DOPS

RECYCLING TECHNOLOGIES

DCI™ (Direct Carbon Immobilization)
An introduction to the technology

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DOPS Recycling Technologies

A Dutch startup developing a new technology, Direct Carbon Immobilization, DCI™.

The DCI™ technology makes value from residues currently incinerated, land filled or composted.

DOPS Recycling Technologies' mission is to contribute to a sustainable world by offering a materials recovering technology for all hydrocarbon containing waste and residues.

Our technology sequesters carbon in a way to create new value instead of emitting CO_2.

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DCI™, what it is:

A **high temperature** chemical **conversion** and **separation** technology.

Multiple processes within a **shaft reactor** based on a smart **refractory structure.**

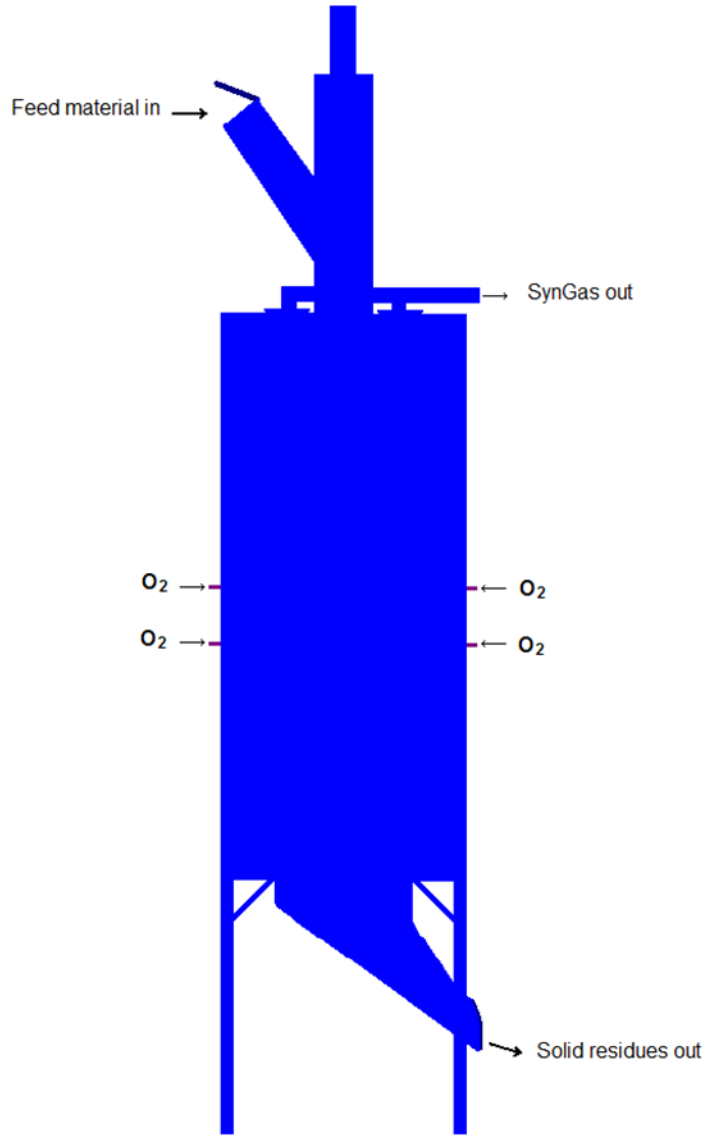
For all waste and residual materials containing **hydrocarbons**.

Driven by its own **internal energy,** with very little **CO_2** formation**.**

Producing **base molecules**:

Syngas (H_2 and CO)
Solid **Carbon,**
Clean **Metals** and
Minerals (e.g. CaO, P, S, etc)

