CRYOHUB - Cryogenic Energy Storage at Refrigerated Food Warehouses to Enhance the Sustainability of Cold Chain and Power Supply

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Reducing energy consumption throughout the food cold chain

- **40%** of the global food output require refrigeration
- **17%** of the electricity consumption worldwide is used for refrigeration and air conditioning, including **8%** for industrial refrigeration

Involvement of renewables – a must and key factor for enhancing the sustainability of the sector

Cold storage energy use in EU

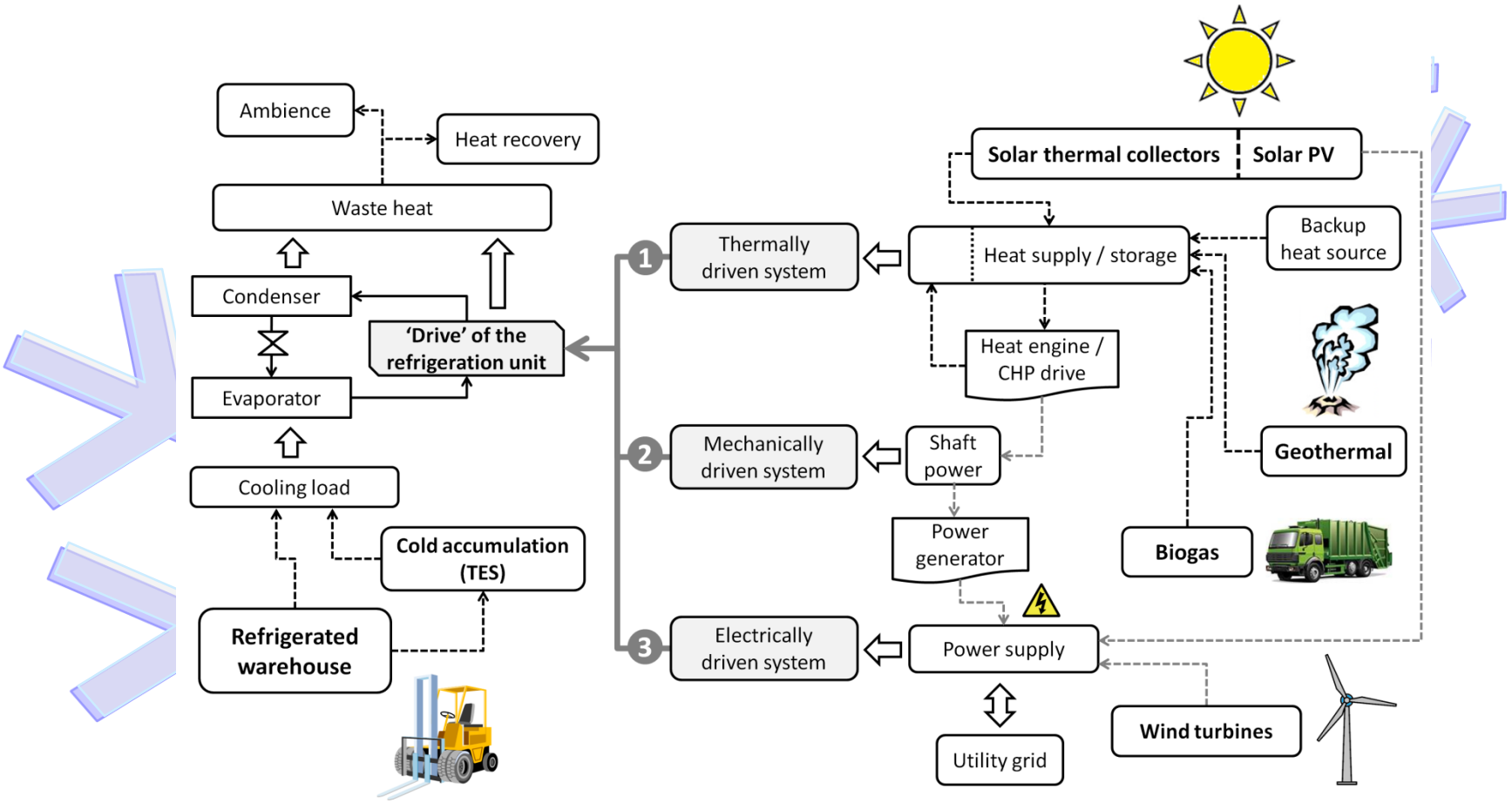
Energy use of the sector (EU) has been estimated at **12,5 TWh** per year (average **41,5 kWh/m³** per year).

