



**POLITECHNIKA  
GDAŃSKA**

WYDZIAŁ ELEKTROTECHNIKI  
I AUTOMATYKI

# NUCLEAR POWER

## LECTURE 4

Gdańsk 2018

# NUCLEAR POWER – LECTURE 4

---

1. The first hydro power plants
2. Classification of hydropower plants
3. Hydro power stations in the world
4. Hydro power plants in Poland
5. Wind power plants in the world
6. Wind power plants in Poland



# INTRODUCTION TO HYDRO POWER PLANT

---



**Hydropower** is electricity generated using the energy of moving water.

**150 countries**  
**about 3673 TWh (2012)**  
**16% world production**

# INTRODUCTION TO HYDRO POWER PLANT

Tab. Technical hydropower potential of Poland, GWh/annum

L.p.	Water system	Potential	L.p.	Water system	Potential
1	<b>Vistula + catchment basin</b>	<b>9 270</b>	14	<b>Oder + catchment basin</b>	<b>2 400</b>
2	Vistula	6 177	15	Oder	1 273
3	<b>Left bank tributaries</b>	<b>513</b>	16	<b>Left bank tributaries</b>	<b>619</b>
4	Pilica	170	17	Nysa Kłodzka	134
5	Brda	119	18	Bóbr	320
6	others	224	19	others	165
7	<b>Right bank tributaries</b>	<b>2 580</b>	20	<b>Right bank tributaries</b>	<b>507</b>
8	Dunajec	814	21	Warta	351
9	Wisłoka	126	22	others	156
10	San	714	23	<b>others (mainly small rivers in Pomerania)</b>	<b>280</b>
11	Bug	309			
12	Narew	179			
13	others	438	<b>TOTAL (poz. 1+14+23)</b>		<b>11 950</b>

## WATERWHEEL – XX BC

---

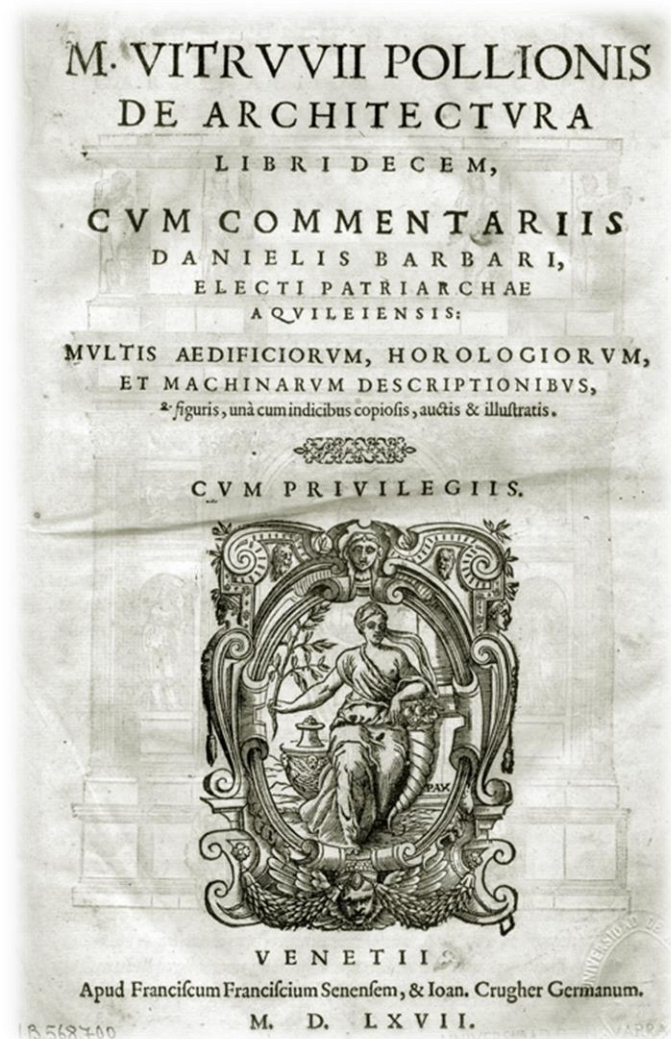


- The first mention was made in the Babylonian code of laws. In the Code was a paragraph about penalties for thefts of waterwheels.
- It was the oldest devices to transform water energy to mechanical; it was the first motor
- The oldest water motor (waterwheels) was made on wooden.

# WATERWHEEL – I BC

---

In Roman Empire architect - Marcus  
Vitruvius described waterwheel  
in poem „Architecture”;  
poem was created in 25-23 BC.



# WATERMILL

---

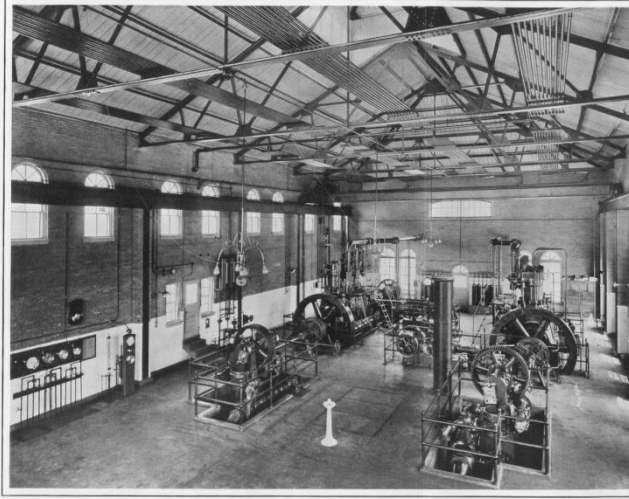
**Watermill** or **water mill** is a mill that uses hydropower. It is a structure that uses a water wheel or water turbine to drive a mechanical process such as milling (grinding), rolling, or hammering.





## XIX-XX CENTURY

---



- **1827 year** - Benoit Fourneyron, the French engineer has constructed first water turbine.
- **1882 year** - The World's First Hydroelectric Power Plant Began Operation September 30, 1882 on Fox River (Appelton, USA). Hydro power plant generated electrical energy to paper factory.



## XIX-XX CENTURY

---



- **1884 year** - Allen Pelton american engineer created impulse turbine, which could work with high water drops
- **1921 year** Prof. Wiktor Kaplan created hydro turbine on the variant of a propeller turbine.

