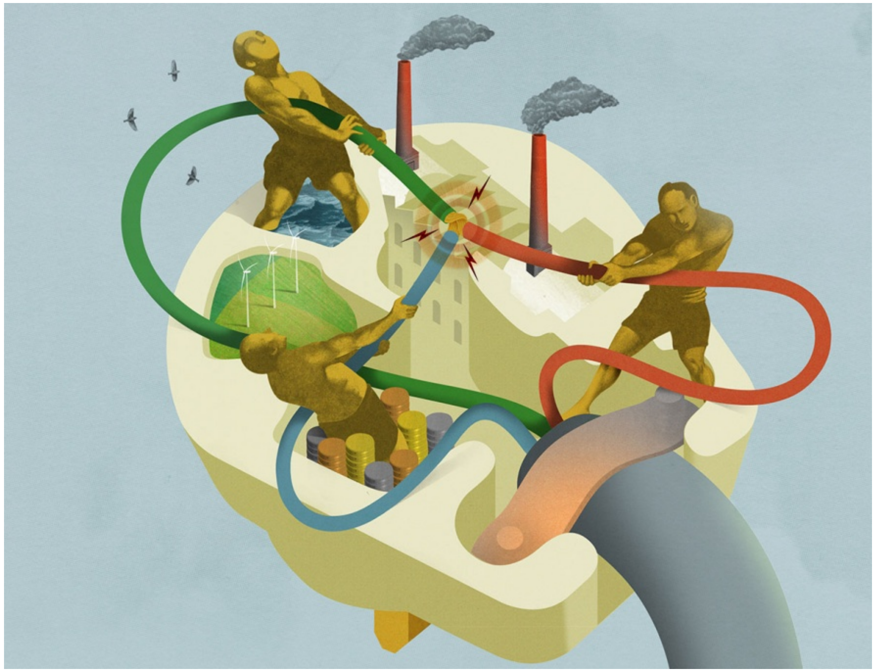
~1,5-2 €/100 km



Source: http://elmo.ee

Conclusions 1

- National energy strategy has to be oriented to the Recomendations of World Energy Council and European Union energy Plot guidelines
- Regional cooperation is inevitable, and National Energy strategies of neibornhood countries have to be matched
- Lithuanian energy without fossil fuels by 2050; the exclusive focus has to be paid on Lithuanian urban air quality



- It is necessary to strengthen energy competence; training process of all levels and improvement of creativity have to be emphasized starting even from the kinder gardens
- Only based on new development and high competence ambitious aims create national prosperity

Energy sources

There are five ultimate primary sources of useful energy:

The Sun

The motion and gravitational potential of the Sun, Moon and Earth

Geothermal energy from cooling, chemical reactions and radioactive decay in the Earth

Human-induced nuclear reactions

Chemical reactions from mineral sources

http://www.mpoweruk.com/images/
Solar-power-plant.jpg

Renewable energy

There are many forms of renewable energy. Most of these renewable energies depend in one way or another on sunlight

Wind and hydroelectric power are the direct result of differential heating of the Earth's surface which leads to air moving about (wind) and precipitation forming as the air is lifted.

Solar energy is the direct conversion of sunlight using panels or collectors.

Biomass energy is stored sunlight contained in plants.

Other renewable energies do not depend on sunlight, such as:

Geothermal energy is a result of radioactive decay in the crust combined with the original heat of accreting the Earth

Tidal energy is a conversion of gravitational energy

http://www.mpoweruk.com/images/
Solar-power-plant.jpg

Renewable energy

Renewable energy supplies are much more compatible with sustainable development than are fossil and nuclear fuels, in regard to both resource limitations and environmental impacts. Consequently almost all national energy plans include four vital factors for improving or maintaining social benefit from energy:

Increased harnessing of renewable supplies

Increased efficiency of supply and end-use

Reduction in pollution

Consideration of lifestyle

http://www.mpoweruk.com/images/
Solar-power-plant.jpg

Photo-voltaic cells

Photovoltaics (PV) covers the conversion of light into electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon studied in physics, photochemistry, and electrochemistry.

A typical photovoltaic system employs solar panels each, comprising a number of solar cells, which generate electrical power. The first step is the photoelectric effect followed by an electrochemical process where crystallized atoms ionized in a series, generate an electric current. PV Installations may be ground-mounted, rooftop mounted or wall mounted.

http://www.mpoweruk.com/images/
Solar-power-plant.jpg

Concentrating Solar Power Plants

Concentrated solar power systems generate solar power by using mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a small area. Electricity is generated when the concentrated light is converted to heat, which drives a heat engine (usually a steam turbine) connected to an electrical power generator

http://www.ucsusa.org/sites/default/files/styles/large/public/images/2015/02/energy-renewable-concentrating-solar-plant.jpg?itok=uRmUKujo

Wind power plant: horizontal

It is a device that converts the wind's kinetic energy into electrical power. The term appears to have been adopted from hydroelectric technology (rotary propeller). The technical description of a wind turbine is aerofoil-powered generator.

Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.

http://pictures.4ever.eu/data/download/fun/wind-power-plant,-sea-173740.jpg

Wind power plant: vertical

The main rotor shaft is set transverse to the wind (but not necessarily vertically) while the main components are located at the base of the turbine

This arrangement allows the generator and gear-box to be located close to the ground, facilitating service and repair

http://ecdc-library.wikispaces.com/file/view/Vertical-axis-wind-turbine.jpg/356540950/Vertical-axis-wind-turbine.jpg

Hydroelectric energy: dam

Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water

In 2015 hydropower generated 16.6% of the worlds total electricity and 70% of all renewable electricity, and is expected to increase about 3.1% each year for the next 25 years

http://www.pennenergy.com/content/dam/Pennenergy/online-articles/2013/December/KerrDam.jpg

Hydroelectric energy: tidal

Tides are more predictable than wind energy and solar power

Among sources of renewable energy, tidal power has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability

http://static.progressivemediagroup.com/uploads/imagelibrary/nri/power/projects/Strangford%20tidal/Strangford.JPG

Hydroelectric energy: tidal

Tidal power, also called tidal energy, is a form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity

Although not yet widely used, tidal power has potential for future electricity generation

https://avisionforgalway2030.files.wordpress.com/2015/08/15-tidal-and-hydro-energy-courtesy-british-high-commission-ottawa-flickr.jpg

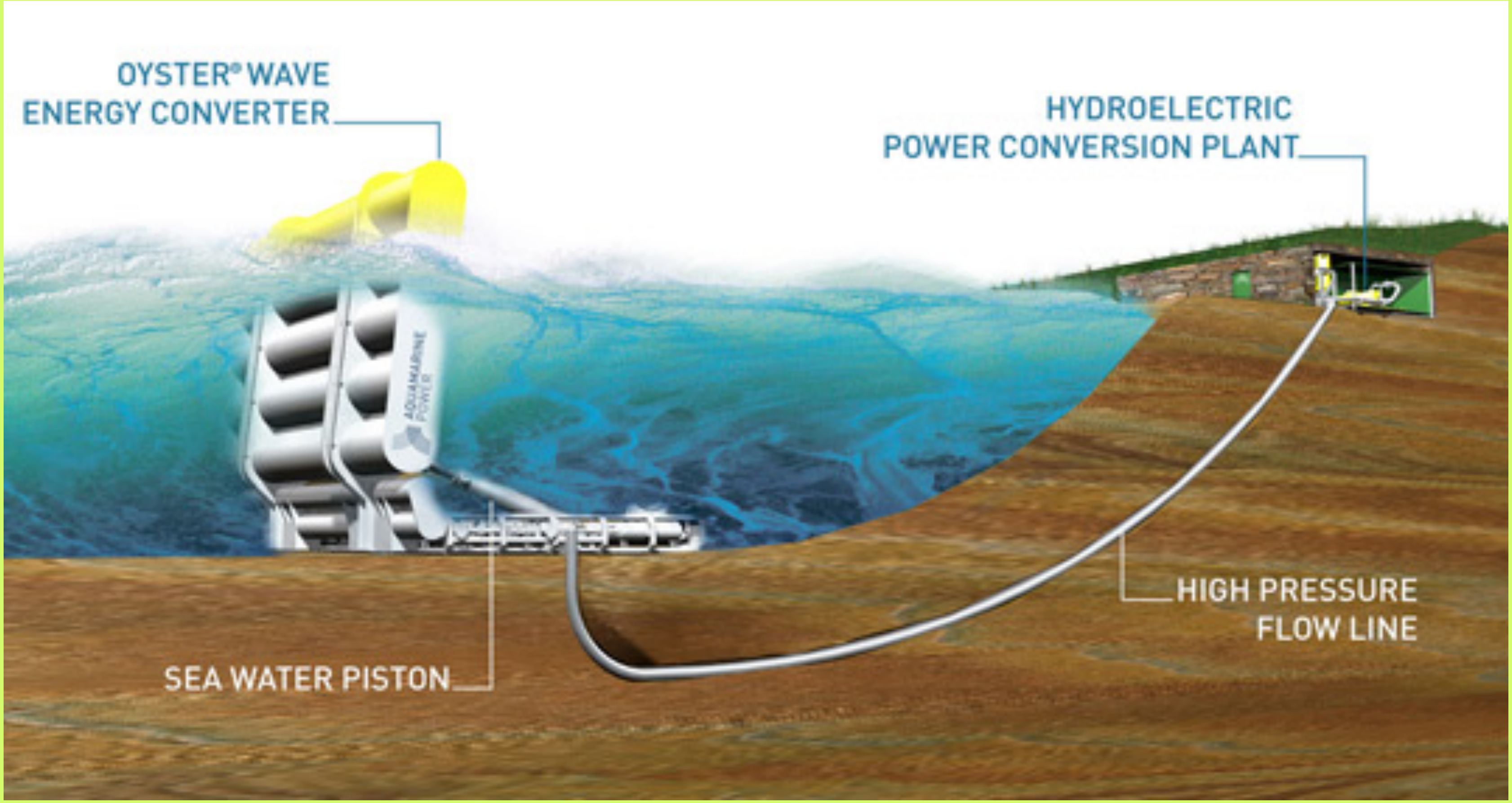
Wave energy plant: (manufacturer WERPO)

Wave power is the transport of energy by wind waves, and the capture of that energy to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs). A machine able to exploit wave power is generally known as a wave energy converter (WEC)

Wave power is distinct from the diurnal flux of tidal power and the steady gyre of ocean currents. Wave-power generation is not currently a widely employed commercial technology, although there have been attempts to use it since at least 1890. In 2008, the first experimental wave farm was opened in Portugal, at the Aguçadoura Wave Park