- Average power consumption is **1500 MW**
- Max consumption (“loading”) up to **3000 MW**

Total wind energy capacity in EU 28 exceeds **142 GW** in 2015

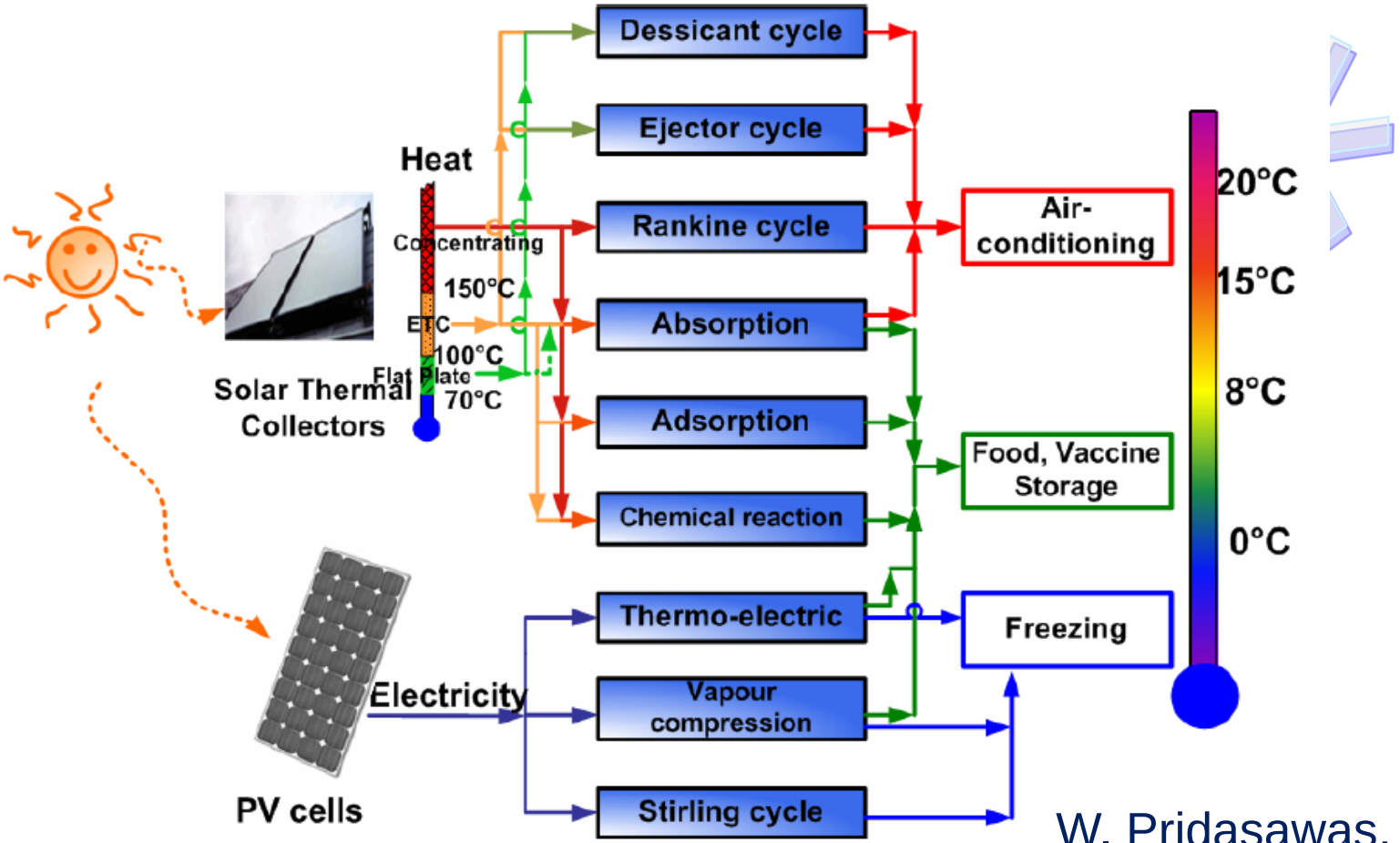
The wind power capacity installed by the end of 2015 could produce, in a normal wind year, **315 TWh** of electricity, enough to cover **11.4%** of the EU's electricity consumption (source: EWEA and Eurostat)

Integration of RES in refrigerated warehousing



Various integration options (Fikiin and Stankov, 2015)

Solar Refrigeration Principles



W. Pridasawas, 2006

Three feasible concepts

- **Solar electric refrigeration** – PV panels are used as a power source for traditional vapour-compression refrigeration system.
- **Solar thermo-mechanical refrigeration** – solar heat is converted to mechanical work to drive the compressor of a vapour-compression refrigeration system.
- **Solar sorption refrigeration** – solar thermal collectors provide driving heat for an adsorption or absorption refrigeration plant.