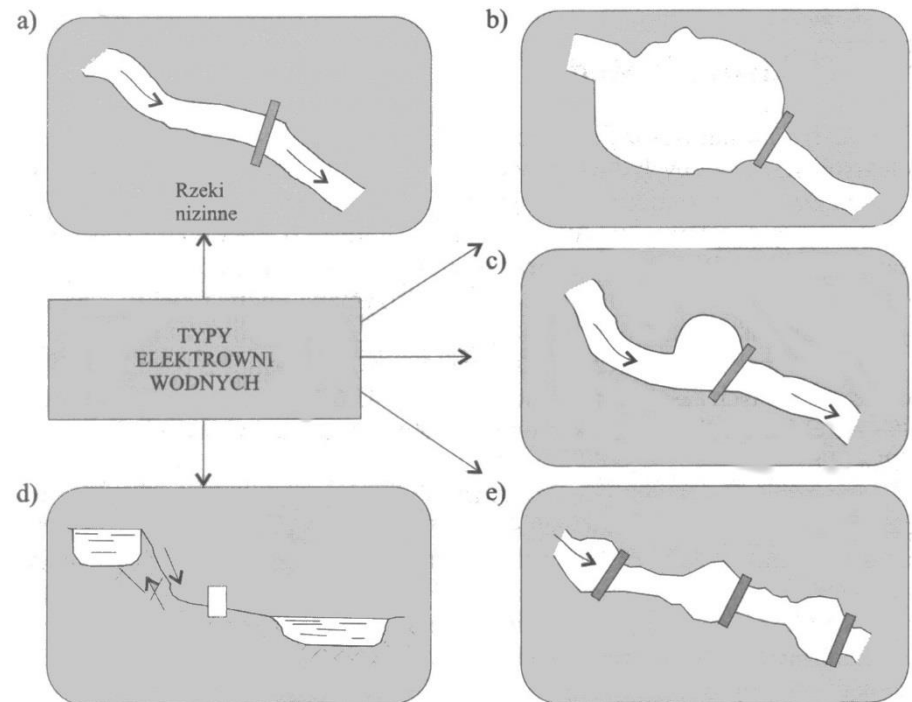
# CLASSIFICATION OF HYDRO POWER PLANT

Hydroelectric power plants can be divided into power plants due to the type:

- using inland water energy
- using ocean water energy.

Power plants (commercial HPP) located in inland waters are additionally subdivided into:

- river hydro plant, without storage
- power plant
- water storage power plant with small storage
- Pumped- storage power plant
- Cascade power plant



# CLASSIFICATION OF HYDRO POWER PLANT

---

Offshore hydro power plant :

- **Tidal power plant** (wave) - power plants obtain energy from waves or sea currents
- **Marine thermal power plant** - Electricity is produced from thermal energy, which comes from the temperature difference between warm surface layers and cold layers that come from the depths of the sea.

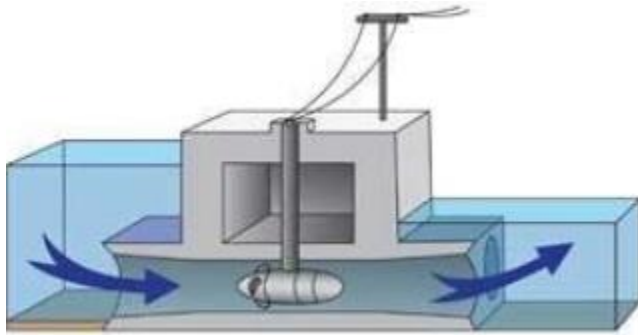
**Wave Dragon** – project, Nord Sea



# CLASSIFICATION OF HYDRO POWER PLANT

---

**Tidal power plant** (wave) - power plants obtain energy from waves or sea currents



flow



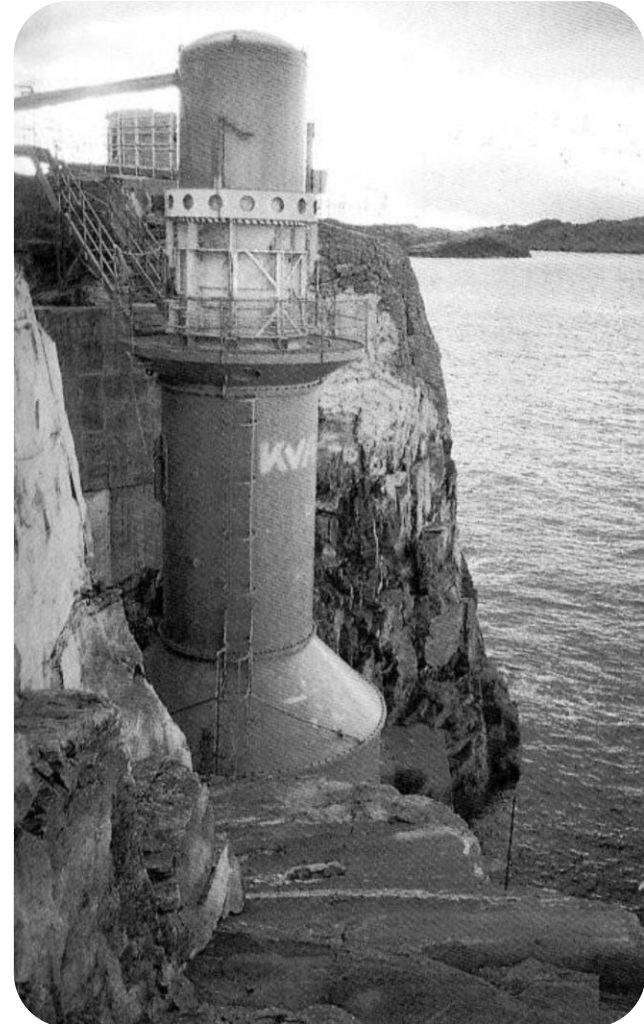
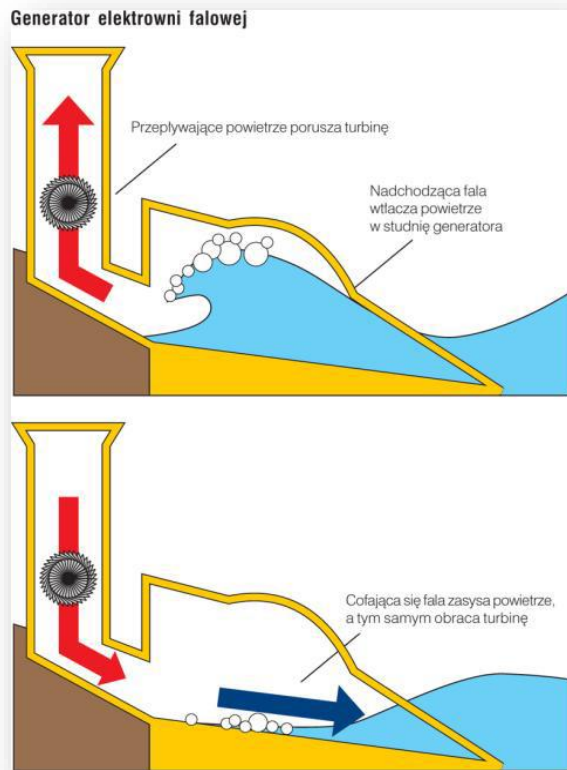
Fot. Turbine of tidal power plant in Bretany (France)  
La Manche canal.



