# High-Efficiency Ammonia Production from Water and Nitrogen


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## Overview

### Project Vision

The project aims to design and implement advanced components (e.g. catalyst and membrane) to transform the efficiency of electrochemical synthesis of ammonia (ESA) using air, water and renewable energy.

### Project Impact

The proposed project is anticipated to significantly increase the efficiency of ESA at an appreciable current density; it may ultimately lead to the reduction of ammonia production cost by 30% compared to conventional Haber-Bosch process.

### Innovation

- High-performance selective catalysts to boost ammonia synthesis while inhibiting hydrogen evolution
- Durable high-temperature alkaline membranes (>100 ℃) to promote the ammonia production reaction
- State-of-the-art electrolyzer cell design to maximize the ammonia production efficiency

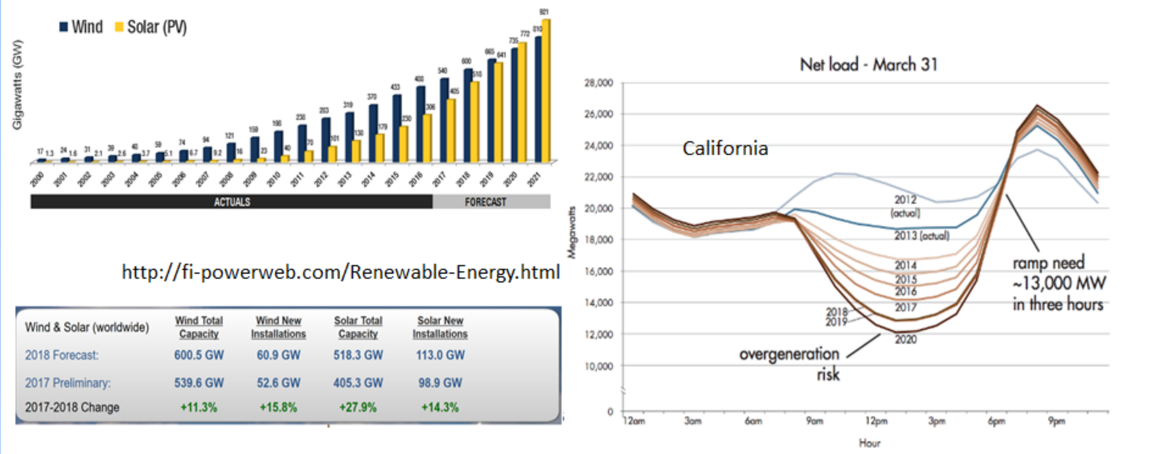
| Institute | Tasks | Timeline |
|---|---|---|
| SUNY | $N_2$ Reduction Catalyst | Q1-Q6 |
| UD | Alkaline Membranes | Q1-Q6 |
| NREL | Cost Analysis | Q1-Q8 |
| GINER | MEA Design and Test | Q3-Q12 |

| Metric | State of the Art | Proposed |
|---|---|---|
| *Ammonia production rate (mol/h-cm²)* | *$10^{-5}$* | *$10^{-4}$* |
| *Faradaic efficiency* | *30%* | *50%* |
| *Current Density (mA/cm²)* | *25* | *150* |