Solar Electric Refrigeration

The 9 MW solar array on the rooftop of a refrigerated warehouse at the Gloucester Marine Terminal in New Jersey

Solar PV-driven Refrigeration

Solar park on the roof of MTC Logistics' cold store at the Port of Baltimore

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Bonn, Germany, 6-7 June 2016

Renewable Energy in Refrigerated Warehousing

The Los Angeles' largest commercial solar installation on the rooftop of the Konoike-Pacific cold-storage warehouse in Wilmington

Solar PV-powered Refrigeration

Solar park at the U.S. Foods' facility in La Mirada, California

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Integration of RES in refrigerated warehousing:
Further reading and details

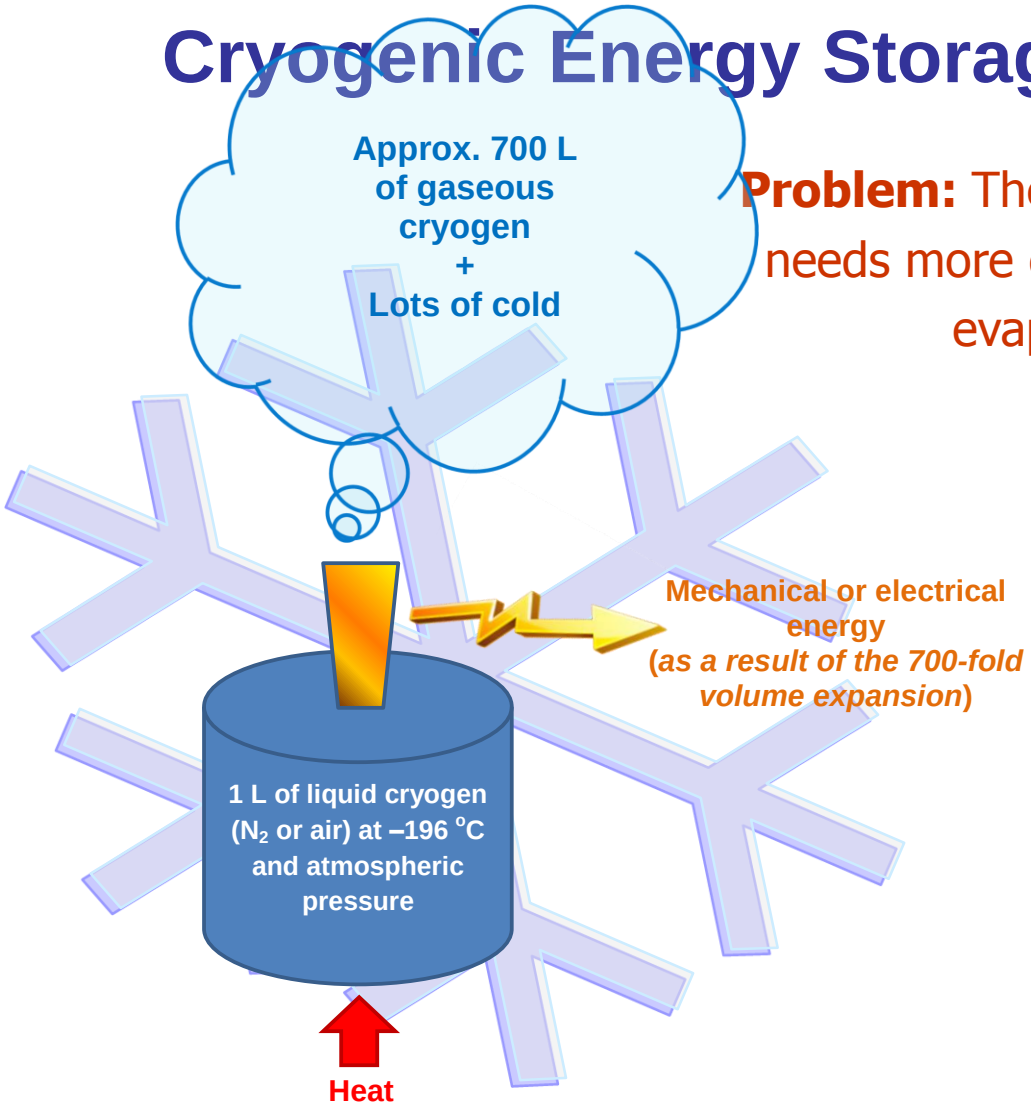
Book chapter published:

