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SOLUTIONS FOR A CARBON NEUTRAL PULP AND PAPER PRODUCTION

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The pulp and paper industry is one of the most resource-intensive industries and is number four in the energy consumption ranking after metal and non-metal producers and the chemical industry, and number that correspond to 2% of global green house gas (GHG) emissions. As a result, efforts are made almost daily to use resources as efficiently as possible. Much has already been achieved, but the added aspect of global warming caused by high CO2 emissions has put the spotlight on energy production in conjunction with efficiency and has made it a challenging, if not existential, issue in the pulp and paper industry. But it should also be mentioned that the pulp and paper industry, with its high variance of different products on the one hand and the various often biogenic and recyclable raw materials on the other, has a better starting position compared to other industries. In addition to the processes in the pulp and paper industry, which are comparable at first glance, this diversity is increased by the transformation to carbon-neutral generation: standardized fossil fuel power plants are no longer the key. This opens up many variants, combinations and alternatives for generating energy, which in turn have different requirements that cannot be met everywhere. Renewable energy generation such as wind energy, for example, requires a location with sufficient wind, and the same applies to solar energy. Due to the fluctuation of this type of energy generation, storage or a supplement would be required etc. Energy generation and distribution becomes more complex.

The chemical pulp production for instance can be energy self-sufficient and almost carbon-neutral on biomass. With the pulp and paper industry as a pilot industry years ago, the Energy System Design (ESD) tool was therefore developed in order to work out a concept together with the respective site on how to achieve climate-neutral pulp and energy production in a roadmap under the specific ecological and economic conditions including installed base consideration. The ESD is not limited to energy generation but pursues a holistic approach such as energy optimization through waste heat recovery with heat pumps, for example under considerations on local boundaries and carbon emissions. This paper informs about the ESD, gives insights about the workflow as well as it describes on different references in the pulp and paper industry about the procedure and the result in different use cases: shift to biomass and heat pump paper production, renewable energy to e-fuel, power to heat solution with hydrogen, kinetic heat (turbo heater- technology) for tissue mill as well as different hybrit applications on the way towards a sustainable Pulp- and Paper production.

In the course of climate change, a transformation is taking place towards carbon-neutral, sustainable energy generation, including production, which goes hand in hand with the efficient use and consumption of energy. As an industry based on sustainable raw materials, the pulp and paper industry cannot ignore this either. This means that the provision of thermal and electrical energy is not based on a single energy source, but requires a more complex solution consisting of various coordinated components and units (hybrid power plant with various coordinated energy generators plus distribution, storage, consumers, etc.). to meet the requirement for continuous production as is standard in pulp and paper production. Due to this requirement for continuous production and the need for both

electrical and thermal energy, the pulp and paper industry relies on multiple energy sources and generation units (hybrid power plant) and is therefore also advanced in this aspect compared to other process industries. However, the pulp and paper industry is still based to a certain extent on fossil fuels as well as on fossil fuel-based power generation through heat (steam). With the use of renewable energies such as wind and solar, for example, heat and power generation are decoupled. In order to understand the many aspects and limits of a production. The Energy System Design tool was developed to analyze the many aspects and limits of a production and to transfer an existing production to a carbon neutral, sustainable, efficient and naturally competitive pulp and paper production. It is an instrument that, together with SMEs on the subject of energy and the pulp and paper production concerned, creates this transformation to carbon neutral production. It is always a customer- and location-based approach, as the framework conditions such as politically prescribed limit values and laws as well as local circumstances on the subject of energy, market conditions, economy and ecology often differ strikingly in some cases. It should also be mentioned that ESD is also used, for example, to increase yields, selectivities and the value of production through product expansion in the course of optimization. A power to x example should be mentioned here, in which the biogenic CO2 from the recovery boiler and the surplus electricity it generates are used to produce e-methanol for shipping.

ESD is an optimal selection of sizing of the conversion and storage technologies for a given energy system under the given constraints. It's technology agnostic, so we can use any technologies that is being decided in the 1st place together with a Pulp- and Paper mill. It's very highly customizable and allowing for scenario evaluation and sensitivity analysis.

ESD is not an engineering tool for establishing guarantees, detailed thermal models like Kravall etc. It is also not evaluation of mods and upgrades and it does not model electricity markets. We are using results from that. It is a tool which comes into action ahead of FEED step and overlaps it partly.

