GIORNATA DELLA RICERCA UCBM

Research activities on Carbon Dioxide Valorization and on Energy Storage

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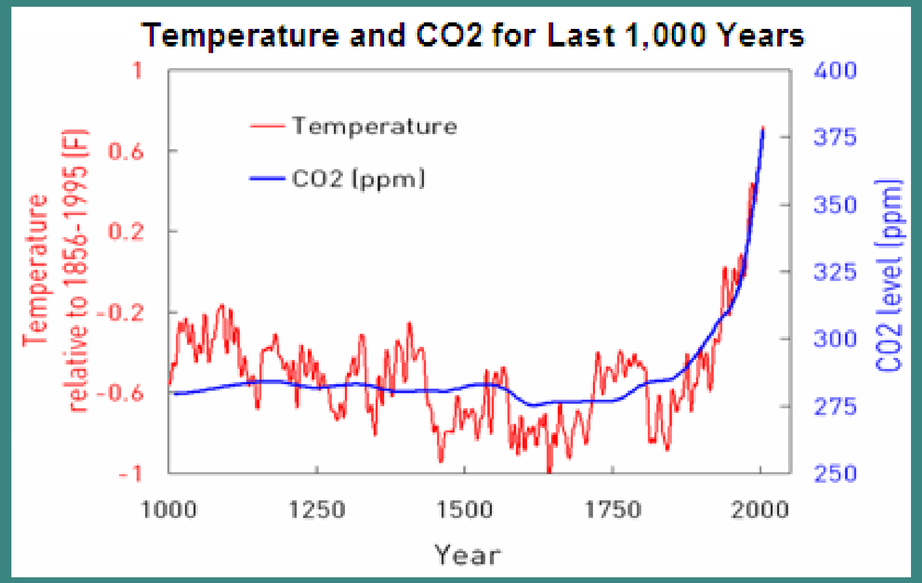
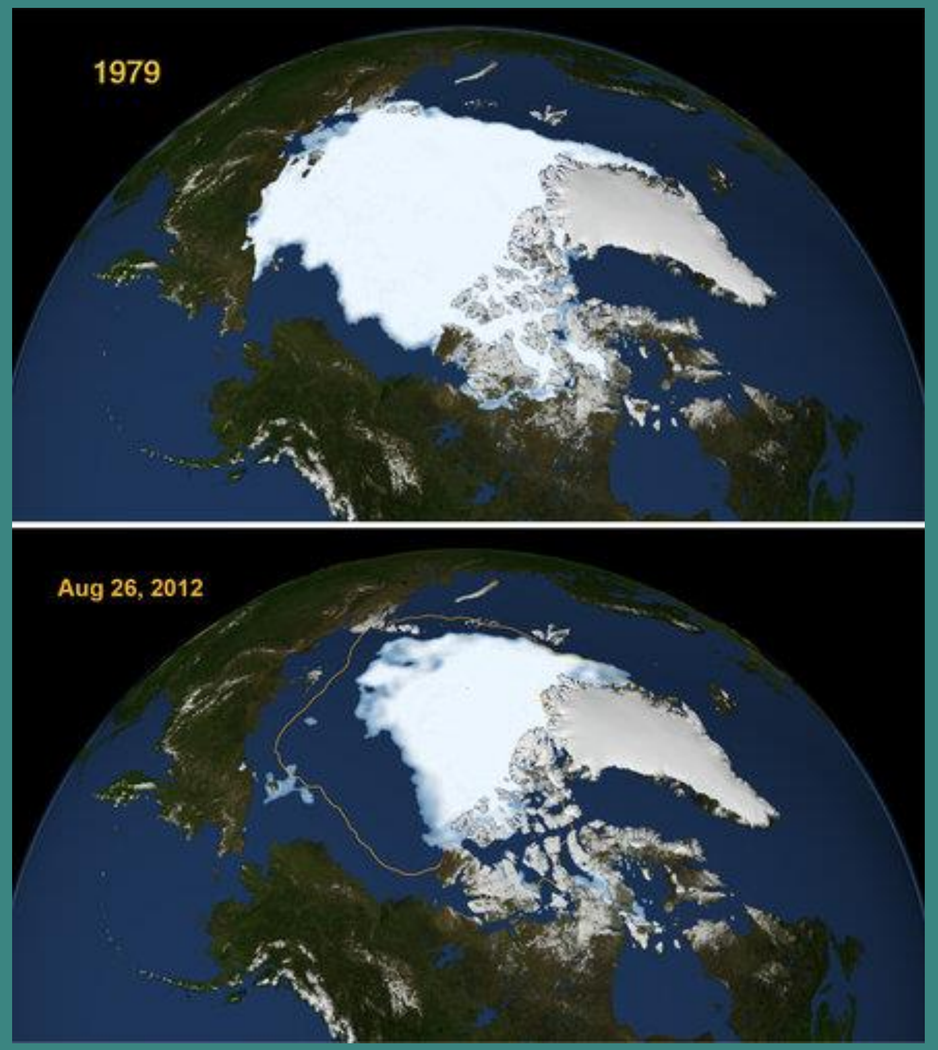
Climate Change