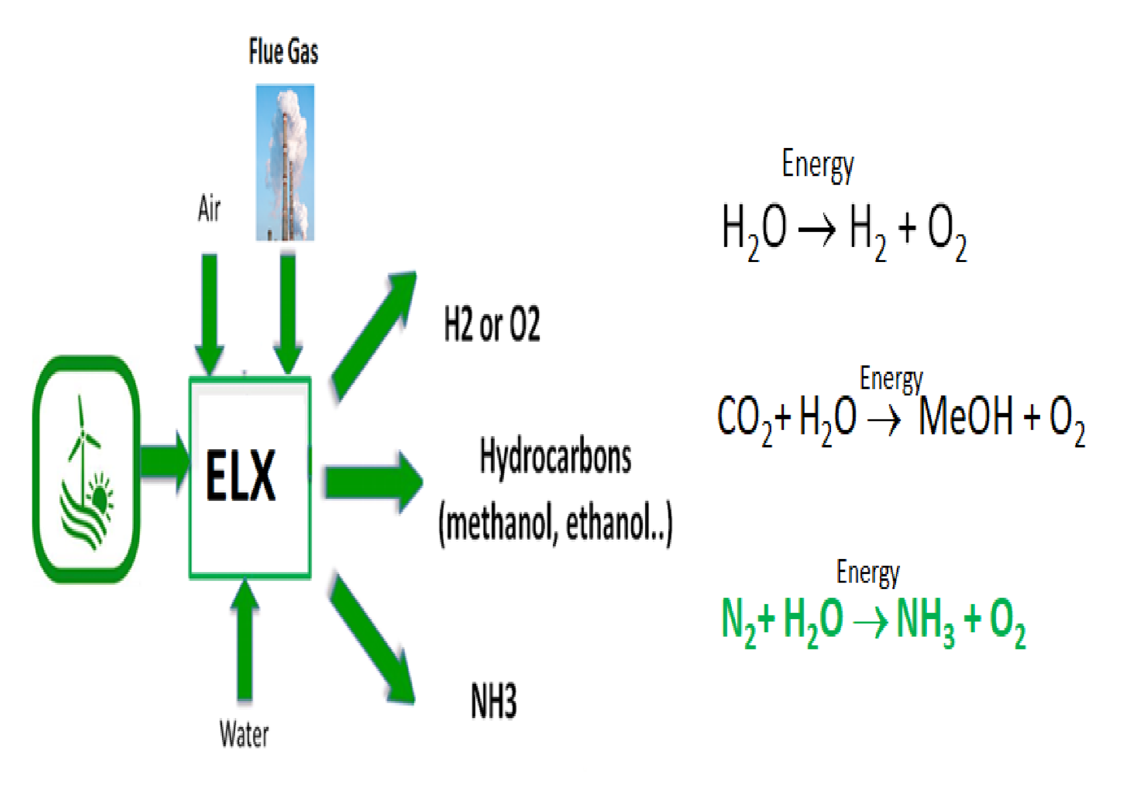
### Tech-to-Market strategy

- Long-term focus: automotive sector as liquid hydrogen carrier
- 1st market: Wind power; 2nd market: Liquid fertilizers
- Licensing / partnership with renewable farms and distributed fertilizer plants

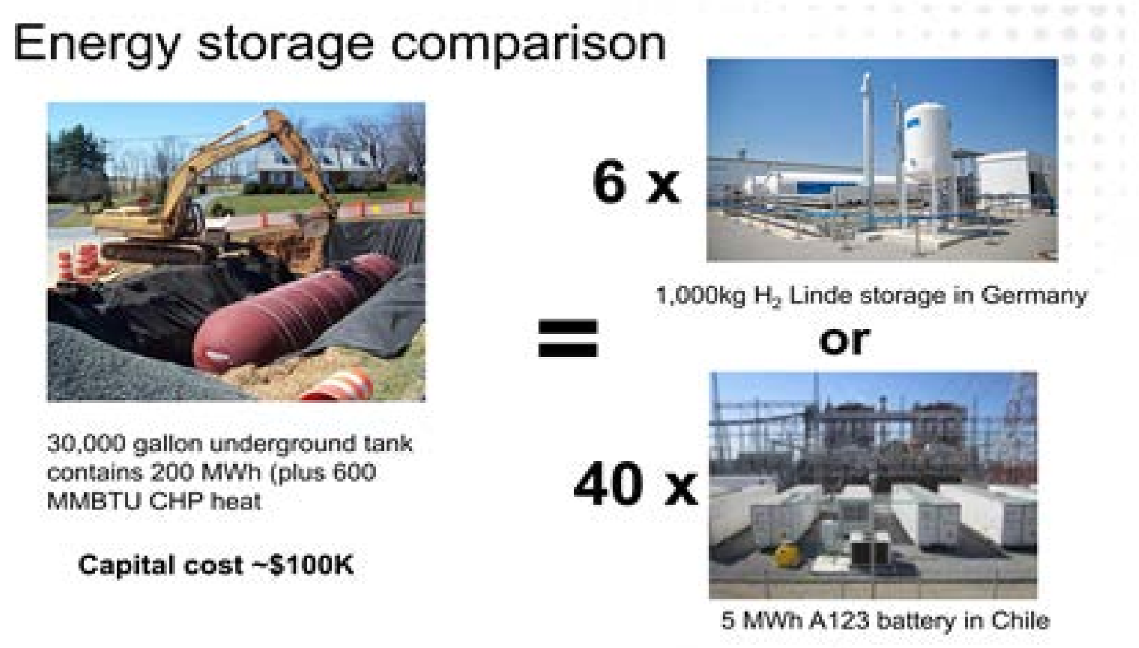
## Motivation




- Renewable Energy installations Increase tremendously over past 20 years
- Excess of renewable electricity during off-peak hours causes grid interruption