ESD is a model based, optimized selection and sizing of energy conversion and storage technologies that meet a specific Pulp- and paper mill´s needs. Based on that it needs use case specific data like

The energy system´s loads, the electricity and heat demand of a pulp- and paper mill

All relevant options for purchasing and/ or selling energy commodities and the corresponding process for, e.g., electricity and green hydrogen

The local renewable potential, for instance the photovoltaic generation profile

The local climate or weather conditions to account for, e.g. the impact of ambient temperature on chiller efficiency

Customer-specific technological preferences, for instance the inclusion of storage prototype or the exclusion of wind turbines for an airport´s energy system

Based on a solid understanding of the customer´s energy needs, targets and site specific boundary conditions, a set of energy conversion and storage technologies is defined and included as an option in a so called model super structure. The technologies are described by performance models on the one hand and cost models on the other. This data is then run through a state-of-the-art modelling and optimization tool that selects and sizes energy conversion and storage technologies. In addition an optimal dispatch is calculated for all storage and conversion units that are selected and sized (fig.1)

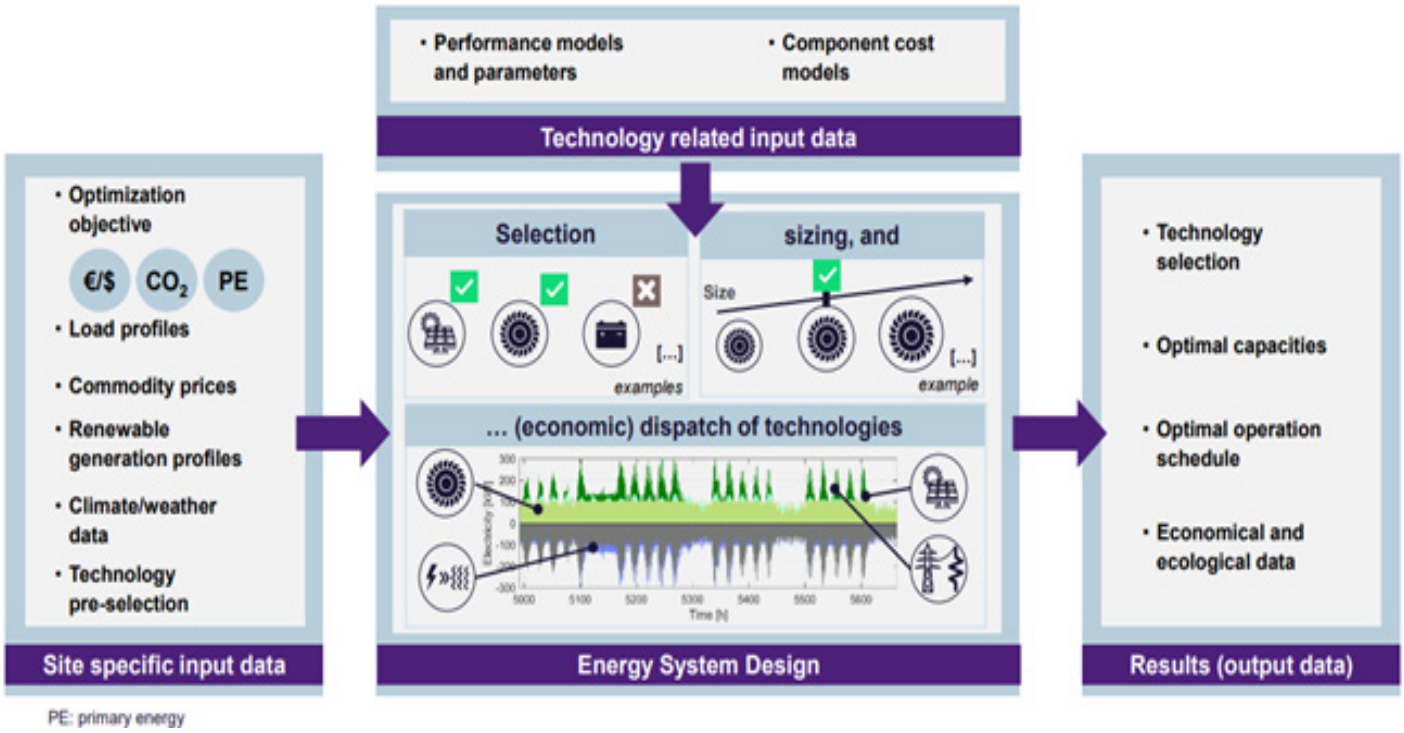

Fig. 1: Energy System Design (ESD): overview data In- and output for a model based tool in order to consider all relevant energy generation methods to develop a tailormade concept for a carbon neutral Pulp- and paper production

An ESD can be used for both existing and new systems. In the case of existing plants, the actual state is first recorded and in the case of a new plant, the benchmark market is used in combination with customer preference and local conditions. This actual state serves as a reference or starting point for the development of a solution for carbon-neutral production. The period, investment and boundary conditions are agreed and taken into account in advance with the respective production (fig. 2)