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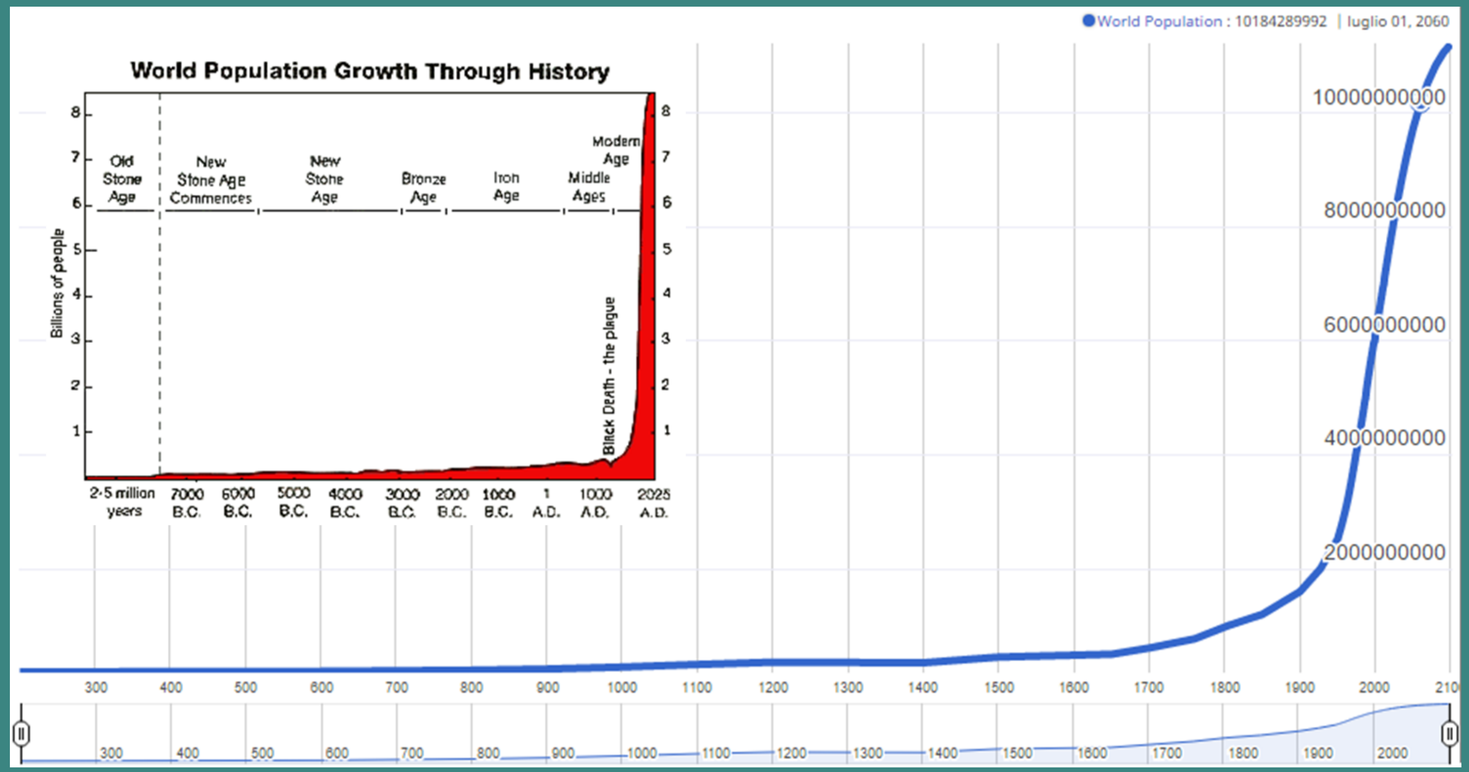
Climate Change

World population will go from 5 billion in 2000 to more than 10 billion in 2100!



