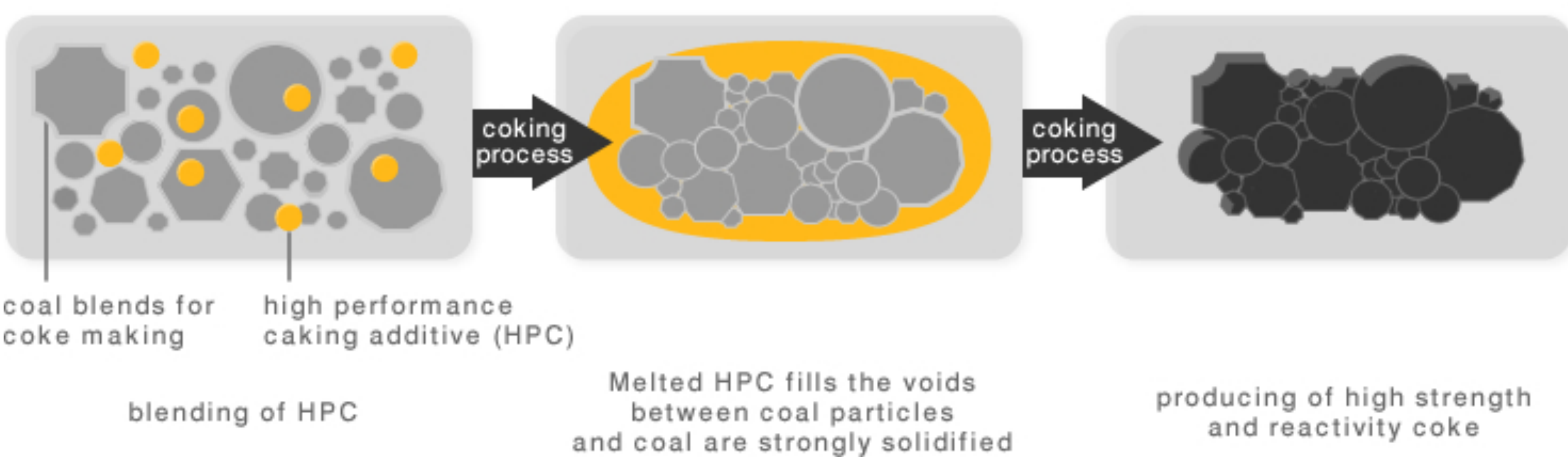
Technologies to support COURSE 50

Improvement of coke

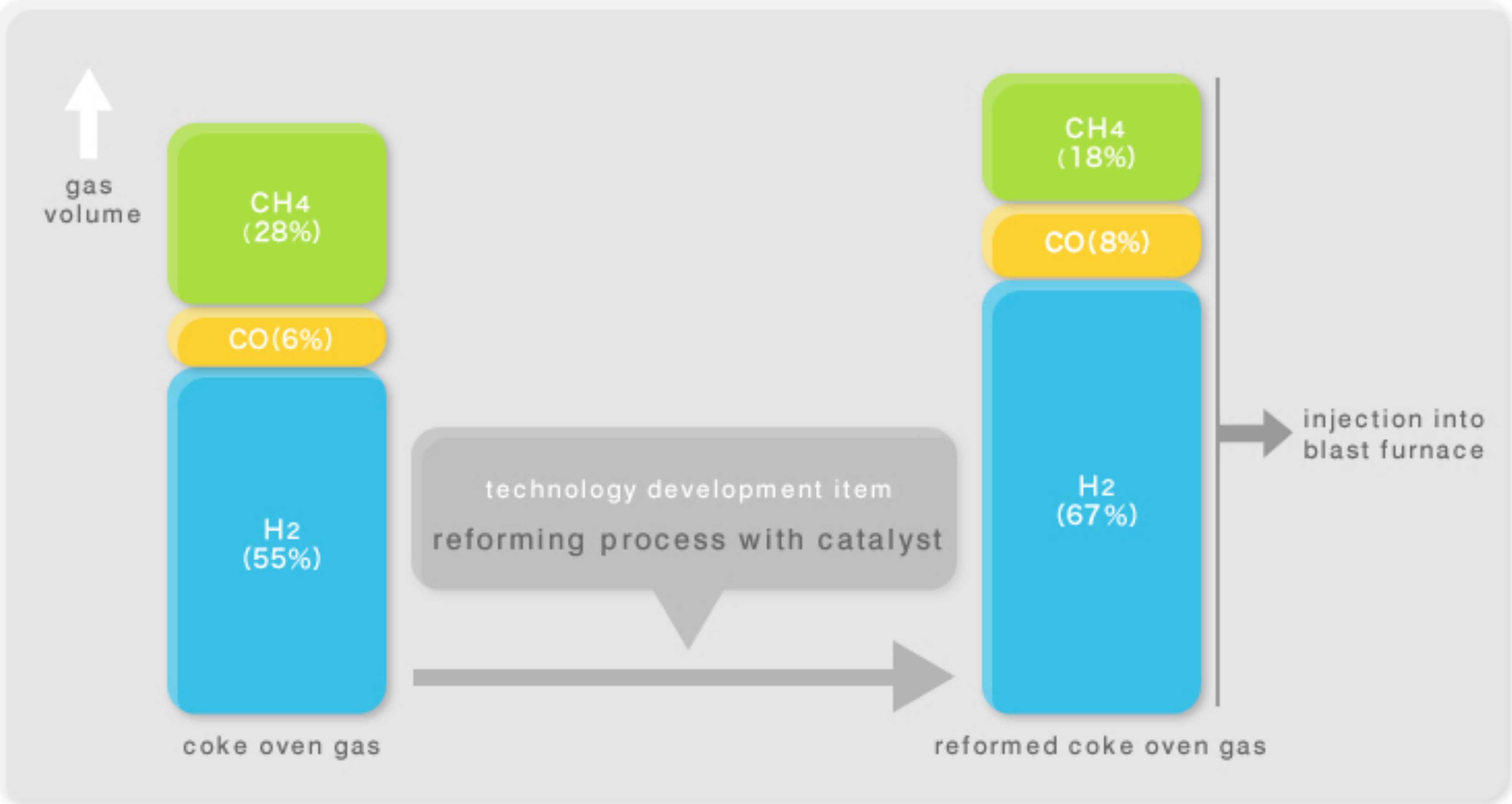
The characteristics required for coke for hydrogen reduction

It is expected that CO_2 emissions will be decreased in blast furnaces when iron ore is reduced by hydrogen contained in reformed coke oven gas, because the coke feed ratio can be lowered compared with the conventional practice. On the other hand, it is foreseen that high strength coke is required to maintain the gas permeability necessary for the reduction reaction of iron ore under reduced coke feeding rates, in blast furnaces. In addition, the endothermic reaction associated with the hydrogen reduction will decrease temperatures inside blast furnaces, which necessitates the use of coke with high reactivity. High performance caking additive(HPC) to be developed in this project will have much increased softening and melting characteristics as well as expansibility, and pack together coal particles by filling gaps in between them, realizing increased coke strength. With this effect, higher blending ratio of high reactivity coal, not in use conventionally, will be achieved, realizing the production of improved coke with high strength as well as high reactivity.

producing the strong and reactive coke that can be suited to the change of blast furnace conditions by applying the high performance caking additive(HPC)



Increase the hydrogen composition in the coke oven gas



The necessity for R&D

In case of procuring hydrogen externally to reduce iron ore in a blast furnace, CO_2 is emitted at hydrogen production sites.

Present situation

Coke oven gas, generated during coke - making process, contains hydrogen in excess of 50%. The gas is currently utilized effectively as the fuel for reheating furnaces within steel plants.

Utilization of unused energy

Enrichment of coke oven gas with hydrogen can be achieved by reforming tar contained in the gas with the utilization of unused energy within the steel plant. Injection of the hydrogen - rich reformed gas, containing CO as well, into a blast furnace can decrease the consumption of coke used for iron ore reduction.

Development of new technologies

In this project, process technology development for the tar reformation is implemented with the use of catalyst which enhances the reformation reaction, using actual coke oven gas at a steel plant.

* Catalyst: a substance which accelerates an aimed chemical reaction while it is not changed before and after the chemical reaction.