# CLASSIFICATION OF HYDRO POWER PLANT

Two main solutions:

- water turbine
- air turbine



Fot. Tidal power plant with air turbine

# CLASSIFICATION OF HYDRO POWER PLANT

---



Thermal hydro energy is used in:

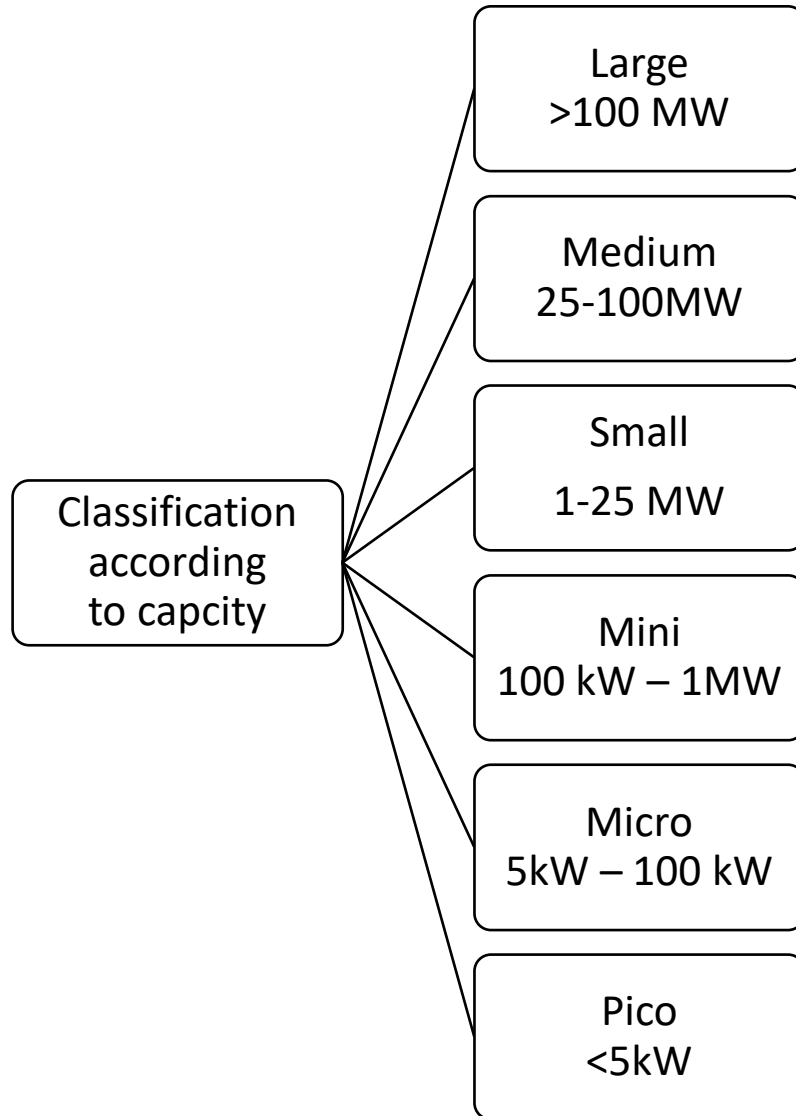
- Indonesia (5 MW)
- Japan (10 MW)
- Tahiti (5 MW)
- Hawaii (40 MW)

fot. Project of thermal power plant platform on Hawaii



# CLASSIFICATION OF HYDRO POWER PLANT

---



# WATER TURBINES – COMPARISON



Type of turbine	Slop, m	Capacity, kW
Tubular Kaplan's turbine	1,5-25	do 50 000
Kaplan's turbine with vertical shaft	8-80	do 200 000
Francis's turbine	10-600	do 850 000
Pelton's turbine	50 - 1200	do 300 000

Źródło: Elektrownie wodne Ich funkcjonowanie i oddziaływanie na najbliższe środowisko

# POLISH HYDROPOWER

---

The first hydroelectric power plant in Poland "Struga" was established in 1896 on the **Słupia River**.

In the interwar period, Poland had 12 hydroelectric plants, each with a capacity of less than 10 MW, their total capacity was **18 MW**.

Before the Second World War, the largest power plant in Poland was located in Pomerania in **Gródek** and supplied Gdynia with electric energy.





# POLISH HYDROPOWER

---



Hydro power plant Gródek – view of machine hall

Start up of the first turbine in Gródek on 24.04.1923 by the president of Poland Wojciechowski



## POLISH HYDROPOWER

---

In the 1930s, larger power plants in Dunajec, Sole and Sanaa were also built in Poland.

After the war, as a result of territorial changes, Poland received hydropower plants in Pilchowice and Dychów. This contributed to the increase of the total power to 160 MW in 1946

In the sixties, several large power plants were opened: in Kornów, Myczkowce, Dęb, Solina, Tresna, Żydowo and Włocławek.

Among the largest hydroelectric plants built in recent years, there are power plants: in Żarnowiec, Nidzica and in Porąbka-Żar.

## POLISH HYDROPOWER

---

It is the **largest Polish pumped storage power plant**, with a power of 716 MW. It is located in Czymanowo by Lake Żarnowieckie. The construction of the power plant started in 1976, and it was opened in 1983.



Fully manmade, the reservoir accumulates electrical power in the amount of 3.6 million kWh. The amount of water provides enough power to feed 716 MW to the electrical system for about 5.5 hours.



