

## 2. Summary of Proposal

(Compile in English within 3 pages.)

Host institution	Kyushu University
Head of host institution	Chiharu Kubo (President, Kyushu University)
Research center	International Institute for Carbon-Neutral Energy Research (I <sup>2</sup> CNER)
Center director	Prof. Petros Sofronis, University of Illinois at Urbana-Champaign, USA
Chief center-project officer (in December 2010)	Yukitaka Murakami (Trustee and Vice President, Kyushu University)
Project summary	<p>I<sup>2</sup>CNER is an international project centered at Kyushu University with a mission to contribute to the creation of a sustainable and environmentally-friendly society by undertaking fundamental research for the advancement of low carbon emission and cost effective energy systems, and improvement of energy efficiency. To reach this overarching objective, I<sup>2</sup>CNER is conducting research of such phenomena as adsorption, dissolution, diffusion, chemical reduction of species, and reaction and interaction of gases with matter in the framework of multiphase fluid and solid systems. These phenomena occur at the interface of interactions between materials and gases at all spatial and time scales, from the atomic to those for geological systems, and from nanoseconds to decades. By way of example, the array of technologies that I<sup>2</sup>CNER's research aims to enable includes solid oxide fuel cells, polymer membrane based fuel cells, biomimetic and other novel catalyst concepts, and production, storage, and utilization of hydrogen as a fuel. Our research also explores the underlying science of CO<sub>2</sub> capture and storage technology, and the creation of a CO<sub>2</sub> conversion system for the production of value-added chemicals or the storage of renewable-based electricity. Individual I<sup>2</sup>CNER research efforts are advancing and intimately tied to scenarios of technology combinations for a carbon-neutral energy Japan through short-, mid-, and long-term milestones in roadmaps toward ultimate research targets. I<sup>2</sup>CNER, in concert with the Satellite Institute at the University of Illinois, has established a significant presence on the campus of Kyushu University, creating an environment that fosters the climate and culture for interdisciplinary research and education collaborations with leading researchers across the world.</p>
Mission statement and/or center's identity	<p>I<sup>2</sup>CNER's mission is to contribute to the creation of a sustainable and environmentally-friendly society by conducting fundamental research for the advancement of low carbon emission and cost effective energy systems, and improvement of energy efficiency. The array of technologies that I<sup>2</sup>CNER's research aims to enable includes Solid Oxide Fuel Cells, Polymer Membrane based fuel cells, biomimetic and other novel catalyst concepts, and production, storage, and utilization of hydrogen as a fuel. Our research also explores the underlying science of CO<sub>2</sub> capture and storage technology, and the creation of a CO<sub>2</sub> conversion system for the production of value-added chemicals or the storage of renewable-based electricity. Additionally, it is our mission to establish an international academic environment that fosters innovation through collaboration and interdisciplinary research (fusion).</p>
Research fields	<p><u>Research field:</u> Multi/Inter-disciplinary research that involves chemistry, physics, materials science, mechanics, geo-science, biomimetics, life and computational sciences, economics, and mathematics.</p> <p><u>Significance of the proposed project:</u> The disasters caused by the Tohoku Region Pacific Coast Earthquake,</p>

