



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 °C) to promote the ammonia production reaction
- State-of-the-art electrolyzer cell design to maximize the ammonia production efficiency

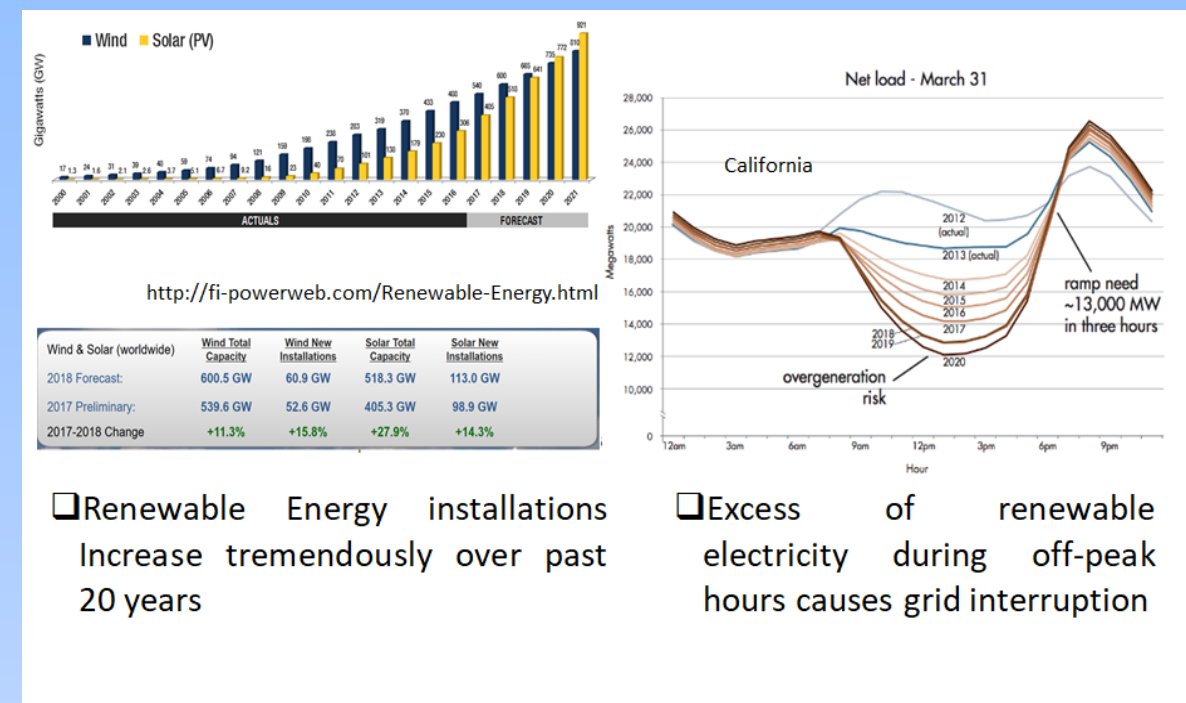
Institute	Tasks	Timeline
SUNY	N ₂ Reduction Catalyst	Q1-Q6
UD	Alkaline Membranes	Q1-Q6
NREL	Cost Analysis	Q1-Q8
GINER	MEA Design and Test	Q3-Q12

Metric	State of the Art	Proposed
Ammonia production rate (mol/h-cm ²)	10 ⁻⁵	10 ⁻⁴
Faradaic efficiency	30%	50%
Current Density (mA/cm ²)	25	150