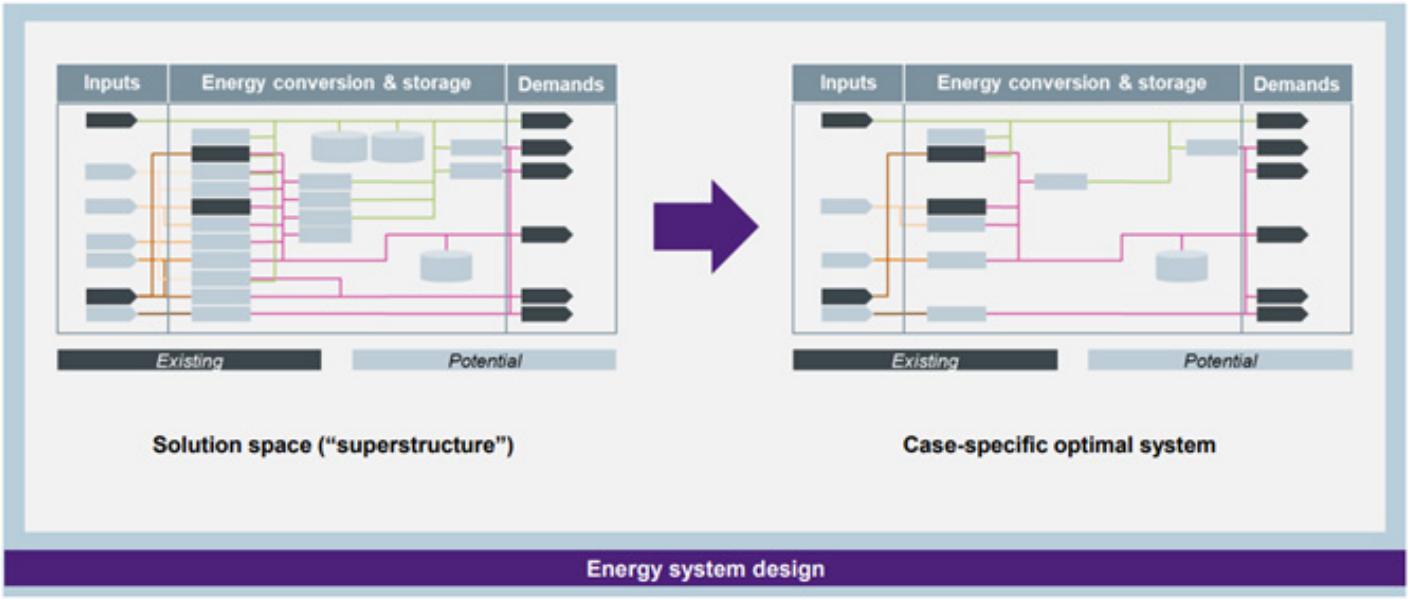

Fig. 2: Energy System Design (ESD): Brownfield approach to define the present status (Existing) first and develop different scenarios and timeline for a carbon neutral mill

The ESD is not only based on static balances and values, but also considers trend loads, fluctuations in all flows and resources used from the raw material, the product, additives, the water balance, cooling, etc. The ESD also takes into account energy flows within the production process. Energy flows are also considered within the production process, which are used to increase efficiency and optimize energy use (fig. 3 and 4).

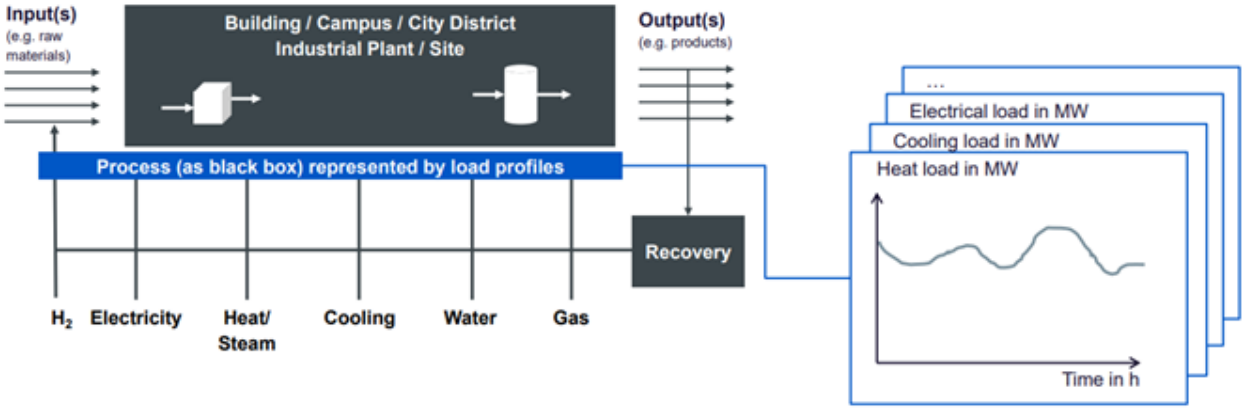

Fig. 3: Energy System Design (ESD) is a dynamic working tool and considers load profiles and changes of the mill