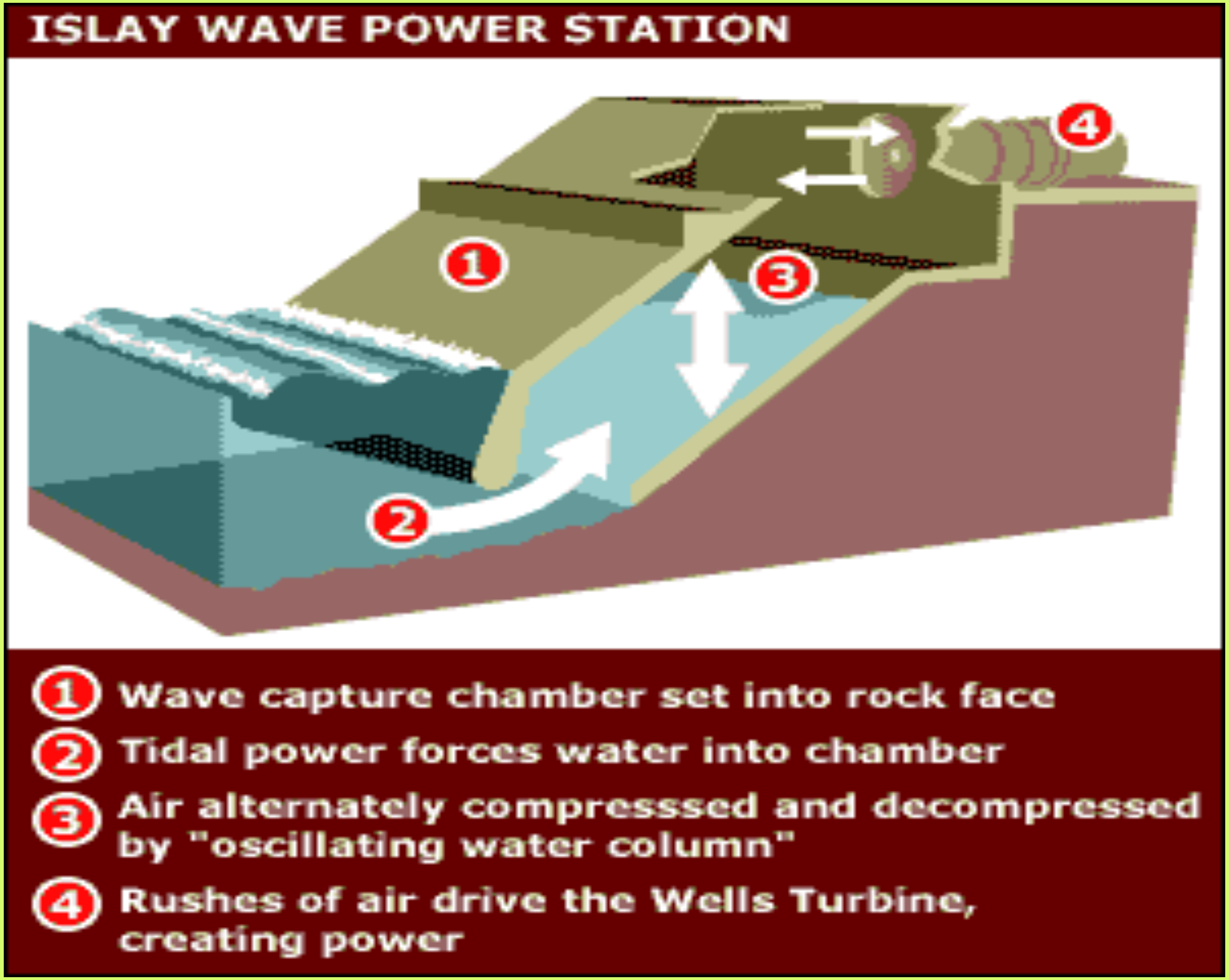
http://subseaworldnews.com/wp-content/uploads/2012/06/SDE-to-Build-Sea-Wave-Energy-Plants-in-Ecuador.jpg

Wave energy plant: "Oyster"



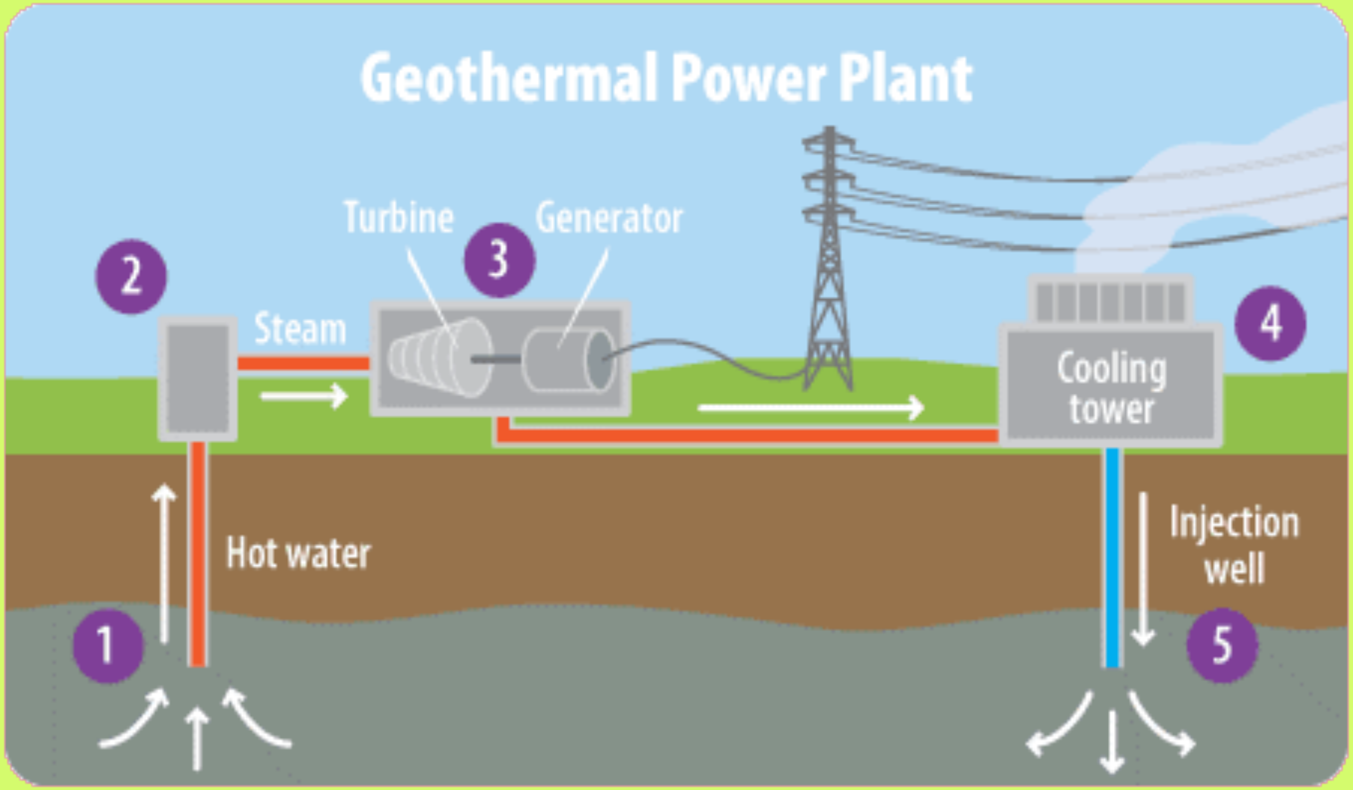
http://assets.inhabitat.com/files/oysterpower4.jpg

Wave energy plant: ISLAY wave power station



http://news.bbc.co.uk/olmedia/1030000/images/_1032148_wave_generator_inf300.gif

Geothermal energy

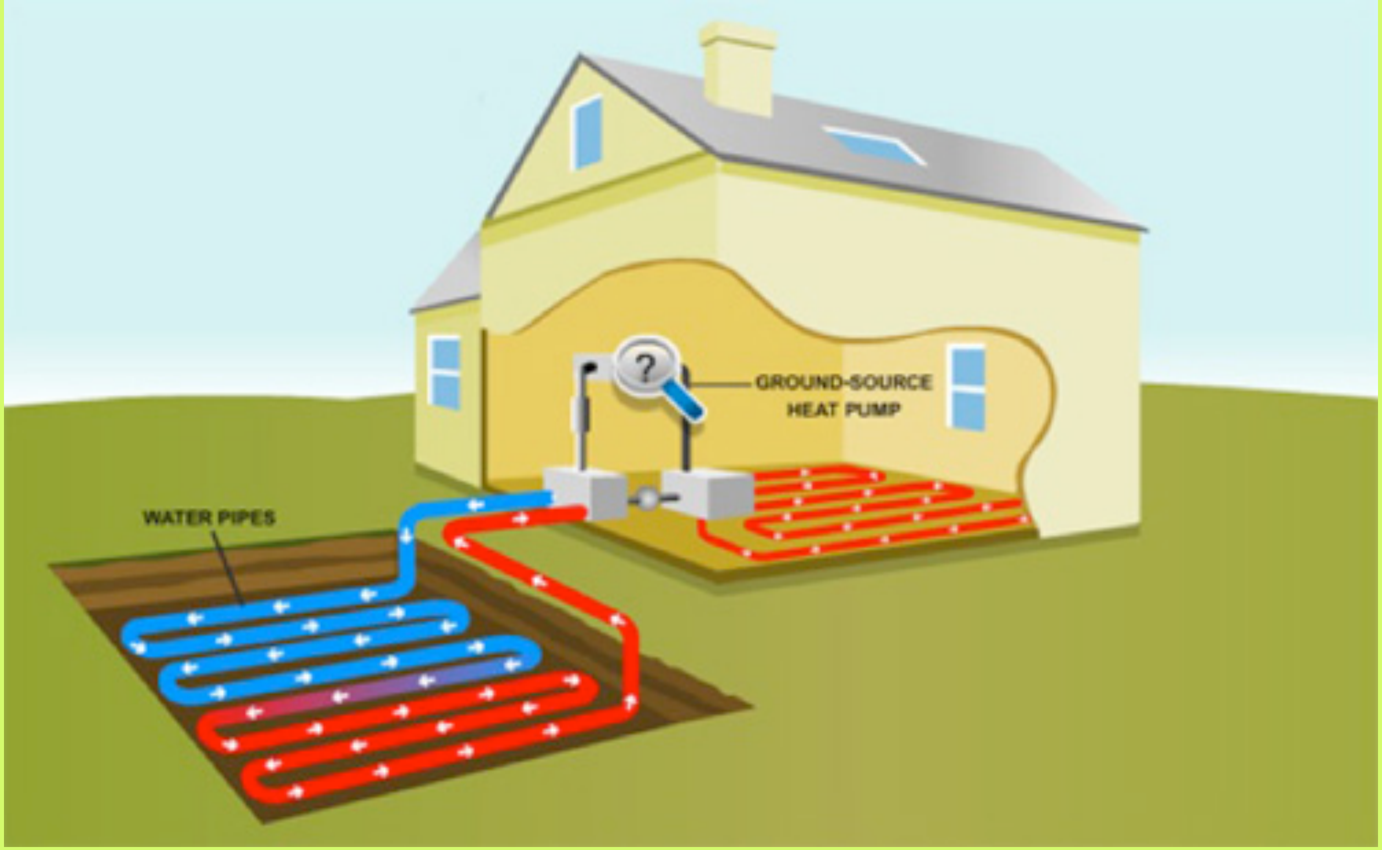


Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is the one that determines the temperature of matter. The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of materials (in currently uncertain but possibly roughly equal proportions).

