

# International Institute for Carbon-Neutral Energy Research



## Catalytic Materials Transformations Revised Roadmap

July 2015



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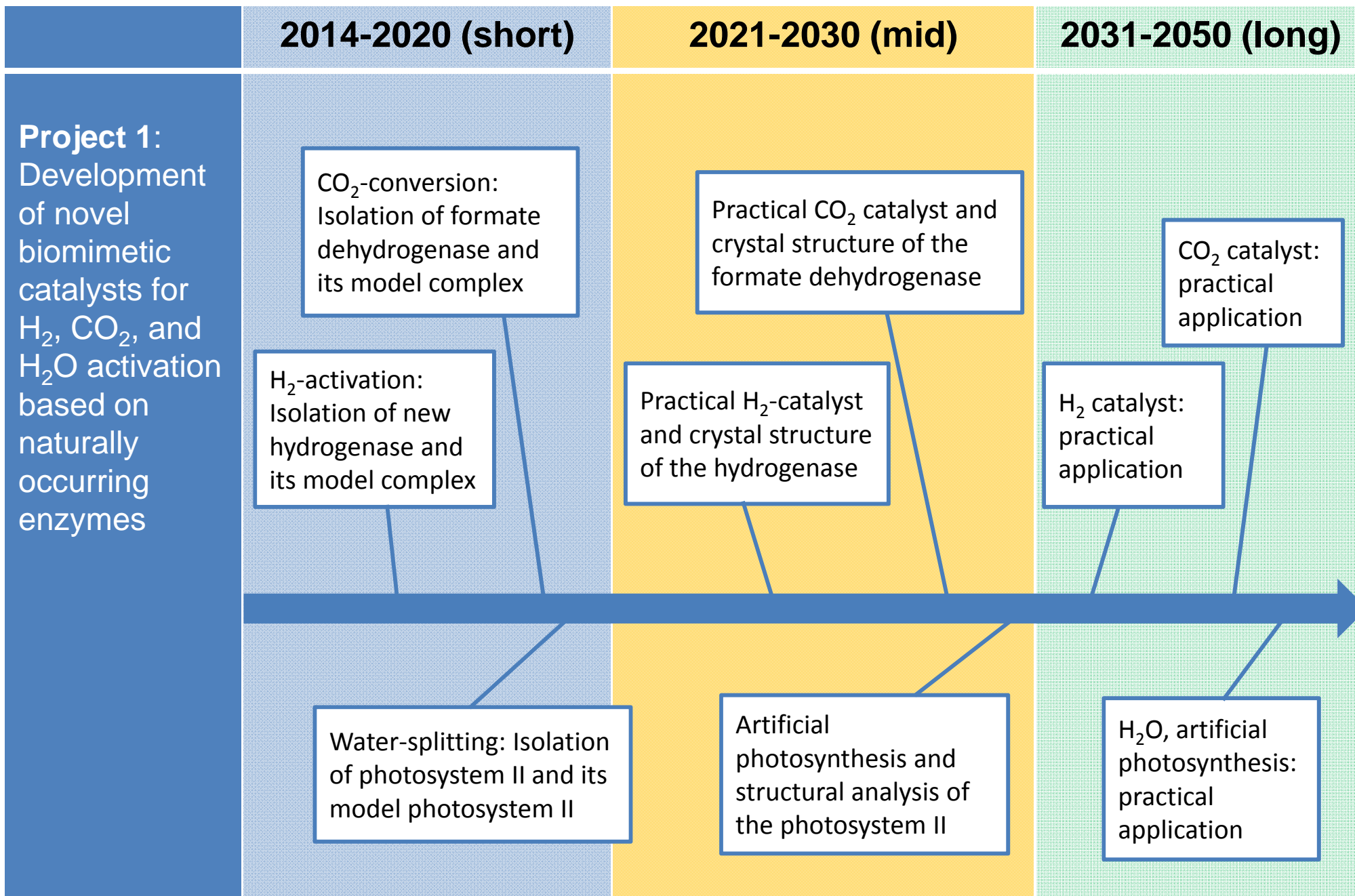


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# Division Objectives

- **Contribute to the creation of innovative carbon-neutral technology by developing “*Novel Catalysts,*” underlining both aspects of basic science and engineering.**
- The activities are focused on investigations of catalysis-related “*Solar Energy and Energy Conservation,*” all of which have the potential to significantly increase energy efficiency and reduce CO<sub>2</sub> emissions in energy, power or industrial production processes.

