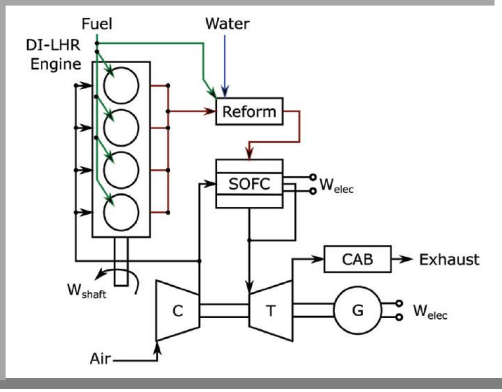


학생자율연구 연구실 및 연구 주제 소개

에너지시스템 전공 오세철

2024년 3월 7일

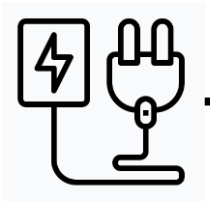
발표 개요

- 연구 배경
- 연구실 소개
- 연구 테마 및 할당 연구 주제
- 향후 연구 확장 계획

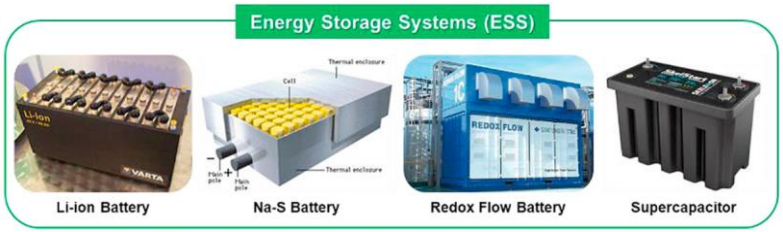
연구 배경

- The best '**sustainable**' way to use energy with **stationary** process is..

Solar (Heat, PV), wind, hydro, etc.



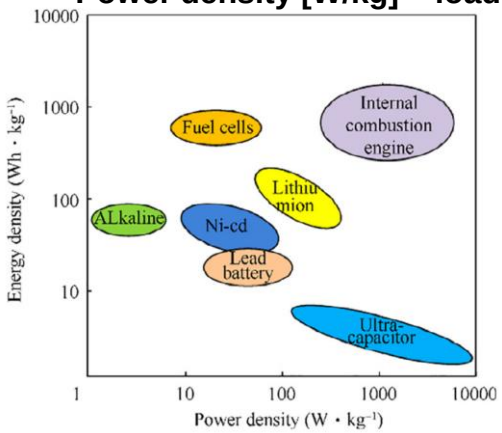
Electricity



Energy storage system & consumption

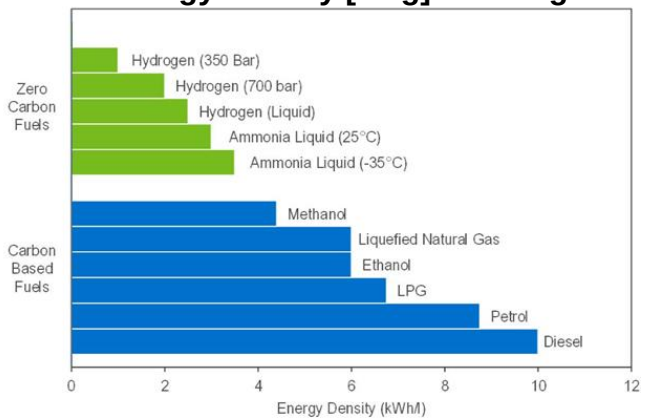
- However, in the case of **mobility**, we have to consider further…

Power density [W/kg] – load



Power and Energy density for various 'devices'

Energy density [J/kg] – mileage



Energy density for various 'fuels'

Global Policies (emission standard)

LCA: Life Cycle Assessment

연구실 소개

Net Zero Energy Conversion Laboratory

탄소중립 에너지 변환 연구실

1. Net-Zero feasibility based on **LCA** point of view
2. In-depth study of **next generation fuels** (ammonia, hydrogen) for various purposes
3. Not just **GHG emissions**, but also **harmful emissions** (NOx, SOx, PM, etc.)