	<p>tsunami, and Fukushima nuclear accident have brought to the fore serious issues related to the energy infrastructure and future of Japan. There exists a vital need to develop sustainable sources of energy without CO<sub>2</sub> emissions, and to establish safe and reliable carbon capture and storage (CCS) systems for the realization of a carbon-neutral energy Japan. The importance of I<sup>2</sup>CNER is that it specifically focuses on the development of science-driven technological solutions to key challenges along the path toward a carbon-neutral Japan. In fact, the I<sup>2</sup>CNER research roadmap addresses fundamental science issues underlying a large number of the technologies envisioned in the Fourth Strategic Energy Plan of the government of Japan announced in April 2014, such as the development of next generation power generation technologies, energy conservation, distributed energy systems to raise efficiency, realization of the hydrogen economy, next generation of automobiles, etc.</p>
<p>Research objectives</p>	<p>Our research efforts are addressing project objectives within thematic research clusters (divisions). Within each project, research is carried out along a roadmap, which is continuously updated as research progresses, with short-, mid-, and long-term milestones, and ultimate targets. The research objectives toward a carbon-neutral energy society are summarized as follows:</p> <ul style="list-style-type: none"> <li>• Use of solar energy to produce hydrogen through organic photovoltaics (PV) driven high temperature electrolysis and photo-electrochemical water splitting; and develop energy conservation devices: organic light emitting diode and low friction bearings.</li> <li>• Develop predictive performance models for materials subjected to hydrogen-affected fatigue, fracture, wear, and seizure that revolutionize design and materials selection of components in hydrogen service.</li> <li>• Development of more durable, efficient, and lower cost fuel cells, including polymer electrolyte fuel cells (PEFCs) and solid oxide fuel cells (SOFCs).</li> <li>• Expand material thermophysical property information and thermal science and engineering to help enable the most effective use of materials in carbon-neutral energy society technologies and to improve the energy efficiency of thermal processes.</li> <li>• Research and develop new carrier materials for enhanced mobile and stationary storage of hydrogen, as well as for hydrogen delivery.</li> <li>• Develop (i) breakthrough novel biomimetic based catalysts and pathways for the carbon neutral production of power (fuel cells), hydrogen, and hydrocarbon fuels based on solar energy resources; (ii) new catalysis for fuel oxidation and regeneration, and novel materials to enable new carbon neutral fuel and energy cycles for electricity storage and energy distribution.</li> <li>• Development of highly efficient materials for CO<sub>2</sub> separation in power generation and industrial processes, and creation of energy efficient and cost effective CO<sub>2</sub> conversion system for (i) production of value-added chemicals, such as a liquid fuel or their intermediates or (ii) the storage of renewable-based electricity.</li> <li>• Identify and investigate key pore-scale processes that drive effective residual, solubility, and mineral CO<sub>2</sub> trapping in geologic formations typical of Japan; Translate this understanding to the development of methods for accurate reservoir characterization to ensure safe and enhanced CO<sub>2</sub> storage; Develop new effective methods for monitoring injected/leaked CO<sub>2</sub> in sub-seabed geologic formations, and identify field-scale CO<sub>2</sub> behavior.</li> <li>• Provide carbon emission, energy efficiency, and cost analysis of current and emerging I<sup>2</sup>CNER and other energy processes, technology, and infrastructure to help ensure I<sup>2</sup>CNER and global energy related research is well targeted toward a carbon neutral society. Continuously review and revise the Institute's vision and roadmap toward a carbon-neutral society based on I<sup>2</sup>CNER and other energy system</li> </ul>