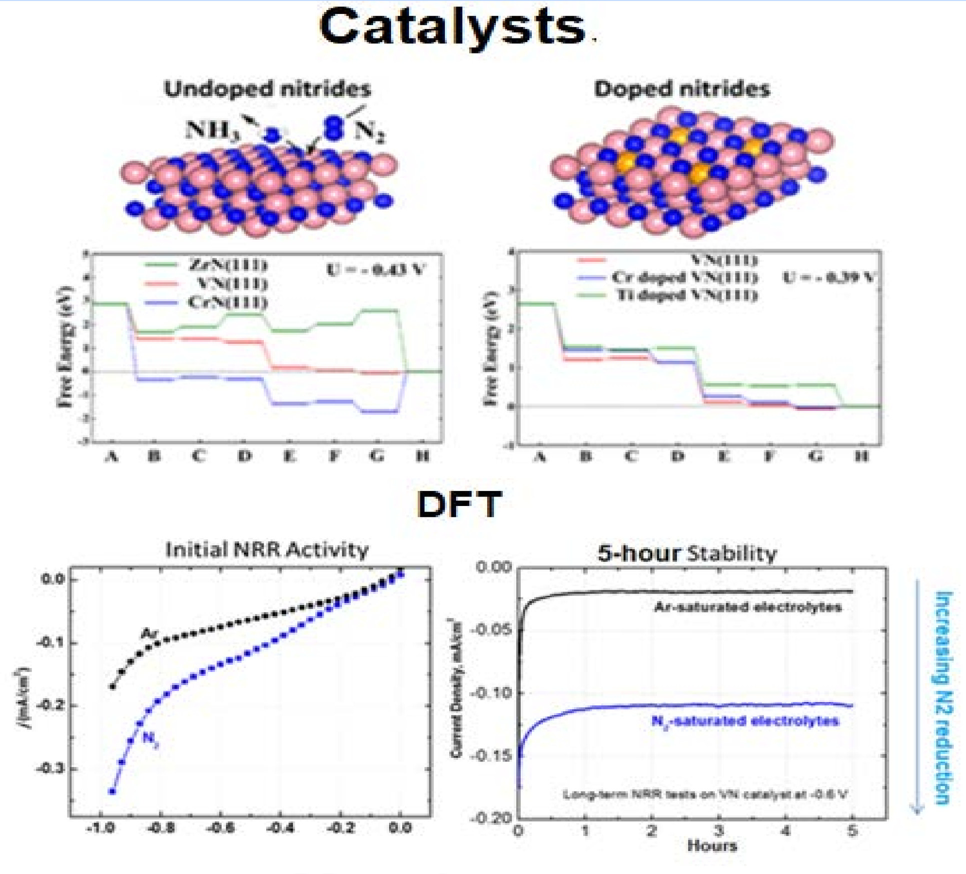

- Converting renewable energy to fuels or using air, water or wastes

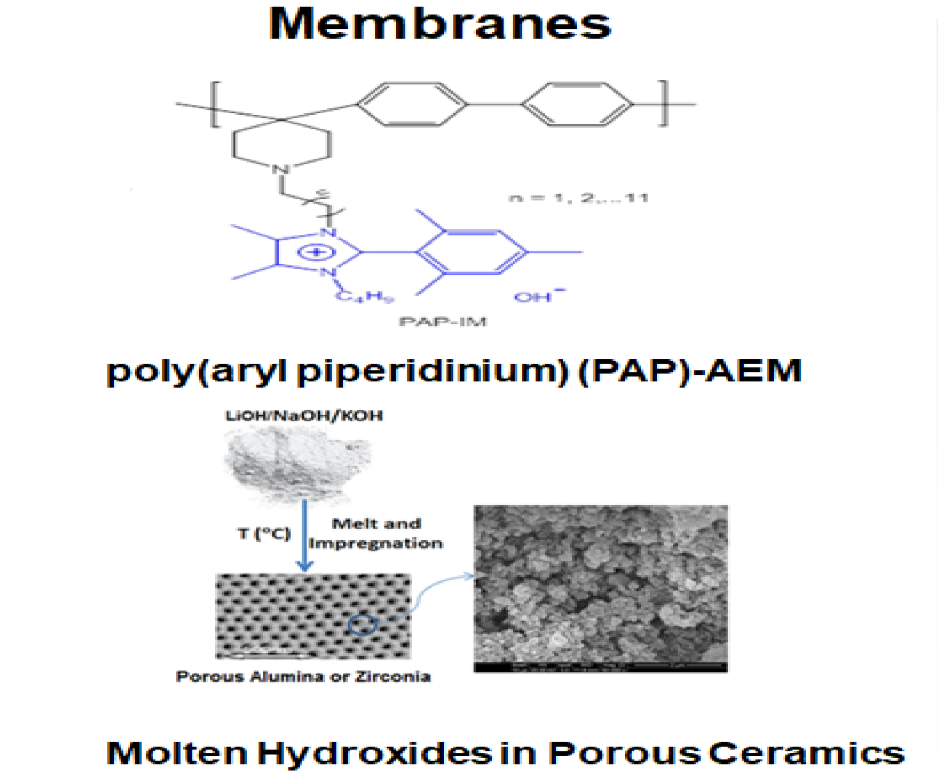



Soloveichik, H2 @scale at NREL, 2016

## Approach

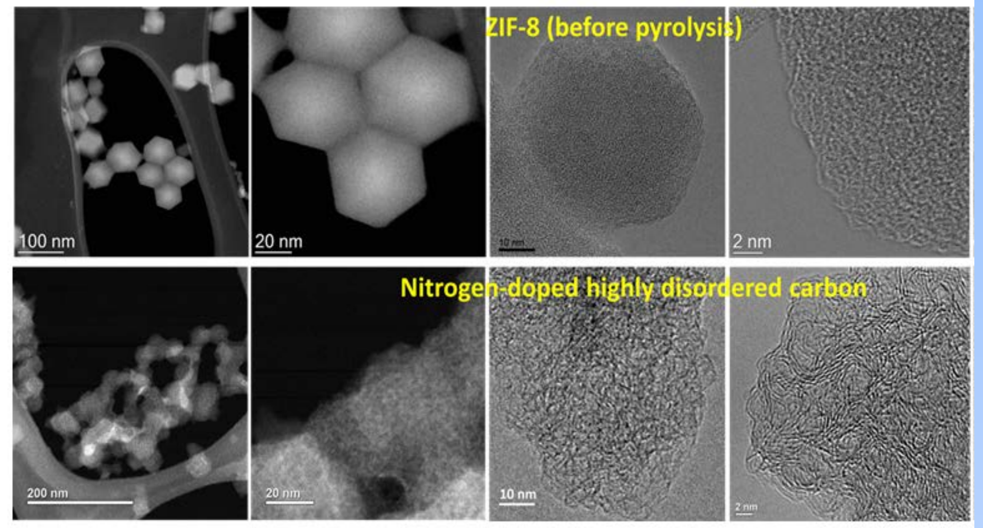