Cantera

MATLAB python

Cantera 기반 시뮬레이션 + lab-scale 실험

이화여자대학교 EWHA WOMANS UNIVERSITY

세종대학교 SEJONG UNIVERSITY

한국기계연구원 KOREA INSTITUTE OF MACHINERY & MATERIALS

한국에너지기술연구원 KOREA INSTITUTE OF ENERGY RESEARCH

HYUNDAI MOBIS

SK 이노베이션

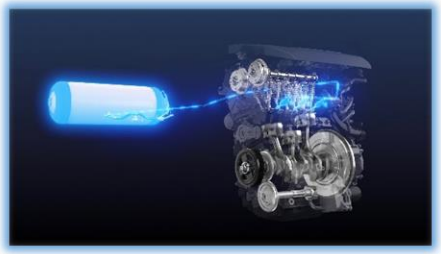
현대중공업 KSOE 한국조선해양

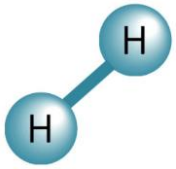
다양한 기관과의 협업 진행 예정

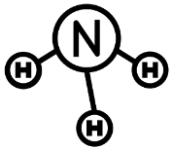
연구 테마

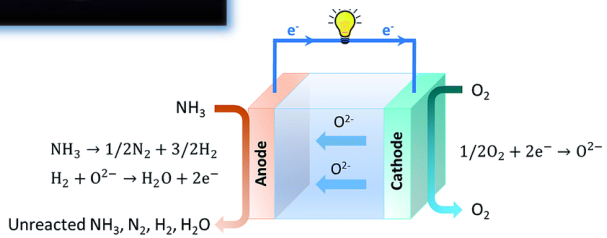
HILS: Hardware-In-the-Loop Simulation

Clean fuel-based energy conversion – combustion and electrochemical basis

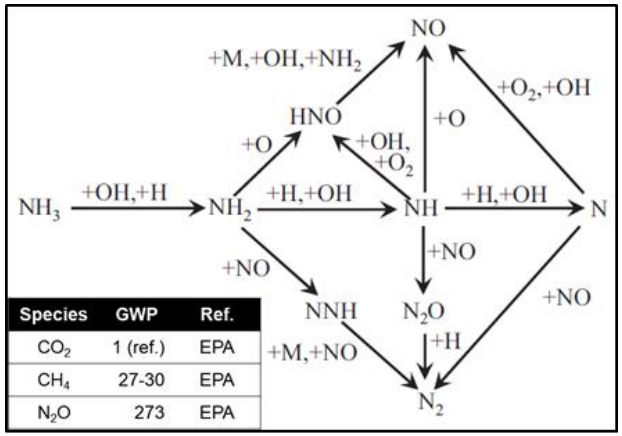








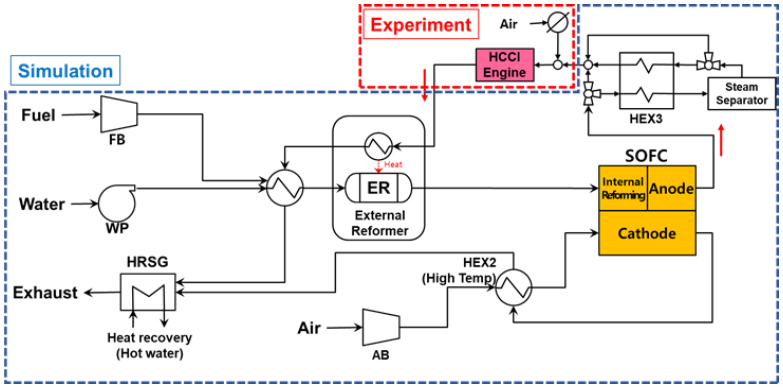
Clean fuel-based energy conversion devices



Species	GWP	Ref.
CO_2	1 (ref.)	EPA
CH_4	27-30	EPA
N_2O	273	EPA

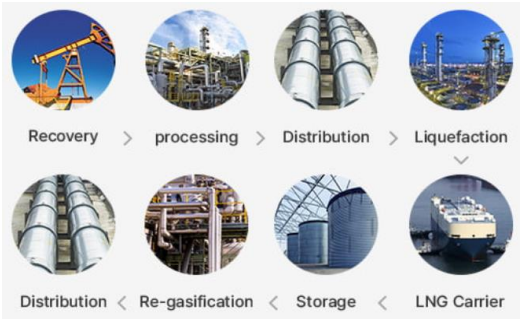
Reducing emissions from energy conversion

Thermodynamic system modeling and analysis (HILS)