The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface

https://www3.epa.gov/climatechange/kids/images/4-1-5-geopower.gif

Geothermal energy



http://tcpermaculture.com/site/wp-content/uploads/2014/02/Geothermal.jpg

Bio (biomass) energy: biofuel

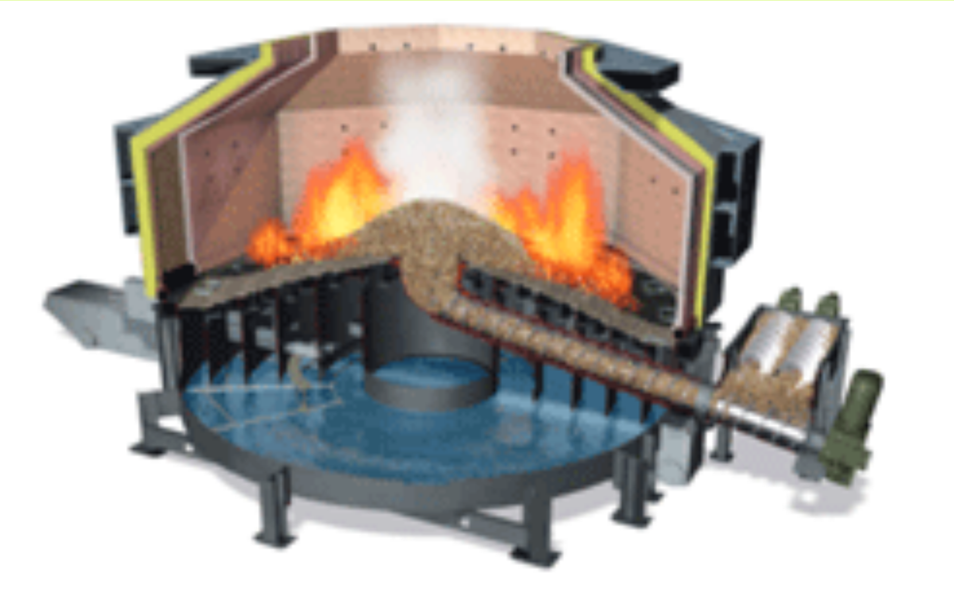
A biofuel is a fuel that is produced through contemporary biological processes, such as agriculture and anaerobic digestion, rather than a fuel produced by geological processes such as those involved in the formation of fossil fuels, such as coal and petroleum, from prehistoric biological matter. Biofuels can be derived directly from plants, or indirectly from agricultural, commercial, domestic, and/or industrial wastes

Renewable biofuels generally involve contemporary carbon fixation, such as those that occur in plants or microalgae through the process of photosynthesis.

Other renewable biofuels are made through the use or conversion of biomass (referring to recently living organisms, most often referring to plants or plant-derived materials).

http://top10listsnow.com/wp-content/uploads/2013/01/biofuel-energy1.jpg

Bio (biomass) energy: BioGrate combustion technology



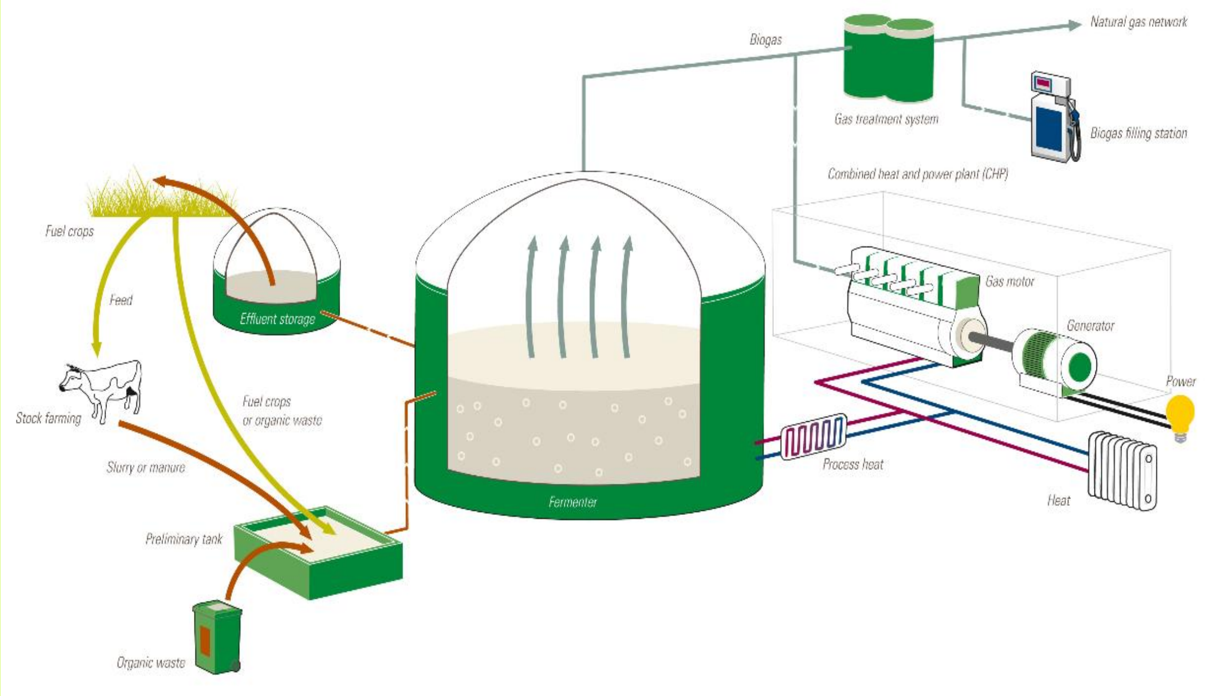
BioGrate solution is suitable for power and heat production with a wide variety of biomass-based solid fuels, such us bark, wood chips, sawdust and peat. It is a rotating grate with a conical primary combustion chamber, and its fuel input ranges from 8 to 20 MW

The fuel is fed from BioGrtae combustion technology underneath to the center of the grate. It is dried in the middle of the grate by the heat that radiates from the refractory lining bricks and the flames without disturbing the burning fuel bed in the combustion zone

After complete combustion of the residual carbon, the ash falls from the edge of the grate to an ash space filled with quenching water

http://www.valmet.com/globalassets/products/energy-production/power-plants/modularized-powerplants/biograte.gif

Bio (biomass) energy: biogass

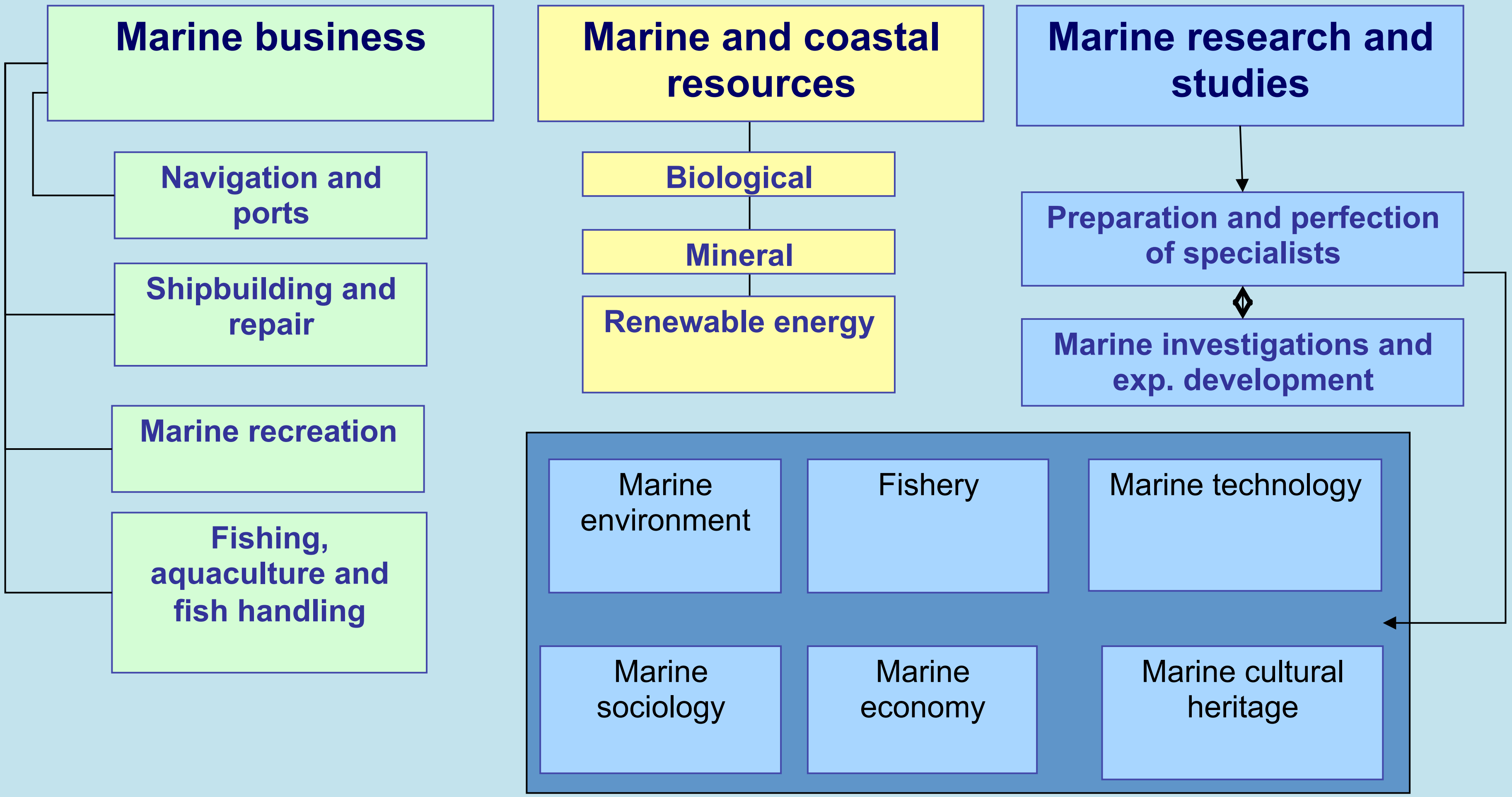


Biomass is organic matter derived from living, or recently living organisms. Biomass can be used as a source of energy and it most often refers to plants or plant-based materials which are not used for food or feed, and are specifically called lignocellulosic biomass.

