Applications of Renewable Energy Systems in Buildings and Industry

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IF 4.968 (2017)

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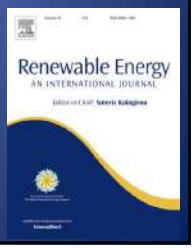
IF 4.900 (2017)

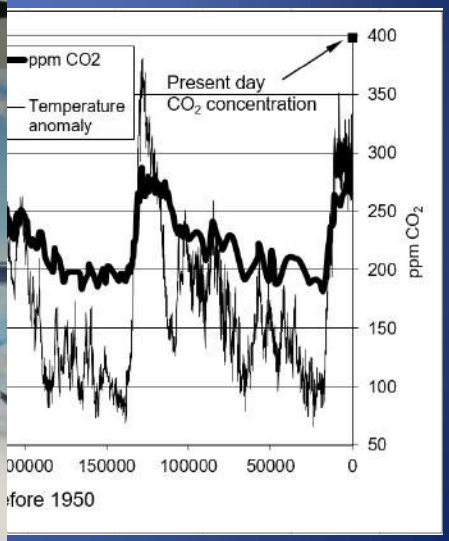


Convincing Evidence

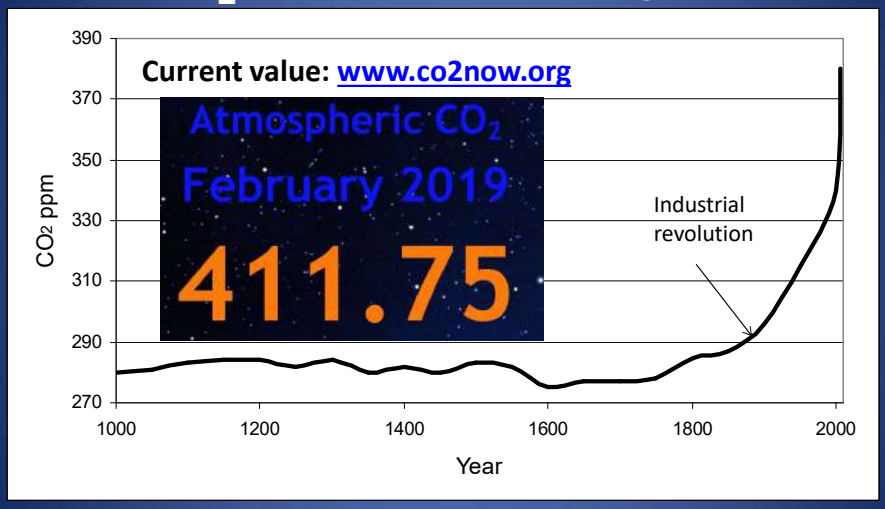
The term Climate Change represents better the situation instead of Global Warming

Effect of Climate Change on Bangladesh

Temperature anomaly and CO_2 concentration From Vostok ice-cores (East Antarctica)



CO_2 in the last 1000 years



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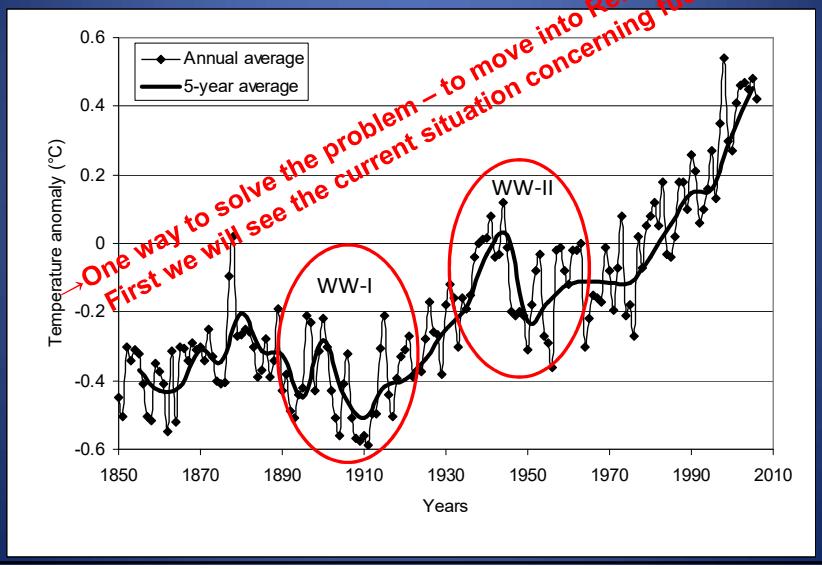
A closer look at the temperature of the planet since 1850