Fikiin K. and Stankov B. (2015). Integration of renewable energy in refrigerated warehouses. Chapter 22, In *Handbook of Research on Advances and Applications in Refrigeration Systems and Technologies.* Eds: Gaspar P.D. and da Silva P.D., 1st edition, Engineering Books, IGI Global, Pennsylvania, USA, pp. 803-853

http://bit.do/renewable-refrigeration

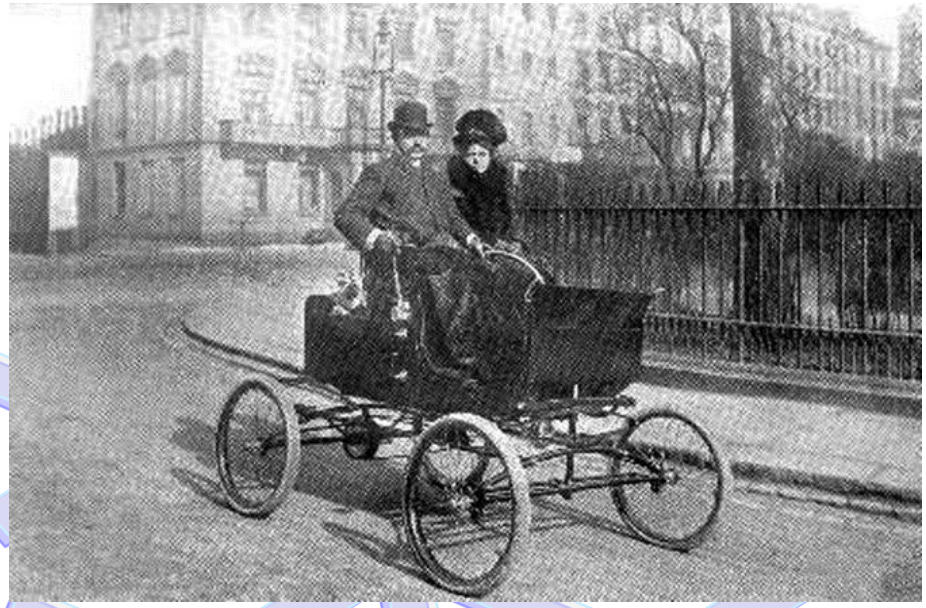
http://bit.do/renewable-refrigeration-pdf

Cryogenic Energy Storage: *Basic Principle*

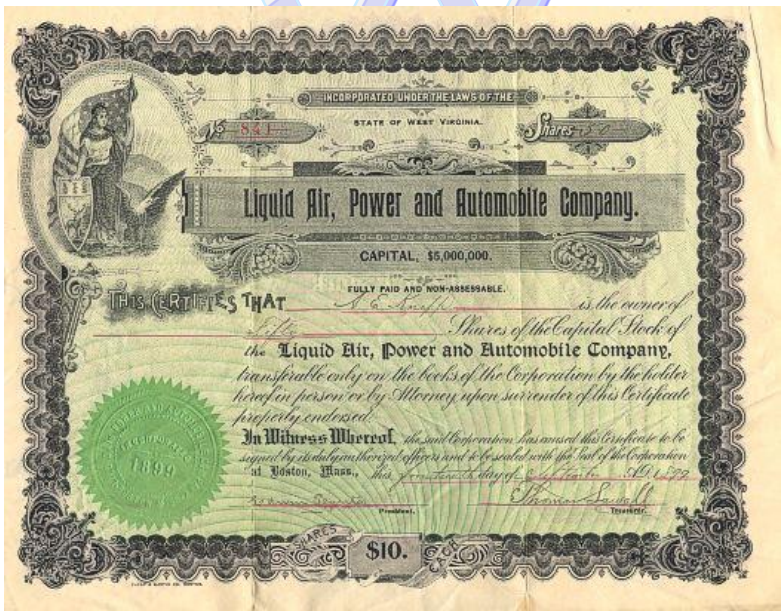


Problem: The liquefaction of unit mass of cryogen needs more energy than it can be extracted when evaporating it – **poor efficiency of CES**

