HYDROGEN PRODUCTION USING **SOLID OXIDE ELECTROLYZER CELL (SOEC)** AND **SMALL MODULAR REACTORS (SMRs)**

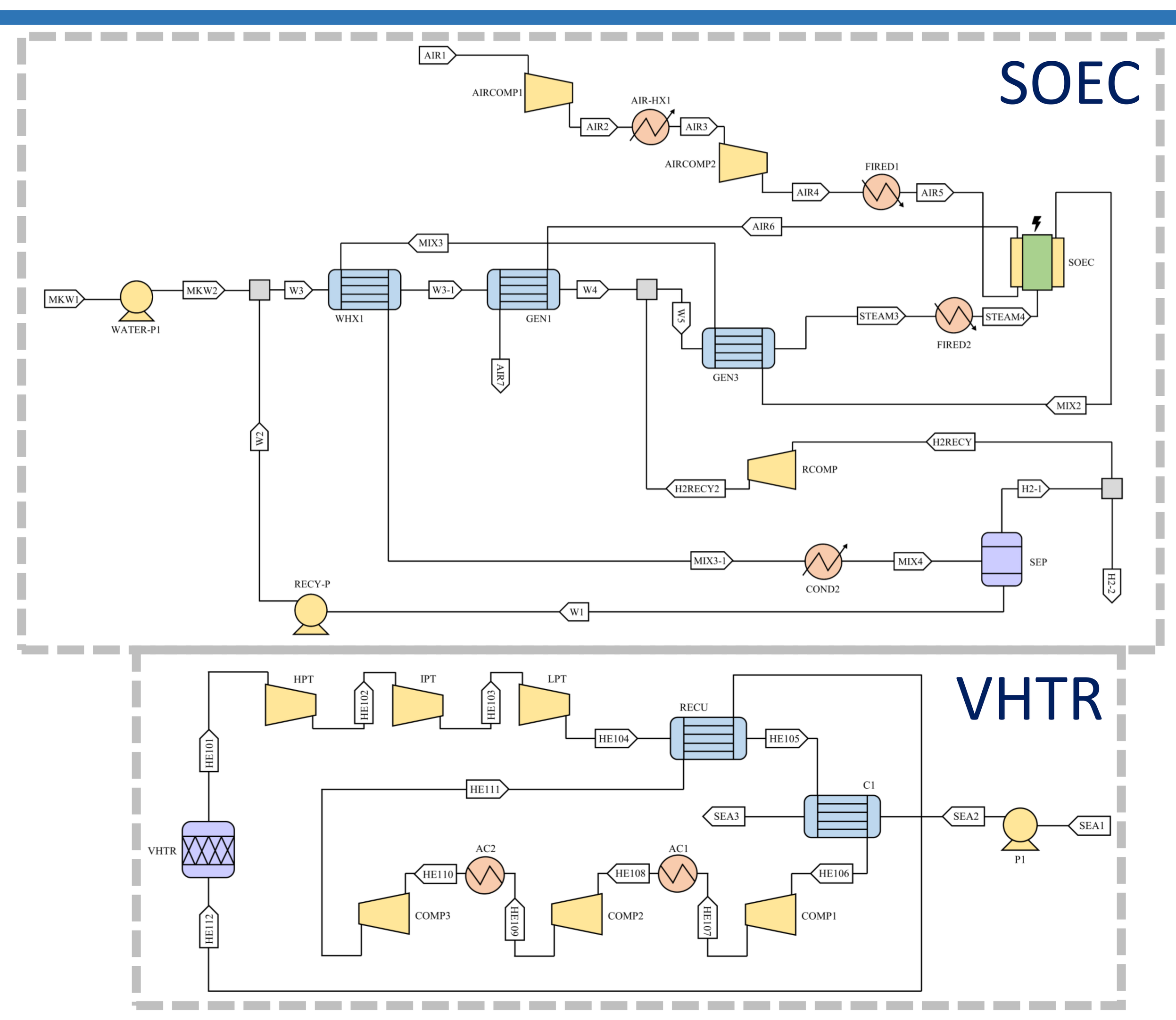
Jung Min Lee[a], Sang-il Lee[c], Deok Hoon Kye[c], Hyun Jae Park[c], Kyungtae Park[a]*, Jeeyoung Shin[b]*, Woosung Park[b]*

[a]Department of Chemical and Biological Engineering, Sookmyung Women's University, Seoul 04310, Republic of Korea
[b]Department of Mechanical Systems Engineering, Sookmyung Women's University, Seoul 04310, Republic of Korea
[c]Hyundai Engineering Co., Ltd., Seoul 03058, Republic of Korea
**Corresponding authors: ktpark@sm.ac.kr, jshin@sm.ac.kr, wpark@sm.ac.kr*