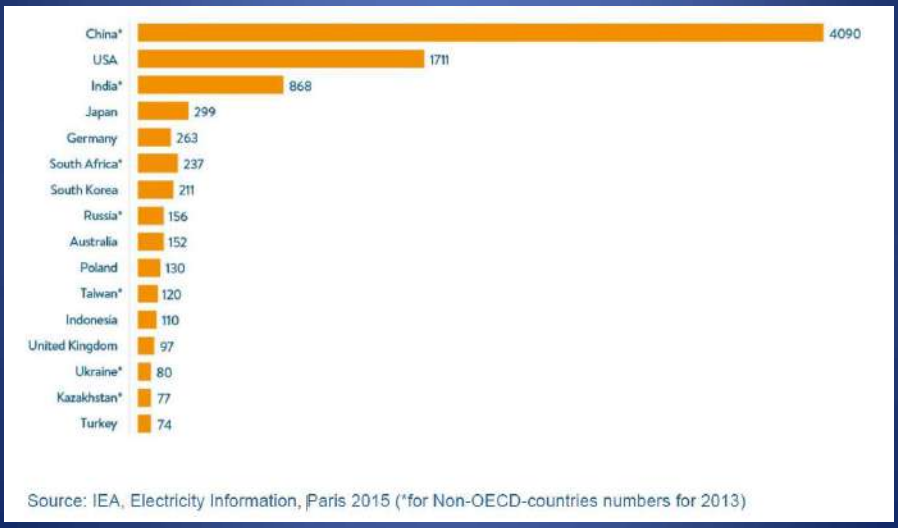


Conventional Fuels - Reserves

- Coal >100
- Crude Oil ~ 56 Years
- Natural Gas ~ 52.8 Years

Biggest problem: Environmental problems related to the use of these fuels

2014 Country ranking – Coal-fired power generation (TWh)



Source: World Energy Resources – 2016 Report

Renewable Energy Systems

Solar power (solar thermal & PV)

Hydro systems

Wind energy systems

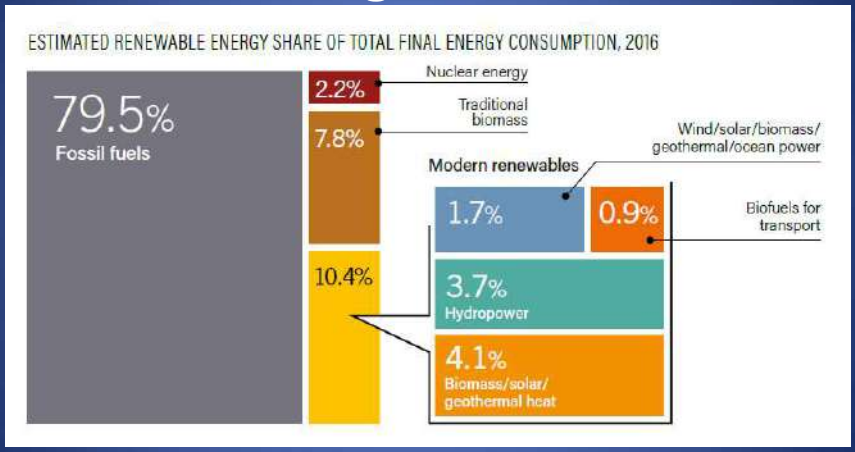
Biomass-Biogas-Biofuels

Renewable Energy Indicators 2017

		2016	2017
INVESTMENT			
New investment (annual) in renewable power and fuels[1]	billion USD	274	**279.8**
POWER			
Renewable power capacity (including hydro)	GW	2,017	**2,195**
Renewable power capacity (not including hydro)	GW	922	**1,081**
Hydropower capacity[2]	GW	1,095	**1,114**
Bio-power capacity	GW	114	**122**
Bio-power generation (annual)	TWh	501	**555**
Geothermal power capacity	GW	12.1	**12.8**
Solar PV capacity[3]	GW	303	**402**
Concentrating solar thermal power (CSP) capacity	GW	4.8	**4.9**
Wind power capacity	GW	487	**539**
Ocean energy capacity	GW	0.5	**0.5**
HEAT			
Solar hot water capacity[4]	GW_{th}	456	**472**
TRANSPORT			
Ethanol production (annual)	billion litres	103	**106**
FAME biodiesel production (annual)	billion litres	31	**31**
HVO production (annual)	billion litres	5.9	**6.5**

Source: Renewable 2018: Global Status Report, REN21

Global Status Report 2018- KEY figures



Source: Renewable 2018: Global Status Report, REN21

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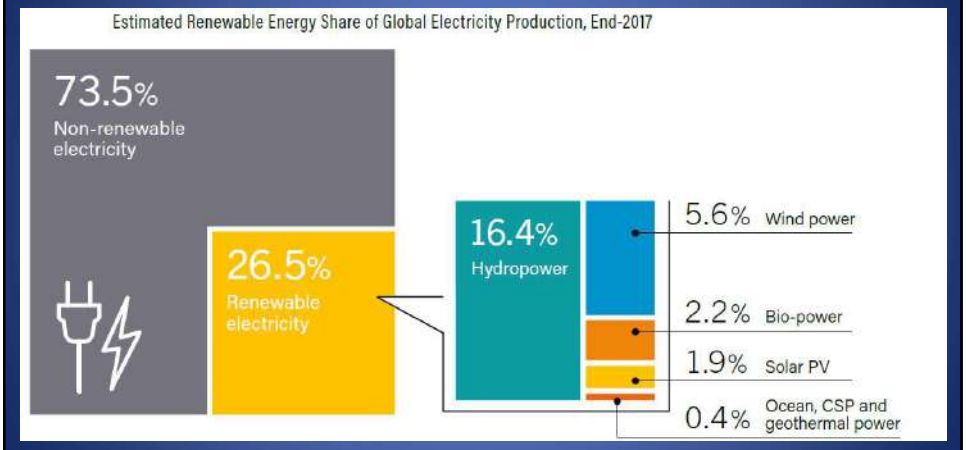
Global Status Report 2018- KEY figures