Engines powered by cryogenically stored energy



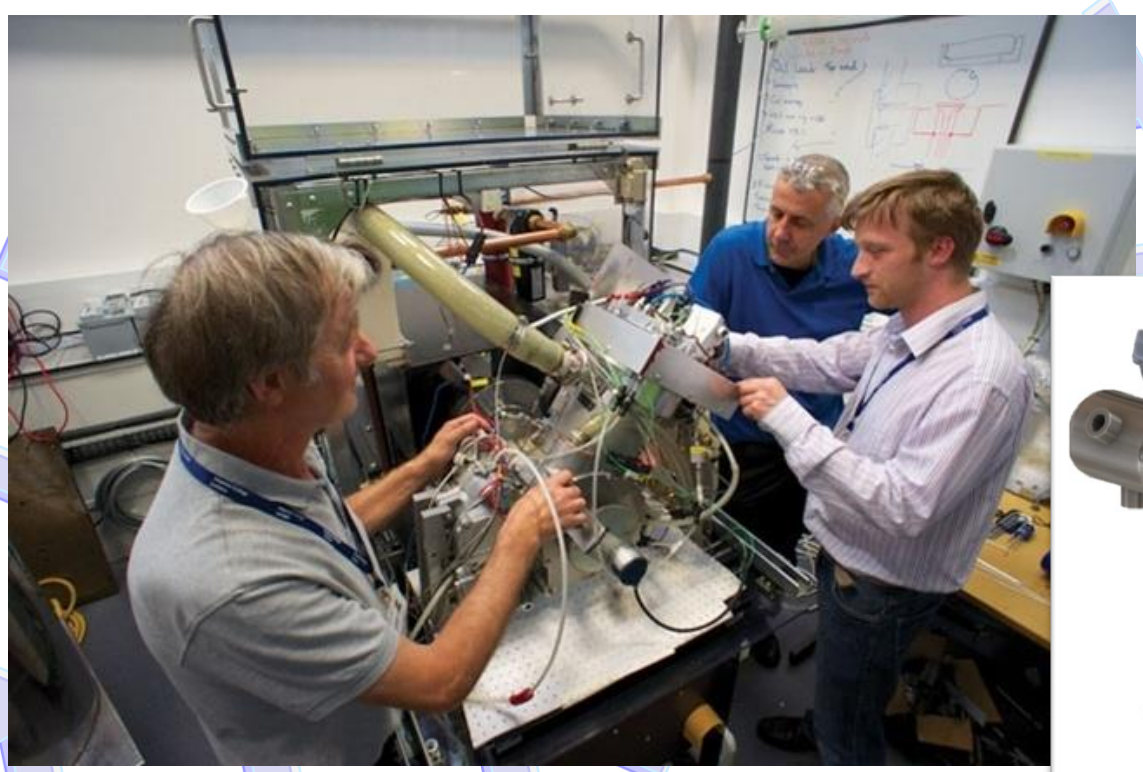
Liquid Air Car in 1903, *New York Times*



Certificate from the Liquid Air, Power and Automobile Company, 1899

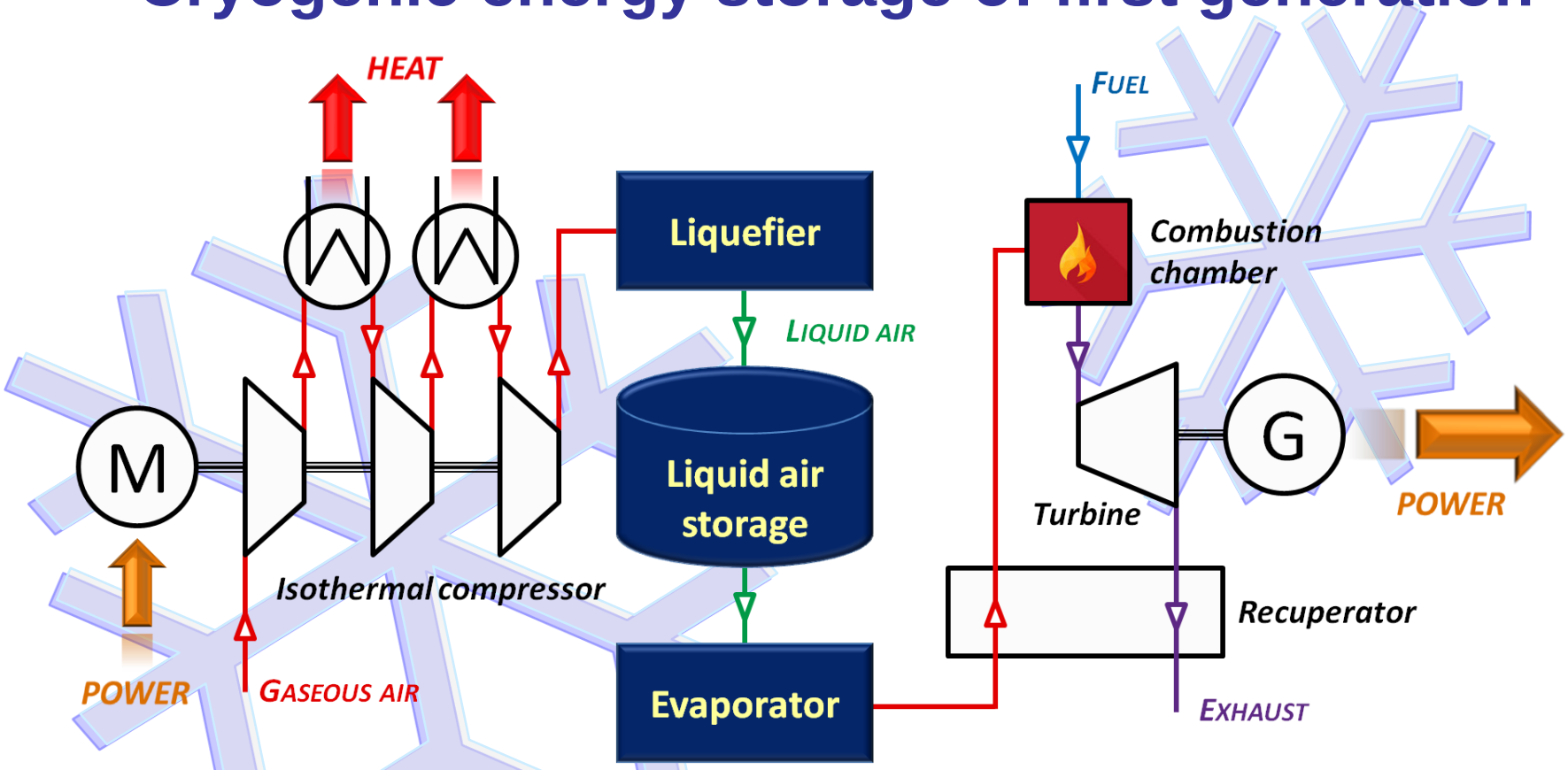
In 1899 Hans Knudsen designed a car called *Liquid Air* and demonstrated it at a London motor show in 1902 (although this has allegedly been a modified Locomobile steamer).