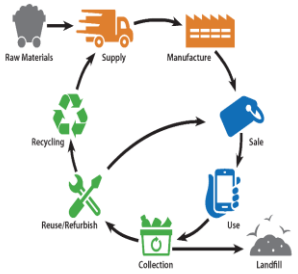


Fuel cell distributed power generation system – 0D modeling with exp. data

Life Cycle Analysis for various fuels and powertrains



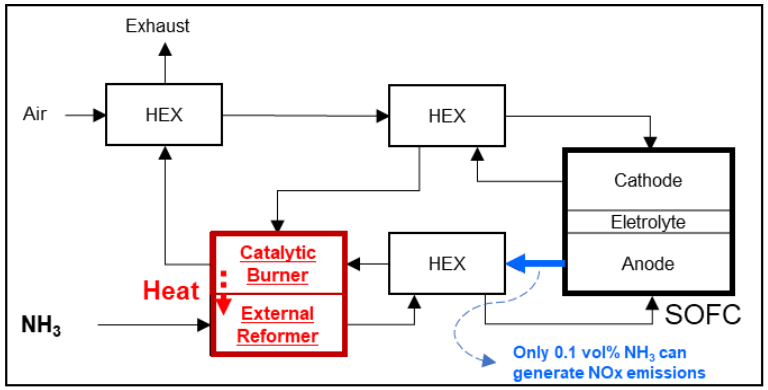
H_2 and NH_3 Life Cycle Assessment



Recycling wasted battery

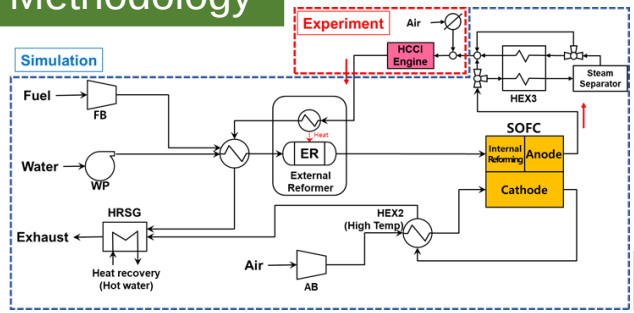
연구 주제 1

- 암모니아 SOFC 연료전지 시스템 모델링 – 촉매연소 실험 결과 적용 (HILS)



- Cantera 기반 암모니아 SOFC 연료전지 시스템 0D 모델링
- 암모니아 산화 촉매 NOx 측정 실험 결과 기반 시스템 운전점 예측 시뮬레이션

Methodology



MATLAB SIMULINK

Cantera

LabVIEW

Configuration of fuel cell system modeling (example from former study)

Flow reactor experiment setup for decomposition and oxidation of ammonia

- System **0D modeling** (SOFC, BoP, heat exchanger, etc.) via **Cantera** toolbox and MATLAB software
- Adopting experimental data with Labview-based DAQ

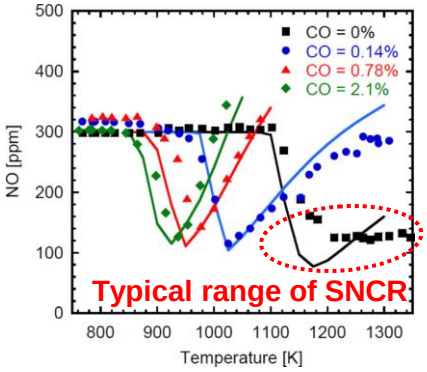
System analysis

- Customizing catalyst-support materials and test
  - ➔ Reforming ratio (i.e. duty) and decomposition T
  - ➔ NOx selectivity, especially N_2O pathway

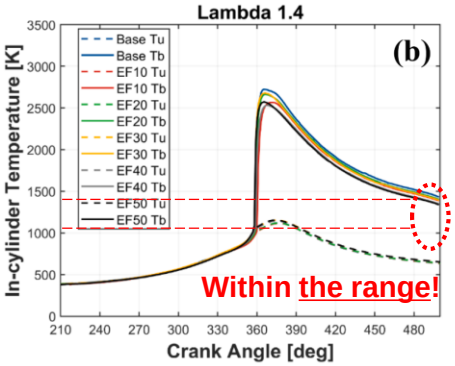
Catalytic oxidation and reforming exp. (main BoP)