Source: Renewable 2018: Global Status Report, REN21

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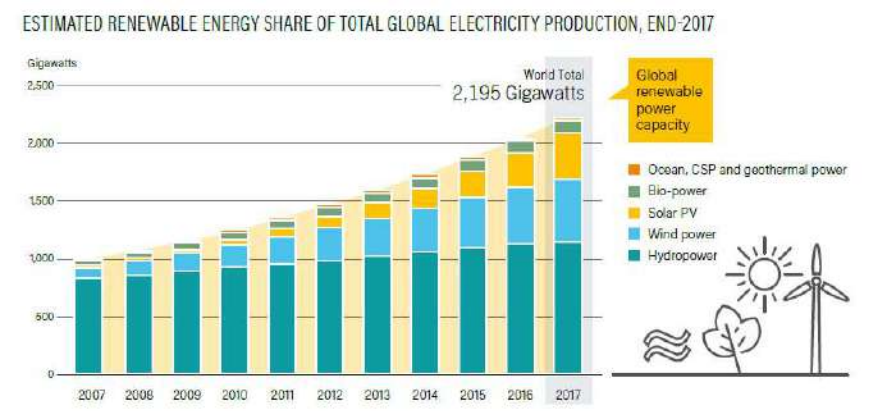
Global Status Report 2018- KEY figures



Source: Renewable 2018: Global Status Report, REN21

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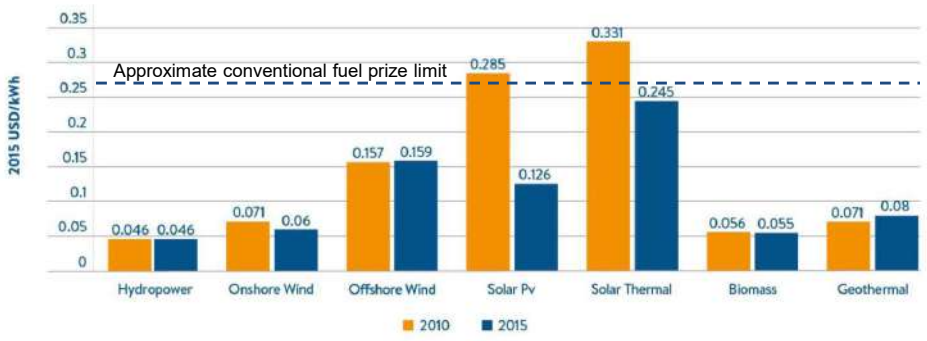
Trends in Global Renewable Energy Levelized Cost of Electricity (LCOE) from 2010 until 2015



Obstacles in RES penetration:

1. Price per kWh – Now RES are cheaper
2. Permission procedures – need simplification

Source: World Energy Resources – 2016 Report

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Solar Thermal Power

- Systems utilising either the thermal radiation or the light of solar irradiance.
- Solar thermal systems
  - *Low temperature* systems (mostly for water heating and industrial processes)
  - *High temperature* systems (mostly for CSP and high temperature industrial processes)
- Solar photovoltaics

Types of Solar collectors

Motion	Collector type	Absorber type	Concentration ratio	Indicative temperature range (°C)
Stationary	Flat plate collector (FPC)	Flat	1	30-80
	Evacuated tube collector (ETC)	Flat	1	50-200
	Compound parabolic collector (CPC)	Tubular	1-5	60-240
Single-axis tracking			5-15	60-300
	Linear Fresnel reflector (LFR)	Tubular	10-40	60-250
	Parabolic trough collector (PTC)	Tubular	15-45	60-300
	Cylindrical trough collector (CTC)	Tubular	10-50	60-300
Two-axes tracking	Parabolic dish reflector (PDR)	Point	100-1000	100-500
	Heliostat field collector (HFC)	Point	100-1500	150-2000

Note: Concentration ratio is defined as the aperture area divided by the receiver/absorber area of the collector.