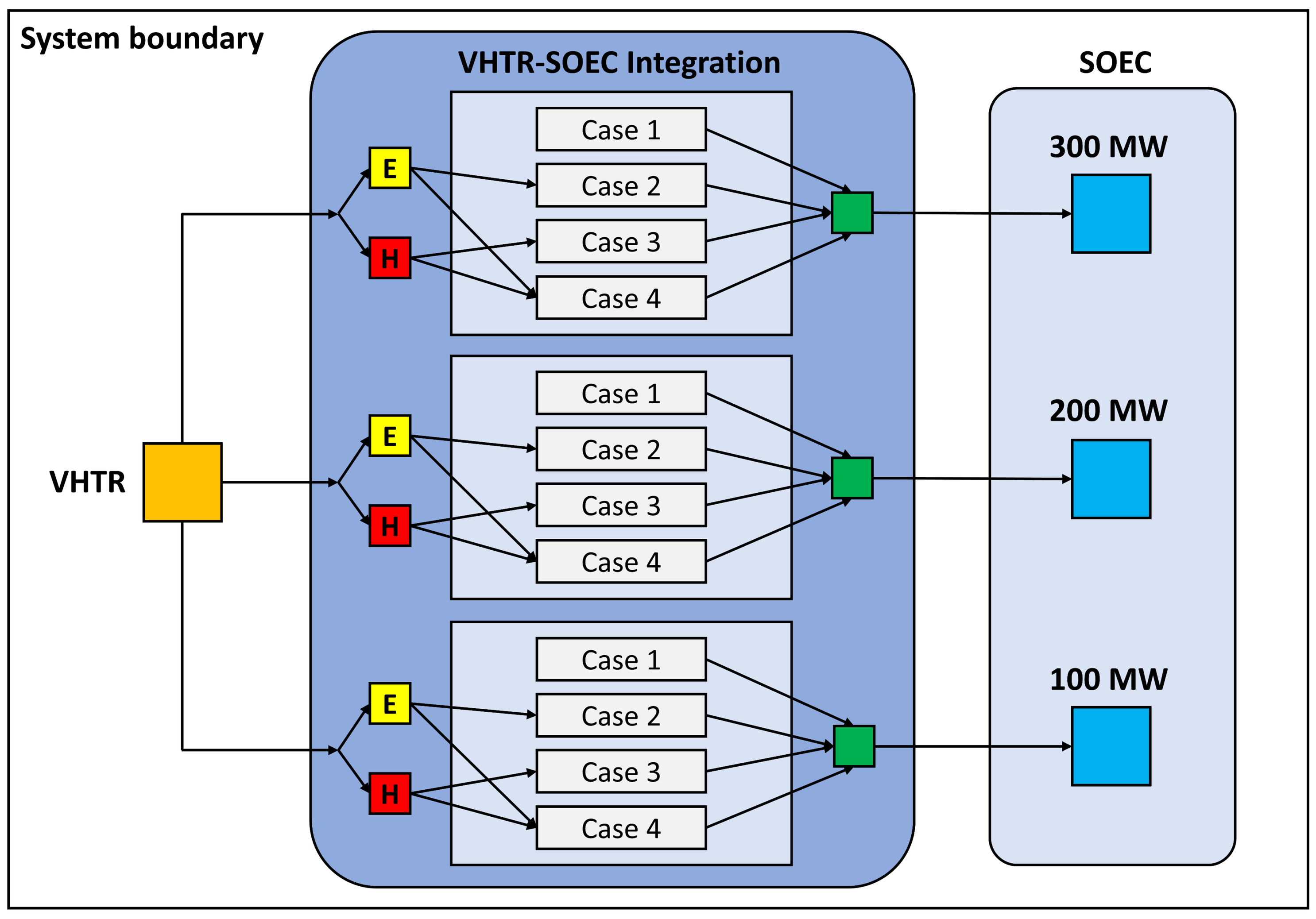
Introduction

- Hydrogen production via economic and sustainable ways is essential to contribute to carbon neutrality since carbon dioxide emission from steam methane reforming is prodigious.
- Solid Oxide Electrolyzer Cell (SOEC) is appropriate for large hydrogen production than incumbent water electrolysis methods since the cost of the PEM membrane catalyst and the operating voltage of Alkaline water electrolysis are high.
- The integrated SOEC-SMR systems can be a solution as an efficiently coupling method. One of the SMRs, Very-high Temperature Reactor (VHTR), was chosen for this study.

Flow diagram



Case studies



Methods

1. Optimization framework

- The **optimization** is performed with the PSO algorithm by interconnecting MATLAB and ASPEN PLUS V11.
- The **objective function** is defined as follows:

$$\eta_{ex} = \frac{W_{net}}{Exergy\ input}$$

where η_{ex} is exergy efficiency, W_{net} is the net electrical power generated in the VHTR cycle.

