

International Institute for Carbon-Neutral Energy Research



Catalytic Material Transformation Revised Roadmap

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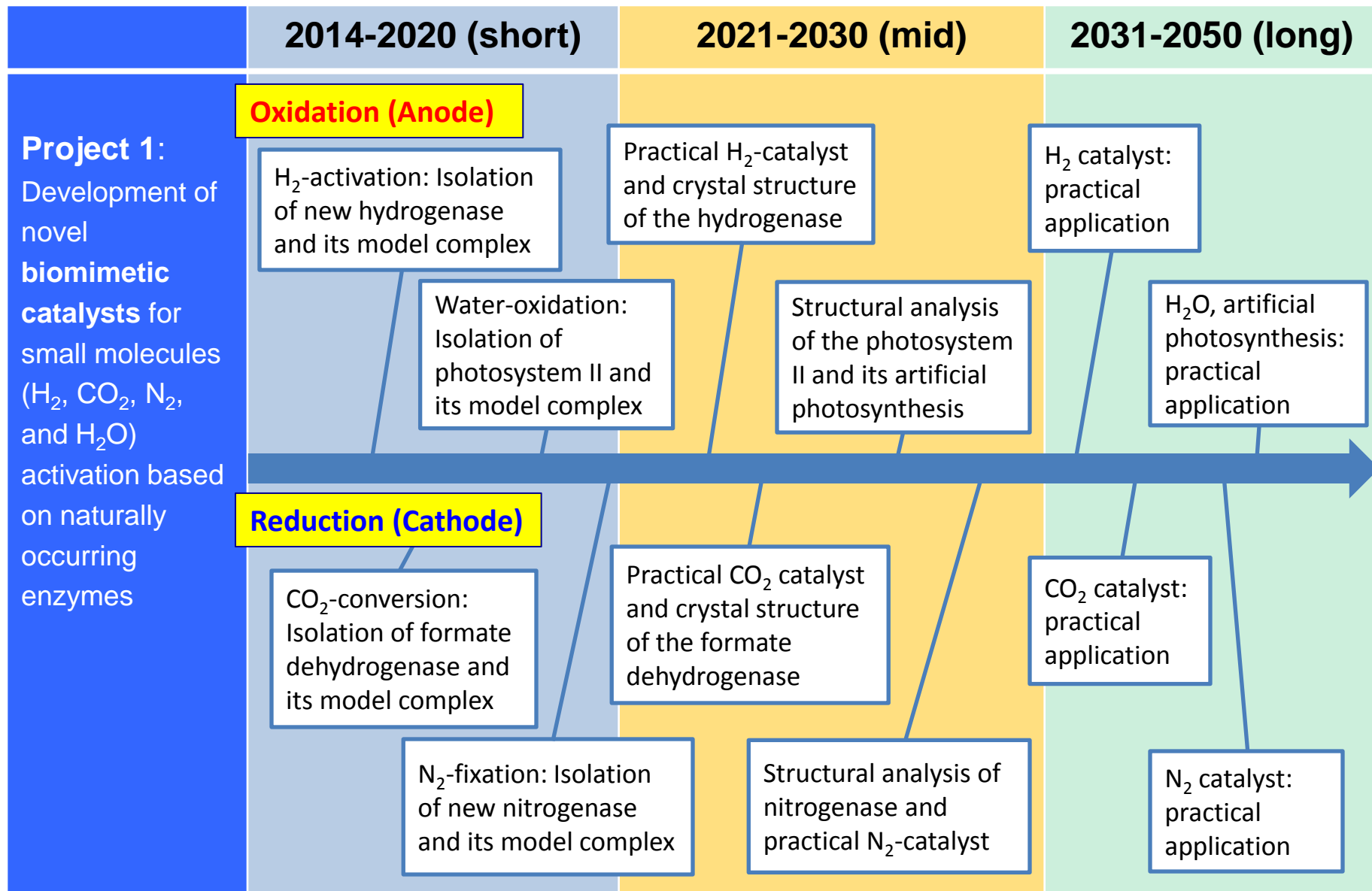
Division Objectives