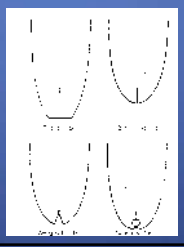
Low temperature collectors

- Flat plate collectors

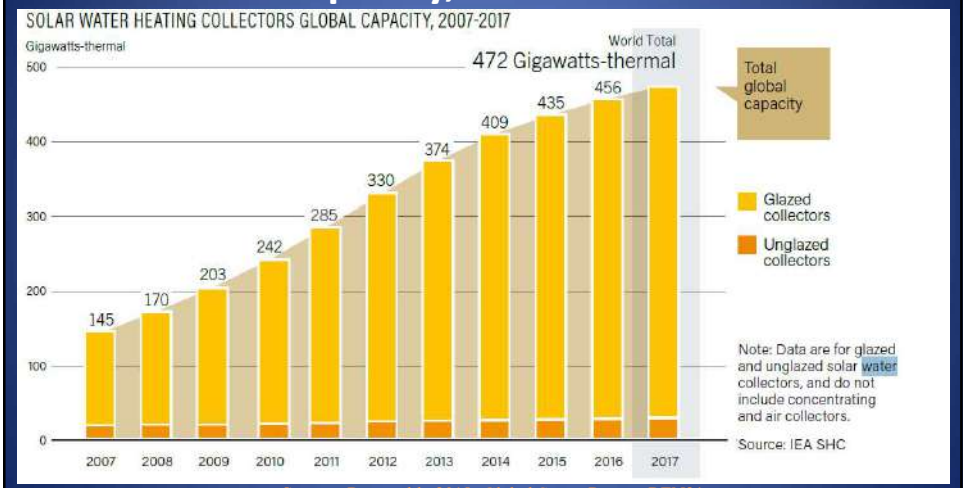


- Evacuated tube collectors


- Compound parabolic collectors




Solar Water Heating Collectors Global Capacity, 2006–2017



Source: Renewable 2018: Global Status Report, REN21

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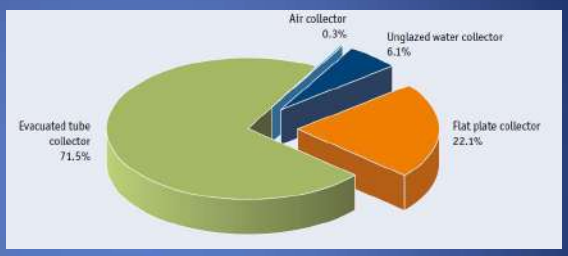
Solar water heating in Cyprus
A success story

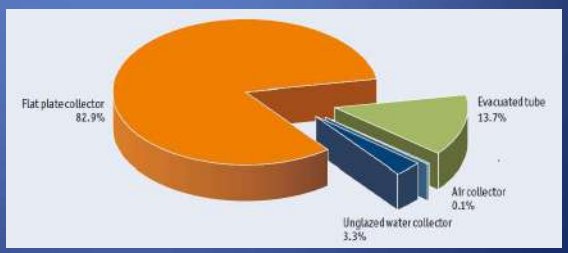
93% of all houses in Cyprus have a SHW – world record

Distribution of the total installed capacity in operation by collector type in 2016

World



Europe



Source: Solar Heat Worldwide: Global Market Development and Trends 2017, Edition 2018

Large solar water heating system

Mechanical Eng. Labs – Solar cooling

300 kW system based on LiBr technology

Funded by EU

Building Integration of Solar Thermal Systems –TU1205 - BISTS

COST Action TU1205

- Building Integrated Solar Thermal Systems (BISTS)
- Action Chairman
- Participation:
  - 22 EU countries
  - two non-COST countries, USA and Canada

BISTS balustrade/railing feature

Solar collectors act as balcony railings of the building, China

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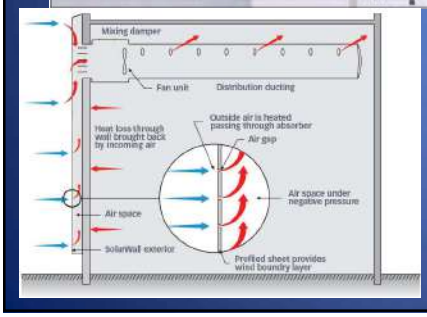
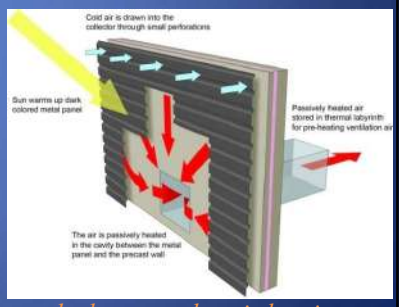
Transpired collector

→ One of the mostly used system

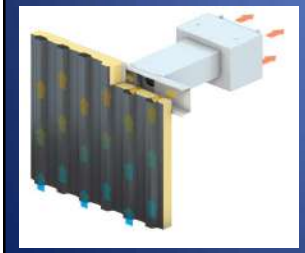
Bombardier (Canadair Facility), Montreal



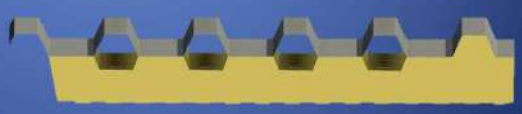


In 1996 it was the largest solar air heating system in the world.

Kingspan facade solar air heater



Location: Doncaster, UK



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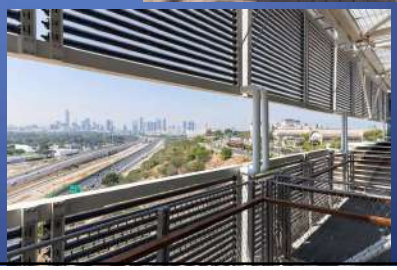
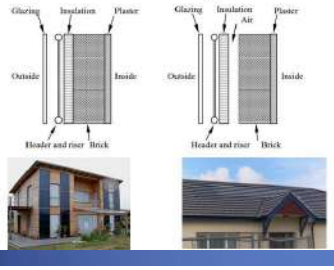
Evacuated tube collectors

