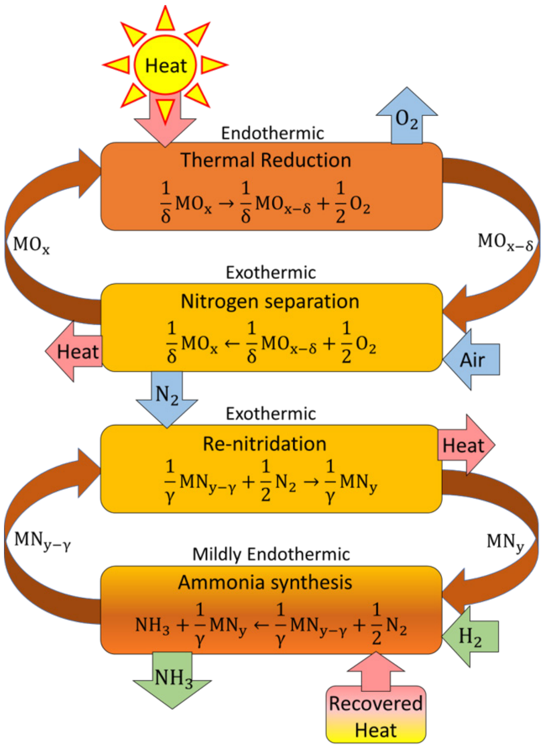
Solar-Thermal Ammonia Production (STAP)

Patent Pending
SD# 15033.1
Technology Readiness Level: 3
Concept Demonstrated Analytically or Experimentally

A greener and more renewable pathway for ammonia production

Ammonia (NH_3) is an energy-dense chemical and vital component of fertilizer and other chemical commodities. NH_3 is currently synthesized via the hydrocarbon intensive Haber-Bosch (H-B) process at high pressures of 150-300 bar and moderate temperatures of 350-500 °C. Hydrocarbons provide the heat and mechanical work required to drive this process and are also the source of the starting materials essential to the reaction.

As a result, the H-B process accounts for ~1.4% of total global CO_2 emissions. The development of a low pressure renewable pathway to NH_3 synthesis that uses concentrated solar irradiation for the process heat instead of hydrocarbon combustion could significantly decrease or potentially eliminate greenhouse gas emissions in the chemical production of this commodity chemical. It could also avoid the cost, complexity, and safety issues inherent in high-pressure processes.



The STAP process consists of two cycles. The first cycle (top) illustrates nitrogen separation from air using concentrated solar heat. The second cycle (bottom) ammonia production at pressure an order of magnitude lower than HB.

A process developed by researchers at **Sandia National Laboratories** in collaboration with **Arizona State University** and the **Georgia Institute of Technology** have developed an advanced solar thermochemical looping technology to produce and store N_2 from air for the subsequent production of NH_3 via a two-stage process which uses recyclable metal oxide and metal nitride materials to perform the chemistry. The net result is NH_3 produced from sunlight, air, and green H_2. The aim of the Solar-Thermal Ammonia Production (STAP) project is to demonstrate a sustainable pathway for NH_3 production that uses concentrated solar irradiation in place of the hydrocarbon resource and decreases pressure requirements by about one order of magnitude compared to H-B.

ip.sandia.gov
ip@sandia.gov

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525. SAND2022-6925 M

Solar-Thermal Ammonia Production (STAP)

Patent Pending
SD# 15033.1
Technology Readiness Level: 3
Concept Demonstrated Analytically or Experimentally

The aim of the Solar-Thermal Ammonia Production (STAP) project is to demonstrate a sustainable pathway for NH_3 production that uses concentrated solar irradiation in place of the hydrocarbon resource and decreases pressure requirements by about one order of magnitude compared to H-B. The Solar Thermal Ammonia Production (STAP) process consists of two cycles. The solar N2 purification process (Cycle 1) is driven by concentrated solar irradiation. In the first step, endothermic thermal reduction of redox-active metal oxide particles removes oxygen from the material.

TECHNICAL BENEFITS

- NH_3 production via a renewable, carbon-free technology
- Inputs are sunlight, air, and hydrogen; the output is ammonia
- Significantly lower pressures than Haber-Bosch
- The process consumes neither the oxide nor the nitride particles, which actively participate cyclically

INDUSTRIES & APPLICATIONS

- Fertilizers
- Fine chemicals
- Concentrating solar technologies
- Transportation/fuels
- End-user for renewable H_2

ip.sandia.gov
ip@sandia.gov

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525. SAND2022-6925 M