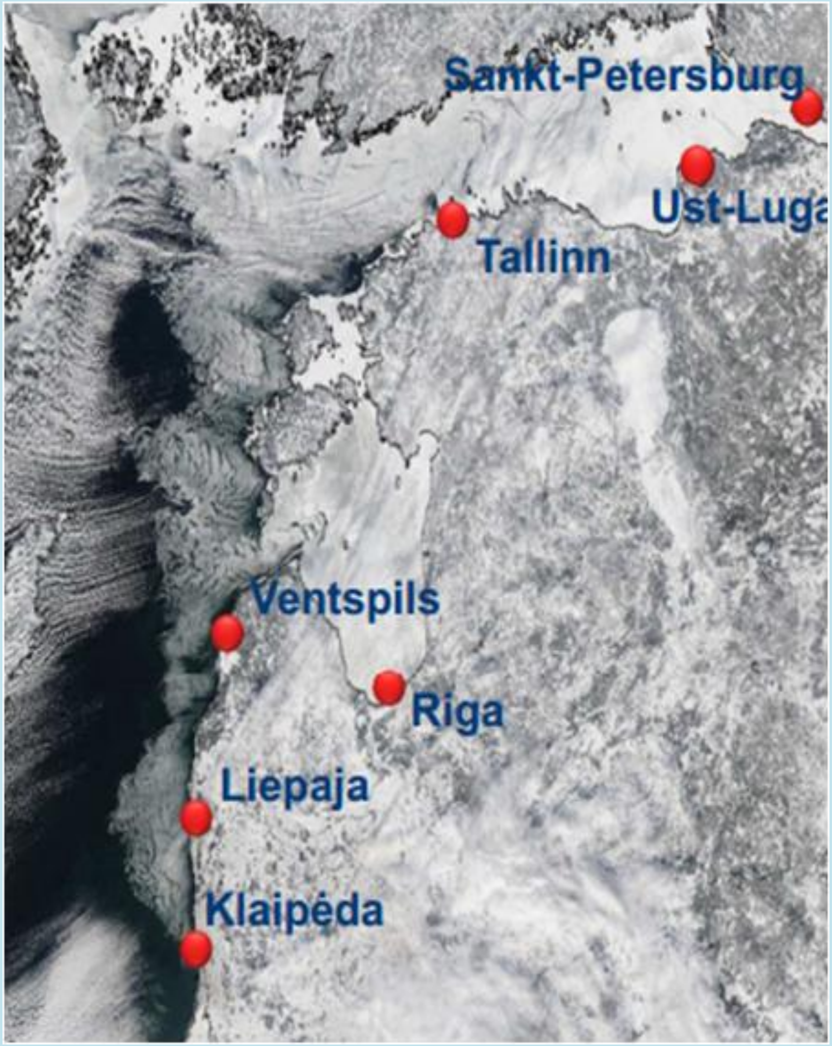
As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel. Conversion of biomass to biofuel can be achieved by different methods which are broadly classified into: thermal, chemical, and biochemical methods

http://4.bp.blogspot.com/-W28lhH1S2Ik/UOWBYIl4JKI/AAAAAAAAMTY/HYLoEBCKSTo/s1600/Screen%2BShot%2B2013-01-03%2Bat%2B8.01.36%2BAM.png

Lithuanian marine/maritime sector



Port Klaipeda

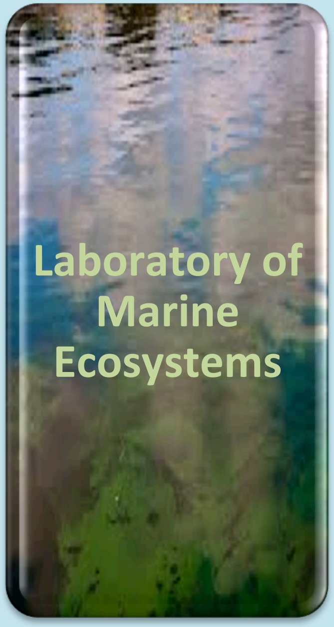


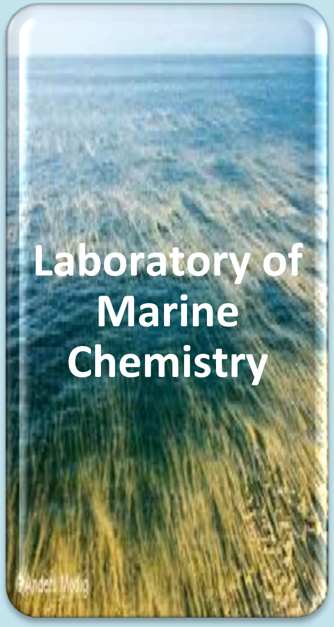
- More than 800 companies are involved in the marine related activities – this gives around 11 % of total working places established in the country

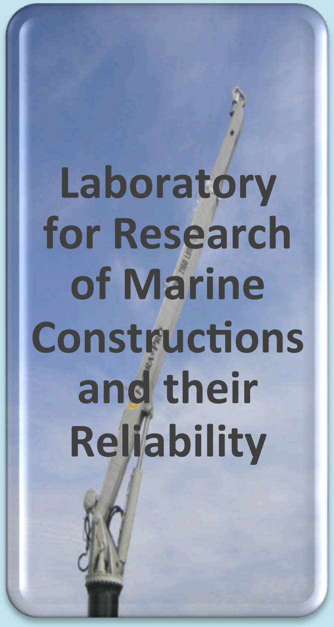
- More than 18 % of Gross Domestic Product is being created in marine sector

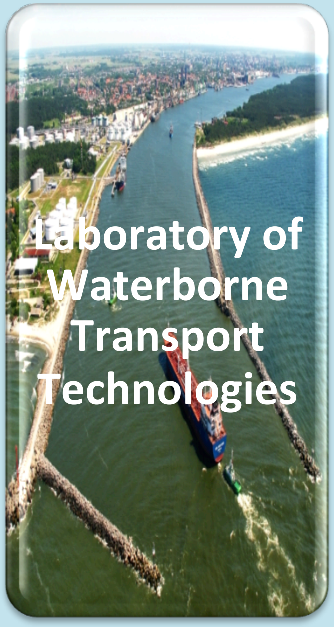
- Port of Klaipeda is one of the biggest in the Eastern Baltic

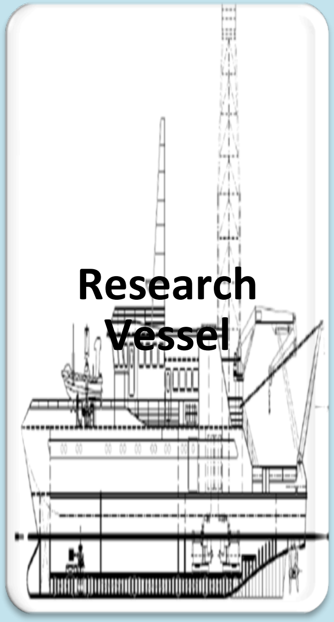
Marine Valley Open Access Research Infrastructure in Klaipėda University







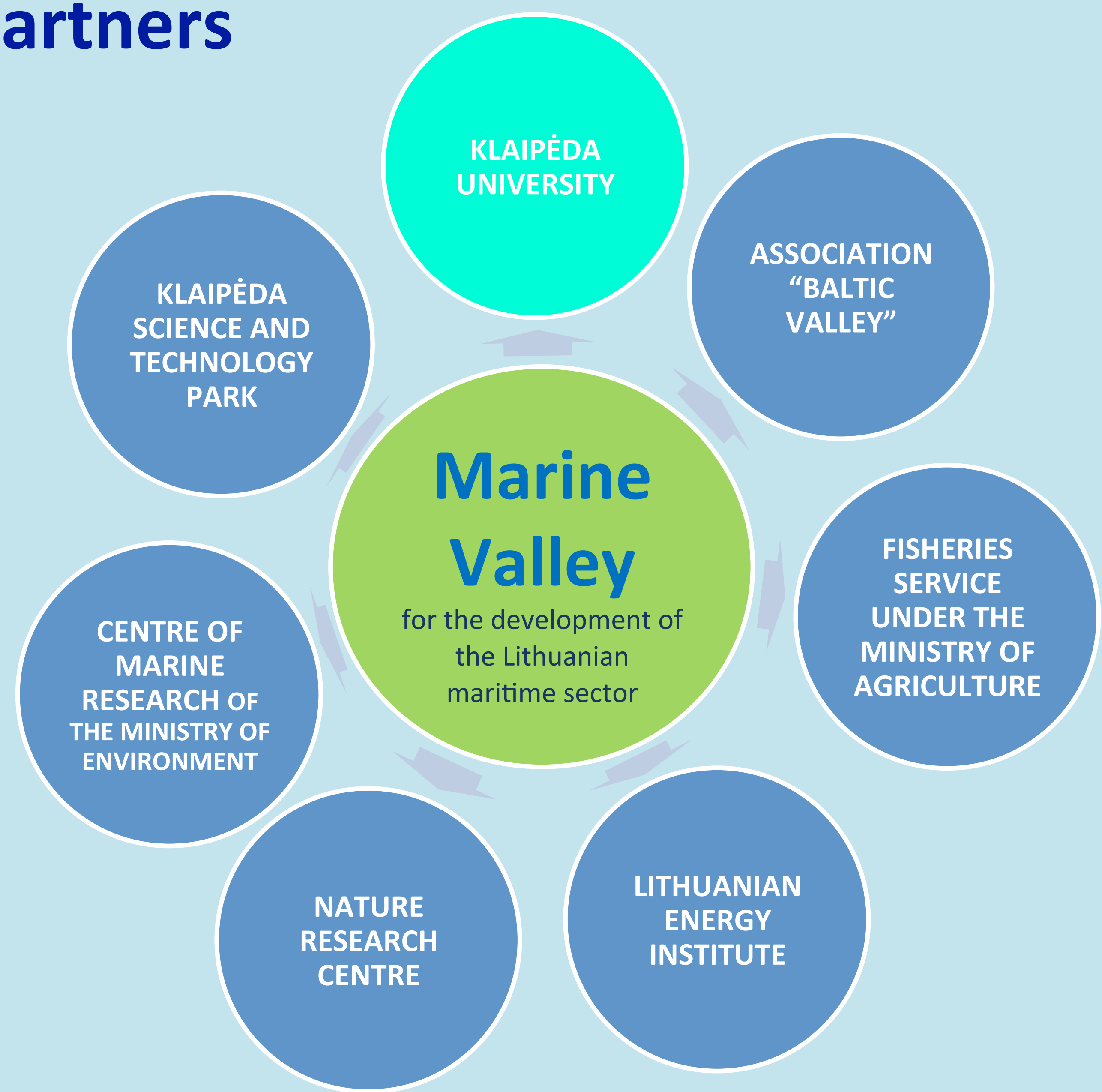




Valleys in Lithuania

Valleys	R&D fields
Sunrise Valley 322,23 mln. Lt (93 mln. Eur)	laser and light technologies, nanotechnologies, semiconductors technologies and electronics, civil engineering
Santara Valley 330,9 mln. Lt (95 mln. Eur)	biotechnologies, innovative medicine, biopharmacy, ICT
Santaka Valley 254,46 mln. Lt (73 mln. Eur)	sustainable chemistry and pharmacy, mechatronics, future energy and ICT
Nemunas Valley 190,24 mln. Lt (55 mln. Lt)	agro biotechnologies, bioenergy and forestry, food technologies, safety and wellness
Marine Valley 206,84 mln. Lt (59,9 mln. Eur)	marine environment and maritime technologies

Main Partners



Main Objectives of the Marine Valley 1

- to create a modern research infrastructure for the general needs of Lithuania's maritime research, academic studies and technological development

- to update and modernize the infrastructure of university-level maritime studies

- to strengthen the interaction between science, academic studies and business activities with a view to better quality of studies

Main Objectives of the Marine Valley 2

- to create conditions for cooperation between maritime businesses and research/academic institutions, as well as for the emergence of knowledge-driven enterprises relying on the commercialization of scientific output, and for increasing global competitiveness of our maritime businesses