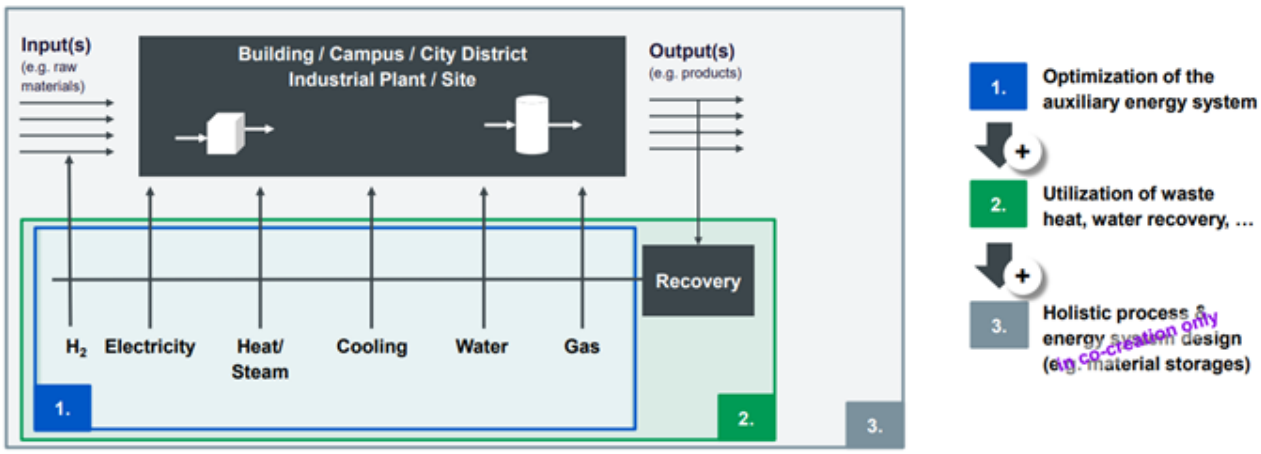

Fig. 4: Energy System Design (ESD) considers different recovery items and optimization procedures in order to develop an efficient pulp and paper production

For the modeling and balancing of scenarios, the ESD draws on a selection of possible energy generation solutions that are based on a combination of conventional and new technologies and in which the process conditions for the selection are taken into account. Fig 5, for example, lists a number of power-to-heat solutions that are important for the pulp and paper industry and can be used for this purpose. The turbo heater, a motor-driven turbine, uses its kinetic energy to generate hot air at temperatures between 100°C and 1000°C and can be used for hood drying in tissue production, which operates at 500°C, or for the lime kiln at a good 1000°C. The turbo heater can also be used in parallel with the HTWP. Alternatively, HTWP can be used in parallel to recover the warm but moist exhaust air from PM drying. There is also a use case as part of the concept in which the process water is cooled down before anaerobic digestion by means of a heat exchanger, which is otherwise usually used to heat the fresh air for drying or to cool the switchgear rooms on the other side.

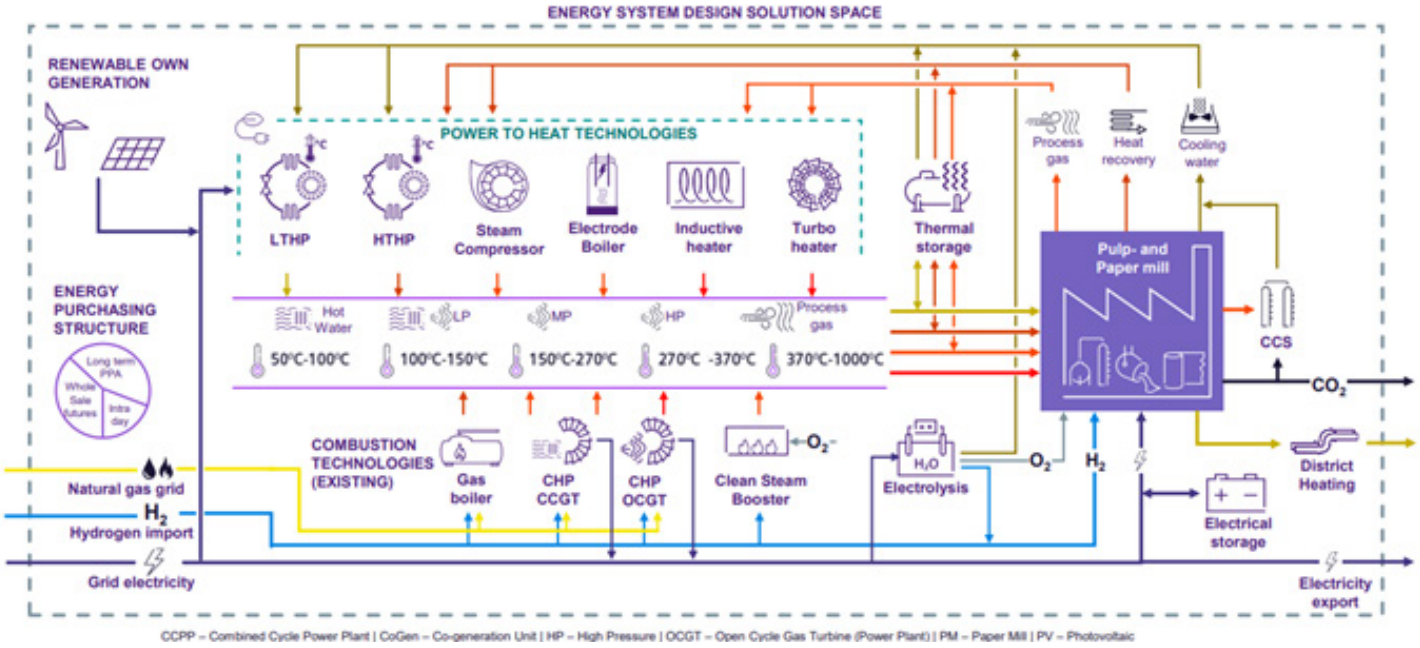

Fig. 5: General overview (selection) of systems to generate thermal- and electrical power