SCR: Selective Catalytic Reduction
SNCR: Selective Non-Catalytic Reduction

▪ 선박용 암모니아-천연가스 엔진 SNCR 시뮬레이션



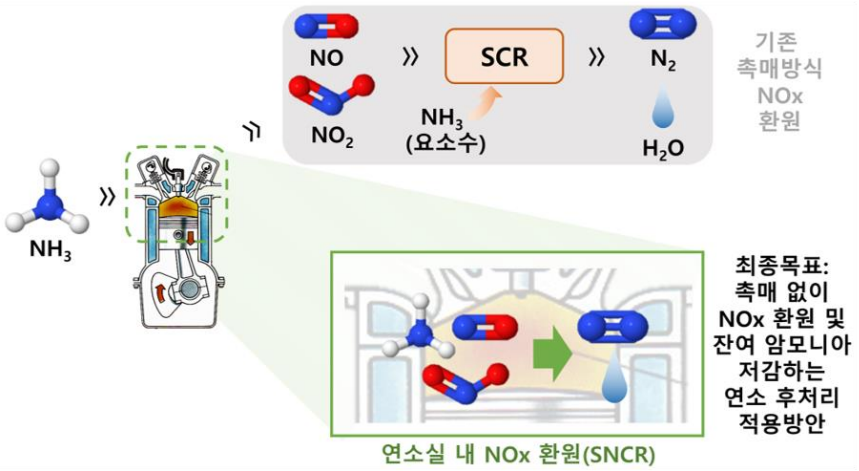
Examples of SNCR with CO existence



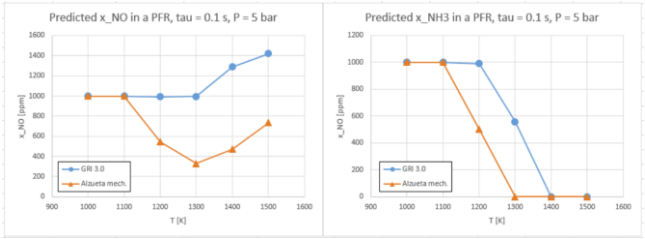
In-cylinder temperature profile from engine exp.

- Cantera 기반 천연가스-암모니아 선박 엔진 연소 – 배기 행정 모사 시뮬레이션
- 촉매 없는 환경에서의 NOx 환원 (암모니아에 의한) 가능성 및 배출가스 동시 저감 가능성 검증

Methodology – 1st step (modeling and sim.)



1. Find the proper mechanism that explains exp. results.



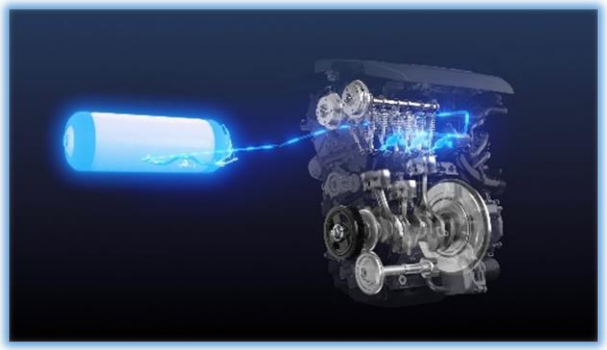
0D simulation results (GRI 3.0 mech. vs. Alzueta's mech.)

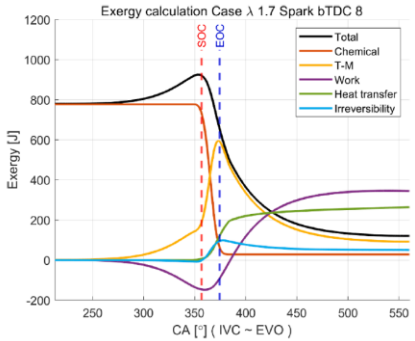
2. Develop 0D model of powertrain. (engine / gas turbine / etc.)
3. Find the condition that ammonia can be exhausted **intentionally** and SNCR occurs.

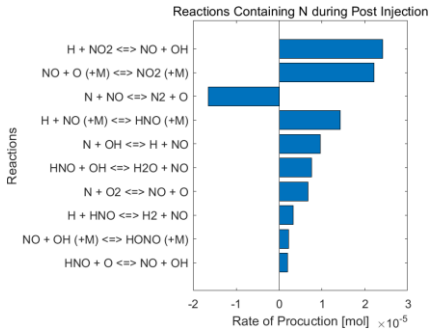
DL: Deep Learning

연구 주제 3,4

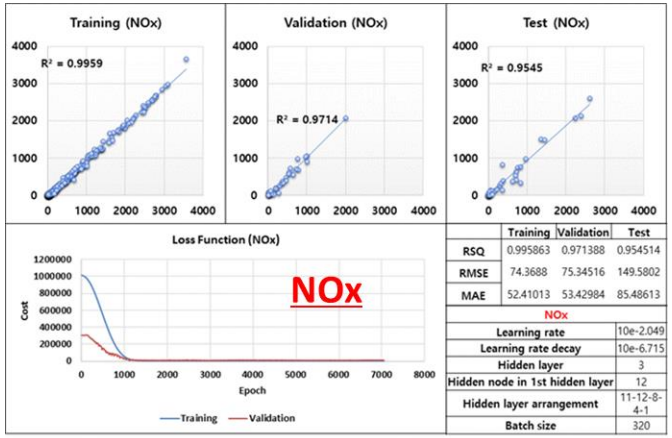
- 차량용 수소 엔진 (H_2ICE) 질소산화물 환원을 위한 수소 후분사 시뮬레이션







