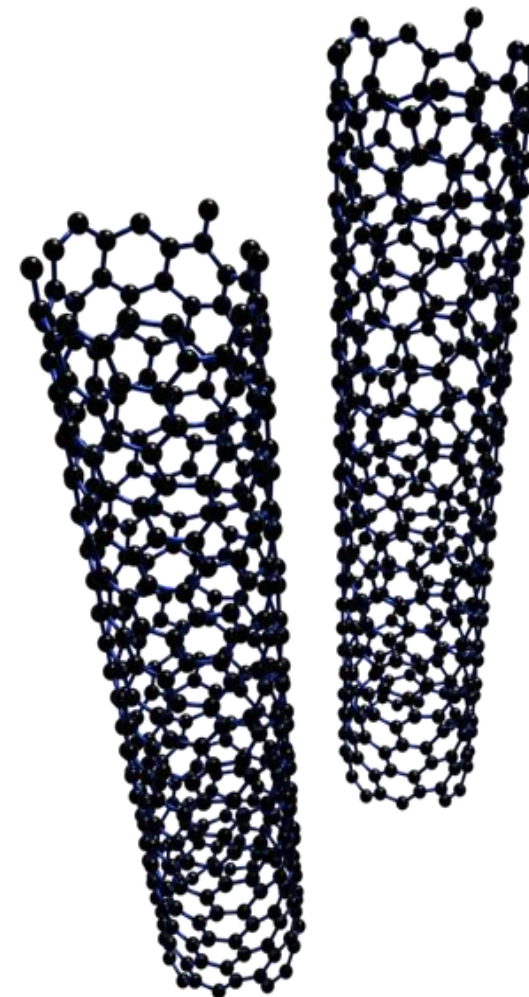




**JSW**  
INNOWACJE

## Project Carbon Nanotubes (CNT)



Katowice, 12.12.2018

- 1) Introduction
  - 1) Project Partners
  - 2) Subject of cooperation
- 2) Carbon Nanotubes (CNT)
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- 3) CNT Market analysis
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## Project Partners

- AGT Management & Engineering
- JSW Innowacje S.A.
- JSW S.A.

## Supporting Partners

- University of St Andrews Scotland
- Eisenmann Anlagenbau GmbH & Co. KG

## AGT Management & Engineering

Headquarters- Steinhausen, Rigistrasse 8, CH-6312 Switzerland

President and sole shareholder - Manfred Lenzi

The owner of LTC technology, which uses the rights to austrian patents

The owner of CCVD technology for the production of carbon nanostructures from syngas with LTC technology (Know-how)

## Reference

- Installation for gasification combined with **LTC** - Low Temperature Conversion in **Jurkloster**, conversion of wood pellets;
- **LTC** installation in **Zaplanie**, conversion of wood pellets, electricity production
- **LTC** installation in **Celje**, conversion of wood pellets and organic waste, production of electricity and fuels.

# Project Partner– JSW Capital Group



## B+R for JSW Capital Group

**The company's activities** include all stages of research and development actions of the JSW Corporate Group, up to feasibility studies and supervision of the realization of projects and implementations.

**The mission** of the company is to develop technologies and systems that increase the potential and capabilities of the Polish mining industry



## JSW Innowacje S.A. Projects in realization

- **Roofbolting Support** (Bolter Miner from JoyGlobal Inc. - Komatsu)
- **Automated Wall Complex** (Integrated longwall automation)
- **Smart Mine**
- **Modern Plant for Carbon Adsorbents Production**  
**Zakład Adsorbentów Węglowych** (Formed Carbon Adsorbents, Dusty Coke Adsorbents)
- **Instalation for Hydrogen separation from Coke Oven Gas** (hydrogen separation)
- **Carbon Fibers Production Technology**  
(cooperation with Fraunhofer Institut)



## St Andrews University Scotland

The oldest Scottish university was founded between 1410 and 1413.

The University of St Andrews gather researchers from around the world to discover and challenge the surrounding world.

The University's activities are very extensive - from local to international topics, university research includes historical, as well as modern scientific breakthroughs.

## EISENMANN

### Eisenmann Anlagenbau GmbH & Co. KG

Systems supplier in the field of surface technology, environmental technologies, heat treatment technology and material flow automation.

The company's key goal is to create new solutions that save energy, increase efficiency and minimize carbon dioxide emissions.

Eisenmann is involved in projects related to renewable energy, technologies for processing new materials and the production of carbon fibers.