Loose and grainy, good to separate

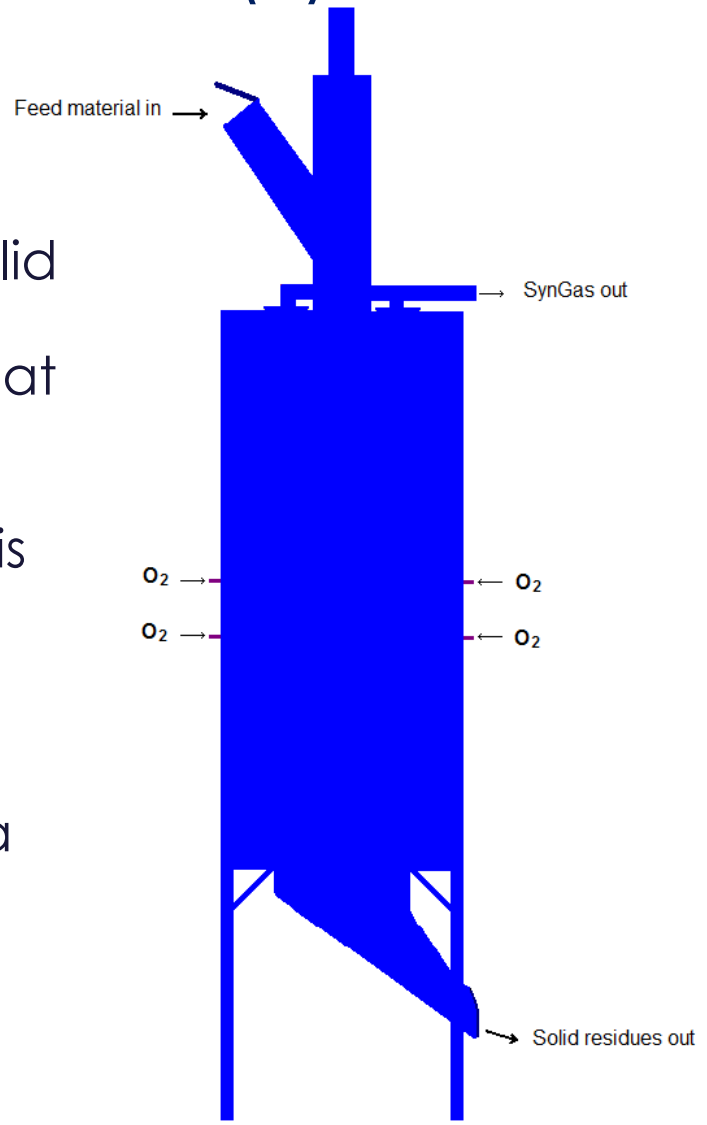


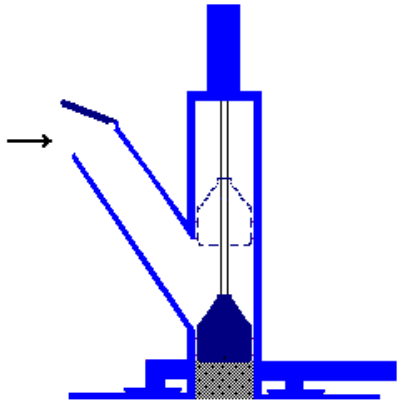
DCI™ how it works (1)

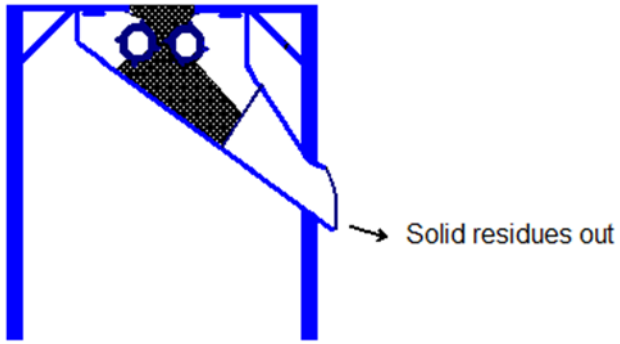
Basis is a shaft reactor where solid materials are continuously fed at the top.

The solid residue is unloaded at the bottom.

The reactor has a gated entry and exit.







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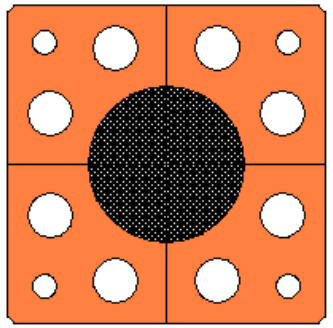
DCI™ How it works (2)