- to increase the competitiveness of Lithuania's marine science and maritime technologies on the international market of marine research and maritime business services; to increase the scope of R&D activities in maritime projects

Near future requirements

The natural change of marine and coastal geo-systems

Growing demand and reasoned use of natural resources

Protection of natural and cultural heritage

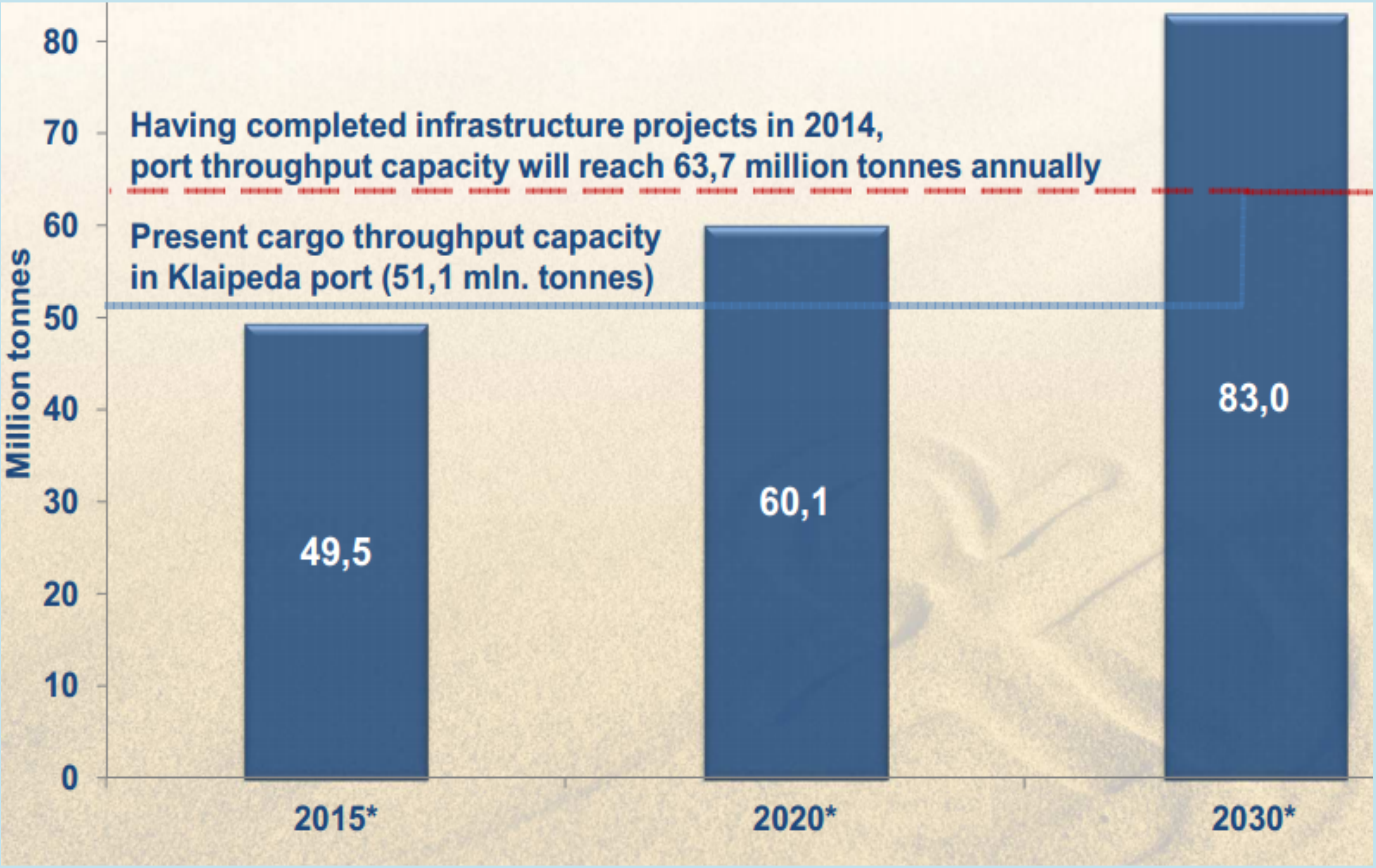
Development of deep sea port in Klaipeda and reconstruction of Šventoji port

Offshore wind energy projects

Activities related to Būtingė oil terminal maintenance

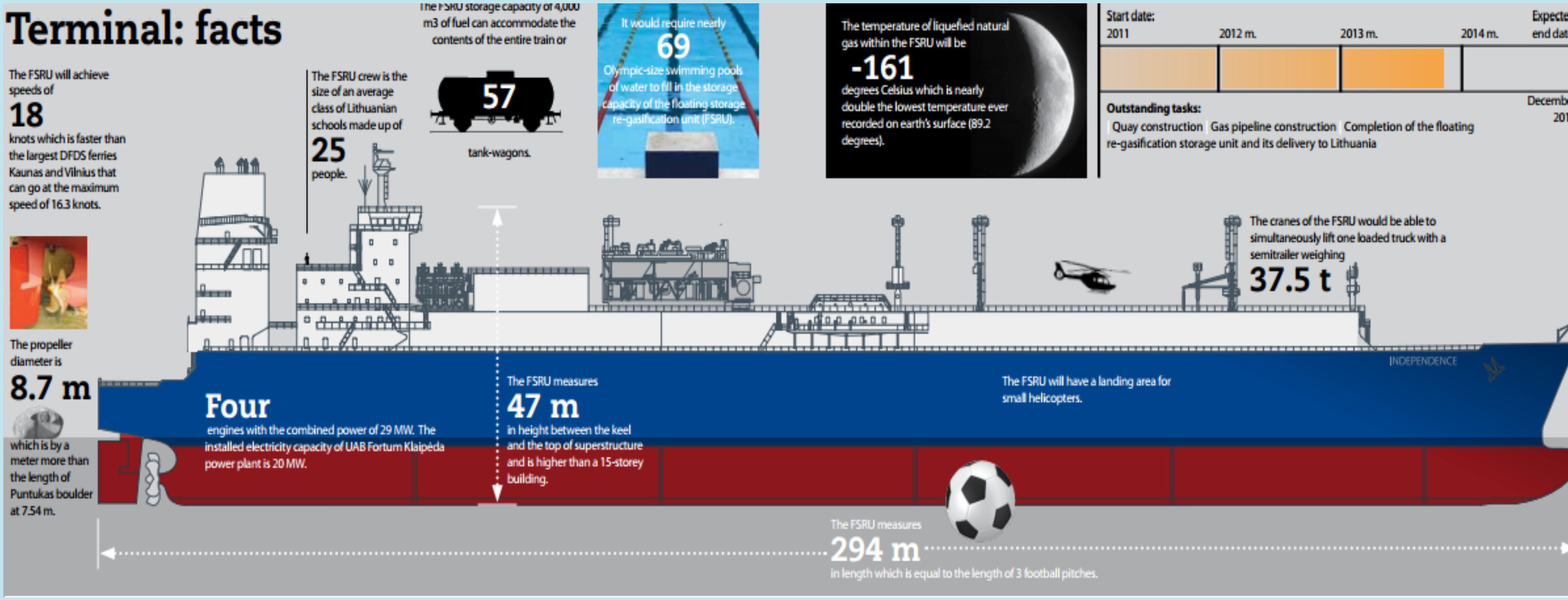
SWED-LIT HDVC link (to increase the security of power supply in both markets)

Near future requirements



Development of port of Klaipeda

LNG operation started in 2014



- **UAB „Naviprofa“ :**

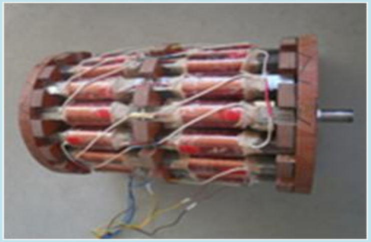
  Creation of programme code of microcontroller and determination of the best electronic elements 2012

  Creation of programme code of optic converter and determination of the best electronic elements, 2013

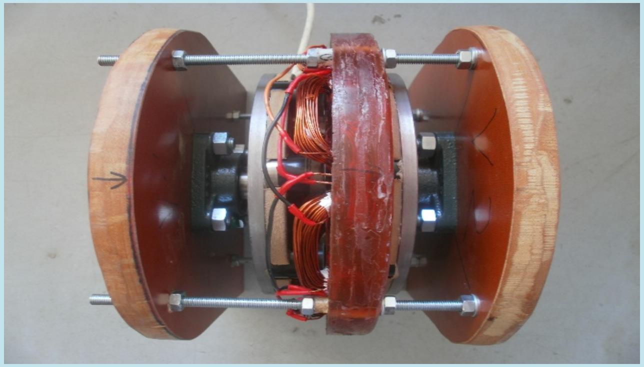
- **UAB „Hoja Electronics“:**

  Research of small wind power plant, 2013

  Investigation of innovative generator or motor with compensated winding, 2012/2013



- **UAB „Idea Group“:** Research of innovative disc electrical generator with permanent magnets, 2012/2013
- **UAB „Proromsta“:** Creation of interactive model for 10 kV electrical network , 2014
- **UAB „Proromsta“:** Interactive modeling tool for pantograph electromechanical system, 2014/2015
- **UAB “Koris”:** Creation of energy consumption and data processing system for prediction of energy demand, 2014/2015



Startup

” Agency for Science, Innovation and Technology (MITA) helps to establish startup companies by providing financial support for research activities”

UAB „ThermalGenerator“ (based on patent of A.Pasilis) was established by master of Electrical engineering Audrius Knolis, 2013

Main topics to be disscused

Future Concepts of coupled Electrical Thermal Energy Systems

Home Automation and Home Efficiency

Redox Flow Battery

Hybrid Energy Systems

Osscillating Eletrical machines

IT based energy management System

Lighting issues

Etc.

INTENSIFICATION OF OIL PRODUCTS BIODEGRADATION PROCESS BY USE OF SOLAR ENERGY

Introduction

Materials & Methods (Experimental Study)

Mathematical Background for Heat Transfer

Discussions of Results

Conclusions

Introduction 1

Bioremediation is one of the most widespread biotechnology methods that take an important place in the protection of environment from contamination with oil and oil products and re-cultivation of soil as well.

Biodegradation of oil products largely depends on the season of the year and usually takes place during the warm season, when microorganisms are active decomposers.

The experiment was carried out and the possibility to use solar water heating system in the biological treatment of oil products from soil was tested. For this purpose solar water heating system was designed. It should be stressed that only recycled materials were used for the system development.

Introduction 2

The experiment was carried out and the possibility to use solar water heating system in the biological treatment of oil products from soil was tested. For this purpose solar water heating system was designed. It should be stressed that only recycled materials were used for the system development

This study analyses a possibility to intensify biodegradation of oil products and to shorten the duration of bioremediation at the same time through the use of solar water heating system

Introduction 3

In the experimental study the dependency of heated water temperature from the outside air temperature was considered. In order to determine the heat transfer process to soil the modelling of the part of defined solar system had been done. The modelling had been realized using FEM (Finite Element Method) computer software constituted on numerical solution of heat equation.