Reformed coke oven gas (hydrogen content is 60%) is fed through conventional tuyeres and upper tuyeres in the shaft of a blast furnace

In a blast furnace, iron ore is charged from the top of the furnace and the reduction gas is introduced into the lower part of the furnace. While the iron ore descends from the top to the bottom in the furnace, it transforms into iron by the reduction reaction. Hydrogen - rich coke oven gas is reformed to increase the hydrogen concentration in this R&D program, and the reformed gas is fed into the blast furnace through middle and lower tuyeres. This process can realize a more rapid, higher - efficiency and less - CO_2 emission iron reduction technology.

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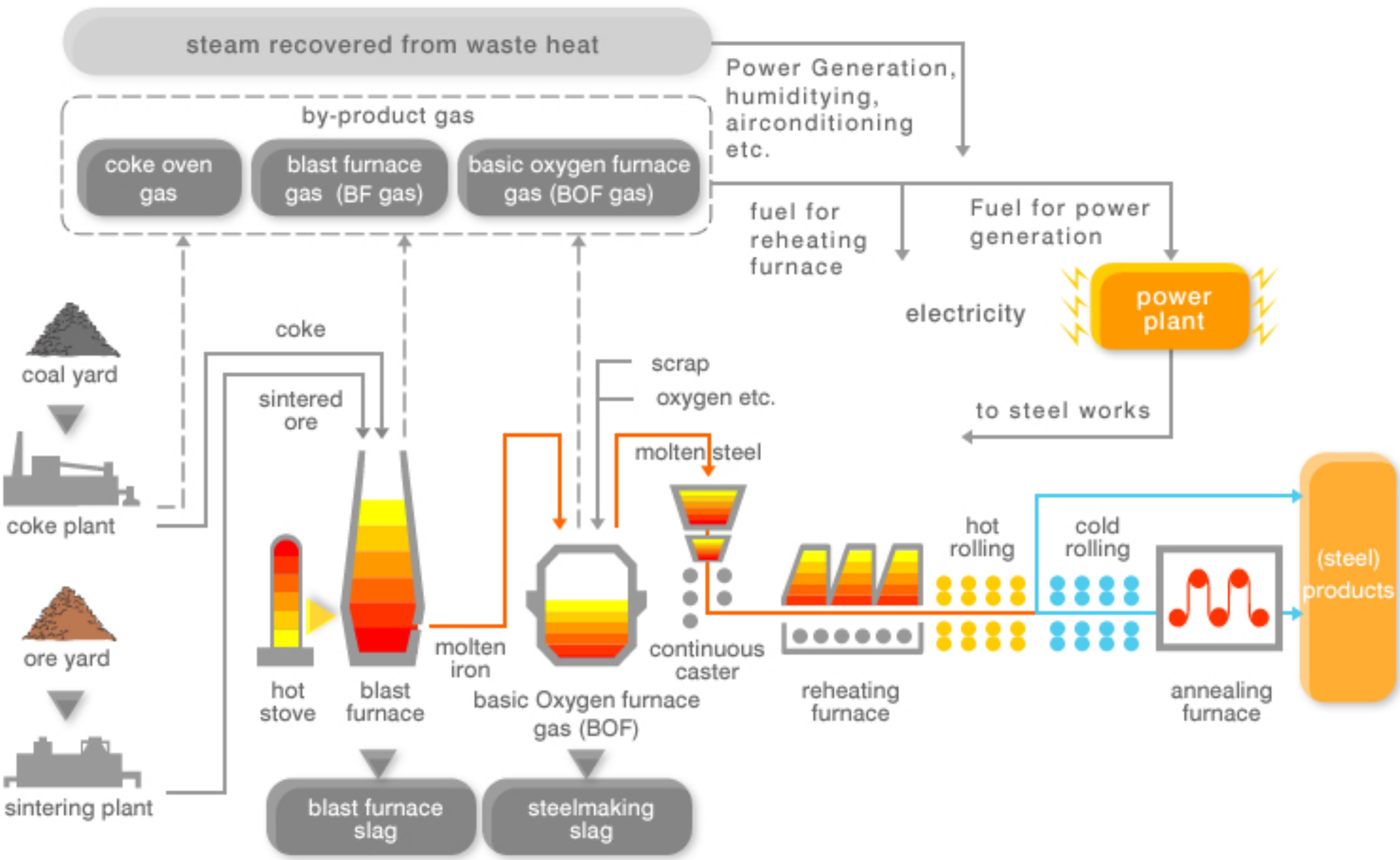
Utilization of unused waste heat

In Japan most of the waste heat generated within steel plants is already recovered as steam or electricity, and is utilized effectively. Based on these world's cutting-edge technologies for energy recovery and saving, the project will develop more advanced technologies to apply conventionally unused waste heat to CO_2 capture - separation and recovery.