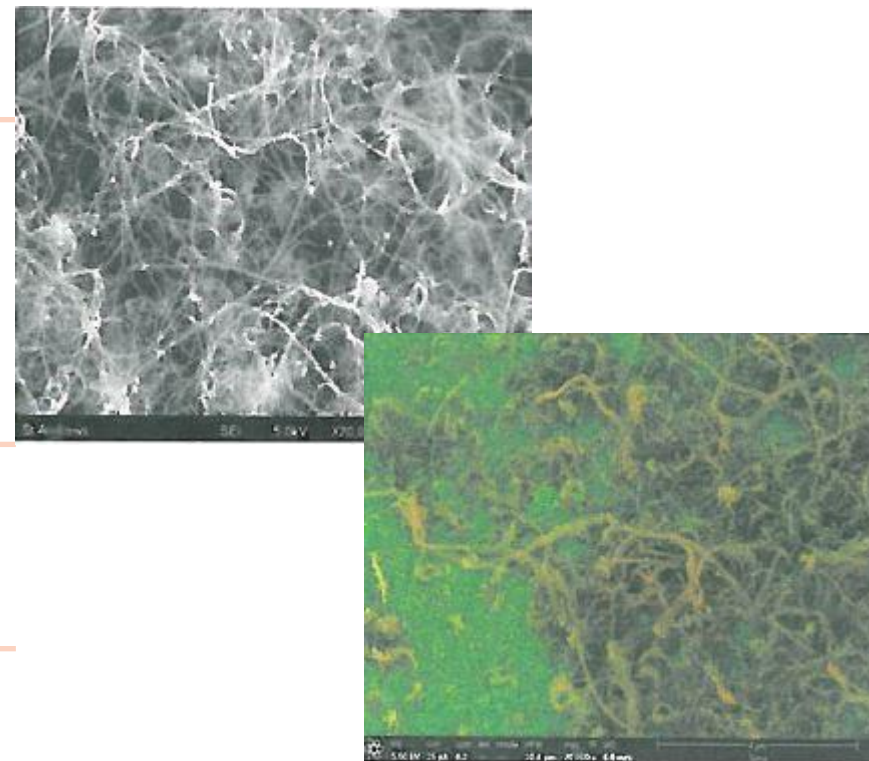
## CNT Project

Production of CNT carbon nanotubes (Carbon Nanotubes) in LTC / CCVD technology

Implementation in the JSW Capital Group **LTC – Low Temperature Conversion** technology and **CCVD – Catalytic Chemical Vapour Deposition** technology

Development of LTC / CCVD technology parameters for methane gas (natural gas)

**The use of gas from demethanization of mines, RDF and plastic for CNT production**



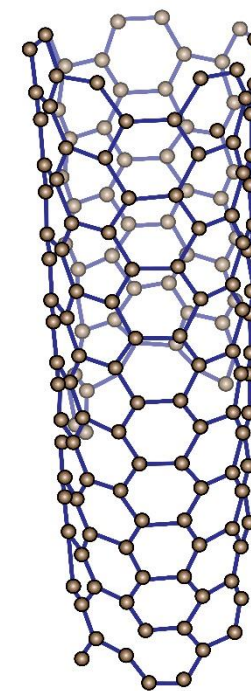


# Carbon Nanotubes (CNT)

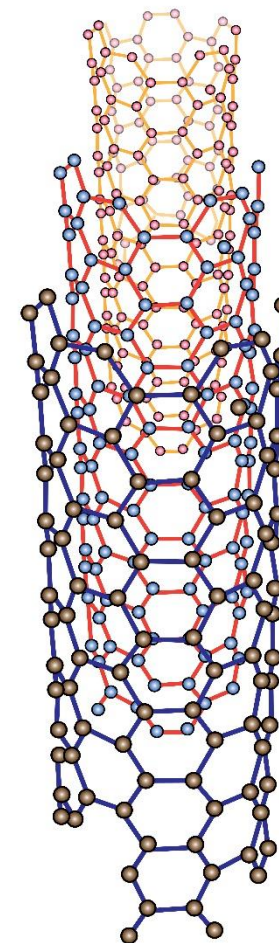
**CNT** – one of the carbon forms in the form of hollow cylinders, whose walls are made of coiled graphene (a one-atom graphite layer):

- **SWCNT** - Single-Wall Carbon Nanotubes, made in the form of cylinders with a diameter of 1 to 1.5 nm.
- **DWCNT**- Double-Wall Carbon Nanotubes - Double with a high level of purity (up to 99%), double-walled carbon nanotubes as well as single-walled carbon nanotubes are used mainly in electronics.
- **MWCNT**- Multi-Wall Carbon Nanotubes represent over 90% of the global market for carbon nanotubes, consisting of multiple layers that are overlapped and rolled to create a cylindrical structure.