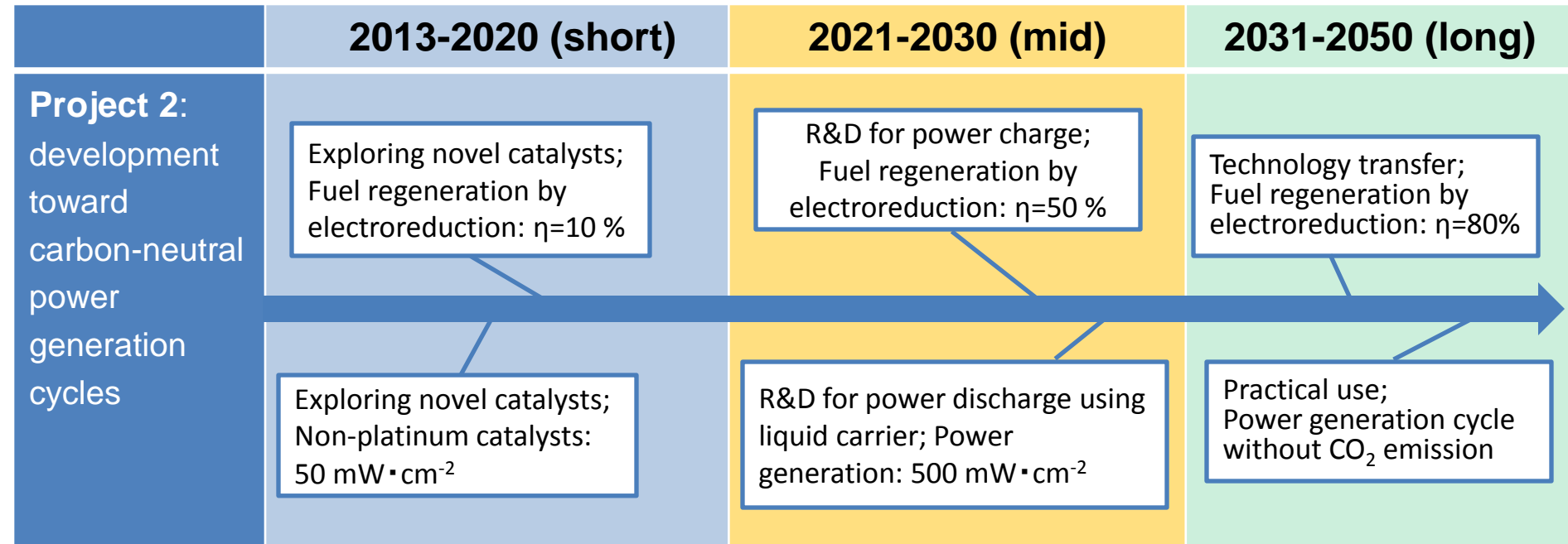
Contribute to the creation of innovative carbon-neutral technologies by developing “*Novel Catalysts*” underlining aspects of both basic science and engineering

- Activities are focused on investigating of catalysis-related ***Bio-inspired Systems for Fuel and Energy Generation and Sustainable Energy Transport and Storage Systems using Tailored Inorganic Nanocatalysts***
 - Development of bio-mimetic catalysts for small molecules (e.g., H₂, N₂, CO₂, and H₂O) activation based on naturally occurring enzymes
 - Production of clean fuels for carbon-neutral power generation cycles using bio-derived energy-carrying materials

Division Projects, Objectives, and Research Efforts

| Projects | Objectives | Research Efforts | Researchers |
|---|---|---|---|
| <p>Project 1: Development of novel biomimetic catalysts for H₂, CO₂, N₂, and H₂O activation based on naturally occurring enzymes</p> | <p>Development and characterization of new catalysts for alternative lower cost and more energy efficient pathways for energy generation: H₂ activation, CO₂ conversion, N₂ fixation, and solar based water oxidation.</p> | <ul style="list-style-type: none"> • Development of new biological and its synthetic catalysts of H₂-activation • New catalysts of CO₂-conversion • Development of new biological and its biomimetic catalysts of N₂-activation • Artificial photosynthesis of water oxidation | <p>Ogo Yoon Matsumoto Yatabe Uchida Tsugawa Nga Rauchfuss</p> |
| <p>Project 2: Development toward carbon-neutral power cycles</p> | <p>Development of catalysis for fuel oxidation and regeneration and production of novel materials for carbon neutral power generation cycles.</p> | <ul style="list-style-type: none"> • Development of selective electrooxidation catalysts • Development of efficient reduction catalysts | <p>Yamauchi Sadakiyo Kitano Yu Sun Takashi Fukushima Cui Xuedong</p> |