The ESD evaluates these versatile alternatives and combinations and develops various scenarios. The next example is one that was used not so long ago in the pulp and paper industry. The first example is an evaluation of a planned expansion of a site in Central Europe (Germany) to double its capacity, whereby the existing line was to be shut down after the new one was started up. It is a packaging paper production plant based on recovered paper. Due to the changing framework conditions for energy production (CO2 certificates, changes in resources, renewable, fluctuation, availability and access of resources, etc.), a preliminary evaluation has become necessary. As a first step, the status quo was recorded together with the operators, the local framework conditions were determined and their needs taken into account, Fig. 6

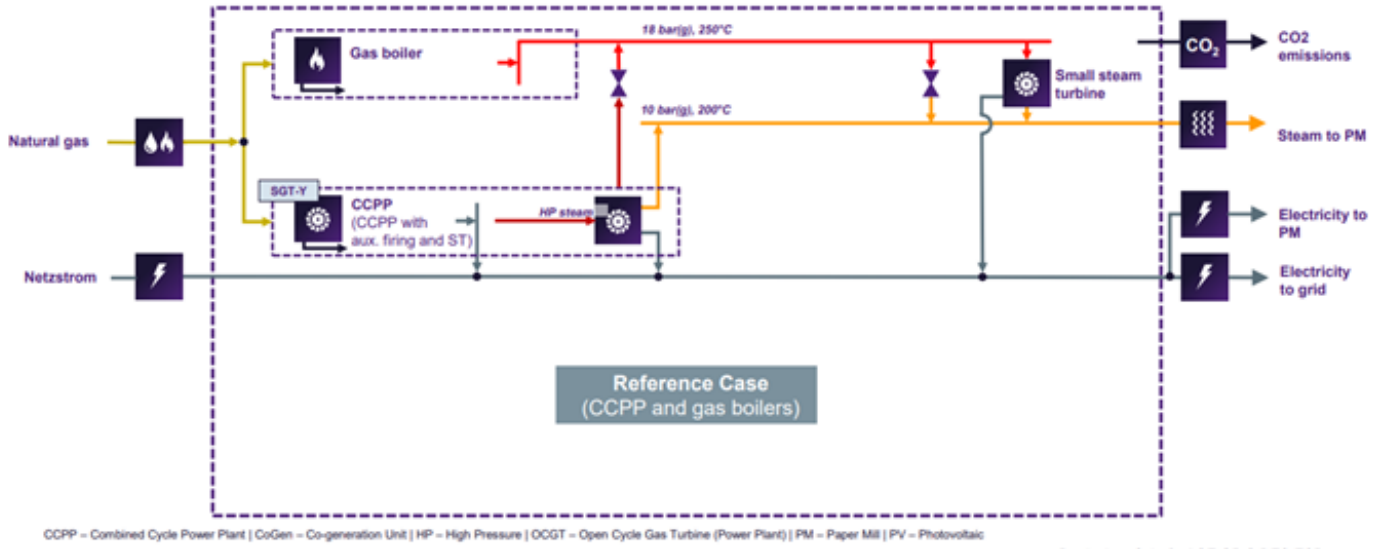

Fig. 6: ESD use case for an OCC based packaging paper line in central Europe, existing status

Based on this, various scenarios were developed from an ecological and economic point of view in order to achieve efficient and sustainable production. Fig 7. shows a scenario in which the existing status (reference) was integrated with renewable energy generation (PV, wind) and energy recovery (HTHP) to increase efficiency.