# POLISH HYDROPOWER

---



Fot. 1975 year – concreting suction pipes



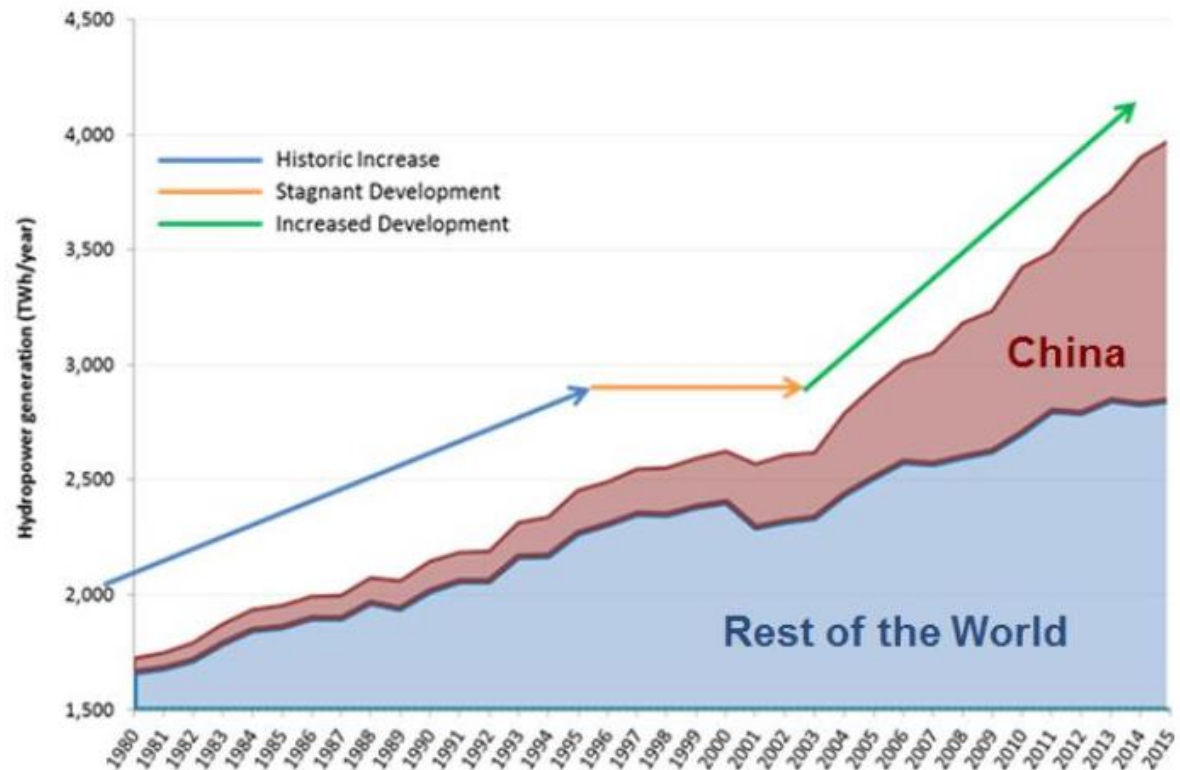
Fig. Polish hydro power plant (the bigger one)



# HYDROPOWER IN THE WORLD

Hydropower is the leading renewable source for electricity generation globally, supplying 71% of all renewable electricity.

Reaching 1,064 GW of installed capacity in 2016, it generated 16.4% of the



# HYDROPOWER IN THE WORLD

---

Tab. TOP HYDROPOWER CAPACITY AS OF 2015, BY COUNTRY

	Total Capacity end of 2015 (GW)	Added Capacity in 2015 (GW)	Production (TWh)
China	319	19	1,126
USA	102	0.1	250
Brazil	92	2.5	382
Canada	79	0.7	376
India	52	1.9	120
Russia	51	0.2	160

# HYDROPOWER IN THE WORLD

---

The **22,500MW Three Gorges hydroelectric power plant** in Yichang, Hubei province, China, is the largest hydropower station in the world. It is a conventional impoundment hydropower facility exploiting the water resource of the Yangtze River.



## HYDROPOWER IN THE WORLD

---

A 181m tall and 2,335m long gravity dam was built as part of the Three Gorges project. The power plant consists of 32 turbine / generator units rated 700MW each, and two 50MW power generators.





# HYDROPOWER IN THE WORLD

---

**The Itaipu hydroelectric power plant** with an installed capacity of 14,000MW ranks as the world's second largest hydropower plant.



- supplies about 17.3% of Brazil's energy consumption and 72.5% of the energy consumed in Paraguay
- 20 generating units with a capacity of 700MW each
- it produced 98.2TWh in 2012

# HYDROPOWER IN THE WORLD

---

The American Association of Civil Engineers recognized the Itaipu power plant as one of the "Seven Wonders of the Modern World,,.



Especially for 37,000 workers, a separate housing estate was built, consisting of 500 blocks, 4 hospitals, schools for 16,000 children, cinemas and restaurants.



## DAM AND HYDRO POWER PLANT XILUODU

---



Foto: [english.cwe.cn](http://english.cwe.cn)

Dam on Yangtze River, start up in 2013 year, capacity 13860MW.

# GURI POWER PLANT, SIMON BOLIVAR POWER PLANT, VENEZUELA

---

- Capacity 10,2 GW
- Dam 1300 m length i 162 m height



# HYDRO POWER PLANT TUCURUI, BRASIL

---

- stage I 1975-1984 years
- stage II 1998-2010 years
- Energy for 13 mln people
- Capacity 8370 MW



(fot. Sócrates Arantes/Eletronorte/Agencia Brasil  
CC BY 3.0 BR)



# ZAPORA GRAND COULEE, STAN WASZYNGTON, USA

---



- construct in 1933-1942,
- 3 unit construct in 1974
- power 6809 MW.

Foto:wikimedia.org © Creative Commons



# HYDRO POWER PLANT SAJAŃSKO-SZUSZEŃSKA, RUSSIA

---

- power 6500 MW
- Over 70 percent energy production goes to the aluminum works of Russian Rusal.
- Constructed in 1968-1978.
- After the collapse of the Soviet Union, it was privatized and its owner is RAO UES



Foto:wikimedia.org © Creative Commons

(fot. PAP/ITAR-TASS/Alexander Kolbasov)

# DAM LONGTAN, CHINA

---



(fot. Qianli zou dan qí CC B)

- power 6426 MW
- it is the highest of this type of roll concrete construction (216,5 m) in the world

# HYDRO POWER PLANT AND ITS IMPACT ON THE ENVIRONMENT

---



Unfortunately, the construction of a hydropower plant changes the ecosystem and the surrounding landscape.



The reservoir created in the river contains stagnant water, which causes that completely different organisms develop there than before the dam, and the accumulation of algae collecting oxygen can lead to massive fish sucking, the accumulation of bottom sediments.



The large tank is characterized by greater evaporation and changes the humidity of the air over a relatively large area.



When raising the water level, coastal erosion and flooding of coastal breeding habitats of birds may occur

# HYDRO POWER PLANT AND ITS IMPACT ON THE ENVIRONMENT

---



Hydroelectric power plants produce "clean" electricity



When generating electricity, there are no gases or sewage that would significantly pollute the environment



Hydroelectric power plants are characterized by low labor intensity - sporadic technical supervision is sufficient for their operation



HPP are an emergency source of energy in the event of damage to the transmission network and regulate water relations in the immediate vicinity.



Construction of a stilling construction results in the creation of a water reservoir, which determines the development of tourism and recreation in a given region.