	analyses.
Outline of management	<ul style="list-style-type: none"> <li>○ I<sup>2</sup>CNER was established as an organization under the direct management of the President of Kyushu University. The Institute Director has direct access to the Office of the President and the Office of the Executive Vice President in charge of Research and Industry Collaboration. The Director is solely responsible for making decisions regarding the planning and conducting of Institute research activities, the formation and composition of the research program areas and divisions, potential division reorganization and redirection of research efforts in response to the feedback from the annual site visit review of the Institute, the recruitment of postdocs and faculty, the establishment of international collaborations and interactions with top research Institutions, the administration of the peer evaluation process of the Institute's research output, and budget implementation. On all of these matters, the Director consults the Science Steering Committee (SSC), which is headed by the Director. Its members (science advisors) are the division Lead Principal Investigators and any other additional members that the Director may deem appropriate.</li> <li>○ A vital component of the Institute is the External Advisory Committee (EAC), which is composed of national and international leaders in the field. This Committee is convened annually or, if deemed necessary by the Director, more frequently. The Committee reviews all aspects of the Institute, including its leadership and management, the research progress being made in each activity, and its plans for any initiatives. The Committee provides the Director with a written report of their findings and recommendations. The final decision regarding Institute activities is the responsibility of the Director. In addition, the Director is advised by the Internal Programs Review Committee, which is appointed by the Director and is tasked with reviewing individual research efforts within I<sup>2</sup>CNER on a regular basis.</li> <li>○ The Director is assisted by two Associate Directors, Prof. Ishihara (responsible for workshop organization, seminar series administration, management of facilities and equipment) and Prof. Takata (responsible for faculty recruitment, international and industrial collaborations, and handling graduate student research matters). The role of the Science Steering Committee and the two Associate Directors is strictly advisory. The Director is solely responsible for making the final decisions.</li> <li>○ The Office of the Director is supported by the <u>Administrative Director</u>, the head of the Institute's <u>Administrative Office</u>, whose purpose is to provide administrative support to the operation of the Institute. The official language of the Institute's Administrative Office is English.</li> <li>○ The Director of the Institute, Professor P. Sofronis, is a faculty member at the University of Illinois at Urbana-Champaign. A Satellite Center has been established at Illinois to serve as the hub to advance student and researcher exchanges, collaborations in the US, and strengthen international research activities. In the Director's absence, the administration of the Institute is governed by document "22. Management and Administration.</li> </ul>
Researchers and other center staffs, satellites, partner institutions	<p>I<sup>2</sup>CNER embarks on its second term as a permanent unit of KU. By FY2019, there will be (10) tenured PIs organically in I<sup>2</sup>CNER. The remainder of the 10-15 PI positions in I<sup>2</sup>CNER (out of the 20-25) will come from either: a) other units of KU through the Intra-University Transfer System, b) through cross-appointments between I<sup>2</sup>CNER and other units of KU, e.g. economics, sciences, mathematics, etc., or c) through cross-appointments between I<sup>2</sup>CNER and its international partner institutes and industry. The vision is that 3 to 4 PIs amongst those tenured will be non-Japanese. As of April 1, 2015, I<sup>2</sup>CNER has a total of 2 full-professor</p>

	<p>and 7 associate professor positions. Apart from the PI categories (a), (b), and (c) above, I<sup>2</sup>CNER will have Visiting Fellows (PI level) and cross-appointed PIs from overseas institutions and industry. Currently, among the 24 PIs in I<sup>2</sup>CNER, 7 are from overseas. We plan to employ about 16 full-time faculty members, 35 to 40 postdocs, about 30 technical staff members, and a number of visiting faculty and scholars from academia, industry, and government agencies.</p> <p>An important component of I<sup>2</sup>CNER is the Satellite Institute at the University of Illinois, which facilitates complimentary research activities and pioneers student and researcher exchanges with the US. A Memorandum of Understanding (MoU) for all levels of interaction between Kyushu and Illinois, and a specific agreement for undergraduate student exchange are now in place. The Satellite headquarters reside in a spacious suite in the Department of Mechanical Science and Engineering, with office space available for visitors from Japan. The Satellite plans to employ about 8 faculty members, 2 postdocs, 10 research assistants and 2 staff members. Satellite faculty laboratories are available for use by counterpart researchers from Kyushu. In addition, campus-level shared-use facilities and laboratories at Illinois are available to all researchers for a usage fee. The Office of Technology Management (OTM) of the University of Illinois will work closely with the Industry-University- Government Collaboration Management Center of Kyushu University (IMAQ) to advance IP management and technology transfer, both nationally and internationally. In addition, MoUs have been signed for research interaction and collaboration between I<sup>2</sup>CNER and the National Fuel Cell Research Center (NFCRC) at the University of California, Irvine and NTNU/SINTEF of Norway. A letter of understanding has been signed with the State of California Air Resources Board (CARB). In addition, there are approximately 20 ongoing collaborative research activities between I<sup>2</sup>CNER PIs, full time faculty, and postdocs, and faculty and researchers from premier institutions worldwide. This list of institutions includes MIT, UC Berkeley, Max-Planck, the University of Oxford, the Helmholtz-Zentrum Geesthacht (HZG) in Germany, the Dalian Institute of Chemical Physics, and the Swiss Federal Institute of Technology Zurich (ETH).</p>
Administrative director	Prof. Yukio Fujiki, Kyushu University
Outline of research environment	<p>I<sup>2</sup>CNER's Building 1 and Building 2 (to be completed next month) accomplish an "all under one roof" concept by housing all PIs, full time faculty, researcher offices, laboratories, and the Administrative Office. These buildings represent the state-of-the-art in design of space for a modern research facility through their common-use laboratories to foster interaction and spacious lounges with electronic blackboards for impromptu meetings. I<sup>2</sup>CNER's laboratories are equipped with state-of-the-art equipment, such as the Low Energy Ion Scattering (LEIS) and the Secondary Ion Mass Spectrometry (TOF-SIMS) for surface and interface analysis. The Institute researchers are assisted by a competent Administrative Office that directs the entire support infrastructure. To foster interdisciplinary research and nurture young faculty and postdocs, programs such as the Competitive Funding Program and Start-up Funds, respectively, are in place. For all institute personnel compensation considerations, a special agreement between I<sup>2</sup>CNER and Kyushu University allows the Institute to follow a special merit-based salary system which deviates from the KU established salary ranges. Evaluation of individual faculty and researcher performance is carried out annually by the Director and the two Associate Directors, or more frequently, if deemed necessary by the Director. Recruitment of well-qualified postdoctoral researchers and faculty is directed by the Faculty Recruiting committee, which includes key members of the Institute, and is supervised by the Institute Director. The corresponding recruitment practices at the University of Illinois are used in the hiring of all Institute research personnel.</p>