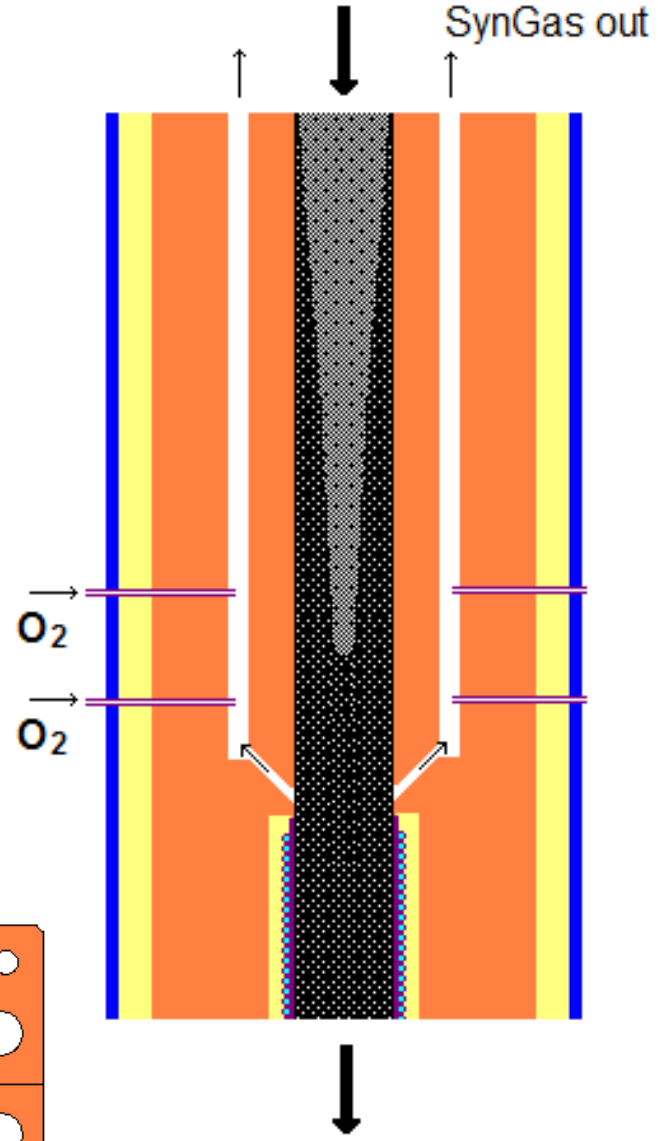
The refractory (fire bricks) heats the material in the shaft.

The resulting syngas can only escape from the shaft by channels around the main shaft.

Within those channels, a small amount of the syngas is combusted to keep the refractory structure at its high temperature.

Within the bottom section of the shaft, the solid material cools down again.





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DCI™

Is a (semi-) continuous process.

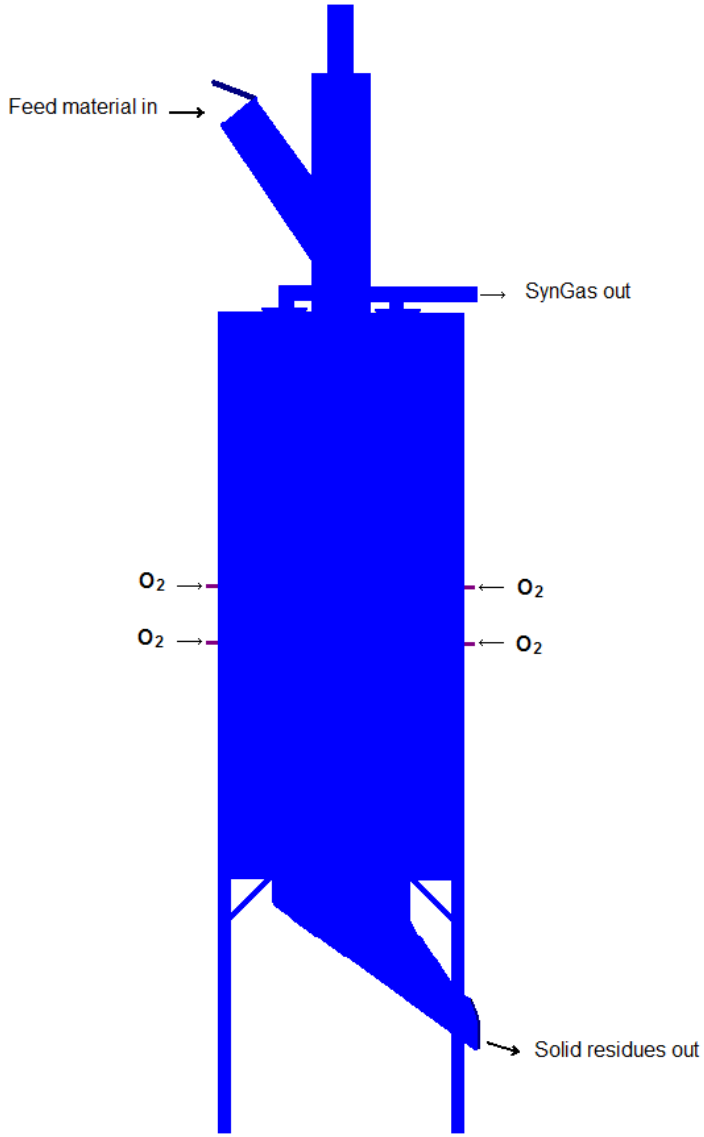
Where several processes develop within a simple reactor shaft, simultaneously but in different zones.