With lower unemployment, because new jobs are created



# SMALL HYDROPOWER

---

## SHP:

- they do not pollute the environment
- they can be installed in numerous places on small watercourses
- they can be designed and built within 1-2 years,
- equipment is widely available, and technology is well controlled
- technical simplicity causes high reliability and long life
- they require few personnel and can be controlled remotely
- scattering in the field shortens the distance of energy transmission and reduces the associated costs

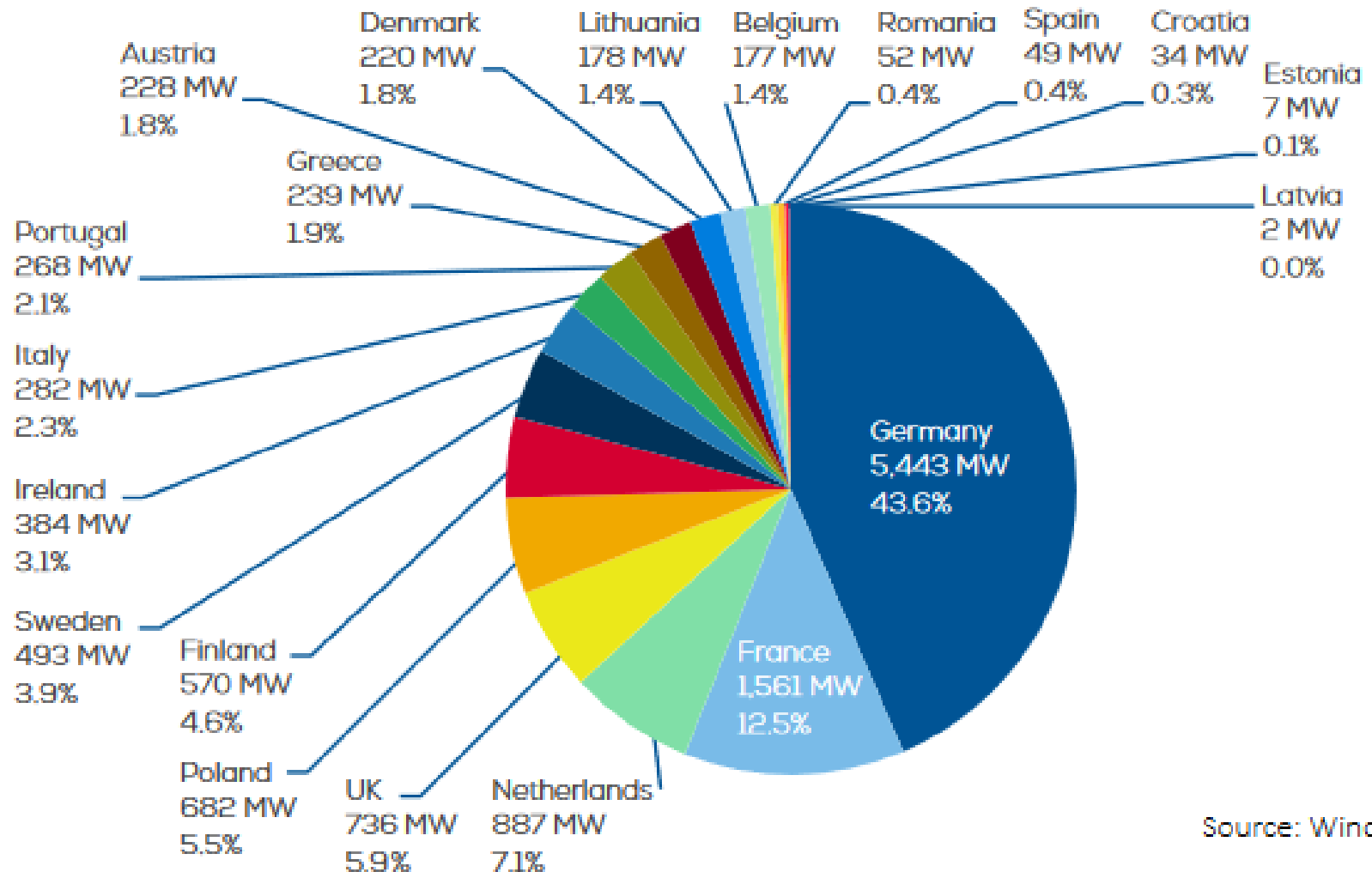
# WIND POWER PLANT

---



# WIND POWER PLANT IN EUROPE

EU market shares for new wind energy capacity installed during 2016. Total 12,490 MW