Porter School of Environmental Studies
Tel Aviv, Israel

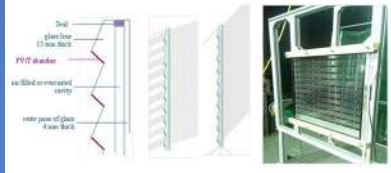


New ideas from COST Action

Flat-plate collector – Façade & Roof

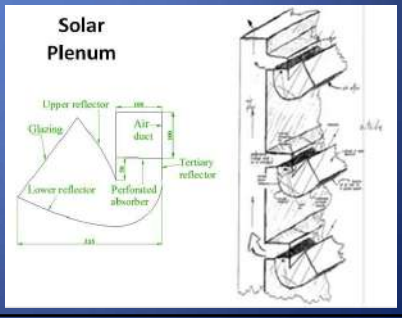


Concentrating PV/T Double Glazing



Hybrid Photovoltaic/Solar Thermal (HyPV/T) Façade Module

Solar Plenum



New applications in China

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BISTS in Hefei, China

High temperature systems

- Parabolic trough collector

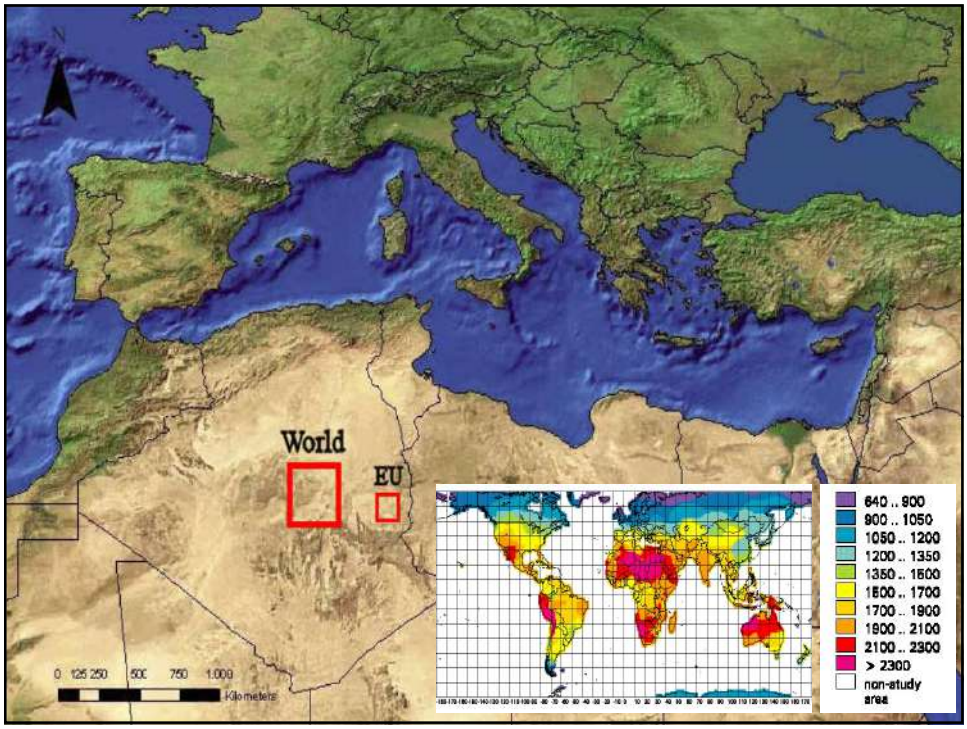
- Linear Fresnel collector

- Solar dish

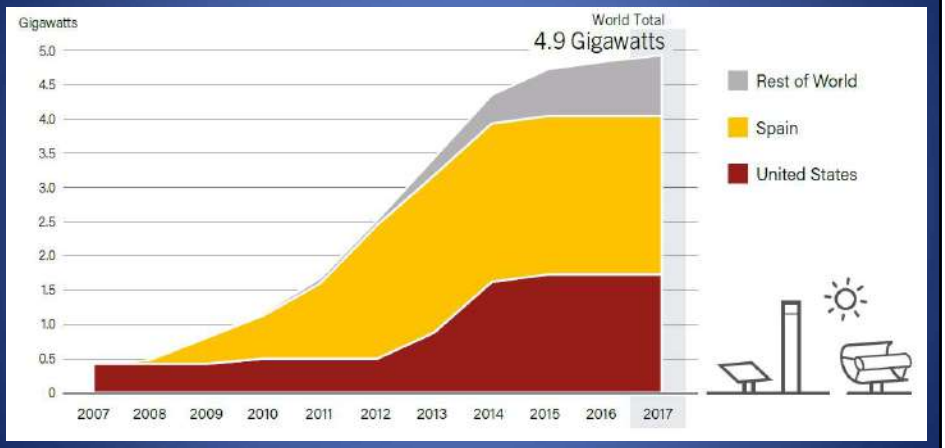
- Solar tower

Solar Two

Gemasolar



Concentrating Solar Thermal Power Global Capacity, by Country/Region, 2006–2017



→ Many CSP systems are under development in many countries of the world
→ All new facilities incorporate thermal ENERGY STORAGE