Current waste heat recovery in steel works



Waste heat application for CO_2 capture - separation & recovery

Energy such as steam and electricity is required for CO_2 capture - separation and recovery - from blast furnace gas. If the energy is procured from external sources, CO_2 will be emitted at the production sites of the energy. Therefore in this project, technology development will be conducted to make use of conventionally unused waste heat that has not been utilized due to technological and/or economic difficulties.

The technologies to be developed to accomplish the aim are as follows:

- **Development of sensible heat recovery from steelmaking slag**
- **Development of Kalina cycle power generation technology**
- **Utilization of PCM, or Phase Change Materials**
- **Utilization of heat pumps**

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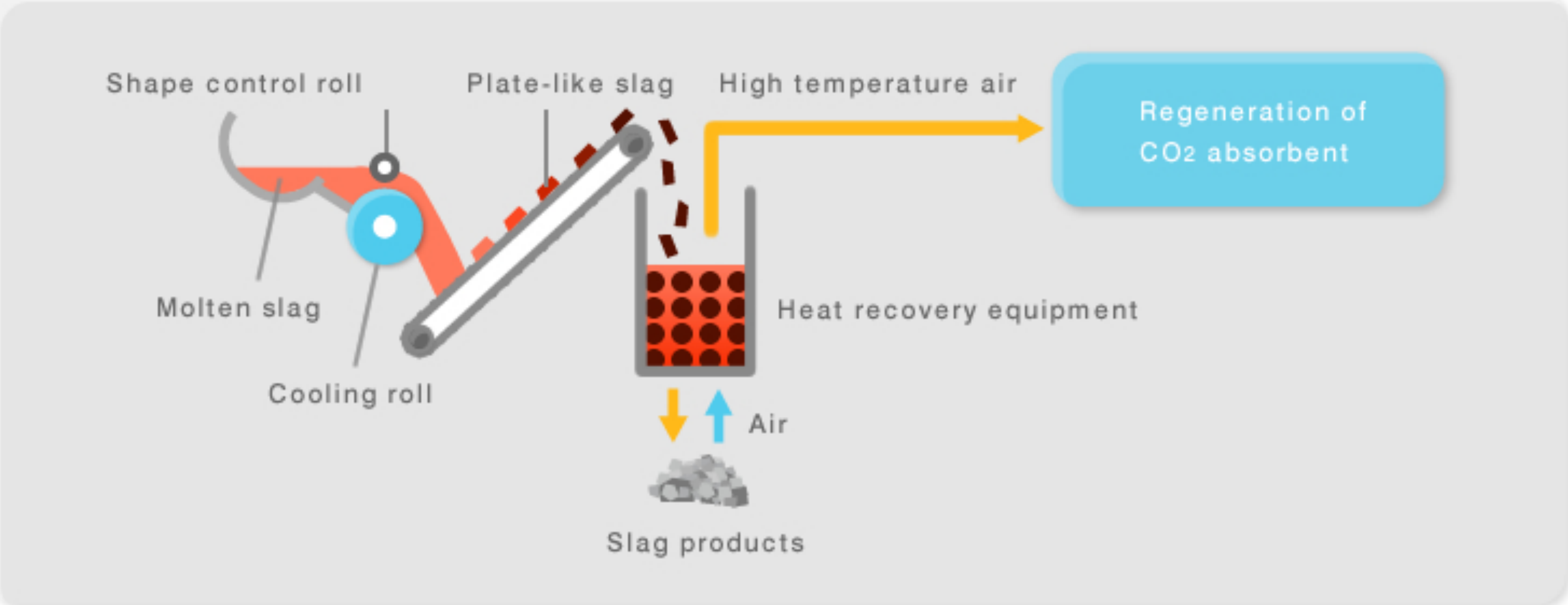
Development of sensible heat recovery from steelmaking slag

It is effective to recover and use unutilized high-temperature waste heat within a steel plant as the thermal energy required to regenerate CO_2-laden chemical absorbents by separating CO_2 from the absorbents. This project will develop a sensible heat recovery process from high-temperature steelmaking slag where molten steelmaking slag at as high a temperature as 1200 ℃ - 1600 ℃ is turned into a product. The key technologies to be developed include cooling method and shape control of slag to realize an effective sensible heat recovery system.