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Outline of indicators for evaluating a center's global standing	<p>I<sup>2</sup>CNER is a mission-driven (Green Innovation) research center, but is focused on basic science. As such, it can be evaluated on the basis of the following metrics:</p> <p>1) Relevance of the I<sup>2</sup>CNER research efforts and objectives to enable the green innovation initiative of the government of Japan; 2) Approach to carrying out research. This can be evaluated by the quality of its publications in high impact, discipline-oriented journals; 3) International awards and number of article citations the Institute's work receives, as indicators of overall standing and visibility; 4) Degree of realization of milestones and targets in research roadmaps; 5) Level of collaboration with international research centers, and efforts and degree of research interdisciplinarity; 6) Number and quality of participating industrial partners; 7) Filing for patents; 8) Technology transfer events.</p> <p>The overriding metric is that quality needs to pervade all I<sup>2</sup>CNER operations.</p>										
Securing research funding	The total amount of research funding acquired by I <sup>2</sup> CNER members including main Japanese Principal Investigators in the past five years (FY2009-2013, JPY/USD=120), is over 19.5 million dollars per annum on average. In the coming years, the goal is to continue securing external research funds at an even higher rate by aggressively pursuing external sources as stated above.										
<p>Appropriations plan</p> <p>(Exchange Rate: JPY/USD=120)</p>	FY	2015	2016	2017	2018	2019	Total				
	Cost (\$ millions)	10.9	10.9	10.9	10.9	10.9	54.5				
Summary of host institution's commitment	<p>The university's strategic vision is summarized by the following: "position the university as a center of global research and education" and "promote the development of new academic fields by pursuing multi/inter-disciplinary research through fostering an academic environment that attracts excellent researchers." In this framework, Kyushu University will embrace and support the Institute with all its resources. More specifically, Kyushu University will enthusiastically:</p> <ul style="list-style-type: none"> <li>• Ensure the success of I<sup>2</sup>CNER as a permanent research institute, and the world's-leading carbon neutral energy research center;</li> <li>• Provide the Director with full authority to enable him to implement and execute the WPI vision for Kyushu University;</li> <li>• Pursue further engagement and interactions with the University of Illinois;</li> <li>• Promote collaboration with industry, and advance IP management and technology transfer, both nationally and internationally;</li> <li>• Invite leading researchers from overseas universities and research institutes to I<sup>2</sup>CNER by utilizing new initiatives, such as I<sup>2</sup>CNER's Fellows Program and Kyushu University's "Cross-Appointment System";</li> <li>• Assist in strengthening the Institute's administrative structure for research and budget implementation;</li> <li>• Work with departmental units to accommodate the participation of researchers in the Institute by utilizing personnel systems, such as the "Intra-University Faculty Transfer System";</li> <li>• Improve the internal system to make English a working language in conducting international affairs;</li> <li>• Re-examine the personnel compensation system (merit-based salary system).</li> </ul>										