Simulation results indicate the dependency of contaminated soil temperature from the outer air temperature as well as comparing the physical experiments results with the modelling results.

Introduction 4

After the analysis of the obtained results it can be concluded that the system is very efficient and ensures qualitative biological treatment of soil contaminated with diesel fuel and black oil both in cold and in warm seasons:

the clean-up rate of diesel fuel in samples tested with solar water heating system was up to 70%, black oil - 46 %, while in control samples the clean-up rate of diesel fuel was 54% and black oil – 26 % during the same period of time.

The duration of treatment of soil contaminated with oil products is decreased accordingly.

Materials & Methods 1

Experimental solar soil heating system and its principle of operation:

A heating system constructed in Klaipeda University and consisting of solar collector, hoses and containers for heated soil was used for the experiment and heating of soil contaminated with oil products

This system was made from recycled materials, i.e. waste metal and construction materials.

The elements of the system were insulated additionally in order to reduce the heat loss and to increase the efficiency of the system. Solar collector is the most important device of the system. It absorbs the heat of the sun rays and transfers it to the water circulating inside (heat transfer medium).

Materials & Methods 2

Experimental solar soil heating system and its principle of operation

A reflector was installed additionally inside the experimental solar collector, which is unusual to other solar collectors (Fig. 1), as well as water collection/accumulation tank (absorber). The reflector diverts the sun rays to the water tank (absorber).

As the water tank is installed inside the solar collector, the heated water could maintain heat longer.
Such solar collectors are more suitable to be used in such climatic conditions that are characteristic of Lithuania

Materials & Methods 3

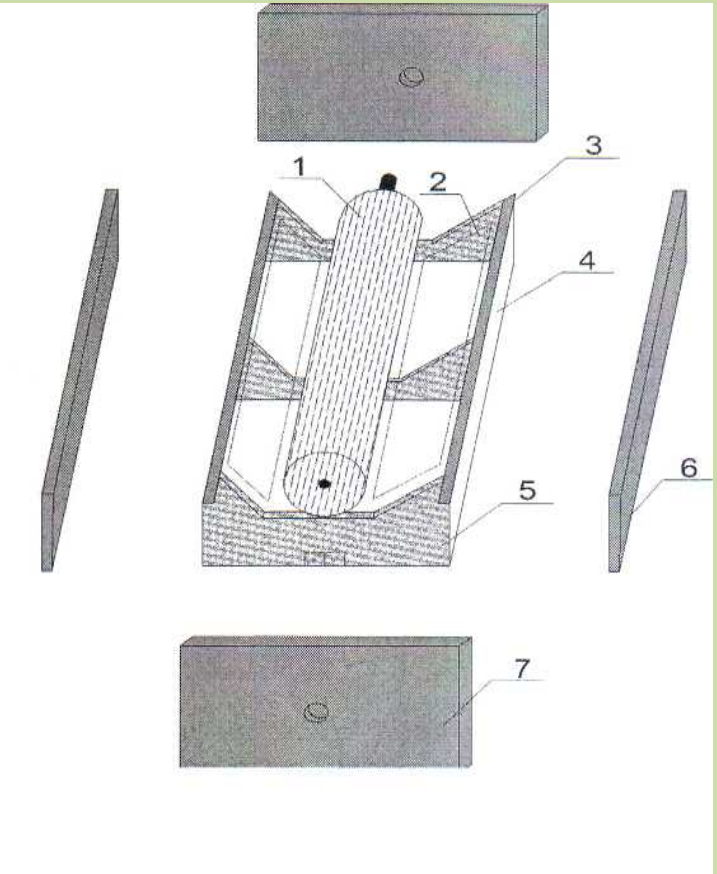


Fig. 1. Elements of solar collector: 1 – Water tank (absorber); 2 – Reflector; 5 – Housing of reflector; 6 – Side heat insulation plates; 7 – Back heat insulation plates.

Materials & Methods 4

Using a rotating trolley (Fig. 2), the solar collector is oriented to the sun and is positioned at 55° angle in respect of the horizon. The more perpendicular is the angle of radiation in respect of the collector, the sooner the water inside the absorber is heated

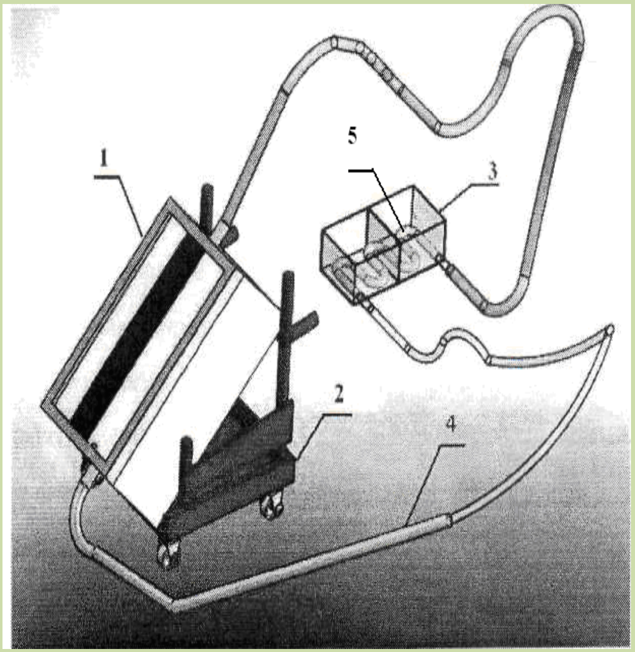


Fig. 2. Heating system scheme: 1 – solar collector; 2 – collector rotation trolley; 3 – heated container/tank filled with artificially contaminated soil; 4 – hoses with additional insulation; 5 – heating element (coil).

Materials & Methods (4)

The plan and design of experiment

The experiment was carried out in two stages:
During the first stage of the experiment, i.e. since March until May 2009, the warm season was tested/monitored. The measurements repeated during the second stage November – May 2010 and covered both the cold and warm seasons.

A possibility to use solar energy for the heating of water in biological treatment of soil contaminated with oil products was assessed during the tests. 2 tanks filled with 10 kg of soil each were used during the 1st stage and 4 tanks - during the 2nd stage of the experiment.

Materials & Methods (5)

The plan and design of experiment

The soil was contaminated with oil products artificially. A heavy oil product – black oil (15 g/kg) and a light oil product – diesel fuel (15 g/kg) was used as sources of pollution. Soil contaminated with oil products and contained in two tanks was heated with the help of tubes laid in a coil and connected through hoses with the tank inside the solar collector and using the heat of solar energy.

Other two tanks filled with contaminated soil were left as control samples without any additional heating elements.

Materials & Methods (4)

The plan and design of experiment

The soil was fertilized with additional nutrients – nitrogen, phosphorus and potassium fertilizers (N, P, K) once a month during the experiment. Used: ammonium nitrate (NH_4NO_3) – 6 g/10kg of soil, superphosphate ($CaH_2PO_4 \cdot H_2O \cdot CaSO_4$) – 1,10g/10kg of soil, potassium chloride (KCl) – 0,6g/10 kg of soil. The same concentration of fertilizers was added to all the tanks.

During the entire course of the experiment, the soil was aerated once a week by mixing it well and by providing the microorganisms with oxygen in this manner. At least 10% humidity of the soil was maintained regularly.

Mathematical Background for Heat Transfer

For soil temperature evaluation due to heat transfer medium, the modelling of part heating system had been considered. The schematic representation of container with polluted soils sample is presented in Figure 4. The medium's heat capacity as well as the boundary condition should be obtained for the heat transfer simulation in defined structure.

The heat distribution in the media can be presented using heat transfer equation. The heat transfer equation is Fourier's equation presented as below:

$$\frac{\partial T}{\partial t} = \alpha \nabla^2 T + \frac{q_v}{c \cdot \rho}$$

α, c, T , ρ, q_v : Thermal diffusion constant, heat capacity, temperature, material density and volumetric heat flux respectively

∇^2 : Operator of Laplace

Mathematical Background for Heat Transfer (2)

The differential equation of heat transfer can be used for all heat transfer's possible cases. In order to find the solution for the concrete task it is needed to take in account the boundary conditions. The container with soils' contaminated samples should be considered as a multilayer structure in X and Y directions

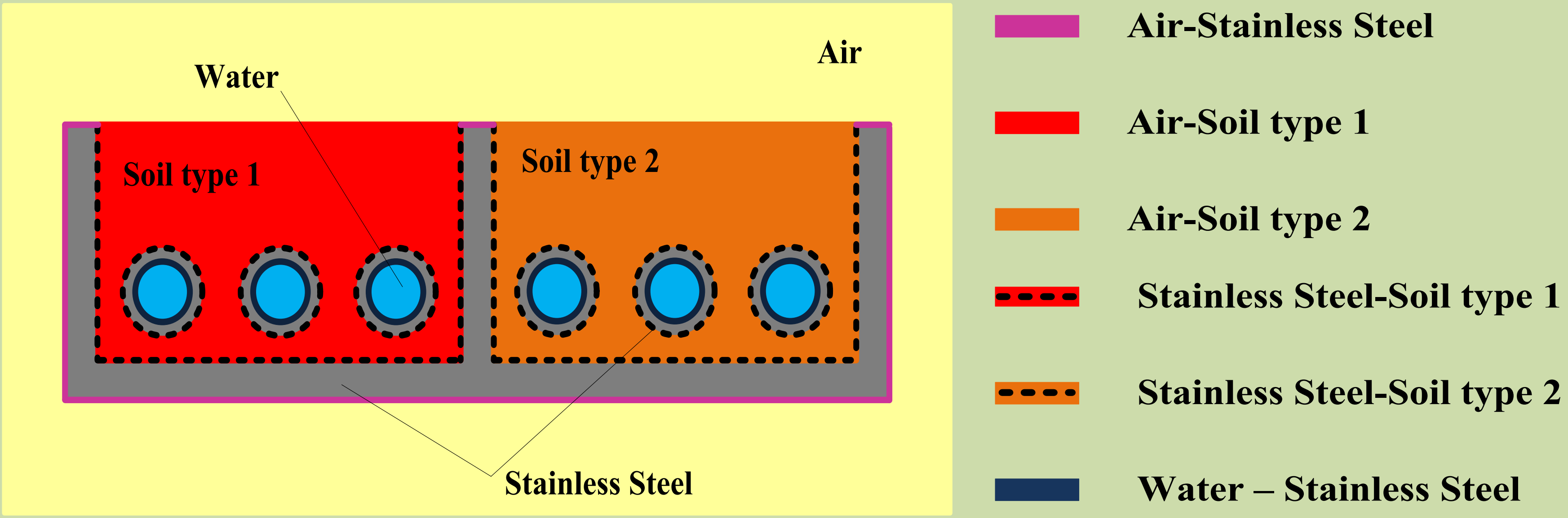


Fig.3. Container's cross-section in XY plane: A- layers and boundaries; B – boundaries' designation.

Mathematical Background for Heat Transfer (3)

For the multilayered structure the temperatures at the layers boundaries can be obtained:

$$T_{(n+1)x,y} = \frac{q_{x,y} \cdot h_{(n,n+1)x,y}}{\lambda_{(n,n+1)}} + T_{(n)x,y}$$

$T_{(n+1)x,y}$ $T_{(n)x,y}$ are temperatures at the structure's layer boundaries along x and y axis respectively.