## CARBON NANOTUBES



Single-walled  
Carbon Nanotube



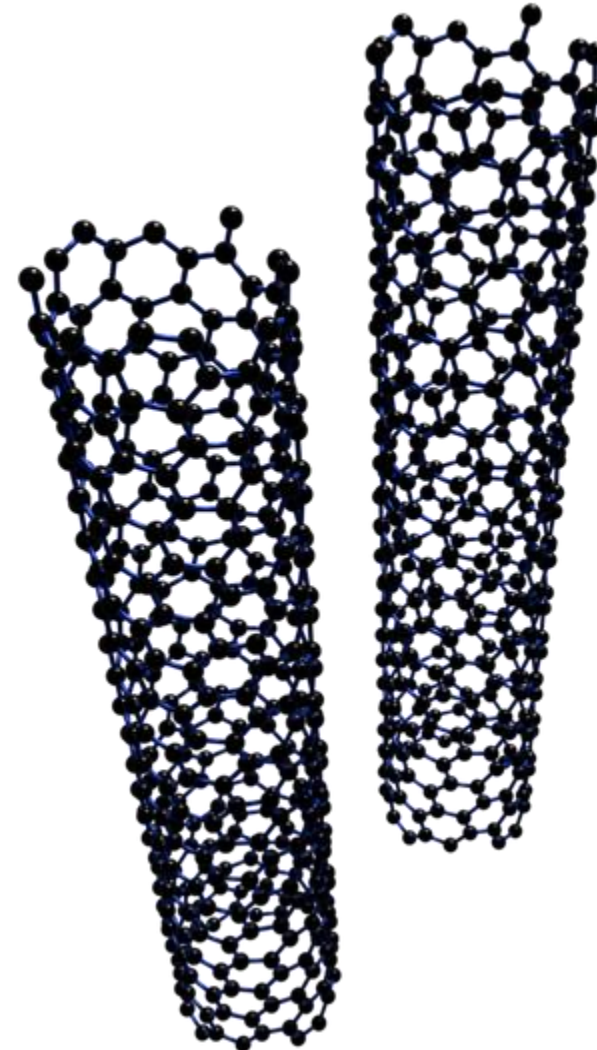
Multi-walled  
Carbon Nanotube



# CNT Properties

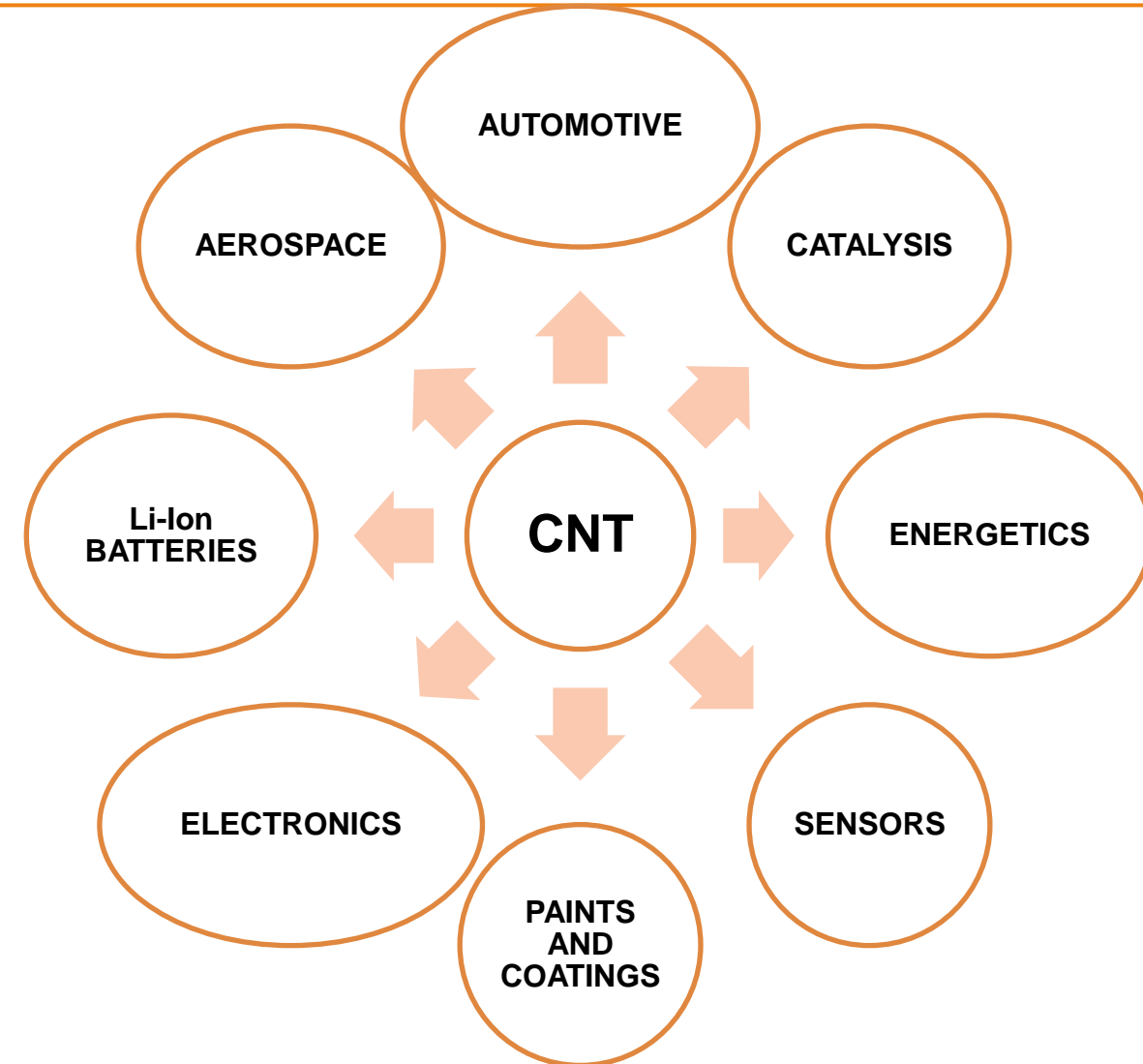
- ☐ High tensile strength (100 times greater than steel) - use together with polymers for the production of composites (lightweight structures)
- ☐ High current capacity
- ☐ Electrical conductivity (better than copper conductivity)
- ☐ Very good thermal conductivity
- ☐ The ability to accumulate gases and energy, as well as adaptable chemical reactivity

**CNTs have unique properties that make them used as materials in nanotechnology, electronics, optics and material research.**



# CNT Applications

- The main areas of application of CNT: **electronics (28%)**, **energy (22%)**, **plastics and composites (17%)** and **academic research (12%)**.
- The biggest demand for nanotubes has been presented in the **polymer segment** for several years. In these materials they improve the mechanical properties of the obtained **composites** - also for light constructions, including low-emission and electric car bodies.