Tech-to-Market strategy

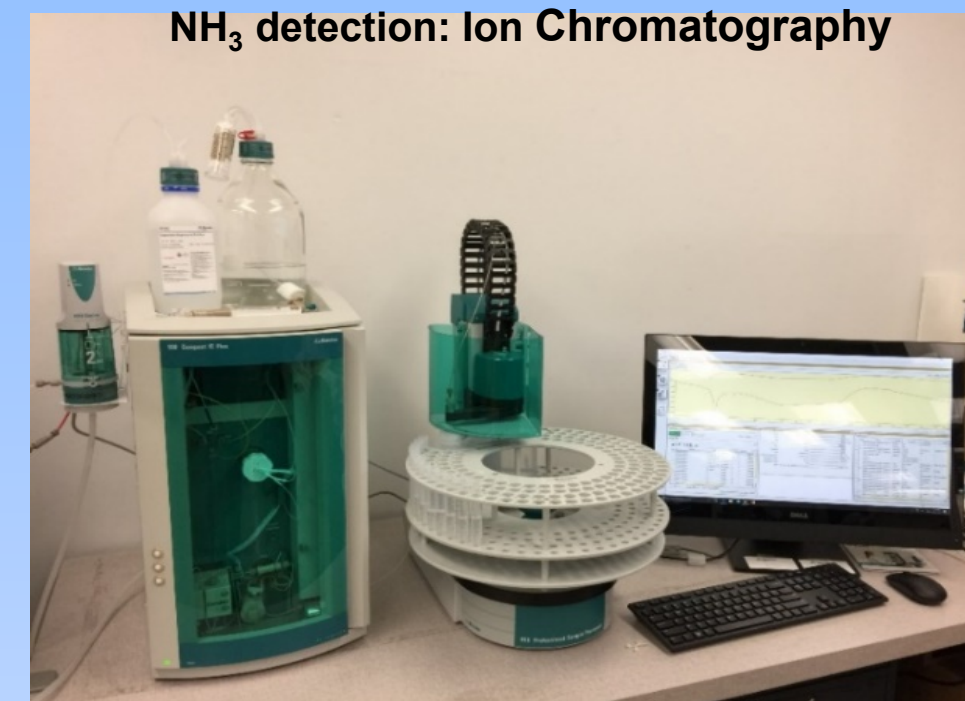
- Long-term focus: automotive sector as liquid hydrogen carrier
- 1st market: Wind power; 2nd market: Liquid fertilizers
- Licensing / partnership with renewable farms and distributed fertilizer plants