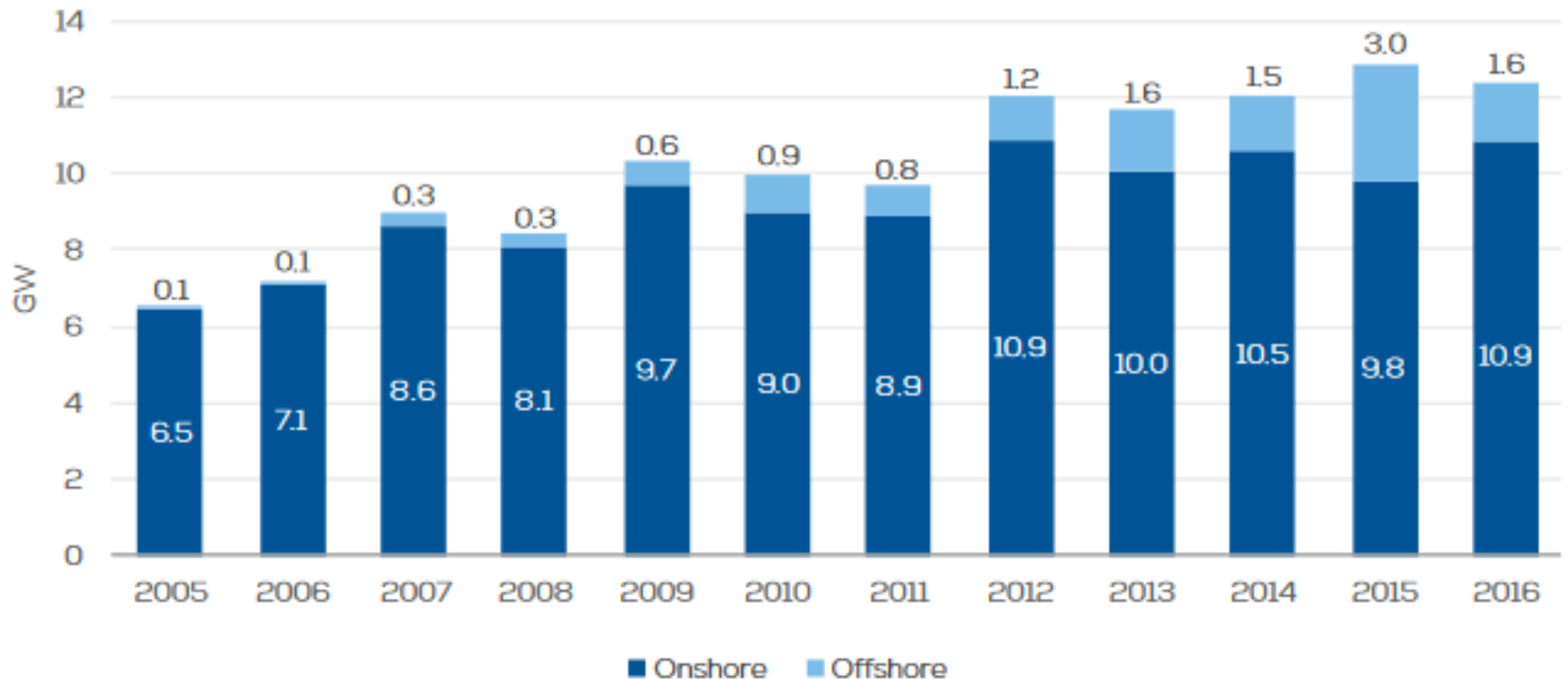


Source: WindEurope

# WIND POWER PLANT IN EUROPE



## Annual onshore and offshore wind installations in the EU



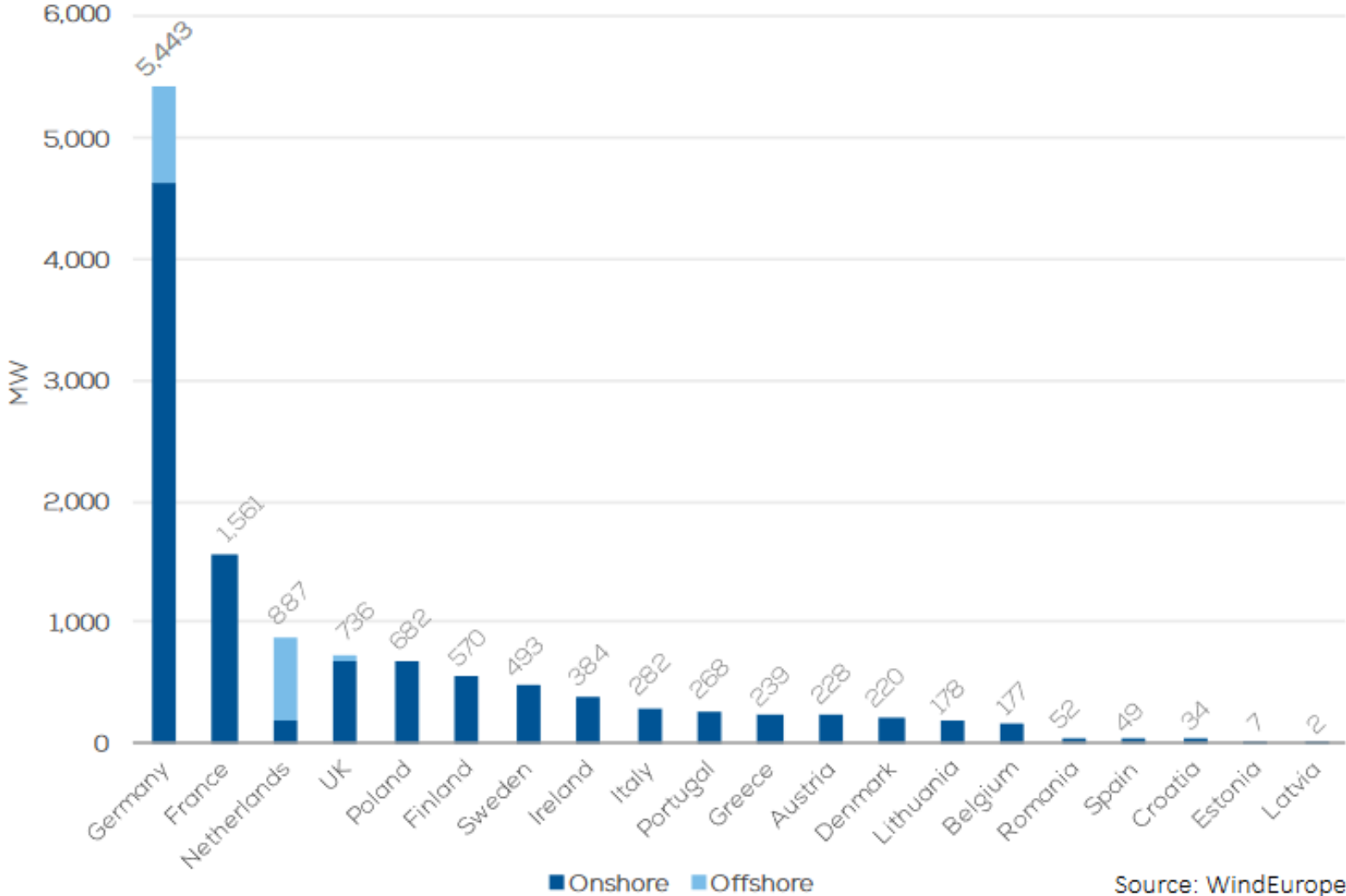
Source: WindEurope





# WIND POWER PLANT IN EUROPE

EU Member State 2016 installed wind capacity onshore and offshore. Total: 12,490 MW



Source: WindEurope

## WIND POWER PLANT IN THE WORLD

---

Liderzy energetyki wiatrowej na świecie – moce farm wiatrowych na koniec 2012 roku

Global wind energy leaders – wind capacities at the end of 2012

Kraj / Country	MW	%
ChRL / China	75 324	26,7%
USA	60 007	21,2%
Niemcy / Germany	31 308	11,1%
Hiszpania / Spain	22 796	8,1%
Indie / India	18 421	6,5%
Wielka Brytania / UK	8 445	3,0%
Włochy / Italy	8 144	2,9%

# WIND POWER PLANT IN THE WORLD

---



## The Gansu Wind Farm Project, China (the Jiuquan Wind Power Base)

- group of large wind farms
- currently under construction.
- a goal capacity of 20,000 MW by the year 2020.
- more than 92,000 wind turbines have been built across China, capable of generating 145 gigawatts of electricity

# WIND POWER PLANT IN THE WORLD

---

## The Alta Wind Energy Center (AWEC), Mojave Wind Farm, USA



- is located in Tehachapi Pass of the Tehachapi Mountains, in Kern County, California.
- the largest wind farm in the United States
- installed capacity of 1,547 MW
- 5000 wind turbine
- Constructed in 70 – 80 XX w.



# WIND POWER PLANT IN THE WORLD

---



Roscoe Wind Farm – Texas, USA



- power 781,5 MW
- 627 wind turbine
- Start operation in w 2009 r.