Source: Renewable 2018: Global Status Report, REN21

CSP Thermal Energy Storage Global Capacity and Annual Additions, 2007-2017

Source: Renewable 2018: Global Status Report, REN21

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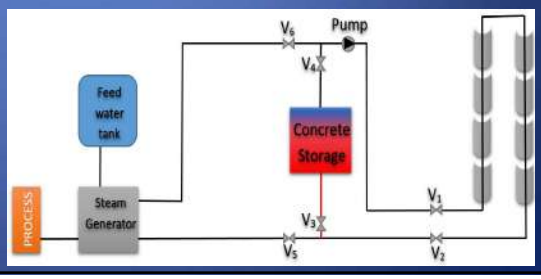
Parabolic Trough System

Central receiver system

Eurodish

Industrial Applications

- Industrial process heat
  - Low temperature/pressure steam
  - Thermal desalination
  - Various heating and cooling applications
- KEAN PTC system



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KEAN System

Photovoltaics

- Four basic technologies:
  - Polycrystalline silicon cells
  - Monocrystalline silicon cells
  - Amorphous silicon cells

  - Other thin film cells

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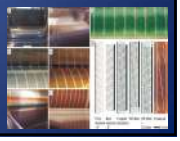
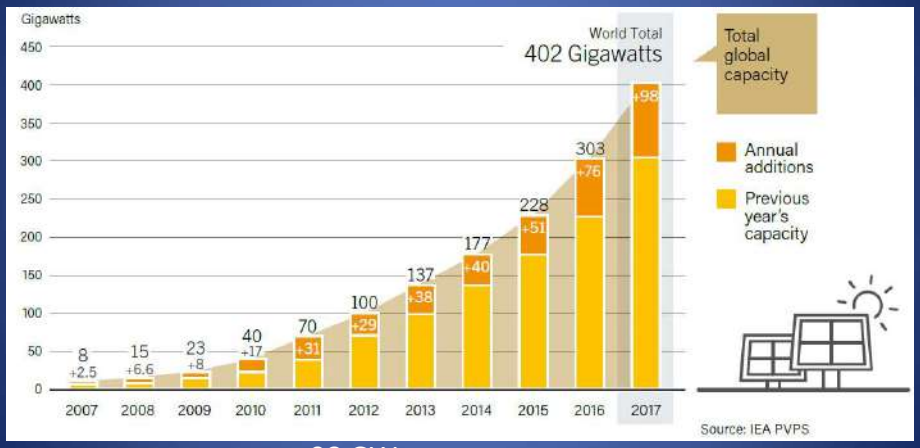


Solar PV Global Capacity and Annual Additions, 2006-2017



→ During 2017, at least 98 GW of solar PV capacity was added worldwide – equivalent to the installation of more than 40,000 SOLAR PANELS EVERY HOUR.

Source: Renewable 2018: Global Status Report, REN21

Top 10 countries for PV

TABLE 1: TOP 10 COUNTRIES FOR INSTALLATIONS AND TOTAL INSTALLED CAPACITY IN 2017

	TOP 10 COUNTRIES IN 2017				TOP 10 COUNTRIES IN 2017	
1	China	53 GW	1	China	131 GW
2	USA	10,6 GW	2	USA	51 GW
3	India	9,1 GW	3	Japan	49 GW
4	Japan	7 GW	4	Germany	42 GW
5	Turkey	2,6 GW	5	Italy	19,7 GW
6	Germany	1,8 GW	6	India	18,3 GW
7	Australia	1,25 GW	7	UK	12,7 GW
8	Korea	1,2 GW	8	France	8 GW
9	UK	0,9 GW	9	Australia	7,2 GW
10	Brazil	0,9 GW	10	Spain	5,6 GW

Source: Snapshot of Global PV markets 2018: IEA PVPS

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Photovoltaics in Cyprus

- Main technologies:
  - Polycrystalline silicon cells
  - Monocrystalline silicon cells
  - Amorphous silicon
- In CY conditions for every installed kW there is an output of 1500 kWh/year.
- Optimum inclination 31 degrees.

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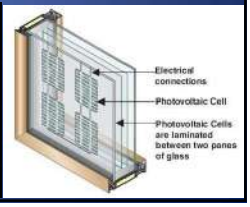
New research: Building-integrated fibre-reinforced solar technology (*Bfirst*)

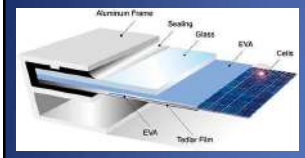
SEVENTH FRAMEWORK PROGRAMME

bfirst fibre-reinforced solar technology



B*first* ideas.....