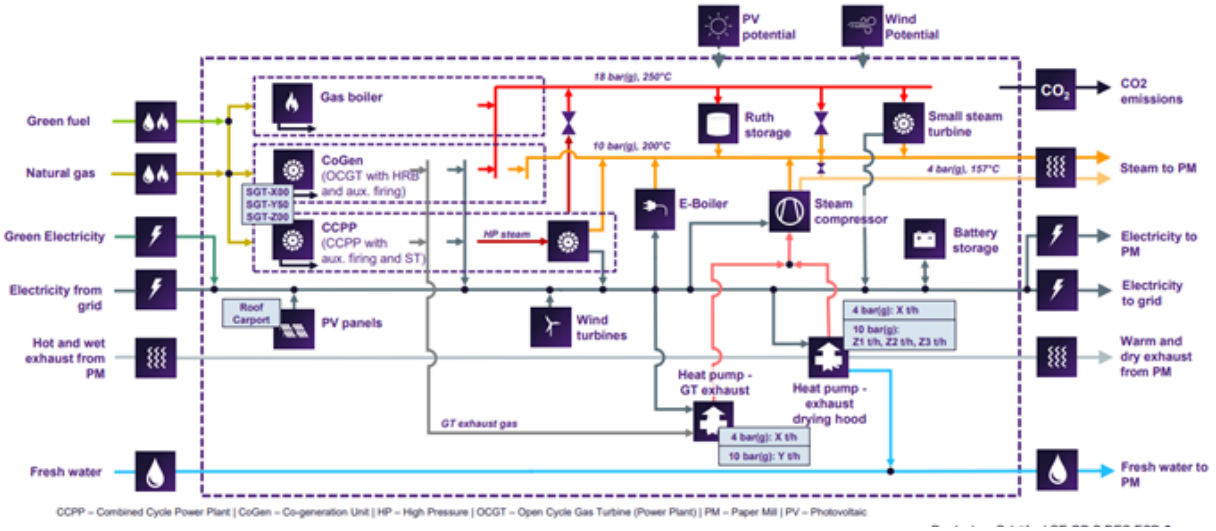

Fig. 7: One ESD scenario use case for an OCC based packaging paper line in central europe

The different use cases and scenarios are analyzed and compared with KI Parameters. KIs could be for instance the Invest and Totex, carbon neutrality status, efficiency. ..We will also consider funding programs which could support the transformation towards carbon neutral pulp- and paper production

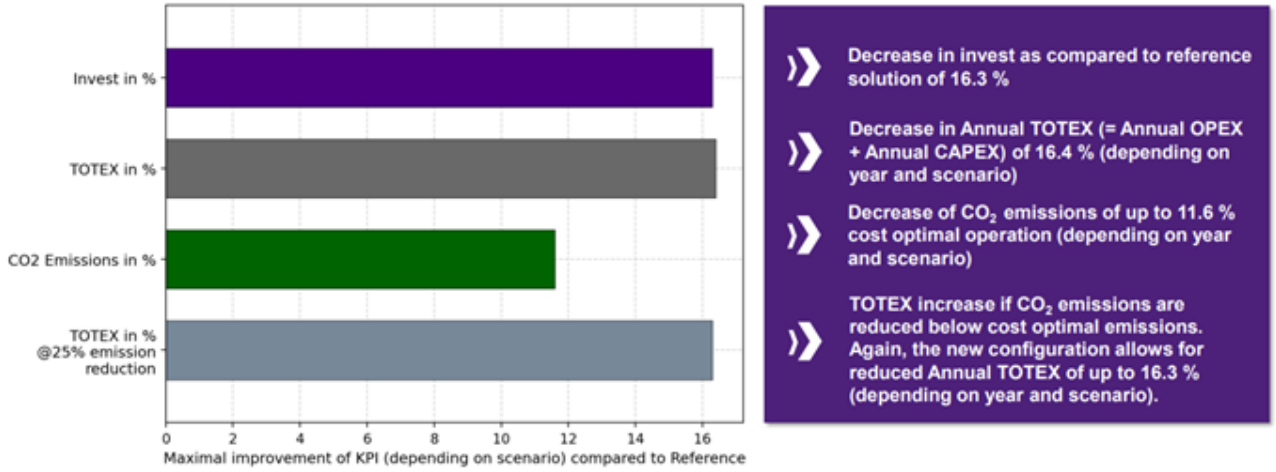

Fig. 8: ESD use case scenario Improvements based on KPIs indicators for an OCC based packaging mill in central Europe

Another use case describes a transformation of an integrated paper production for packing on waste and virgin fiber in east Europe, Fig. 9. The main task was to define a scenario of the paper production to become a carbon neutral production. Besides others the main energy production was based on a coal power plant, which was utilizing the paper ejects in a small share too. On status quo is shown on fig. 9.