Motivation



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

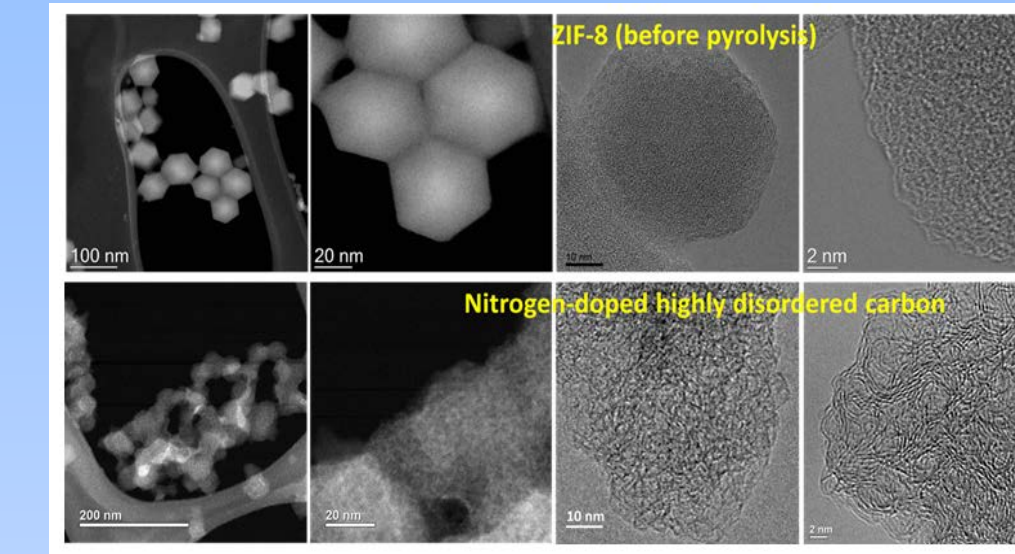
Approach



NH₃ detection: Ion Chromatography

Accomplishments

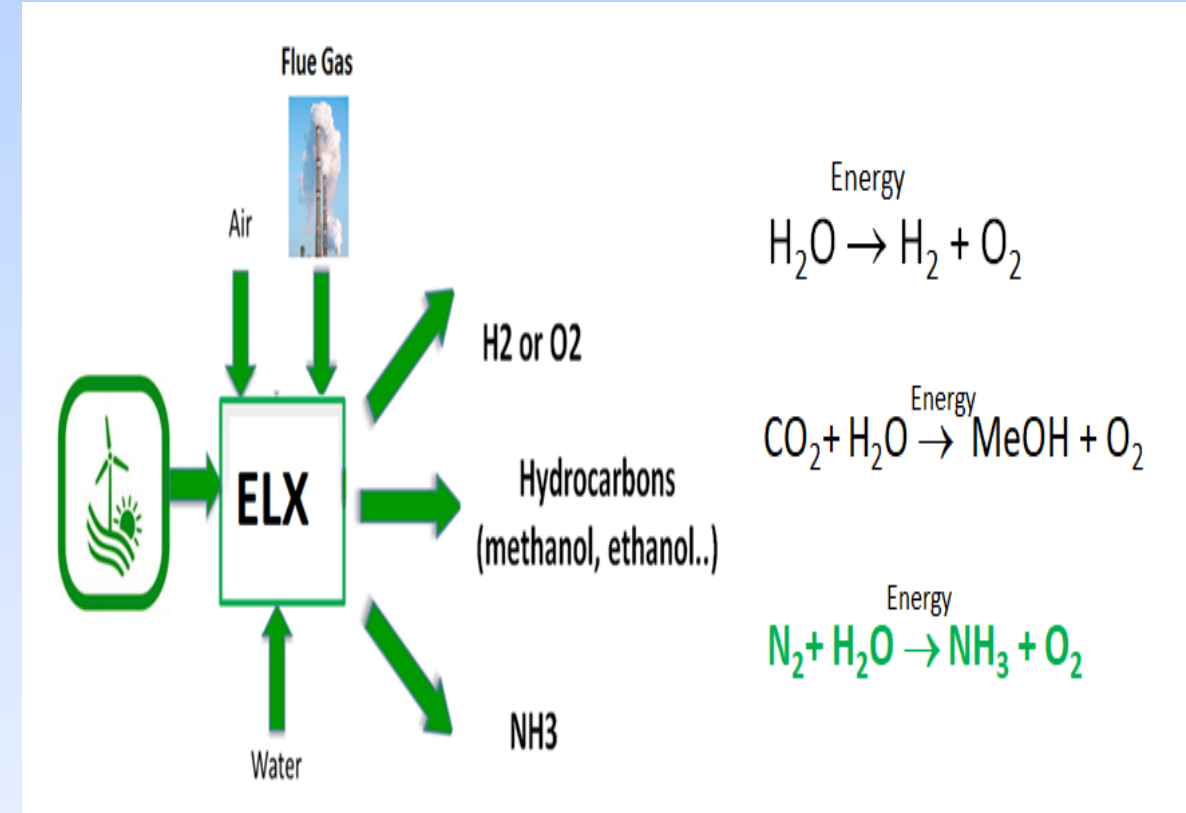
Synthesis of nanoporous and highly disordered carbon from ZIF-8



Nitrogen-doped highly disordered carbon

Summary

ID	Task Name	Year 1				Year 2			
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
1	Task 1: Design and Screening of NRR Catalysts								
2	1.1 Metal nitride catalyst synthesis								
3	1.2 Identify effective alkaline earth and lanthanide promoters								
5	Task 2: Preparation of Anion Exchange Membranes								
6	2.1 Preparation of piperidine monomers and BTMDEM								
7	2.2 Preparation of PAP-IM polymers and membranes								
8	2.3 Preparation of High Temperature Alkaline Electrolyte								
9	Task 3: Assembly and testing of electrolyzer cells								
10	3.1 Electrochemical cell assembly and test station								
11	3.2 Optimize operating conditions								
12	Task 4: Techno-economic Analysis								
13	4.1 Review baseline model and identify intermediate project metrics								
14	4.2 Updated Model with integrated renewable energy demonstration								