- The increase in the share of CNT in applications such as **solar cells, semiconductors, transistors, touch sensors, ultraconductive copper** or **electromagnetic devices**.
- Also used in the **aerospace, military** and **electronic** industries, mainly due to their lightness combined with extraordinary durability.



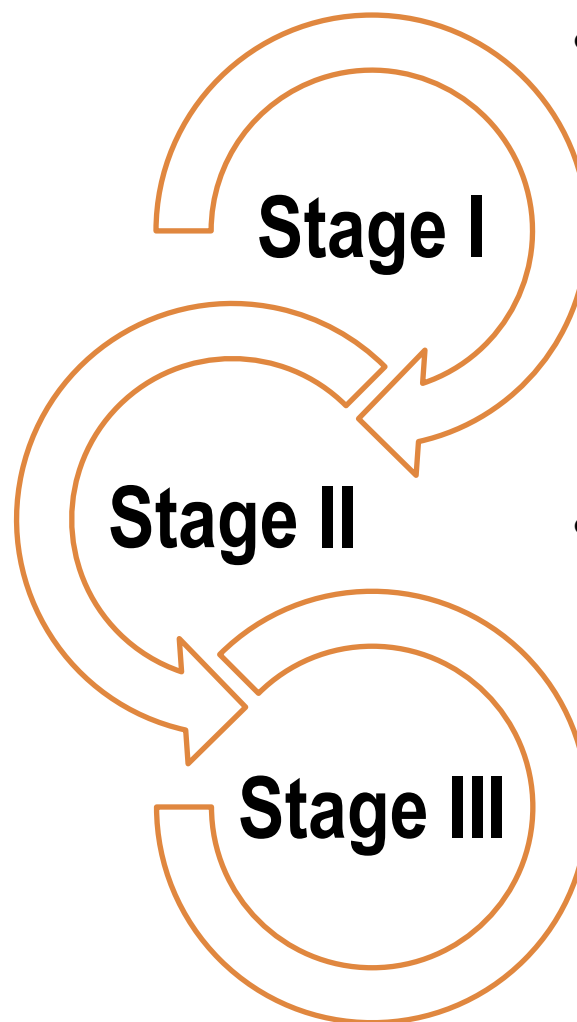
- The market for nanotubes was valued at USD 1.25 billion in 2015 and in the period 2016-2025, the expected development of this market will be at the level of 17.9% per annum.
- **In 2014, 5,000 tonnes were produced. The forecasted production of CNT in 2022 is forecast at 20,000 tons!**
- **Carbon nanostructures account for approximately 28% of the total nanomaterial market.**
- Polymers / composites in 2014 accounted significant share of CNT market being the largest market in which the CNT was used.
- CNT is increasingly used to strengthen polymers through the production of composites