Conventional Photovoltaic Module



Composite Photovoltaic Module

Glass fibre
+
Transparent resin
+
PV cells

Composite PV module

Composite PV Modules

- Flexible
- Lightweight
- Different Geometries
- Different Shapes

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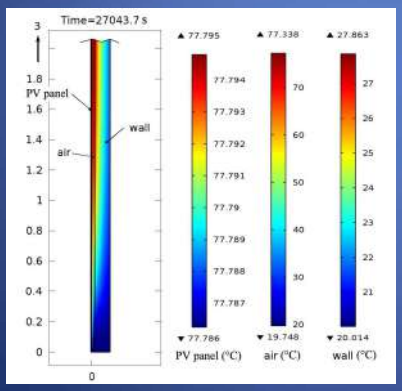
Experimental Setup-CUT contribution

- Testing under solar simulator
- Modelling



Belgian Demonstration Building – BIPV System

- Number of panels installed: 57
  - Metallic structure
  - Panels Overlap
  - No joints between the panels
- Roof Orientation: 10° SW
- Roof Slope: 40°
- Nominal Power: 7.01 kWp
- Quick installation ~ 7.5 hrs
- Installation video

No joints in between the panels

PV Shading-1

PV Shading-2

PV Shading-3

Car park shading

Tracking PV – Applications in Cyprus

20 kW System

Current PV Research

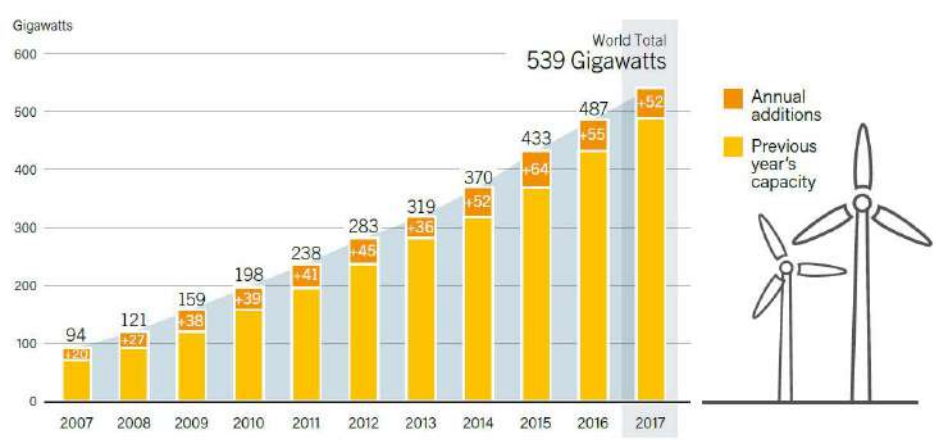
- Higher performance cells/modules
- New nanomaterials applications
- Advanced manufacturing techniques

8.22 MW Alamosa, Colorado, PV solar plant

Very Large Scale PV 66MW-China

Wind Power

Wind Power Global Capacity and Annual Additions, 2006–2017



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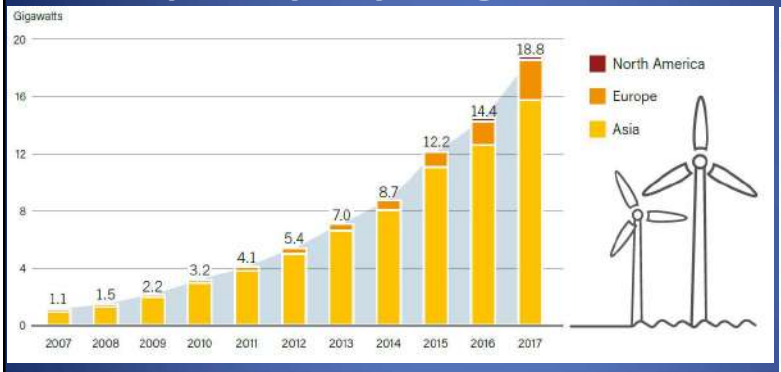
Source: Renewable 2018: Global Status Report, REN21

Wind Power Offshore Global Capacity, by Region, 2006-2017



Source: Renewable 2018: Global Status Report, REN21

→ WIND has become the LEAST-COST option for new power generating capacity in an increasing number of markets.

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Biomass

- Main areas:
  - Biomass
  - Biogas
  - Biofuels (biodiesel)
  - Waste (MSW, landfills [?])