Projects	Objective	Research Efforts	Researchers
<b>Project 1:</b> Development of novel biomimetic catalysts for H <sub>2</sub> , CO <sub>2</sub> , and H <sub>2</sub> O activation based on naturally occurring enzymes	Develop new catalysts for alternative lower cost and more energy efficient pathways for power generation (fuel cells), solar based water splitting hydrogen production, and the conversion of CO <sub>2</sub> to hydrocarbons (fuels).	<ul style="list-style-type: none"> <li>Exploring biological and synthetic catalysts of H<sub>2</sub>-activation</li> <li>New catalysts for CO<sub>2</sub>-conversion</li> <li>Artificial photosynthesis</li> </ul>	Seiji Ogo Ki-Seok Yoon Takahiro Matsumoto Takahiro Kikunaga Mitsuhiro Kikkawa Kazuhiro Kitagawa <b>Thomas Rauchfuss</b>
<b>Project 2:</b> Materials development toward realization of carbon-neutral power generation cycles <b>energy storage and distribution</b>	Development of catalysis for fuel oxidation and regeneration and production of novel materials for carbon neutral power generation cycles.	<ul style="list-style-type: none"> <li>Development of selective electrooxidation catalysts</li> <li>Development of efficient reduction catalysts</li> <li>Development of alkaline electrolytes</li> </ul>	Miho Yamauchi Masaaki Sadakiyo Sho Kitano Shinichi Hata Kazuya Okubo



	2013-2020 (short)	2021-2030 (mid)	2031-2050 (long)
<b>Project 2:</b> development toward carbon-neutral power generation cycles	Fuel regeneration by electroreduction: 1 %	Power generation: $500 \text{ mW} \cdot \text{cm}^{-2}$  Solid alkaline electrolytes: $10^{-3} \text{ S} \cdot \text{cm}^{-1}$	<ul style="list-style-type: none"> <li>Fuel regeneration by electroreduction: 80%</li> <li>Air tolerant alkaline fuel cell: operation in the air</li> <li>Power generation cycle without <math>\text{CO}_2</math> emission</li> </ul>
	Non-platinum catalysts: $50 \text{ mW} \cdot \text{cm}^{-2}$	Solid alkaline electrolytes for high temperature: $120^\circ \text{ C}$	



Project	Ultimate targets	Current Benchmark
<p><b>Project 1:</b> Development of novel biomimetic catalysts for H<sub>2</sub>, CO<sub>2</sub>, and H<sub>2</sub>O activation based on naturally occurring enzymes</p>	<ul style="list-style-type: none"> <li>• H<sub>2</sub> catalyst: low cost and highly efficient practical application</li> <li>• CO<sub>2</sub> catalyst: low cost and highly efficient practical application</li> <li>• Artificial photosynthesis: low cost and highly efficient system</li> </ul>	<ul style="list-style-type: none"> <li>• Ogo first synthesized a functional biomimetic H<sub>2</sub>-catalyst (Science 2013)</li> <li>• Ogo &amp; Yoon first constructed the PEFC with 637-times higher activity H<sub>2</sub>-biocatalyst than platinum (ACIE 2014)</li> <li>• None</li> <li>• None</li> </ul>
<p><b>Project 2:</b> Materials development toward realization of carbon neutral energy storage and distribution</p>	<ul style="list-style-type: none"> <li>• Fuel regeneration by electroreduction: 80%</li> <li>• Air tolerant alkaline fuel cell: operation in the air</li> <li>• Power generation cycle without CO<sub>2</sub> emission</li> <li>• Competitive cost</li> </ul>	<ul style="list-style-type: none"> <li>• Yamauchi first regenerated alcohol (fuel) by electroreduction: &gt;95% Faradaic efficiency (Energy Environ. Sci 2015) .</li> <li>• None</li> <li>• Yamauchi first circulated electric power using an alcohol/carboxylic acid couple without CO<sub>2</sub> emission (Energy Environ. Sci 2015) .</li> </ul>