## Competition:

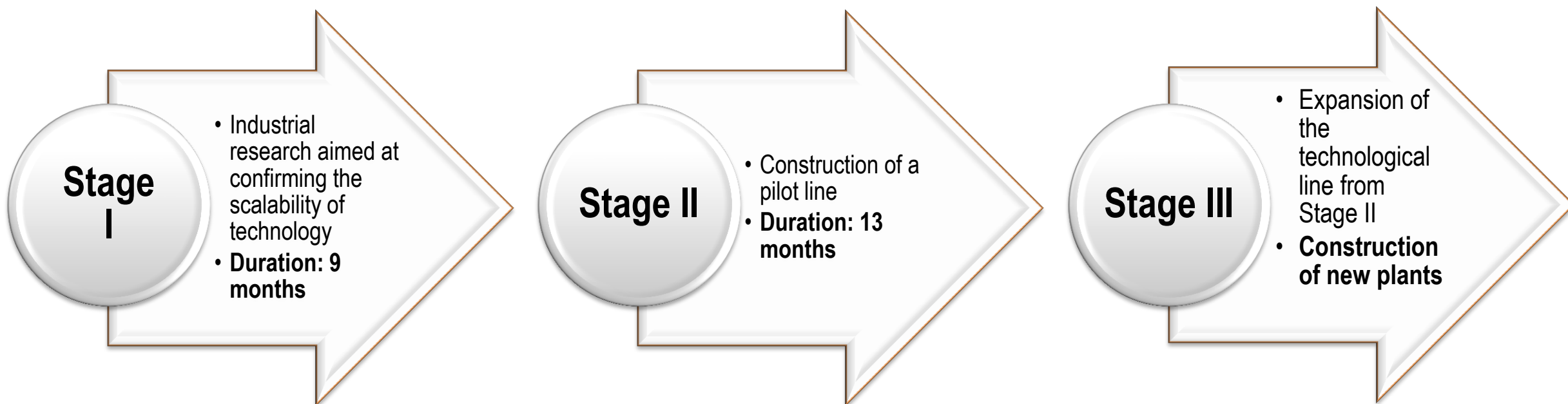
- The largest European producers were able to produce 400 tonnes (Arkema - France), 250 tonnes (Bayer) and 400 tonnes (Nanocyl - Belgium) multi-wall carbon nanotubes annually (MWCNT).
- The largest potential producers in the world are SUSN Sinotech (China), C-Nano (USA) and Showa Denko (Japan), which are able to produce 500-600 tons per year.
- The largest producer of single-walled nanotubes (SWCNT) is OCSiAl TUBALL (Russia), which plans to achieve 60 tonnes of production capacity per year.

**The prices of nanotubes depend on the order of structures and their purity, their range is very wide and currently ranges from 1 to 5 EUR per gram.**

- **Stage 2** – In case of positive completion of Stage 1 and JSWI decision regarding the start of Stage 2, a special purpose company - SPV will be established by JSWI and AGT, whose task will be to build and launch the first Production Line for the production of CNT nanostructures from gases in the location indicated by JSWI (preferred area of Coking Plant Dębieńsko).



- **Stage 1** – research and construction of the CCVD reactor at the University of St. Andrews, in cooperation with Eisenmann. Confirmation of the functionality and scalability of industrial reactors operating on the basis of CCVD Technology, - based on methane gas as a raw material.
- **Stage 3** – Expansion of the production line from Stage II and construction of subsequent Production Lines - within SPV in locations indicated by JSWI and on the basis of input material indicated by JSWI (gas, methane gas from mines or RDF and plastic), according to steps from Stage 2, including purchase of additional 3 CCVD reactors to 1 installed as part of Stage 2.