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

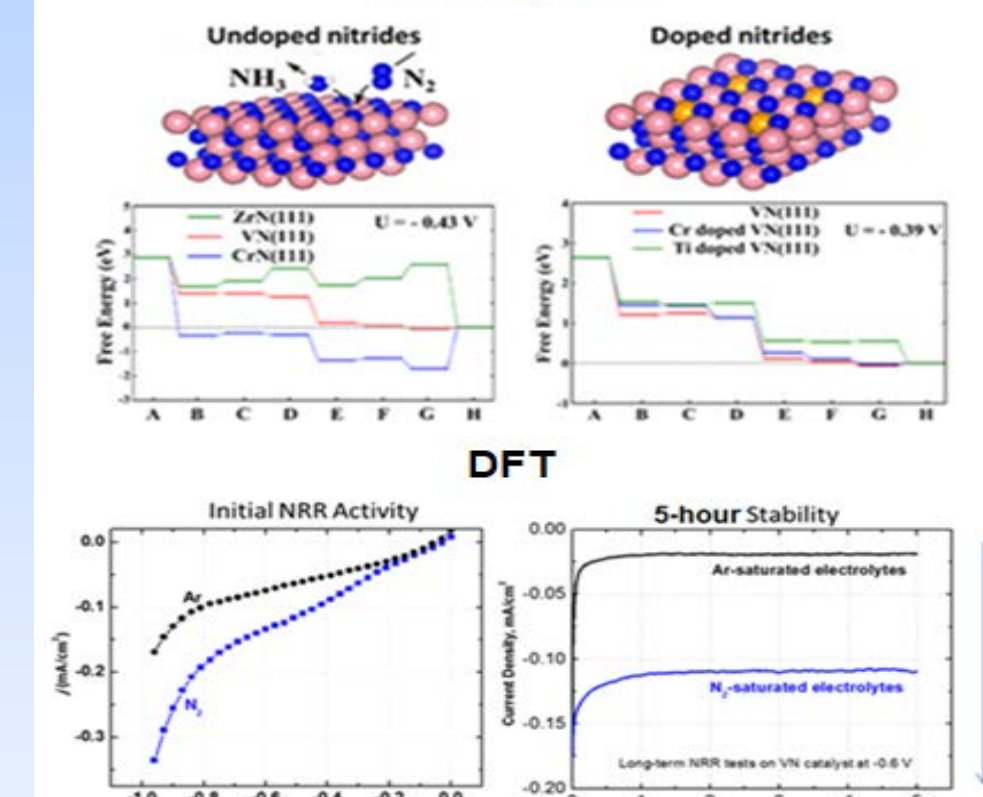
Energy storage comparison

30,000 gallon underground tank contains 200 MWh (plus 600 MMBTU CHP heat)
Capital cost ~\$100K

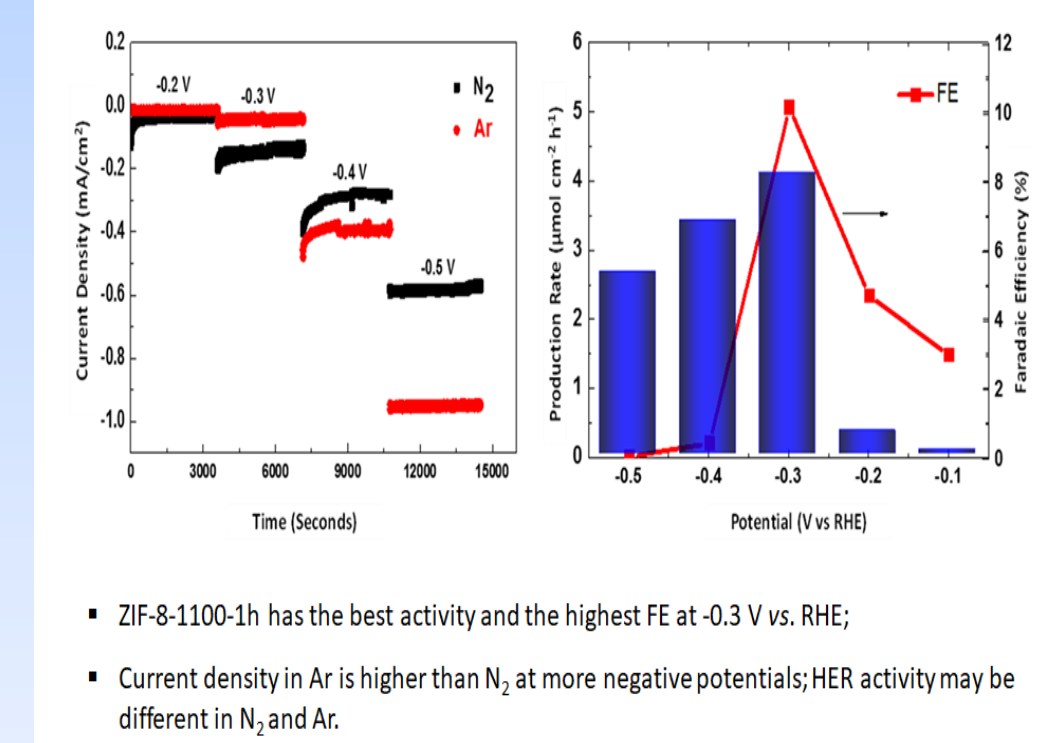
6 x 1,000kg H₂ Linde storage in Germany
or
40 x 5 MWh A123 battery in Chile
Capital cost \$50,000 - 100,000K