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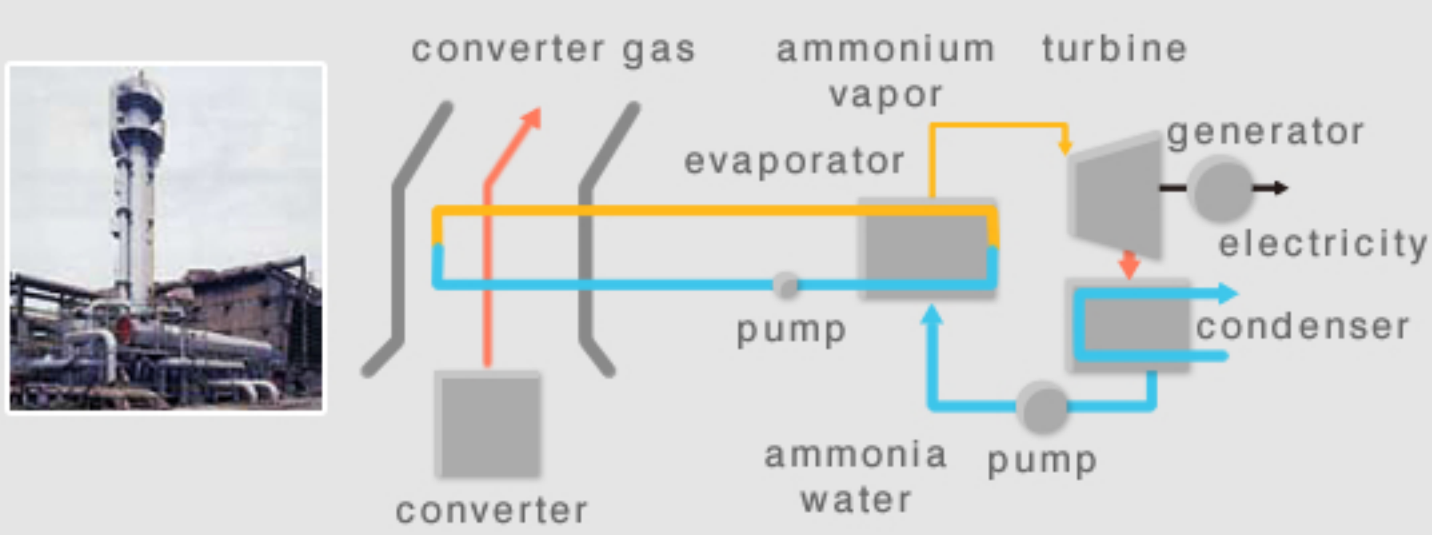
Development of Kalina cycle power generation technology

This project will develop technologies to recover electricity from waste heat to be used for CO_2 capture - separation and recovery. Kalina cycle power generation, using recovered waste heat with temperatures at around 100 ℃, has seen several practical applications around the world. However, due to its high equipment cost and low efficiency of waste heat recovery, it has not come into wide use. The technical issues to be addressed are as follows:

- **Increase of waste heat recovery efficiency through the exploration of suitable low-boiling point medium to be used for low-temperature-heat power generation systems**
- **Development of technologies to reduce size and cost of power generation equipment**