Atmospheric pressure

Temperature in the solids shaft:
From 900 °C to 1100 °C

Temperature in the gas shaft:
From 1100 °C to 1500 °C

Due to long residence times (multiple hours) and high temperatures, conversions are complete.



DCI™, processes in the solid phase

From Top to Bottom

Devaporization

First decompositions (torrefaction)

And

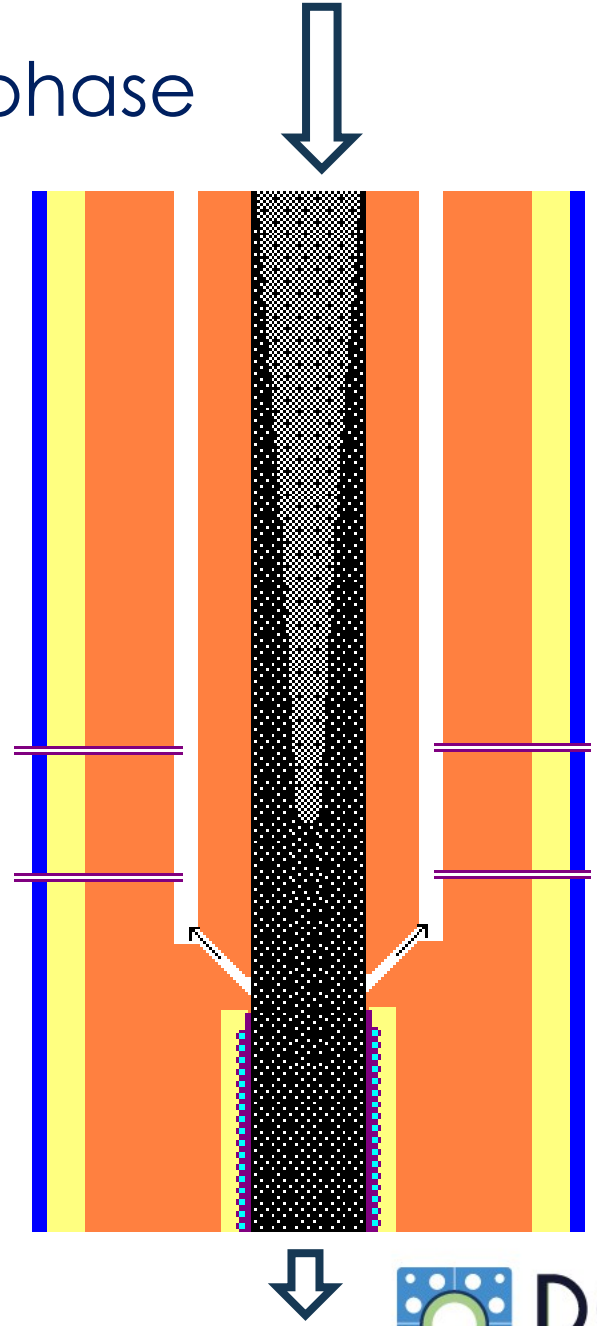
Depolymerization, Devolatilization, Pyrolyzation

From Outer Rim to Core

Carbonization, gasification (but not melting)

(Graphitization)

Cool down



DCI™, processes in the gas phase

Solids shaft:

Evaporation

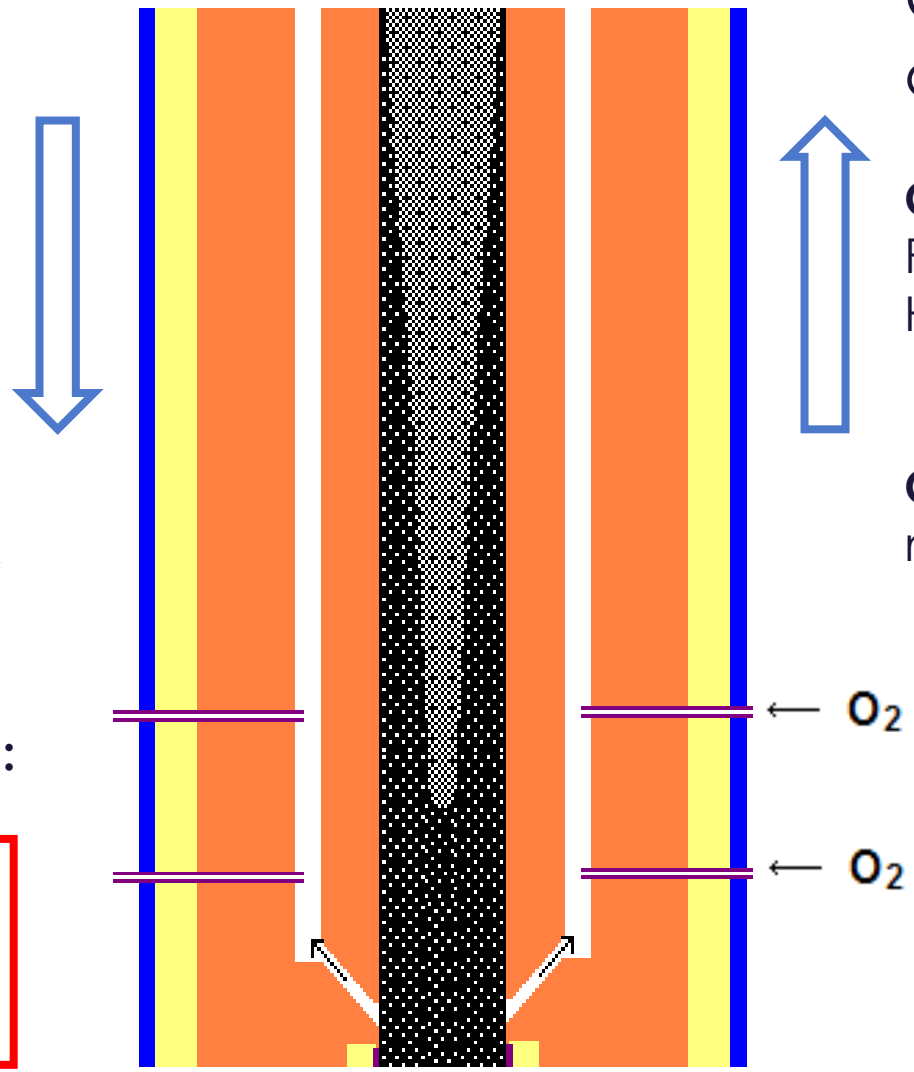
volatilisation

Cracking of **long** carbon-**molecules**

Cracking of **short** & **cyclic** carbon-**molecules**

Boudoir equilibrium:
$CO_2 + C \Rightarrow 2CO$

Filtration in moving carbon bed (soot captured!!)



Combustion channels:

Chemical equilibrium
Reverse watergas shift:
$H2 + CO2 \Rightarrow H2O + CO$

Cracking of persistent molecules:
(fluor-carbons, dioxins)

Partial combustion by O_2 injection

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DCI™-test results from Wood Pellets: Char (~10% of feed) & Syngas (~90% of feed)

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DCI™ Target materials for conversion

All residual materials containing hydrocarbons:

- Mixed Municipal Waste;
- Low value biomass;
- Paper waste;
- Dried sewage sludge;
- Residues from mechanical recycling or pyrolysis heavy tars;
- (Crude) Oil and tank residues, asphalt, roof coverings;
- E-Waste;
- Car deconstruction residues;
- Fiber reinforced plastics (windmill blades, aircraft components).