# WIND POWER PLANT IN EUROPE

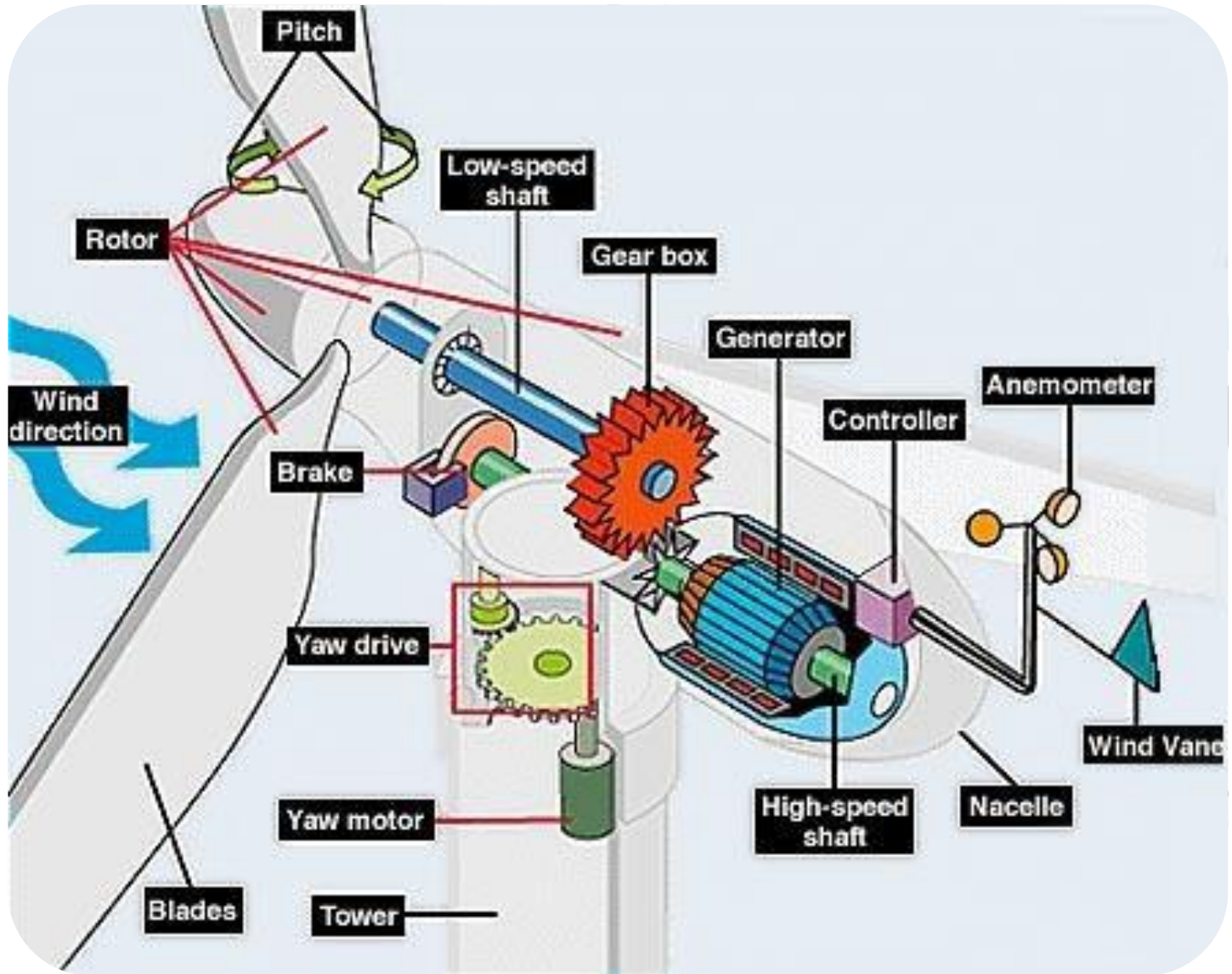
---

## East Renfrewshire Wind Farm – Renfrewshire, Scotland



- power 539 MW
- 215 wind turbine
- Start in 2012

# CONSTRUCTION OF WIND POWER UNIT





# CONSTRUCTION OF WIND POWER UNIT

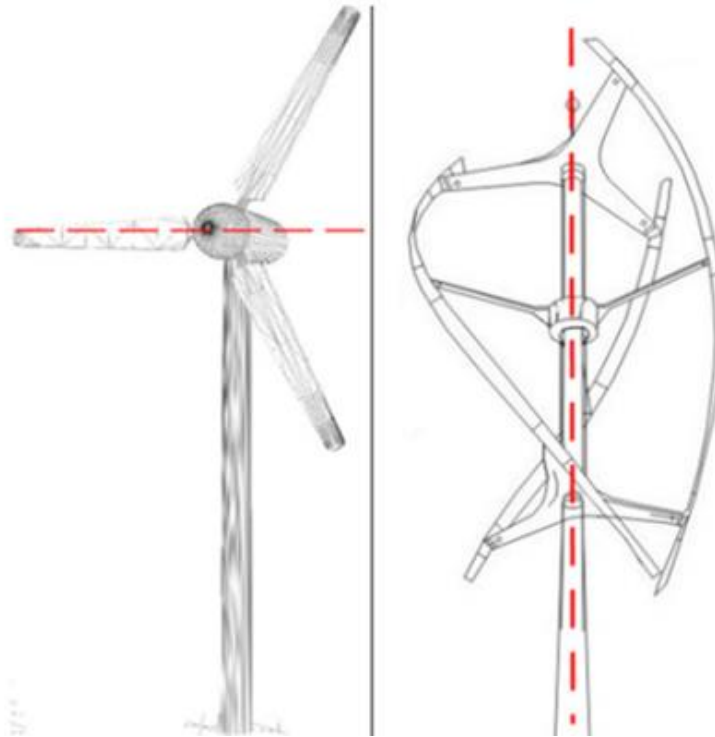
---





# CONSTRUCTION OF WIND POWER UNIT

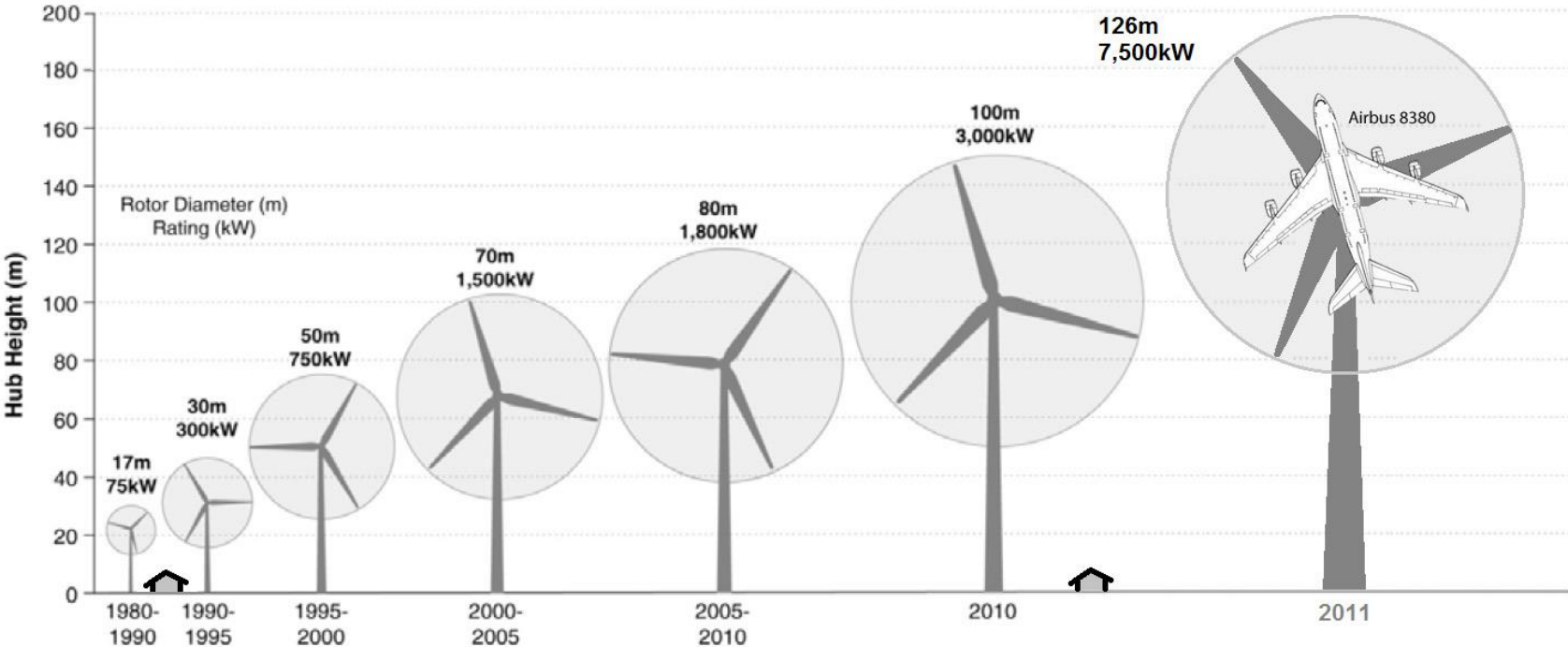