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How to tackle climate change?

- CCS and CCV → **DME production from CO_2-rich syngas**
- Renewable Energies
- Energy Efficiency Tech → **Cold Energy Storage by PCMs**

DME Production

- DME is a clean burning synthetic fuel that can be a substituted for liquefied petroleum gas (LPG) or blended in fuel mix. It has excellent combustion characteristics due to a low auto-ignition temperature. With a cetane number of 55–60, DME can be used as a substitute for diesel fuel in a diesel engine, which would need only slight modifications.

- DME is produced from the syngas (CO/H_2 mixtures with a eventual amount of CO_2, typically below 3%) produced both from fossil fuels (natural gas or coal) and non-fossil-fuel sources (biomass):

  CO hydrogenation: $CO + 2H_2 \leftrightarrow CH_3OH$

  Water-gas shift: $CO + H_2O \leftrightarrow CO_2 + H_2$

  Methanol dehydration: $2CH_3OH \leftrightarrow \mathbf{CH_3OCH_3} + H_2O$

- But, the DME yield is negatively influenced by the CO_2 content in the reactor feedstock (10.9% @ CO_2 / CO= 2.5 vs. 79% @ CO_2 / CO= 0).

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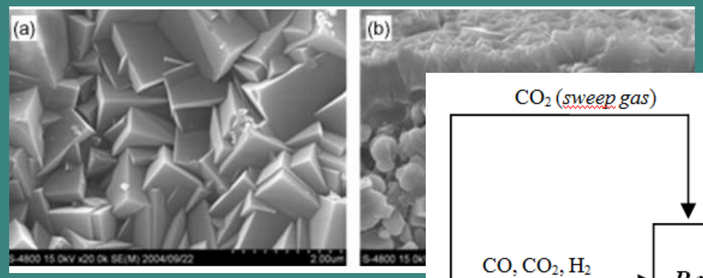
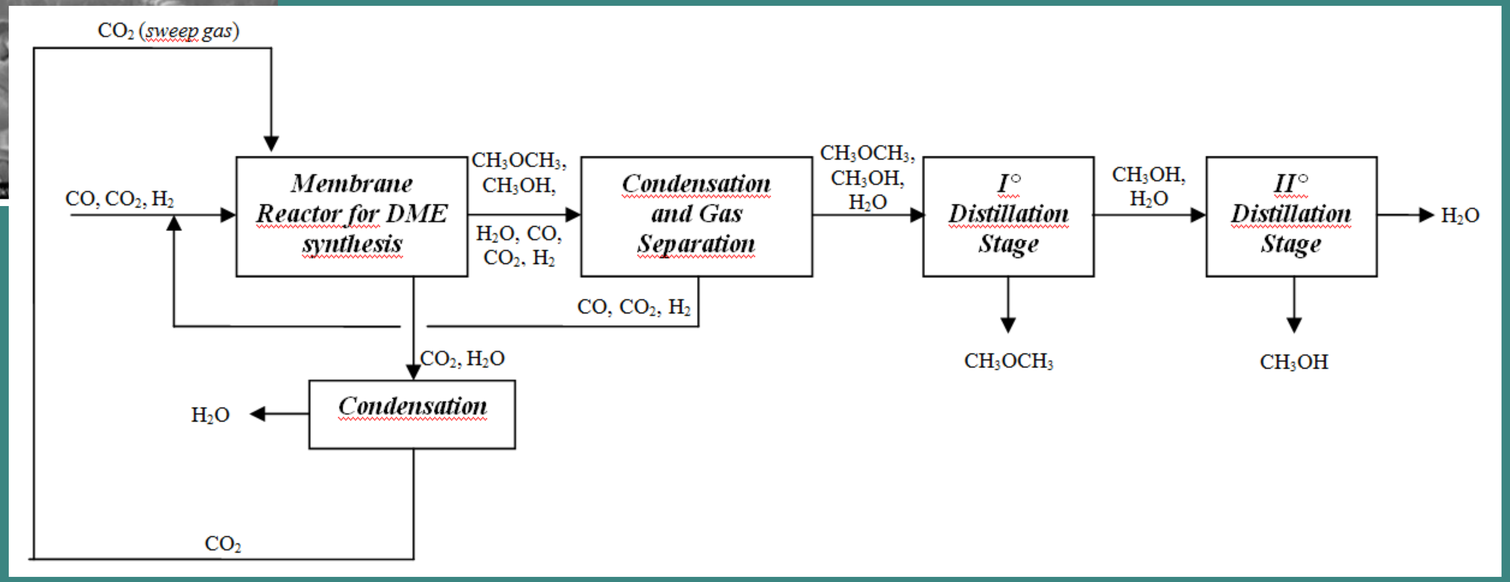
DME Production