An example of Kalina cycle power generation system



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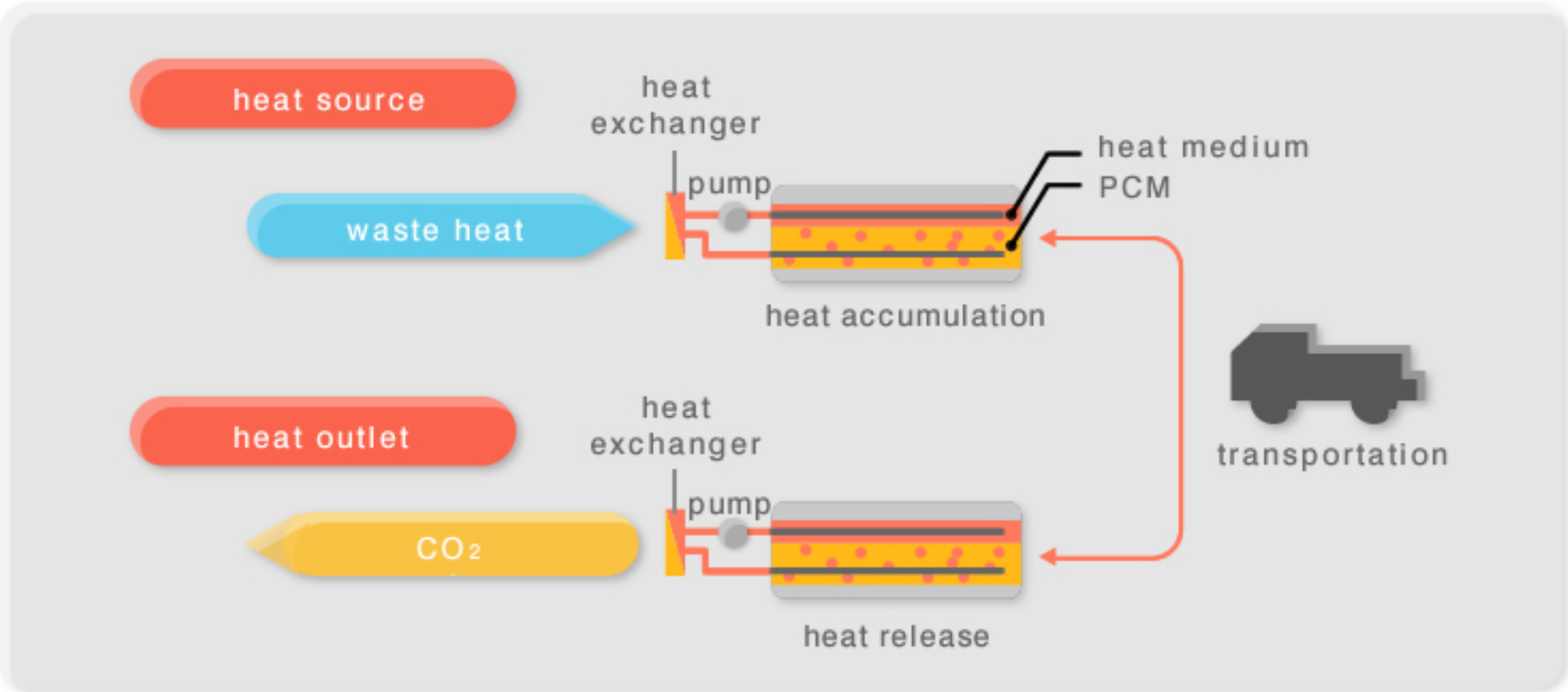
Utilization of PCM, or Phase Change Materials

Development of PCM utilization technology will be conducted to recover and accumulate unused medium to low temperature waste heat, and then transfer and discharge it, with the purpose of utilize it as thermal energy for separating CO_2 from the CO_2-laden absorbents for regeneration in the chemical absorption process.

PCM is a material capable of storing heat with high density by utilizing its latent heat of melting and solidification. Transportation of heat with reduced heat loss can be achieved if PCM is transported in a thermally insulated container. It is expected that waste heat generated intermittently and/or in small amount in a remote area can be utilized as energy for CO_2 capture - separation and recovery - by storing it within PCM.

In this project, development of technologies will be conducted for heat storage and transportation focusing on direct-heat-exchange-type PCM capable of high output, aiming at expanding the useful temperature range.