$NH_3$ detection: Ion Chromatography

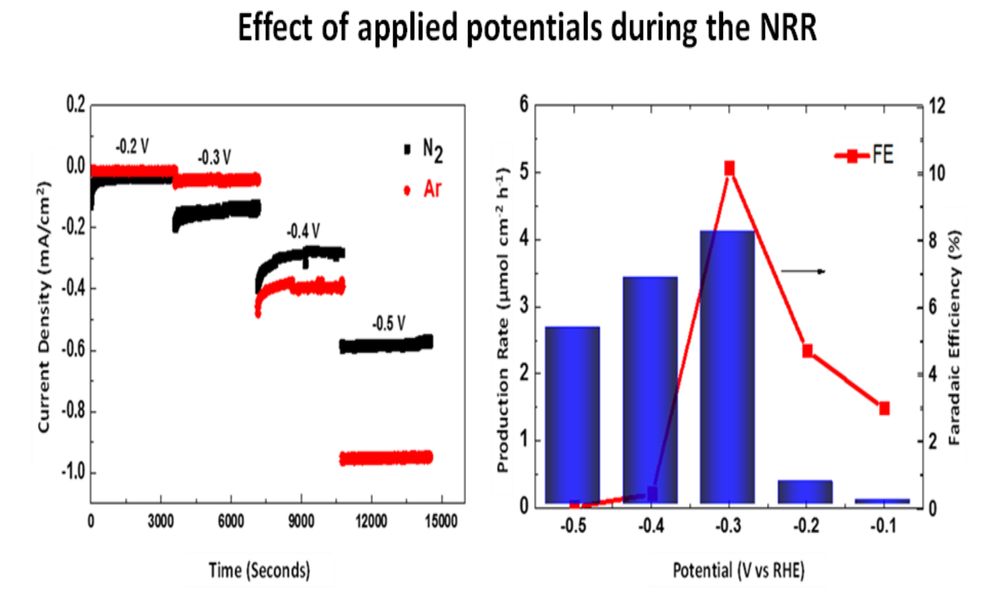


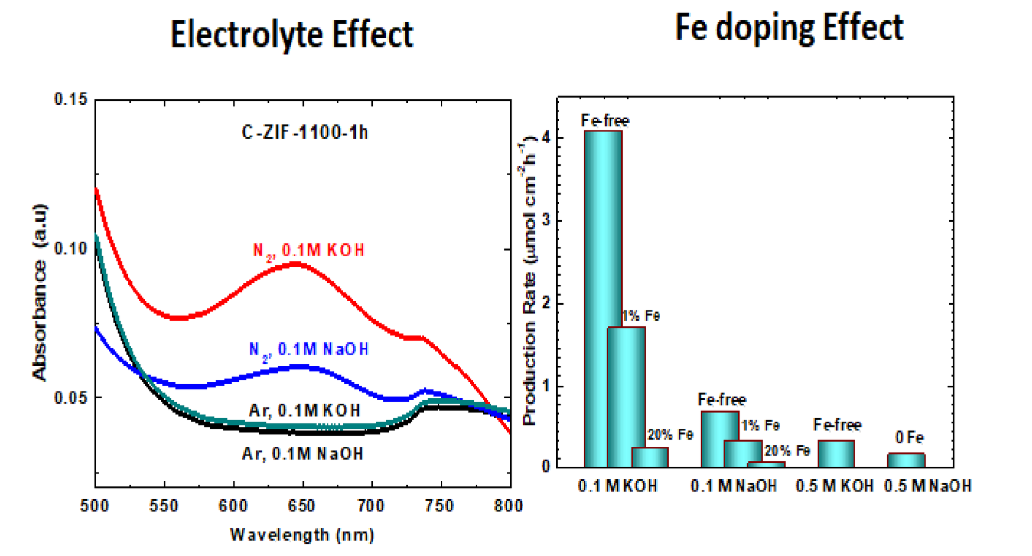

## Accomplishments

Synthesis of nanoporous and highly disordered carbon from ZIF-8



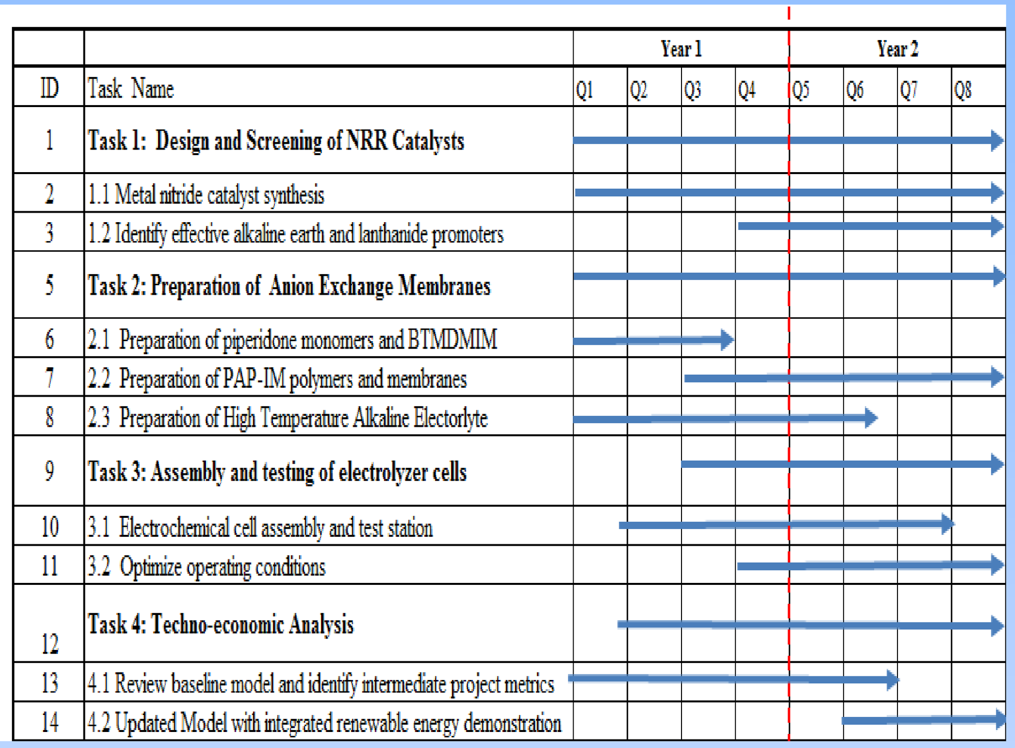