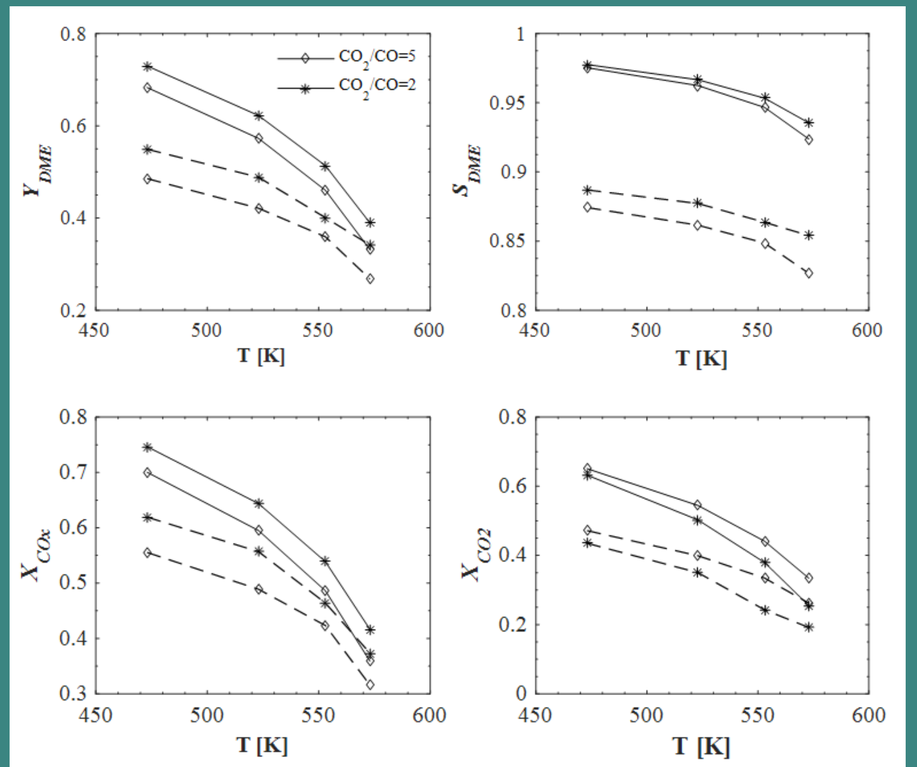
In situ H_2O removal is the only way to overcome the thermodynamic limit of CO_2 conversion since it can accelerate the reverse WGS of CO_2 towards H_2 and CO improving DME production.