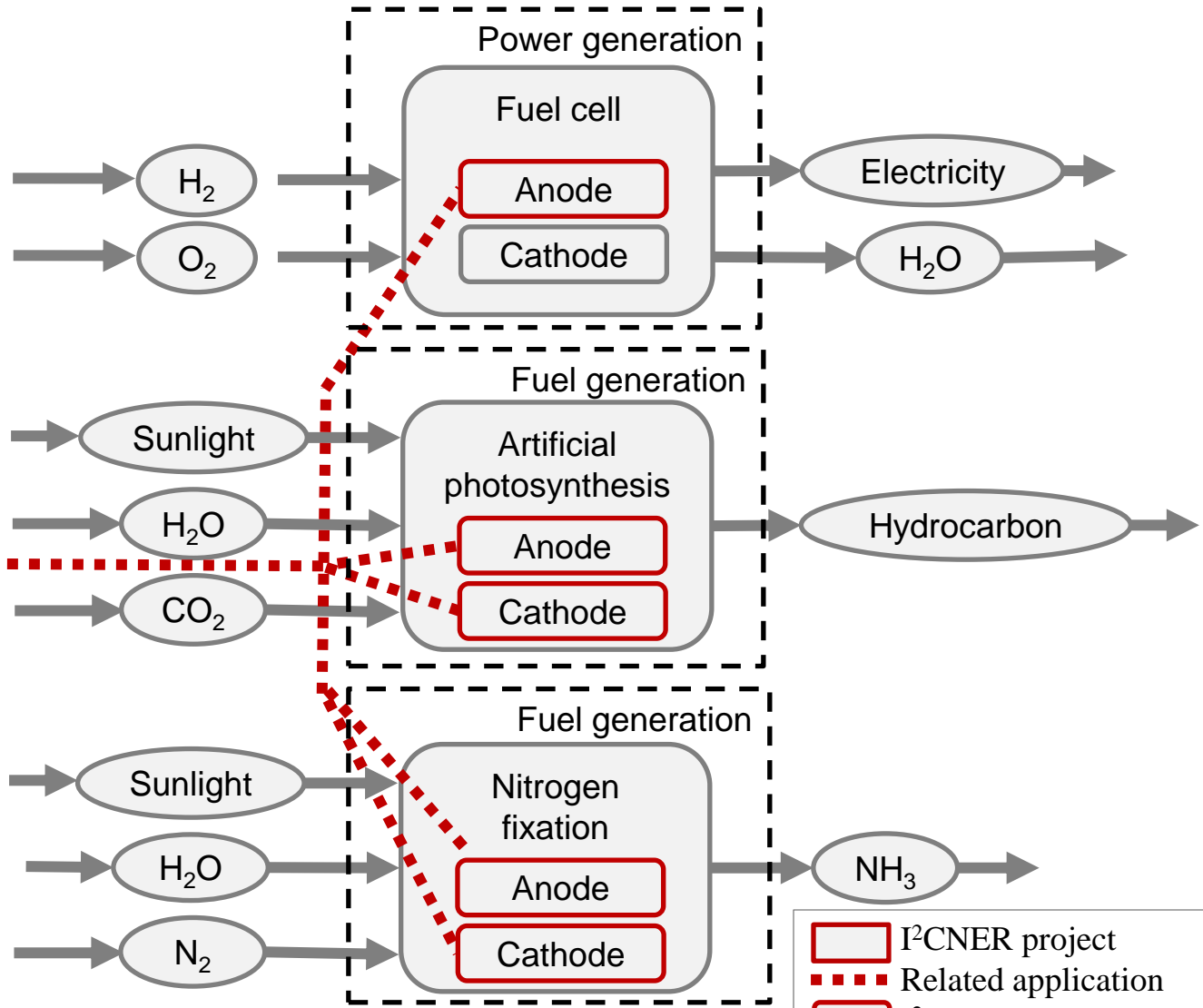


| | Ultimate targets | Current Benchmark | Technology / Application |
|---|---|--|--|
| <p>Project 1: Development of novel biomimetic catalysts for small molecules (H₂, CO₂, N₂, and H₂O) activation based on naturally occurring enzymes</p> | <ul style="list-style-type: none"> • H₂ catalyst: low cost and highly efficient practical application • CO₂ catalyst: low cost and highly efficient practical application • Artificial photosynthesis: low cost and highly efficient system • N₂ catalyst: low cost and highly efficient practical application | <ul style="list-style-type: none"> • Ogo first synthesized a functional biomimetic H₂-catalyst (Science 2013) • Ogo & Yoon first constructed the PEFC with 637-times higher activity H₂-biocatalyst than platinum (ACIE 2014) • None • None | <ul style="list-style-type: none"> • H₂ catalyst of PEFC • CO₂ reduction for hydrocarbon production • Artificial photosynthesis of water oxidation • Ammonia production system |
| <p>Project 2: Development toward carbon-neutral power generation cycles</p> | <ul style="list-style-type: none"> • Fuel regeneration by electroreduction: 80% • Power generation cycle without CO₂ emission • Competitive cost | <ul style="list-style-type: none"> • Yamauchi first regenerated alcohol (fuel) by electroreduction: >95% Faradaic efficiency (Energy Environ. Sci 2015). • None • Yamauchi first circulated electric power using an alcohol/carboxylic acid couple without CO₂ emission (Energy Environ. Sci 2015). | <ul style="list-style-type: none"> • Electricity storage and energy (electricity) import using liquid storage material |

Role & Contribution through Technology

- The role of this division toward a CNS is to produce / use energy by the development of a new catalyst for:
 1. fuel generation (hydrocarbon, NH₃) device from sun light, contributing to providing cheap **low carbon fuel**
 2. Power generation device (fuel cell) using hydrogen, contributing to **efficiency increase** of fuel cell
 3. energy transport and storage systems to transport and store renewable electricity, contributing to **efficient use of renewable** energy and **import of low carbon energy** (electricity)

Project 1
 Development of novel biomimetic catalysts for small molecules (H_2 , CO_2 , N_2 , and H_2O) activation based on naturally occurring enzymes



- I²CNER project
- Related application
- I²CNER project technology
- Technology /end user
- Energy flow
- Type of energy