Engines powered by cryogenically stored energy



In 2001 the British inventor Peter Dearman patented the Dearman Engine believed to improve the efficiency of CES applications.

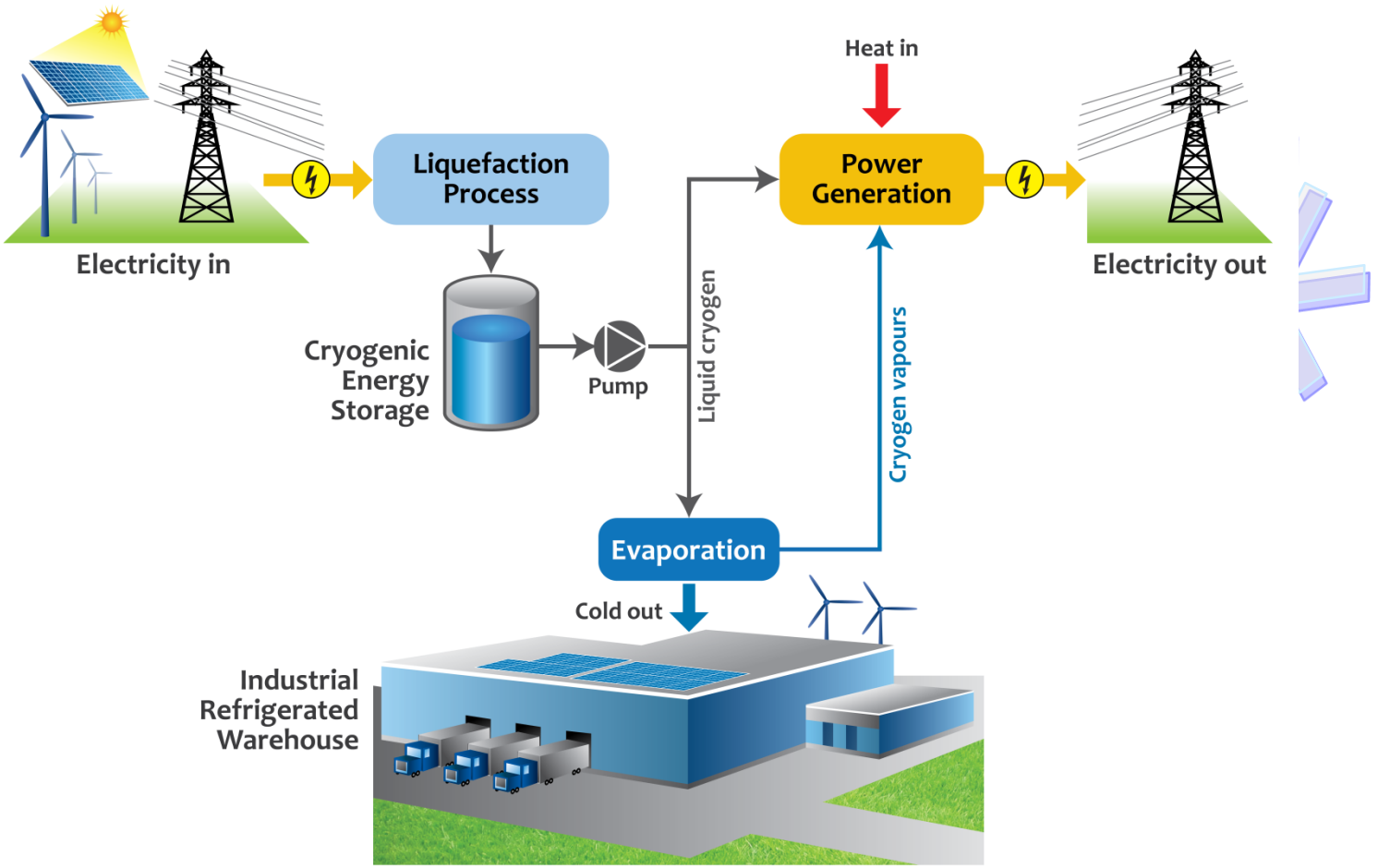
Cryogenic energy storage of first generation