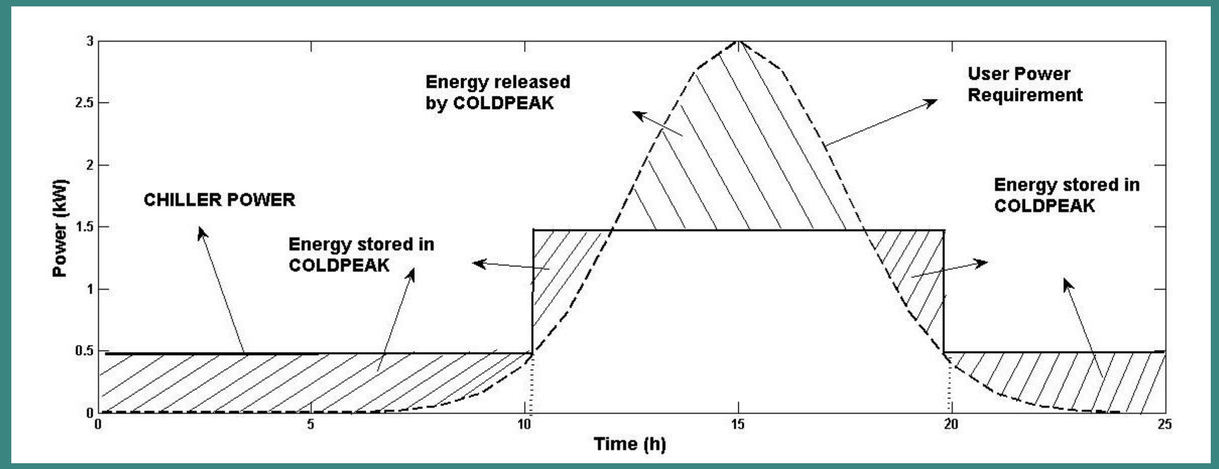
DME Production

Feeding the membrane reactor with a feedstock characterized by a CO_2/CO ratio of 3, the DME yield reaches a value of 0.75 (+31% in respect to the conventional reactor), the X_{COx} and X_{CO2} are 0.75 and 0.69, with an improvement of 15.4% and 30.2%, and the DME selectivity is close to 1.



Cold Energy Storage

- **ColdPeak** is an innovative solution for improving the energy efficiency of domestic Air Conditioning Systems (ACS). It is a storage system based on Phase Change Materials (PCM) by which cold energy is stored solidifying the PCM and then is released liquefying the material.
- The optimized and high performance heat exchange system between the chiller primary fluid and the PCM, allows quick charge and discharge phases, thereby increasing the charge/discharge power and paving the way to the application of the storage system as a peak shaving device.



Cold Energy Storage

- A first prototype has been developed, validating the solution and demonstrating the **ColdPeak** potentialities.
- The prototype can store up to 5 kWh_{cold} and release the energy at a power of 4.5 kW, meaning the tank can be completely charged and discharged in 1 hour approximately.
- The prototype stores energy at 5.5°C, coherently with the needs of a domestic Air Conditioning System (7-12°C cycle). The specific weight and volume are 27.9 kg/kWh_{cold} and 59.9 l/kWh_{cold}. The easiness of the configuration leads to a high level of reliability and safety.