---



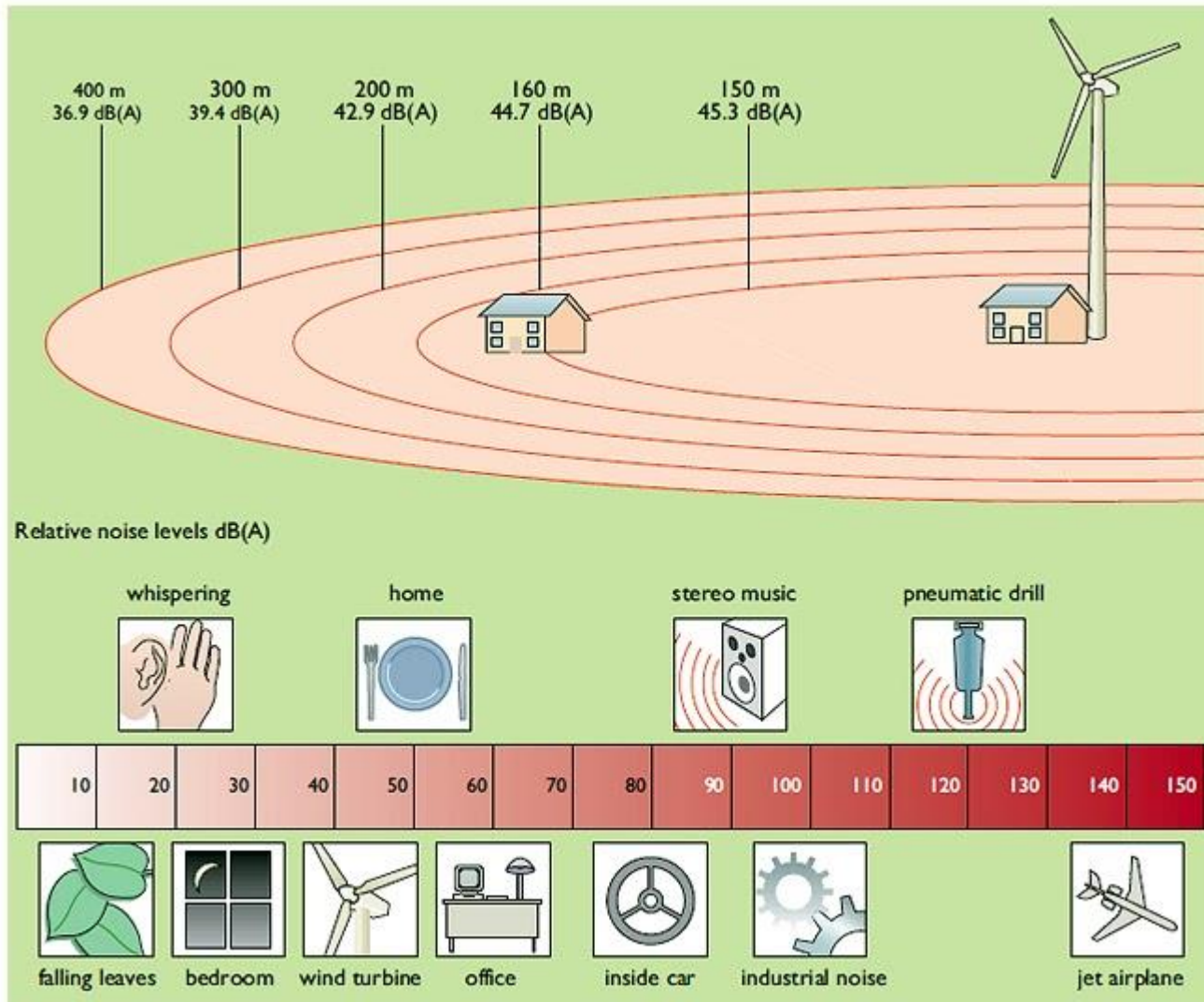
Small wind power plant:

- Vertical Axis Wind Turbines, not depended of wind
- Horizontal Axis Wind Turbines, higher efficiency, often occur

# CONSTRUCTION OF WIND POWER UNIT



# NOISE AND WIND POWER PLANT





**POLITECHNIKA  
GDAŃSKA**

WYDZIAŁ ELEKTROTECHNIKI  
I AUTOMATYKI

**Thank you for your attention**