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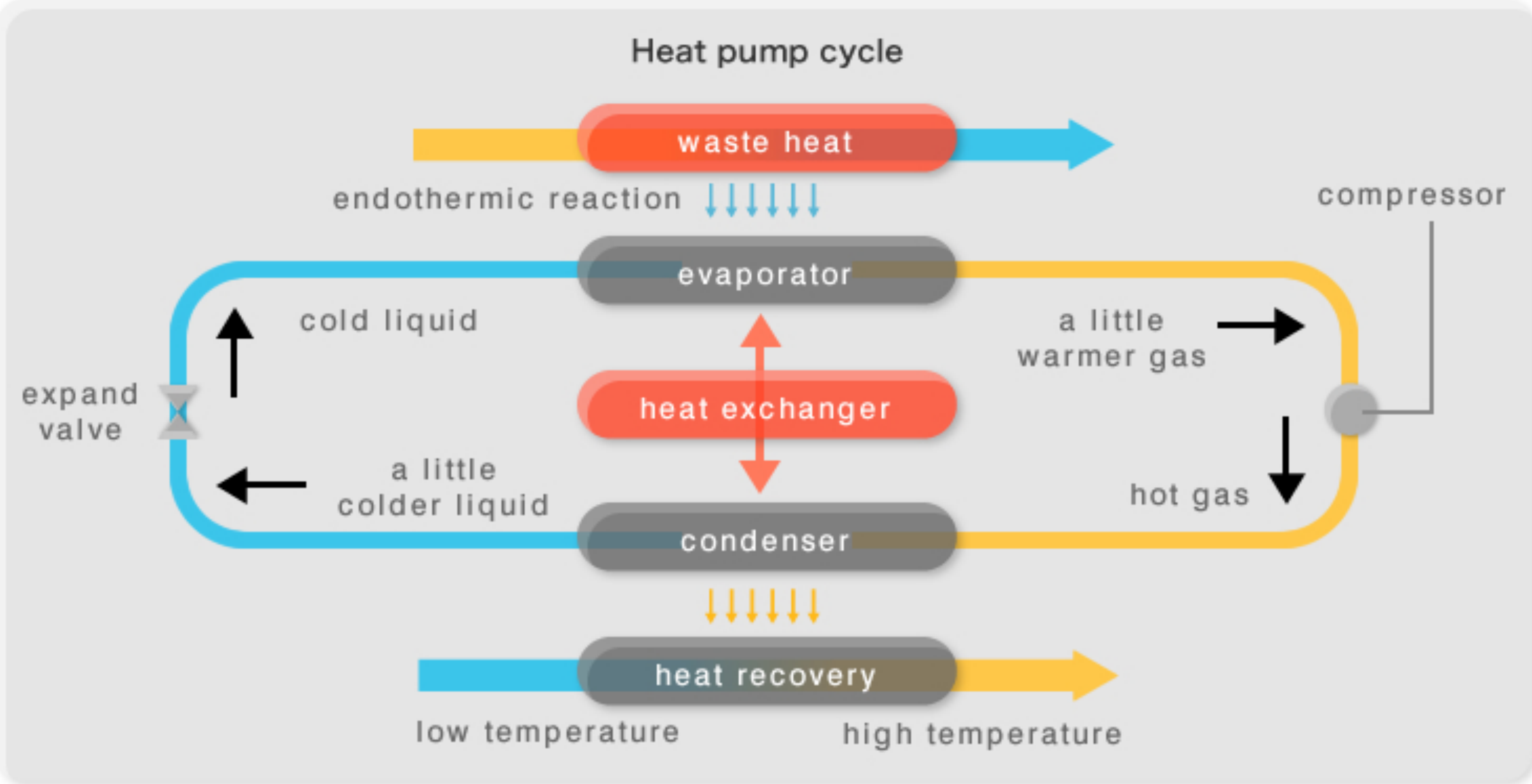
Utilization of heat pump

Development of technologies to utilize heat pumps will be implemented with a view to using medium to low temperature waste heat as heat source for the chemical absorption process for CO_2 capture. A heat pump is a device which moves heat from a heat source to a heat sink using mechanical work, mostly moving heat from a low temperature heat source to a higher temperature heat sink. A higher heat recovery efficiency is expected in the case of small increase in temperature, which is suitable for generating low pressure steam from high temperature water discharge. Heat-activated heat pumps kick in by the difference in temperature between waste heat and surrounding atmosphere, capable of generating higher temperatures without external energy inputs. Therefore heat-activated heat pumps are expected to enable the application of low temperature waste heat, currently not in use despite its abundance, in CO_2 capture - separation and recovery.


Heat pump cycle
waste heat
endothermic reaction
compressor
evaporator
cold liquid
a little
warmer gas
expand
valve
heat exchanger
a little
colder liquid
hot gas
condenser
heat recovery
low temperature
high temperature

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