Soloveichik, H₂ @scale at NREL, 2016

Catalysts



Effect of applied potentials during the NRR



Membranes

poly(aryl piperidinium) (PAP)-AEM

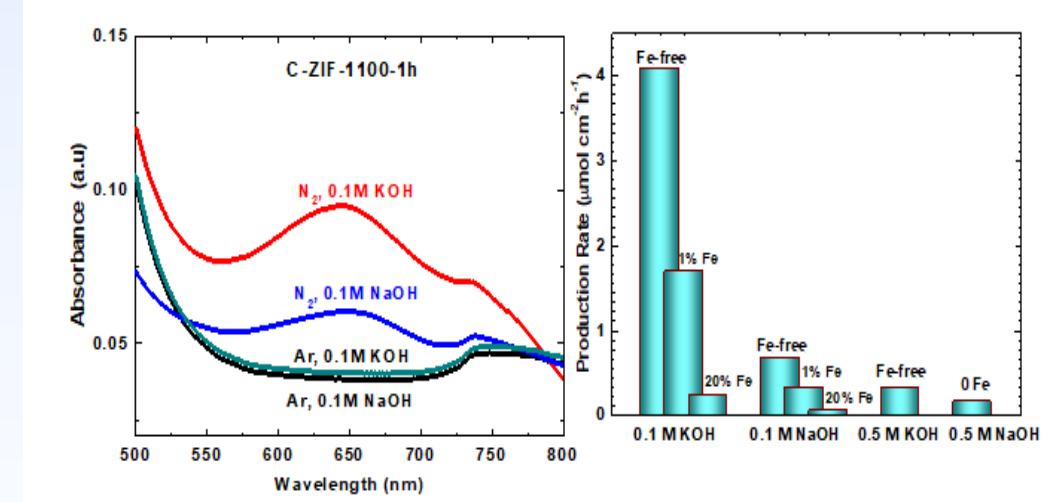
LOH/NaOH/KOH

Melt and Impregnation

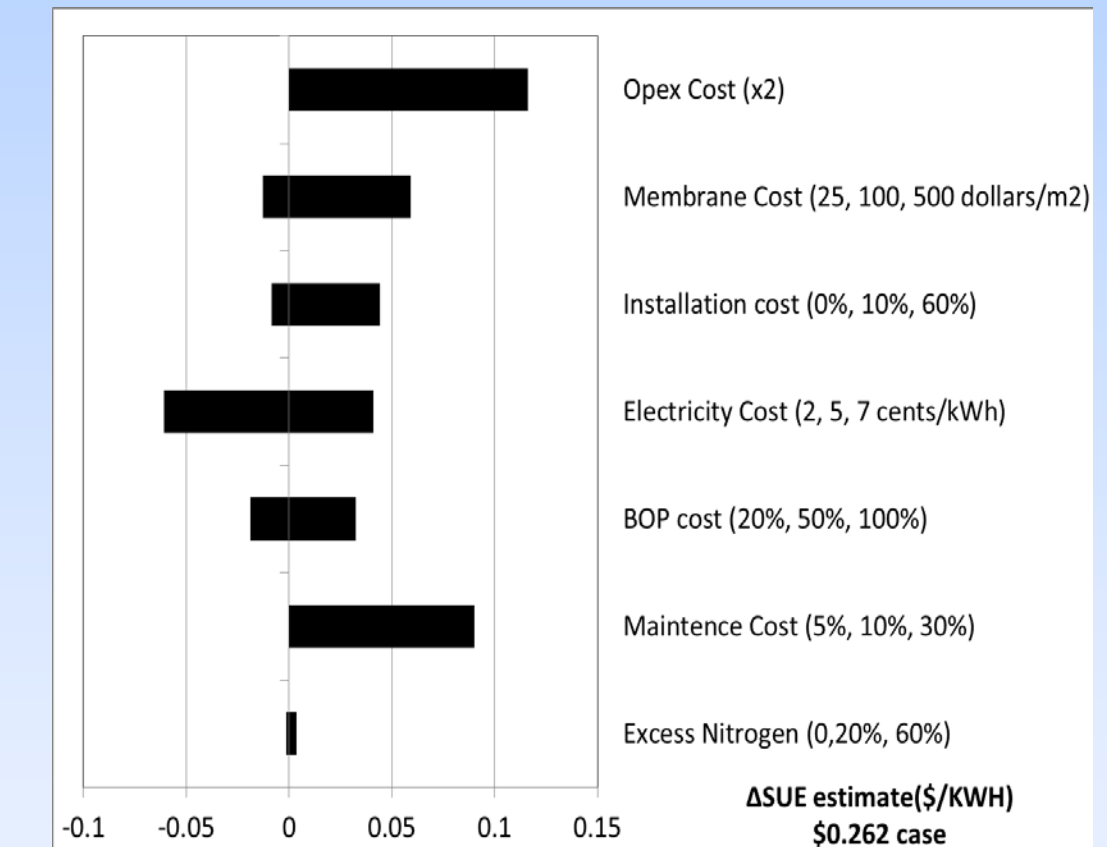
Porous Alumina or Zirconia

Molten Hydroxides in Porous Ceramics

Electrolyte Effect



- KOH is more favorable over NaOH for the NRR during the NH₃ synthesis
- Introduction of Fe doping compromises the NRR activity, leading to reduced production rates



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