2. Exergy (Energy) Analysis

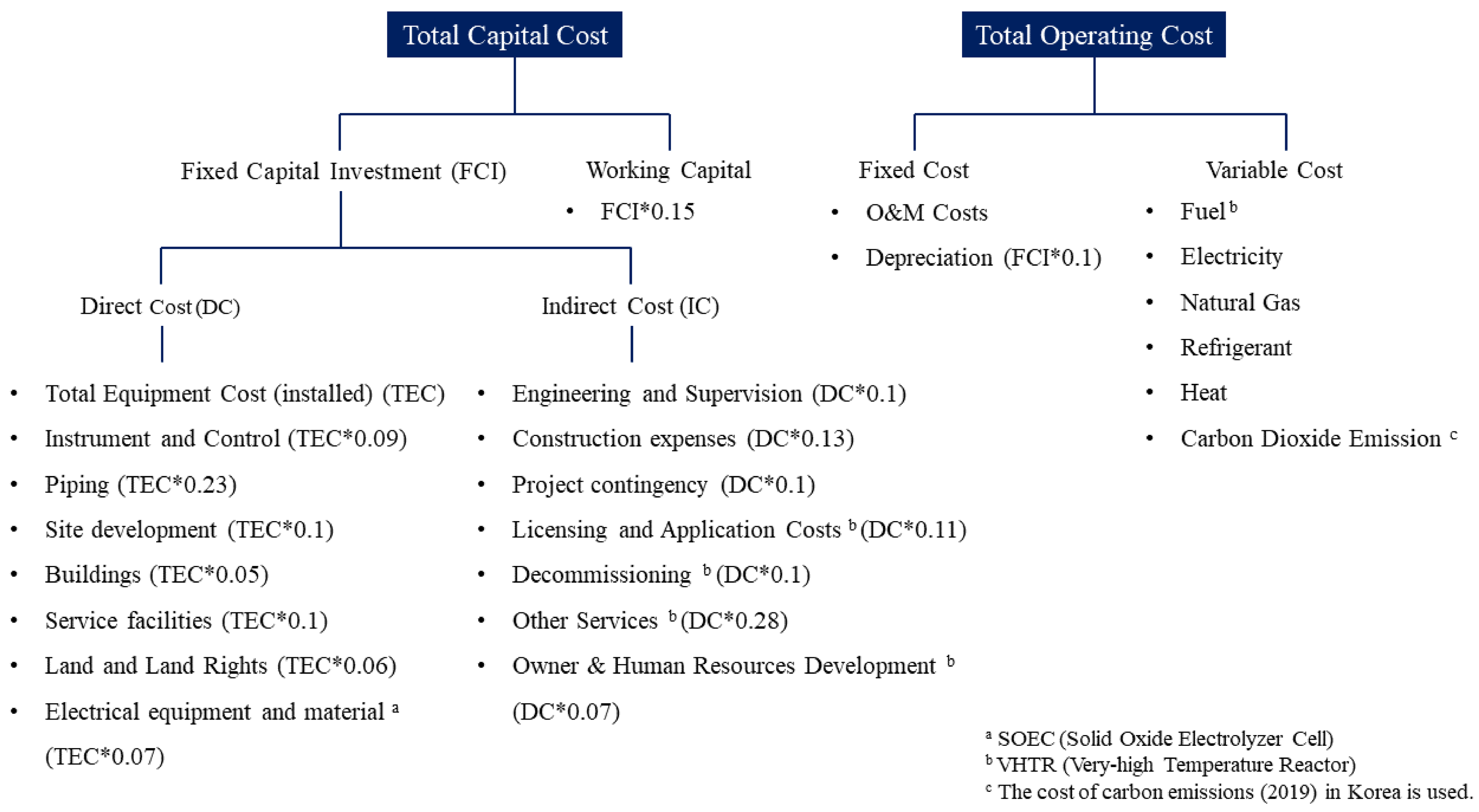
- The **total exergy** is defined as follows:

$$\dot{\psi} = \dot{m}(\varepsilon_{ph} + \varepsilon_{ch})$$

where ε_{ph} and ε_{ch} are physical exergy and chemical exergy, respectively.

3. Economic analysis framework

- The **cost estimation framework** in this study is set up as follows:



Results and Conclusion

System	η_{ex}
AlZahrani et al.	60%
Lu et al.	55%
Kowalczyk et al.	48.9%
Integrated system	36.7%

- In conclusion, the integrated system showed an exergy efficiency of 36.7%. It is caused by electrical and thermal integration with VHTR.
- The range of hydrogen production costs is 4.662-7.122 $/kg along with the electrical output of SOEC.
- The impact of electricity price on hydrogen production costs is the largest, and the range of proportion is 90.7-91.1%.
- The cost of carbon dioxide emissions is 0.008 $/kg, which is decreased 98.6% from the base case.