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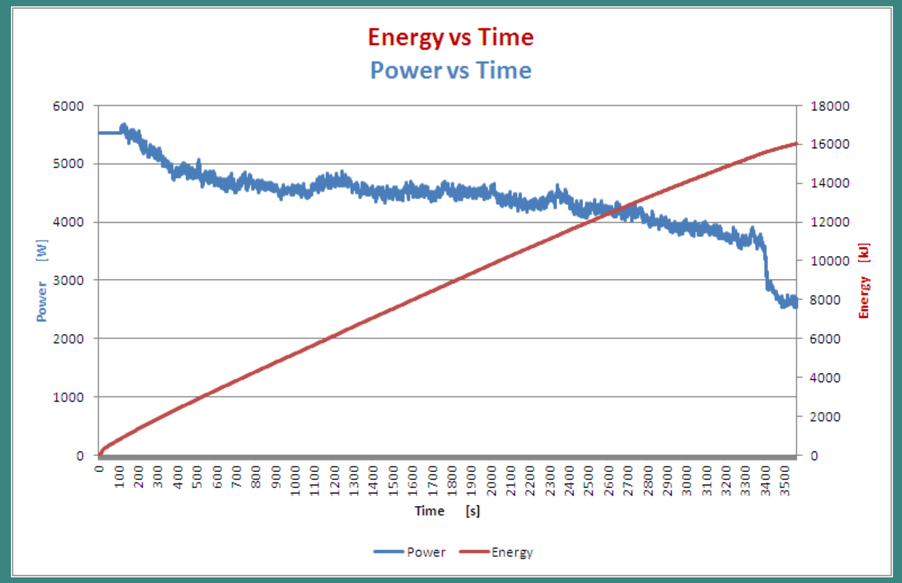
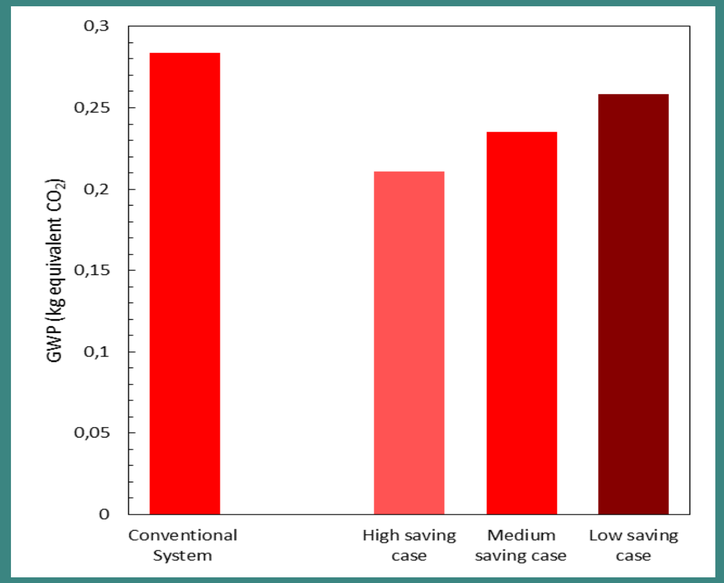
Cold Energy Storage

The LCA study, performed by “Process Engineering” Research Unit, has demonstrated that The environmental footprint that considers the material and the energy to build the ColdPeak is very low if compared with the amount of energy saved thanks to its application (10-30%). As a matter of fact, the LCA study reports that the integration of the cold storage unit allows a significant reduction of environmental footprint in terms of Global Warming Potential (-17%), Acidification Potential (-15.5%), Eutrophication Potential (-18%), Eco-toxicity (-16%), Human Health (-18%) and Fossil Depletion (-18%).





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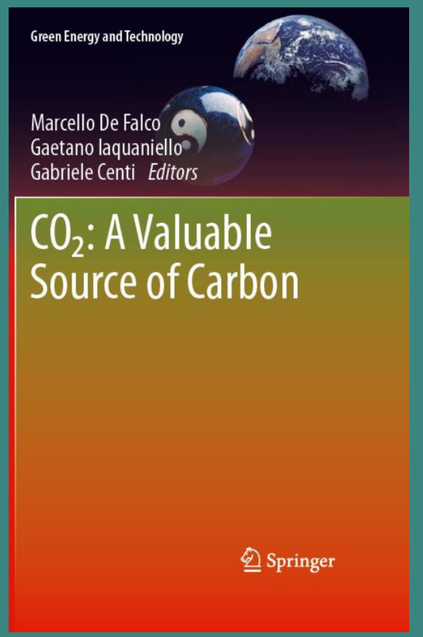
Publications

-) M. De Falco, M. Capocelli, A. Basile "*Selective membrane application for the industrial one-step DME production process fed by CO2 rich streams: modeling and simulation*", International Journal of Hydrogen Energy 42 (2017), 6771-6786.
-) M. De Falco, M. Capocelli, G. Centi, "*Dimethyl ether production from CO2 rich feedstocks in a one-step process: thermodynamic evaluation and reactor simulation*", Chemical Engineering Journal 294 (2016), 400-409.

-) M. De Falco, M. Capocelli, A. Giannattasio, "*Performance analysis of a innovative PCM-based device for Cold Storage in the Civil Air Conditioning*", Energy and Buildings 122 (2016), 1-10.
-) M. De Falco, G. Dose, A. Zaccagnini, *"PCM-Cold Storage System: an Innovative Technology for Air Conditioning Energy Saving"*, Chemical Engineering Transactions 43 (2015), 1981-1986.



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The scientist is the one who devotes the efforts to the improvement of man's life and the safeguarding of the environment in which we live, not to its destruction.

F. Maxwell

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