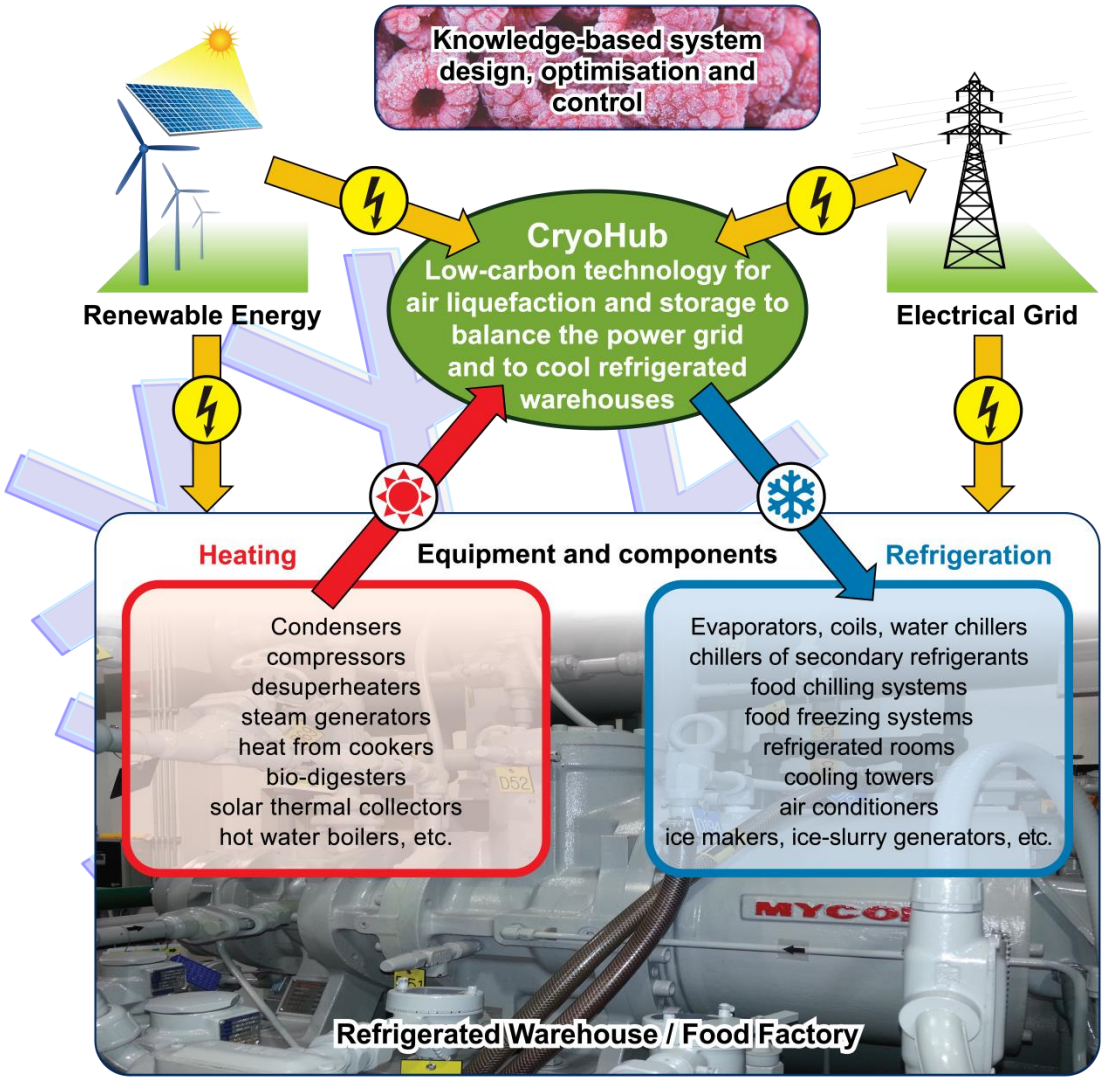
Boiling cryogen aids a conventional combustion engine at peak demands (hybrid system).