$h_{(n,n+1)x,y}$ $\lambda_{(n,n+1)}$ $q_{x,y}$ are width of layer, thermal conductivity, heat flux respectively, while n : layer

Considered structure's schematic representation is shown in fig. 4

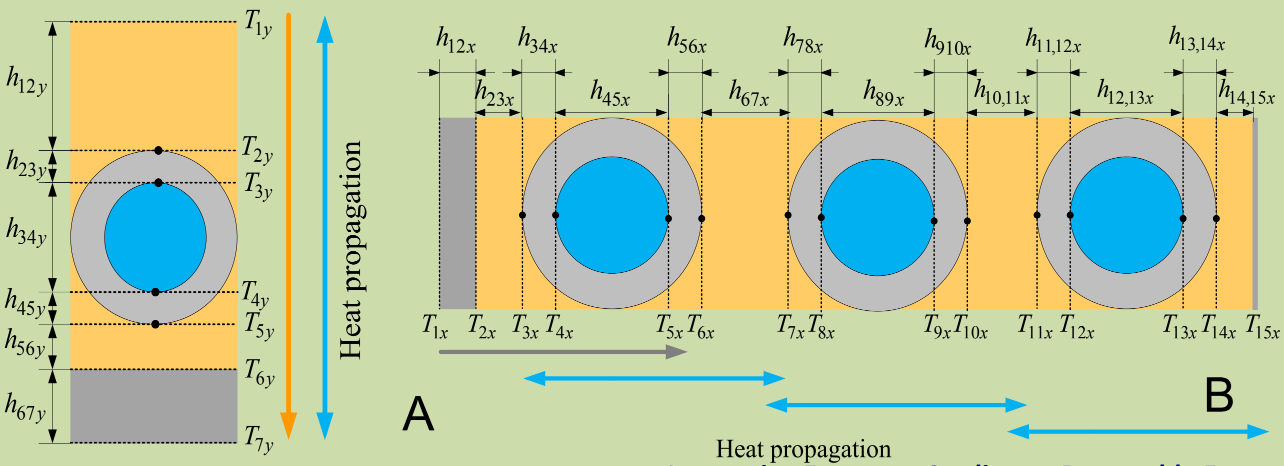


Fig.4. Temperature's definition at the container layers: A) y-axis direction; B) x-axis direction

Discussion of Results

The impact of the outside air temperature on the temperature of the heat transfer medium

During the experiment, the temperature of the heat transfer medium of the solar water heating system was measured. The average outside air temperature was also recorded (in the sunlight and in the shade). The heat transfer medium was heating in the solar collector. The medium flew into the coil in a natural circulation and heated the soil contaminated with oil products. The period between March and May was selected because the total solar radiation is the highest during that period of the year .

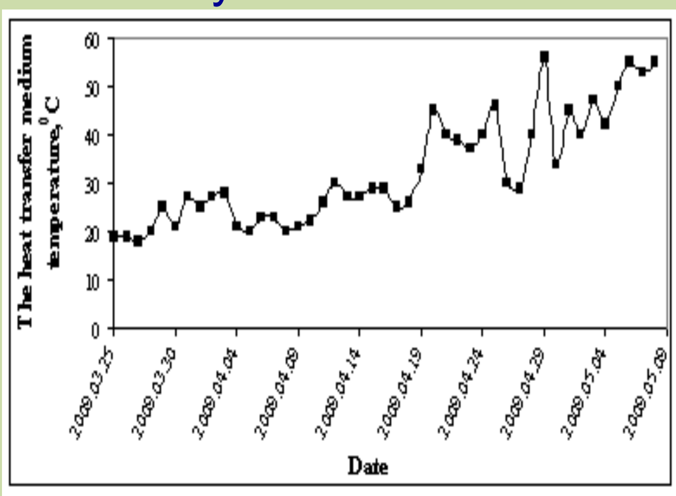


Fig. 5. The change of the temperature of the heat transfer medium during the experiment

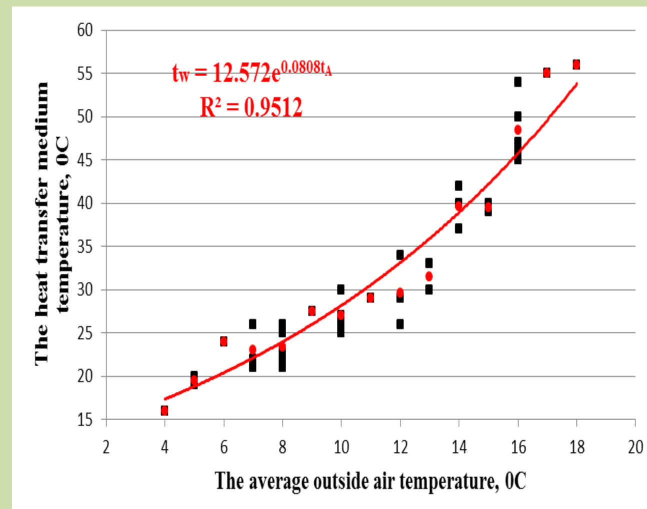


Fig. 6. Impact of the average outside air temperature on the temperature of the heat transfer medium

Discussion of Results (2)

The change of the concentration of oil products in soil and the change of temperature of soil are presented in Fig. 7 that shows that better biodegradation conditions were created for samples, where the soil was heated additionally than in control samples

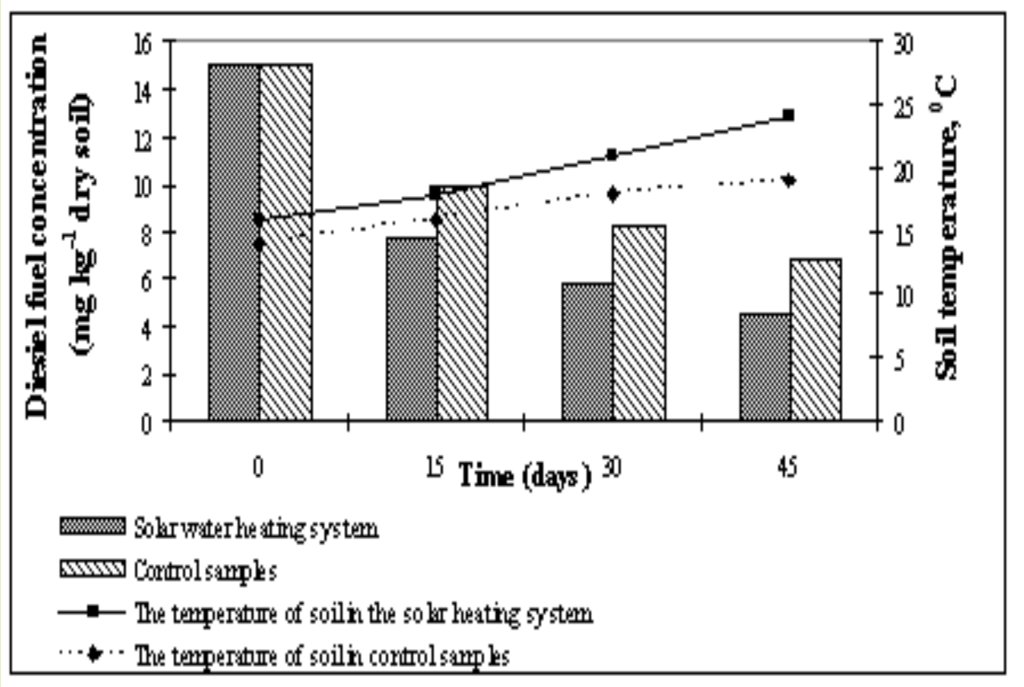
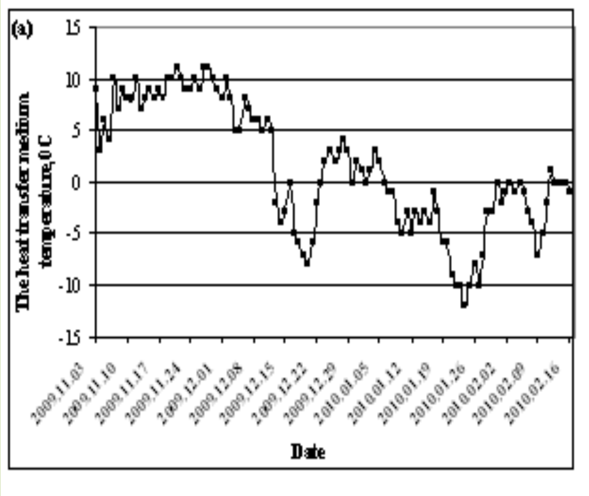


Fig. 7. Change in the concentration of diesel fuel and the temperature of soil in the course of time

Discussion of Results (3)

Impact of outside temperature on the temperature of heat transfer medium



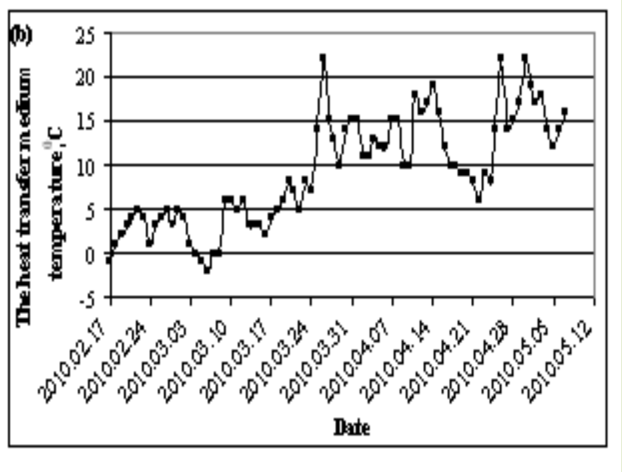
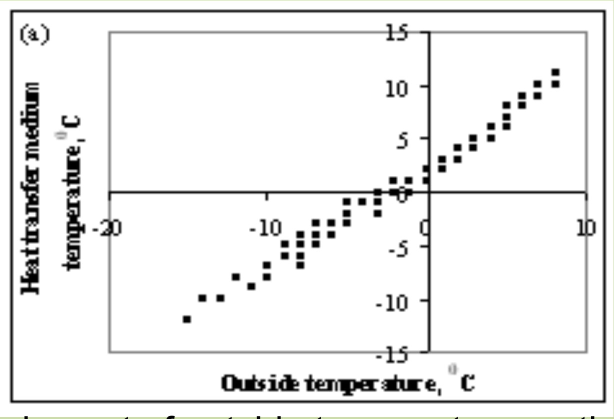


Fig 8. Changes in average temperature of heat transfer medium in the solar water heating system: a) during the cold season; b) during the warm season.



