## SUMMARY OF FINDINGS

## STRIVE Report No. 111

# New approaches for the generation of hydrogen from water using visible light

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Global climate change and security of energy supply are increasingly perceived as the most serious threats facing the world's medium and long-term future. This realisation has led to the establishment of a UN driven Framework Convention on Climate Change and the Kyoto Protocol in 1997. It is clear that increasing $CO_2$ concentrations have the potential to seriously damage our environment and sustainable novel methods to reduce $CO_2$ concentrations are needed. Therefore, EU and G8 leaders agreed in 2009 that carbon dioxide emissions must be cut by 80% by 2050.

The "**hydrogen economy"** is often mentioned as a solution since as a fuel, hydrogen is non-polluting and does not produce $CO_2$. The ultimate realisation of a hydrogen-based economy could potentially result in enormous environmental, societal and economic benefits, together with enhanced security of energy supply. However, the transition from a carbon-based (fossil fuel) energy system to a hydrogen-based economy involves significant scientific, technological and societal barriers. Furthermore, to achieve the full environmental benefit of hydrogen as an energy carrier, low carbon, low polluting, and lower cost processes for producing hydrogen from renewable energy sources must be developed.

The project has demonstrated the first step towards, the development of a green approach to $CO_2$ reduction and recycling has been undertaken. **This project delivers such a technology, where hydrogen can be produced from water at room temperature and this brings us closer, to a much desired green economy.**

**Key Words:** Hydrogen energy, non-polluting, sustainable energy and resource use, low carbon, low cost energy, novel environmental technology development in Ireland, photovoltaic, green economy, green approach to $CO_2$ recycling & reduction, Climate Change, commercialisation.

**Background:** Currently hydrogen is produced in large quantities from fossil fuels, which can be used in the short and medium term, but in the long term it is clearly unsustainable that the hydrogen economy is derived from hydrocarbons. To achieve the benefits of a truly sustainable hydrogen energy economy, hydrogen has to be produced from non-fossil fuel resources, such as water. The most important property of any energy source is its environmental compatibility. Our current energy infrastructure is dominated by fossil fuel use, which leads to greenhouse gas emissions. One of the major challenges facing humanity is

to develop a renewable source of energy to replace our dependence on fossil fuels. Ideally, this new source should be abundant, inexpensive, environmentally clean, and widely distributed geographically.

Although practical methods for the conversion of sunlight to electricity exist, solar generated electricity currently does not compete successful with that of fossil fuels. A number of challenges must be overcome for hydrogen to be used widely as a sustainable energy carrier, low carbon intensive, low polluting and low cost. Achieving this requires the development of innovative material, emerging physical phenomena, novel synthetic techniques and new concept designs (all set out in this project.)

## Key points/ Findings

- This project delivers a technology, where hydrogen can be produced from water at room temperature and this brings us closer, to a much desired green economy.
- The project has identified both inorganic & organic molecules that produce hydrogen efficiently
- The ultimate realisation of a hydrogen-based economy could potentially result in enormous environmental, societal and economic benefits, together with enhanced security of energy supply.
- The project has demonstrated the first step towards the development of a green approach to $CO_2$ reduction and recycling has been undertaken.
- At present the further commercialisation of the results obtained is under way.

## Recommendations

- To achieve the benefits of a truly sustainable hydrogen energy economy, hydrogen has to be produced from non-fossil fuel resources, such as water.
- A number of challenges must be overcome for hydrogen to be used widely as a sustainable energy carrier, low carbon intensive, low polluting and low cost. Achieving such low cost and efficient solar energy production of hydrogen requires the development of innovative material, emerging physical phenomena, novel synthetic techniques and new concept designs.
- Therefore if we are to achieve the full environmental benefit of hydrogen as an energy carrier, low carbon intensive, low polluting, and lower cost processes for producing hydrogen from renewable energy sources must be developed.
- Irish technology development and methods in this field of environmental technology can be exported worldwide to address global issues.

## For Further Information

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## Some Peer Reviewed Publications associated with this report

Wavelength dependent photocatalytic H2 generation using Iridium-Pt/Pd complexes, Suraj Soman, Gurmeet Singh Bindra, Avishek Paul, Robert Groarke, Jennifer C. Manton, Finn M. Connaughton, Martin Schulz, Danilo Dini, Conor Long, Mary T. Pryce and Johannes G. Vos, Dalton Trans., 2012, 41, 12678-12680

Electrocatalytic pathways towards sustainable fuel production from water and CO2, Jane L. Inglis, Brian J. MacLean, Mary T. Pryce Johannes G. Vos, Coordination Chemistry Reviews 2012, 256,(21-22), 2571-2600

The role of bridging ligand in hydrogen generation by photocatalytic Ru/Pd assemblies; Gurmeet Singh Bindra, Martin Schulz, Avishek Paul, Robert Groarke, Suraj Soman,Jane L. Inglis, Wesley R. Browne, Michael G. Pfeffer, Sven Rau, Brian J. MacLean, Mary T. Pryce and Johannes G. Vos Dalton Trans., 2012, 41, 13050-13059

Effect of Water during the Quantitation of Formate in Photocatalytic Studies on CO2 Reduction in Dimethylformamide, Avishek Paul, Damian Connolly, Martin Schulz, Mary T. Pryce, and Johannes G. Vos Inorg. Chem., 2012, 51, 1977-1979