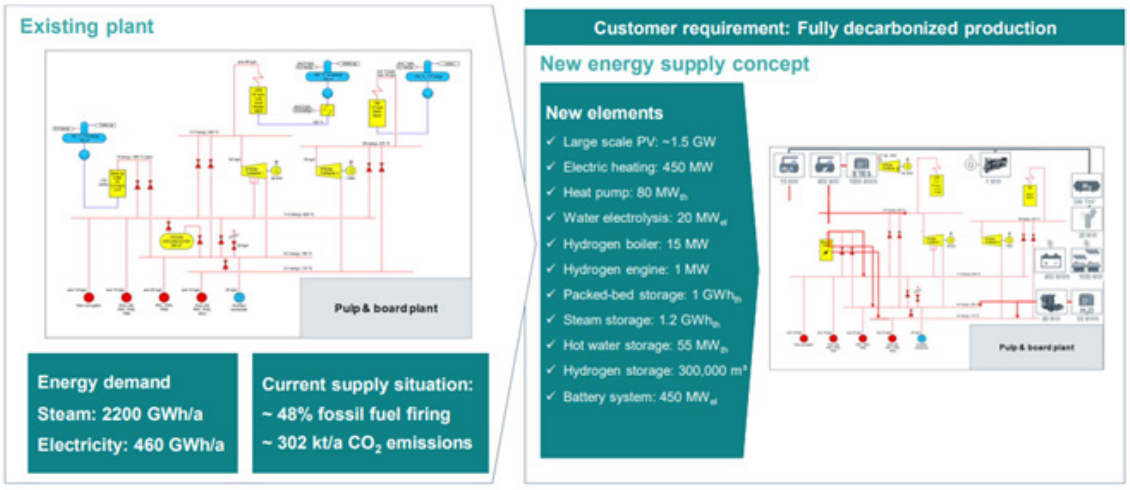

Fig. 9: ESD reference for an integrated packaging paper mill in east Europe

For this reference (base case) a step to step scenario was developed shown in fig. 10 to become a carbon neutral paper production facility. The first step (variant 1) was to perform a shift from coal to native gas. It should be mentioned that also a shift from coal to hydrogen was considered but it is still more costly than native gas at that time. But the gt which were considered are hydrogen ready turbines and would mean a steep carbon footprint reduction which is not shown in fig 10. It should be also added in this use case that wind did not play a role in this proposal due to the fact that the mill is located in an area with low potential even the mill is located not so far from the Baltic sea.

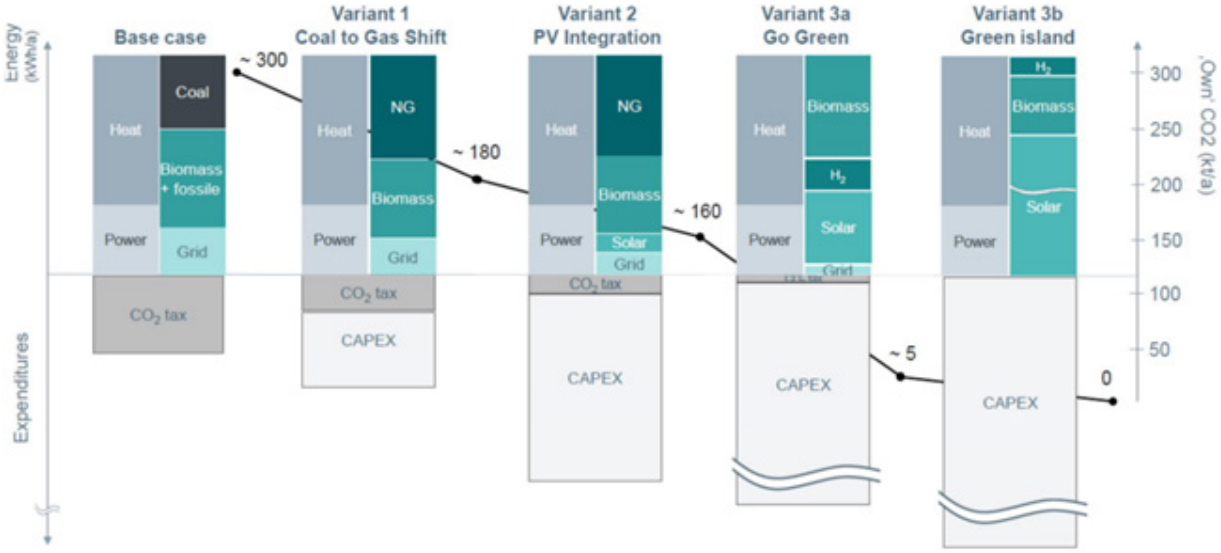

Fig. 10: ESD scenarios of an integrated packaging paper mill in east Europe

That were two uses cases which was performed recently. Due to the fact that the pulp- and paper industry was the pilot industry for the ESD we did it also for Asian productions. One should be mentioned in China in a tissue mill with numerous tissue lines where we recommended and performed a coal to gas shift and saved 12,000 to CO2.annually as a first step. Please visit our internet web side for ESD where the use case is described more in detail in a movie.