Everything currently incinerated, land filled or composted.

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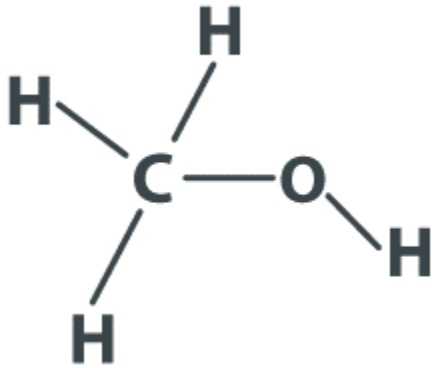
DCI™ Products produced

Gas phase:

- Syngas (**H_2** and **CO** in tuneable ratio's) to produce:
  - Methanol
  - Olefines (gasoline, SAF, diesel, waxes)



Solid phase:

- Carbon:
  - Char, activated carbon as absorbent or as growth substrate;
  - Amorphous, Carbon Black (clean soot);
  - Graphitic;
- Minerals:
  - CaO (e.g. from paper);
  - Particulates (glass, stone, pottery remains, etc);
  - P and S – minerals;
- Metals:
  - Particulate (nuts & bolts, connectors, wires, foils);
  - Molecular bound to carbon.

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DCI™ compared to other gasification processes

Many other gasification technologies let oxygen into solid residue:

- More or all carbon is gasified, high CO or CO_2 load in syngas;
- No carbon sequestrations;
- Oxidize most metals.

Have higher temperatures for solid residue:

- Melt all solids together making it hard to regain metals and minerals from the solid residue;
- With DCI™ process, residue is made up of loose carbon, minerals and metals, easy to separate;

Let syngas come out at cold side:

- Creating tars and longer chain hydrocarbons in syngas;
- Does not breakdown PCA substances, dioxins, PFAS etc.

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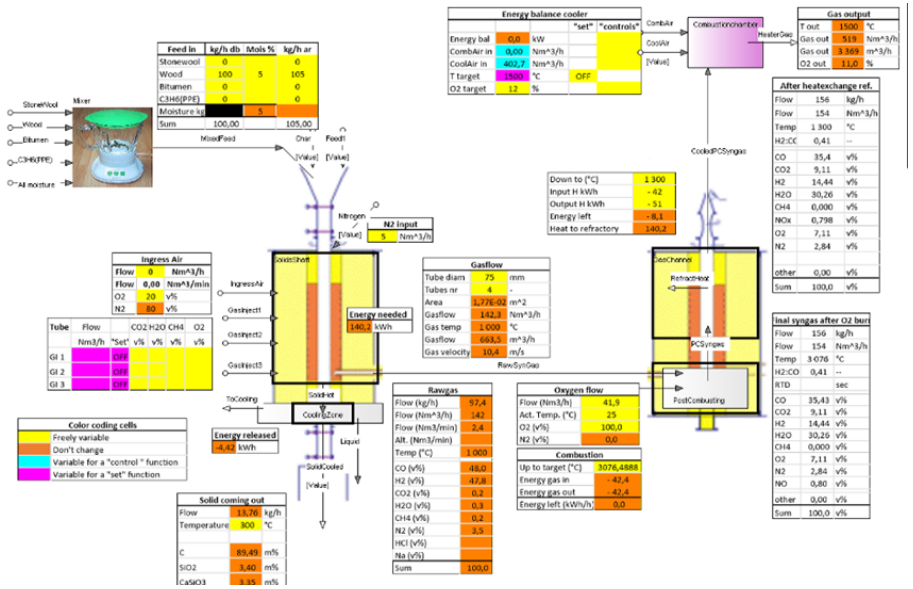
DCI™ current development stage:

TRL 3 proven in 2022

TRL 4 and TRL 5 proven in pilot reactor in 2023

TRL 6 scheduled for Q1 2024.

TRL 7/8: project started with client to design and build first full-scale Demo reactor operating in 2025.



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DCI™ Summary

DCI™ is one of many recycling / gasification technologies in development.

Highlights of DCI™ technology are:

- Simplicity of the reactor;
- Ease of control of the process;
- Most flexible and forgiving for input materials;
- Produces clean, high value syngas;
- Produces high value solid residues;
- DCI™ is among the most carbon – negative technologies available!

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Thank you for your attention

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