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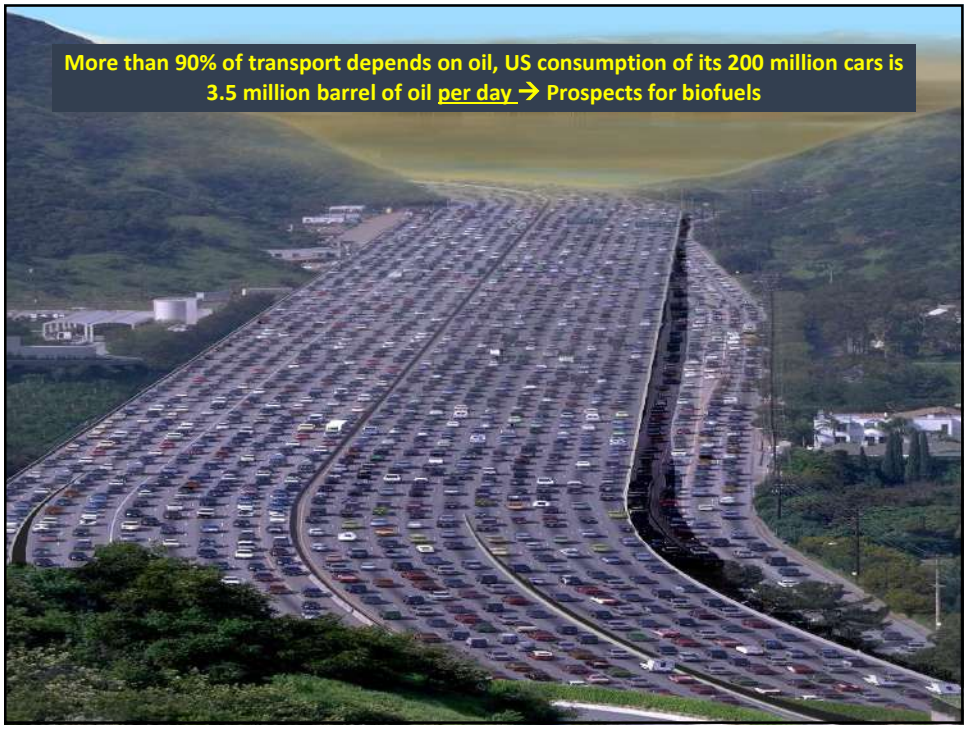
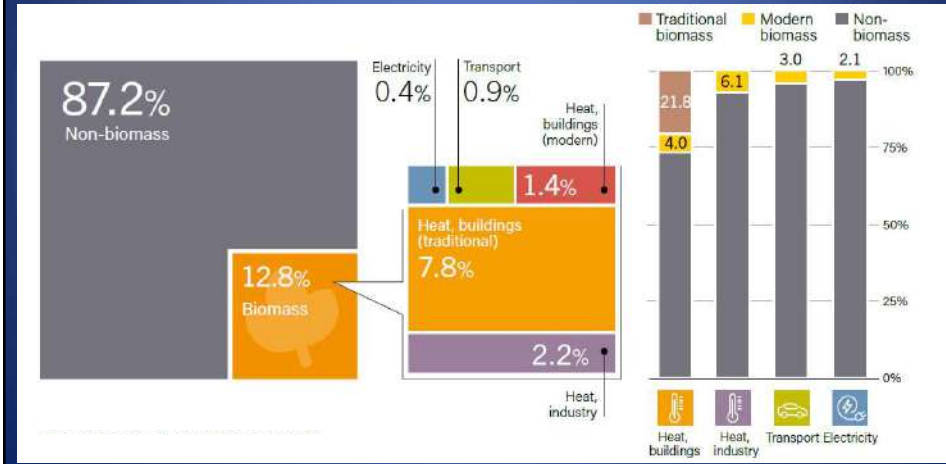
Biomass – Question food for fuel?

→ Land availability for energy crops

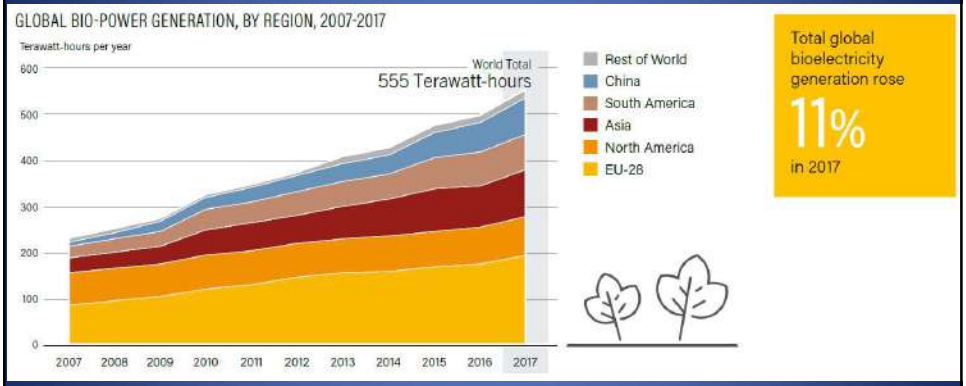


Shares of Biomass in Total Final Energy Consumption and by end-use sector, 2017



Source: Renewable 2018: Global Status Report, REN21

Global Bio-power Global Generation, by Country/Region, 2006–2017



Source: Renewable 2018: Global Status Report, REN21

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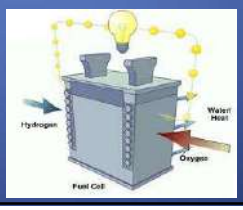
Other areas of renewables

- Ocean energy systems
  - Wave, tidal energy conversion, OTEC

- Geothermal
  - Global output: Power 75 TWh, Heat 75 TWh

- Hydrogen – Fuel Cells



Prospects - Hot research areas

- Increase efficiency of various RE technologies
- Design renewable energy components at lower cost
- Extensive use of RES (many regions, even countries consider transformation into 100% renewables)
  - High shares of renewables
  - Power system transformation
  - Storage/integration (smart energy systems)
- Effective coupling not only for electricity but also heating + cooling and transportation

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Self cleaning areas for PV and solar thermal collectors

- Scientists imitate the Lotus effect via nanotechnology to keep surfaces of solar collector glazing and mirrors clean.

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Concluding:

- There are a lot of possibilities to utilise effectively renewable energy technologies
- These are nowadays more cost-effective options than conventional fuels
- We should never underestimate the climate problem
- It is in our hands to utilise renewables effectively

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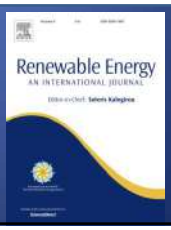

Thank you for your attention

I will be happy to answer questions…

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