International R&D activities related to CES

- **Mitsubishi Heavy Industries (*Japan*)** – tested a CES application and reported it in 1998
- **Highview Power Storage (*UK*)** – tests a pilot CES system (350 kW/2.5 MWh) since 2011
- **Dearman (*UK*)** – comersialises the Dearman engine with emphasis on refrigerated transport
- **Linde Gas and Hitachi Power Europe (*Germany*)** – examined the use of CES in parallel and in comparison with the compressed air energy storage
- **Birmingham Centre of Cryogenic Energy Storage (*UK*)** – houses a state-of-the-art facility for R&D in CES systems



Basic concept for synergistic operation of RES and CES (Fikiin, 2015).



Employing renewable energy to liquefy and store cryogens is capable of balancing the power grid, while meeting the cooling demand of a refrigerated warehouse and recovering the waste heat from its equipment and components (CryoHub, 2015).

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EU Horizon 2020 Project *"CryoHub – Developing Cryogenic Energy Storage at Refrigerated Warehouses as an Interactive Hub to Integrate Renewable Energy in Industrial Food Refrigeration and to Enhance Power Grid Sustainability"* (Grant Agreement No. 691761)

The aim of CryoHub is to:

- Balance the power grid mismatch between power demand and energy generation from renewables
- Store energy generated by renewables before supplying it back to the grid
- Provide an affordable cooling supply during power generation
- Increase the take up of renewable energy
- Reduce peak power demand and help decarbonise the grid

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Refrigerated warehouse and renewable energy mapping

- To map the locations and sizes of large refrigerated warehouses and facilities (which consume over 500 kW of electrical energy on average for refrigeration) to estimate the potential benefits of the CryoHub technology across Europe.
- To map whether these stores have access to renewable energy schemes on site or locally (within 1 km around).
- To determine the potential for stores without access to renewable energy schemes to install RES technologies.

CRYOHUB Mapping Survey

If you wish to:

- boost your company sustainability credentials;
- gain free publicity and a green image across Europe;
- be recognised as an environmental pioneer in a high-profile EU project;
- tune into cutting-edge energy storage research;
- identify methods for energy saving and grid feed-in;

does not miss to apply ASAP for the status of a *'CryoHub Champion',* as detailed in https://www.surveymonkey.co.uk/r/cryohub or http://bit.do/CryoMap

Welcome to the CRYOHUB Survey

CryoHub

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Name

Company

Position in company

E-mail address

Phone number (please include international code)

14. As a new 'Bronze' CryoHub Champion, would you like to enhance further your environmental credentials by a closer collaboration with the project, being involved as:

- [ ] Case study site ('Silver' CryoHub Champion)
- [ ] Demonstration site ('Gold' CryoHub Champion)

Confidentiality

Contact details and technical data entered as input information for the CryoHub survey will solely be used for engineering computations, statistical processing, performance comparison and further contacts with you (if any). This information will be treated in strict confidence and will not be disclosed to any third parties or authorities (including the European Commission).

Disclaimer

Feedback information generated by the CryoHub survey is based on the current state of art and achievements within the CryoHub project. The CryoHub consortium cannot accept any liability for the consequences of the use or misuse of this information, which does not necessarily reflect the official position of the European Commission.

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Done

Our Stakeholders

'Bronze' CryoHub Champions - properly completed the survey.

'Silver' CryoHub Champions - selected hosts for Case Studies

'Gold' CryoHub Champion - Demo Plant host

CryoHub Champions will be rewarded with a Certificate, a prominent acknowledgement in the project website or might be invited to join the **CryoHub Advisory Board**

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Thank you for your attention!

To find out more about

CRYO HUB

See our website at

www.cryohub.eu

and sign up for updates!

Look out for future Workshops and Conferences along with Journal and Magazine articles.





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