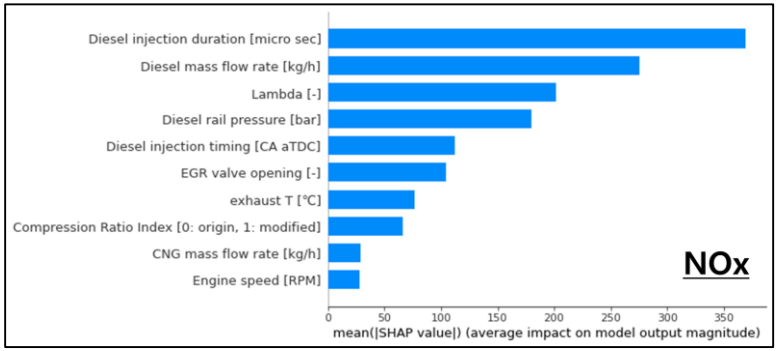
- 디젤-천연가스 발전기 빅데이터 기반 연소/배기 예측 딥러닝 모델 개발



	Training	Validation	Test
RSQ	0.995863	0.971388	0.954514
RMSE	74.3688	75.34516	149.5802
MAE	52.41013	53.42984	85.48613

NOx	
Learning rate	10e-2.049
Learning rate decay	10e-6.715
Hidden layer	3
Hidden node in 1st hidden layer	12
Hidden layer arrangement	11-12-8-4-1
Batch size	320

NOx prediction by using DL model



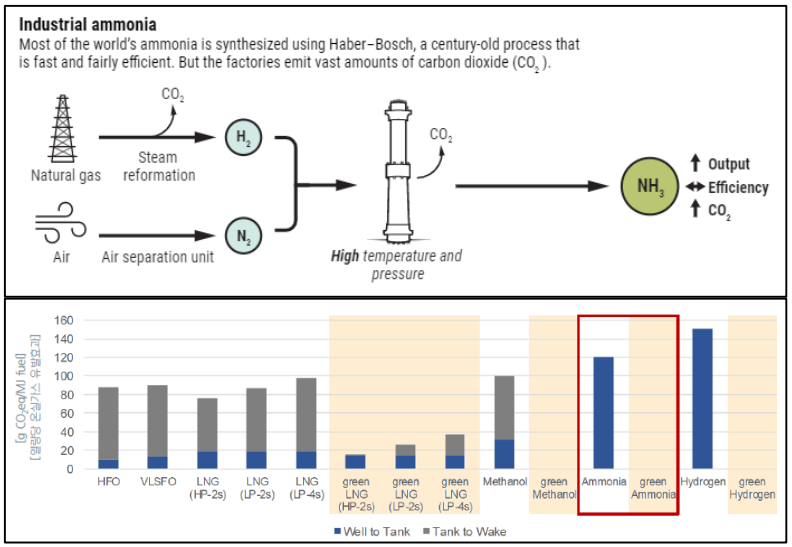
XAI (Explainable AI) SHAP analysis

LCA: Life Cycle Assessment

향후 연구 확장 계획

Idea level

- **LCA** of ammonia for maritime propulsion system



Source: KSOE, Kormarine conference 2022

- Minimizing its GHG emissions through Well-to-Tank (WtT) and Tank-to-Wake (TtW) processes
- Blue ocean and hot issue in maritime field
- Attempts to use LCA contents for education

Idea level

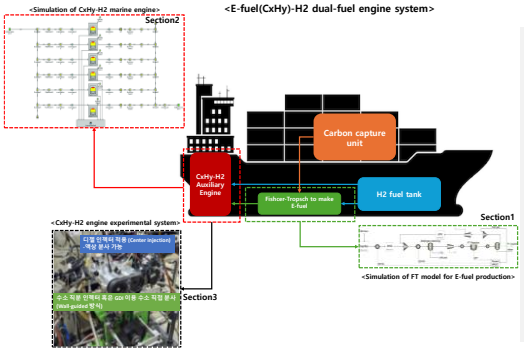
- Minimizing thermal runaway of **wasted battery recycling**

<Wasted battery>

- Higher demands on **wasted battery recycling** due to the electrification.
- Minimizing **thermal runaway** for various types of battery
- Planning **new project** with already-developed consortium

Idea level

- Carbon capture & **E-fuel** generation for maritime propulsion



- Simultaneous capture & generation of carbon dioxide and e-fuel for maritime operation