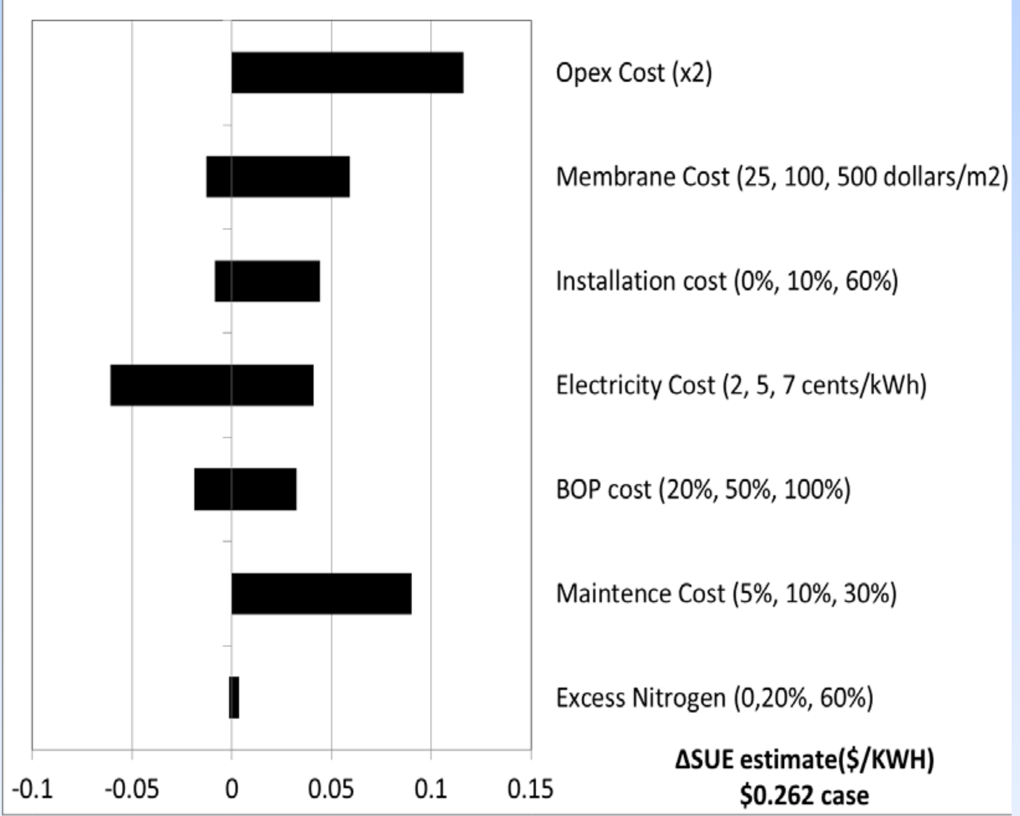

- ZIF-8-1100-1h has the best activity and the highest FE at -0.3 V *vs.* RHE;
- Current density in Ar is higher than $N_2$ at more negative potentials; HER activity may be different in $N_2$ and Ar.




- KOH is more favorable over NaOH for the NRR during the $NH_3$ synthesis
- Introduction of Fe doping compromises the NRR activity, leading to reduced production rates

## Summary





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