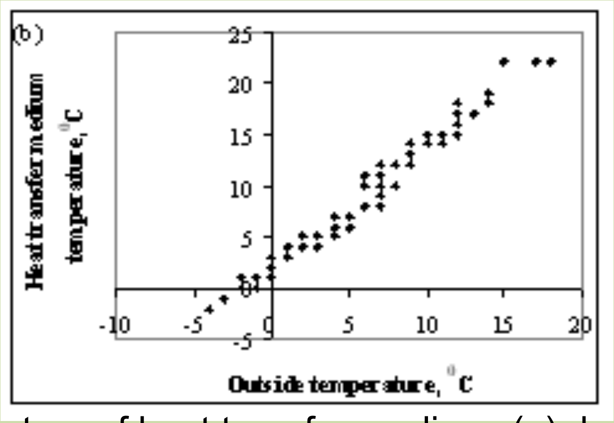


Fig. 9. The impact of outside temperature on the temperature of heat transfer medium: (a) during the cold season; (b) during the warm seasons

Discussion of Results (4)

A conclusion can be made that heat generated by the solar collector intensified the degradation process of contaminants, as the degradation speed of the diesel fuel in samples with the heating system was by 5 times bigger, and of the black oil – by 1.9 times bigger than in samples not connected to the solar collector (Fig. 10).

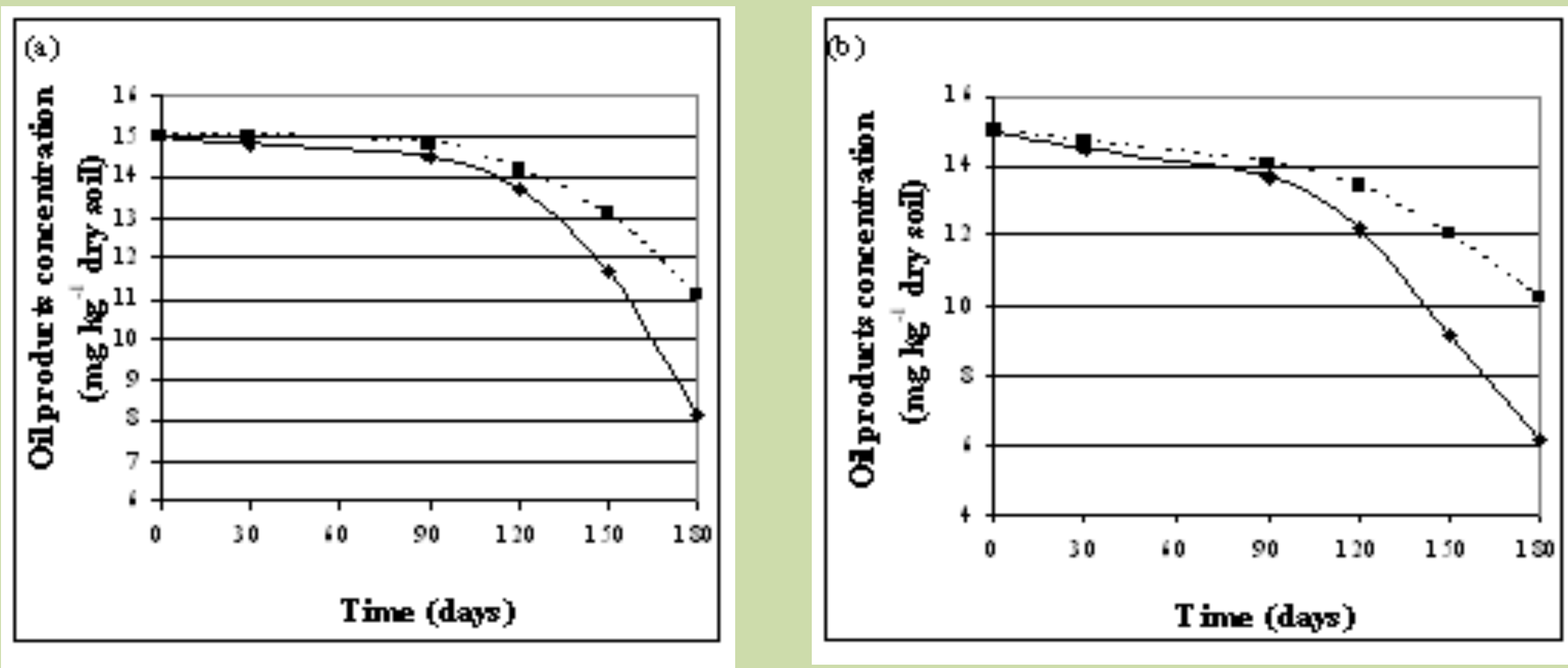


Fig. 10. Change of concentration of oil products in the course of time: (a) – black oil; (b) – diesel fuel (♦ - control sample; ■ – solar water heating system)

Discussion of Results (5)

Modelling Results

The heat distribution at soil samples had been done taking into consideration that the soil had been heated not only by water but also by air. The boundary conditions were calculated using equations of section 3. For the simulation the ambient air temperatures' range between 5 and 20 ^{0}C had been applied. During the experiment the air's average daily temperature were measured as well as the temperature of water.

The dependency of heat transfer medium's temperature from air temperature is presented in the figure 6.

Discussion of Results (6)

Modelling Results

Also, as one of the results of the heat distribution inside of container for the air temperature at 5^0C and heat transfer medium temperature at19 ^{0}C is presented in figure11.The dependencies of contaminated soil samples' temperature at water temperature had been plotted for the next several values of ambient temperature's range. They are presented in fig. 12

Fig. 13 represents the average soil temperature dependency on average water temperatures. As seen this dependency has a linear. However, because of the heat external exchange, it is not possible to keep a precise temperature constantly. For this reason the solar heating system's design should be improved

Discussion of Results (6)

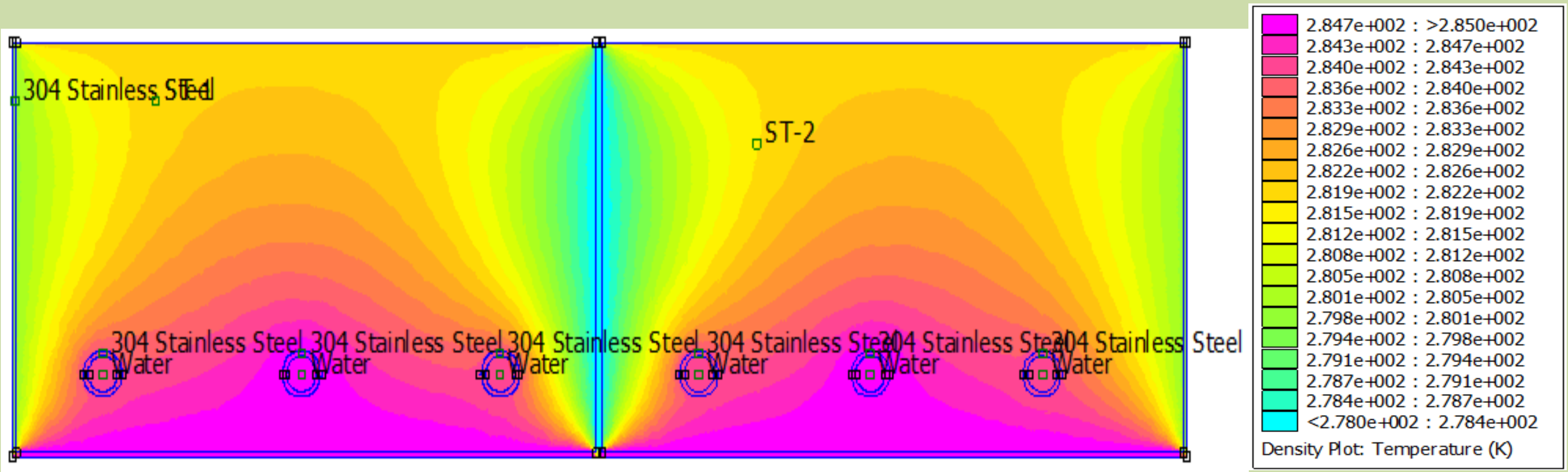
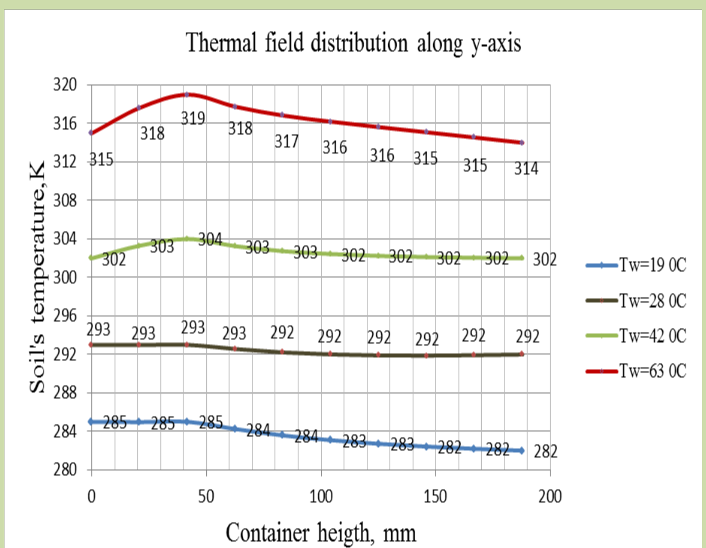


Fig.11. Temperature field's distribution inside of container



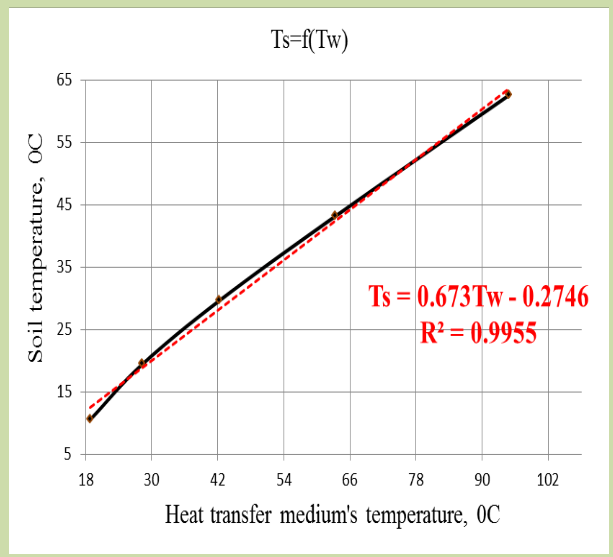


Figure13. The soil' average temperature dependency on heated water

Figure12. Heat distribution inside of container with contaminated soils samples

Conclusions 2 (1)

A designed and constructed experimental solar water heating system (with solar collector) enabled to use solar energy for the heating of soil contaminated with oil products and for the intensification of biodegradation process

After an assessment of the obtained results, we may state that better results of biological treatment of soil contaminated with diesel fuel and black oil are achieved in samples heated with the help of solar collector both, during the cold and warm seasons

Conclusions 2(2)

In order to implement the bioremediation technologies in moderate climate zones successfully, solar water heating system can be used in either ex situ, or in situ in technologies to reduce the duration of contaminated soil treatment, as it helps to start the process sooner and intensifies the process itself.

The heat transfer modelling results shown that the thermal field distribution depended on the ambient air temperature as well as heat transfer media temperature. Unvarying high temperature of water must be applied for the acceleration of the biodegradation process. To achieve such conditions, the design of solar heating system must be improved in order to prevent the external heat exchange with environment or make it as low as possible.

Thank You for Attention