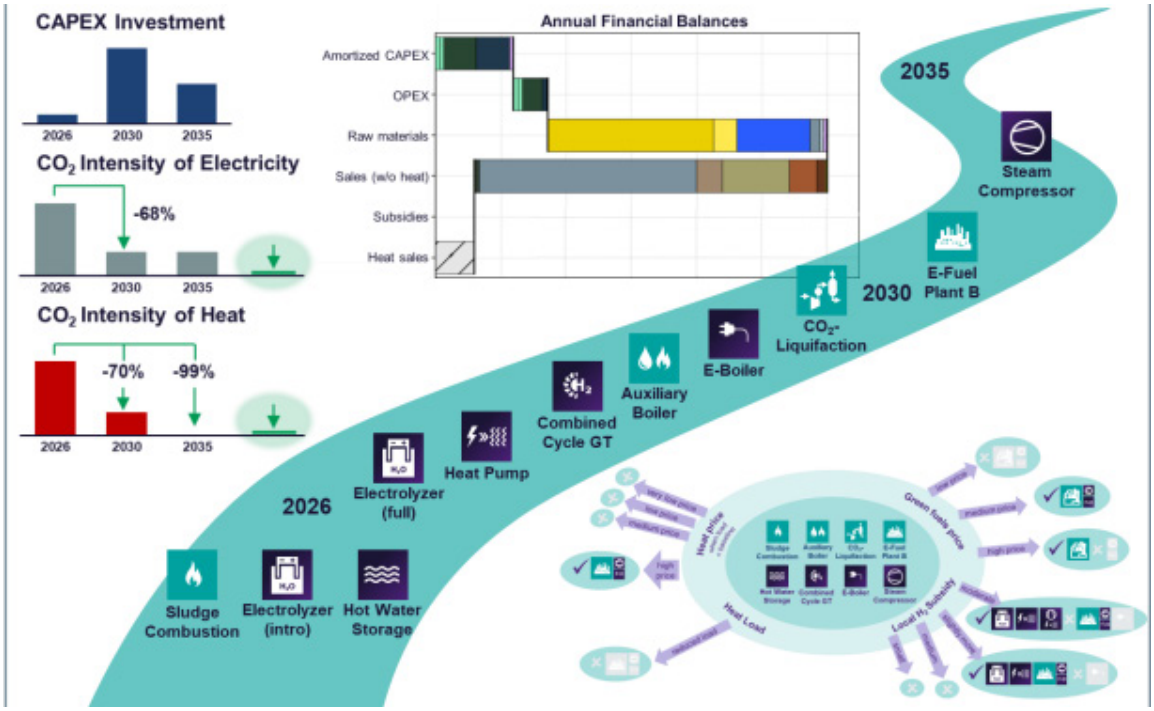

Fig. 11: One ESD scenario for an integrated paper production in north Europe (Scandinavia),

The third use case is a power to e-fuel use case in order to increase the value of an integrated paper production a more general view is shown on fig. 11. It is a use case which is based on CO2 utilization from a biomass based power plant (recovery boiler) to produce e-methanol for the maritime industry. Pulp mills in general which are producing bio carbon dioxide and a surplus of renewable electrical power have the ideal prerequisites and generate a synergy to produce e-methanol. With the ESD such a scenario was developed for this win-win use case: an increased yield and efficiency on the pulp mill side with more value generation. One e-fuel production based on that concept is in erection phase and two additional received permission already to build in Sweden (Fig.12).

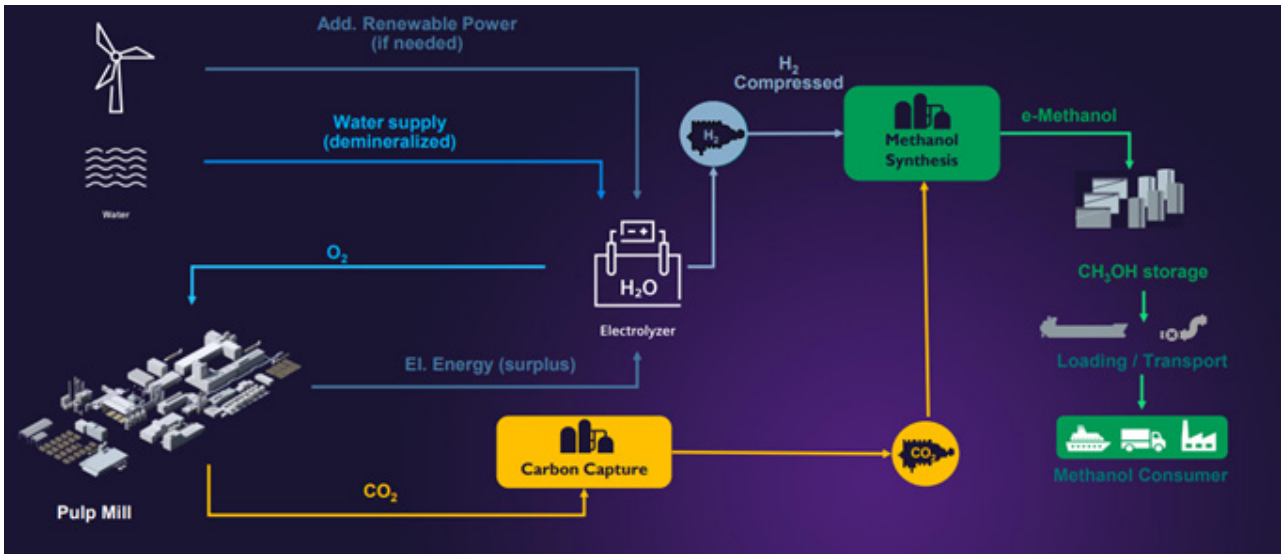

Fig.12: Pulp and paper mills provide ideal conditions for e-methanol production

With ESD and the joined work between the use case´s subject matter experts (SME) for a pulp- and paper mill with the Siemens Energy experts a save procedure was created to develop use cases for a carbon neutral pulp- and paper production. For several ESD use cases in the pulp and paper industry was developed and applied due to the fact that we started the ESD with the pulp- and paper industry as a pilot and it can be stated that the most scenarios which was developed was verified in the realization afterwards.