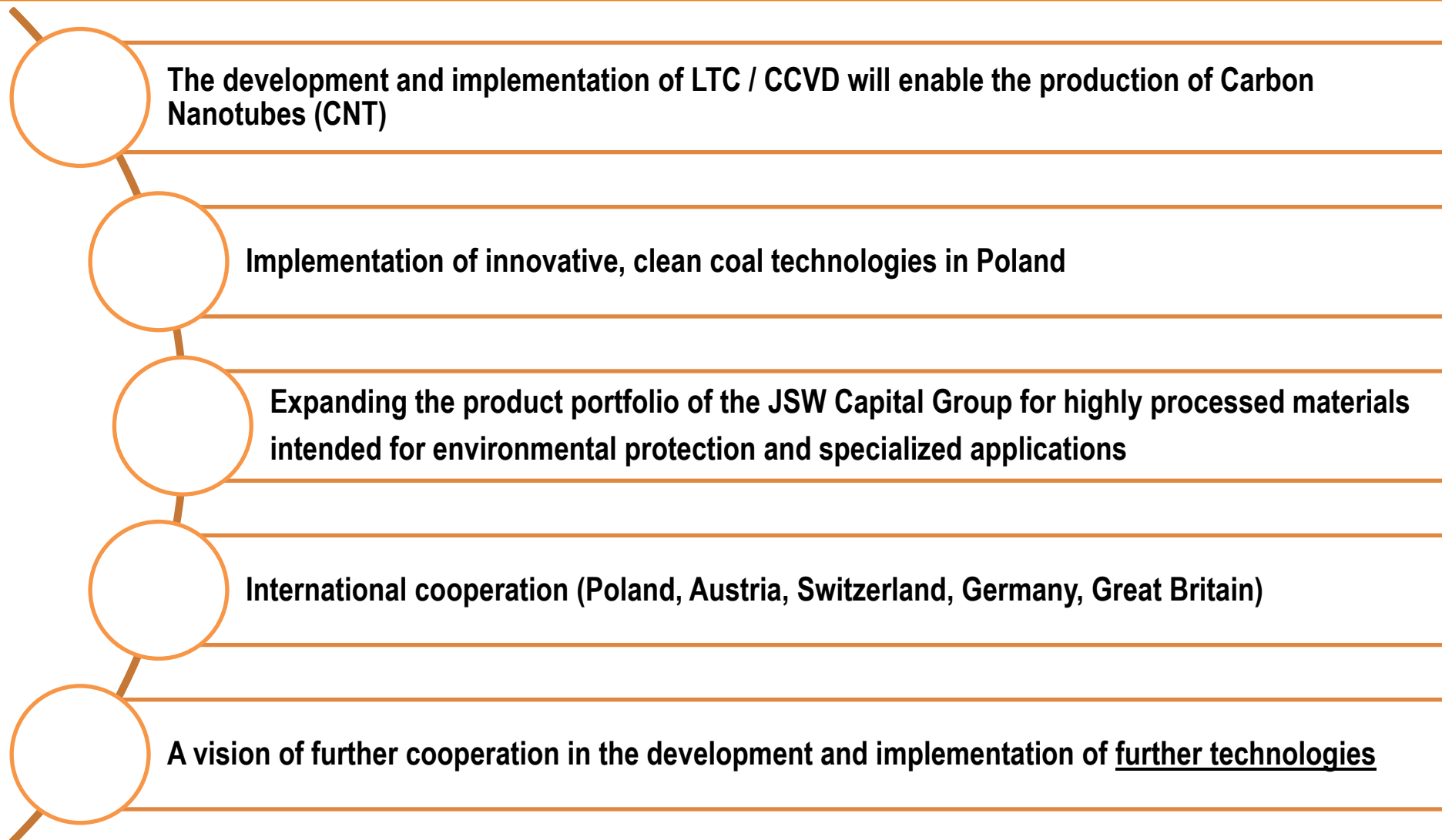
- Industrial research aimed at confirming the scalability of technology
- **Duration: 9 months**

- Construction of a pilot line
- **Duration: 13 months**

- Expansion of the technological line from Stage II
- **Construction of new plants**



# Effects of Project impelentation





**Thank you for attention!**