Stories from the Frontline of Cleantech Innovation

Greenhouse Gas Reduction Technologies

Ontario Centres of Excellence

Where Next Happens

In partnership with

EMISSIONS REDUCTION ALBERTA

NSERC CRSNG

SUSTAINABLE DEVELOPMENT TECHNOLOGY CANADA
TECHNOLOGIES DU DÉVELOPPEMENT DURABLE CANADA

Ontario

ABOUT US

OCE accelerates innovation through game-changing research leading to successful commercialization and vibrant collaboration between industry and academia helping to launch the next generation of products and jobs.

What we do

Ontario Centres of Excellence (OCE) drives the development of Ontario's economy by helping create new jobs, products, services, technologies and businesses.

In partnership with industry, OCE co-invests to commercialize innovation originating in the province's publicly funded colleges, universities and research hospitals. We also support and invest in early-stage projects, where the probability of commercial success and potential total return on innovation are substantial. Another expanding focus for OCE is the development of the next generation of innovators through our entrepreneurship fellowships and programs for students and youth across Ontario.

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News Release

The Province Wants Your Ideas for a Made-in-Ontario Plan

October 19, 2018 4:30 P.M. | Ministry of the Environment, Conservation and Parks

Toronto - Ontario's Government for the People is inviting the public and businesses to have their say on how Ontario can deal with environmental challenges such as climate change.

"We share an opportunity to work together to tackle the big environmental challenges that currently face our province and, indeed, the entire world," said Rod Phillips, Minister of the Environment, Conservation and Parks. "At the same time, Ontario has many resourceful and innovative individuals and businesses - we want to hear from you on how best to balance a healthy economy with a healthy environment."

The public can now comment on some key areas of focus for Ontario's new plan, which will replace the previous government's insistence on imposing a punishing, job-killing carbon tax on Ontario families and businesses, and instead focus on collaborative approaches that will actually help the environment.

In particular, the consultation will focus on resiliency efforts, pollution reduction and how government can better partner with the private sector on sustainable solutions.

The government's new made-in-Ontario environment plan will be released for formal feedback later this fall. It is a comprehensive environmental plan to build a resilient Ontario that protects waters and air, cleans up communities and encourages conservation.

Media Contacts

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Andrew Brander
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Consultati

We want your ideas

About this co

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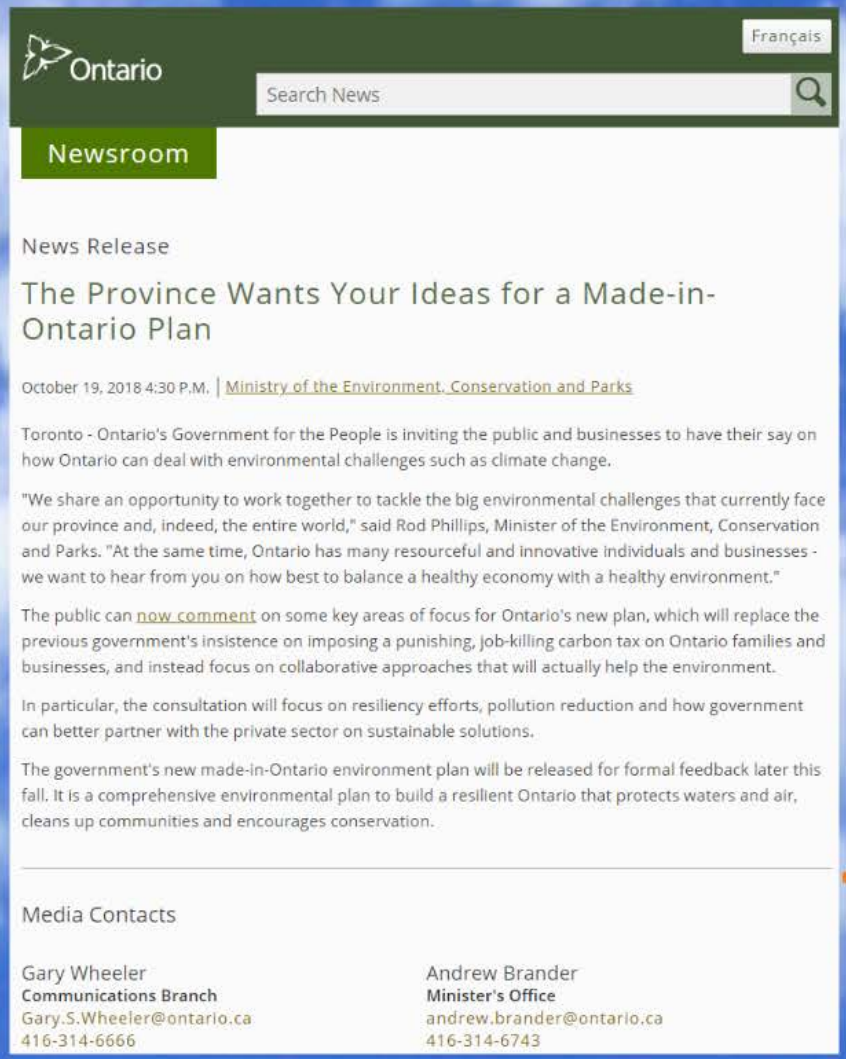
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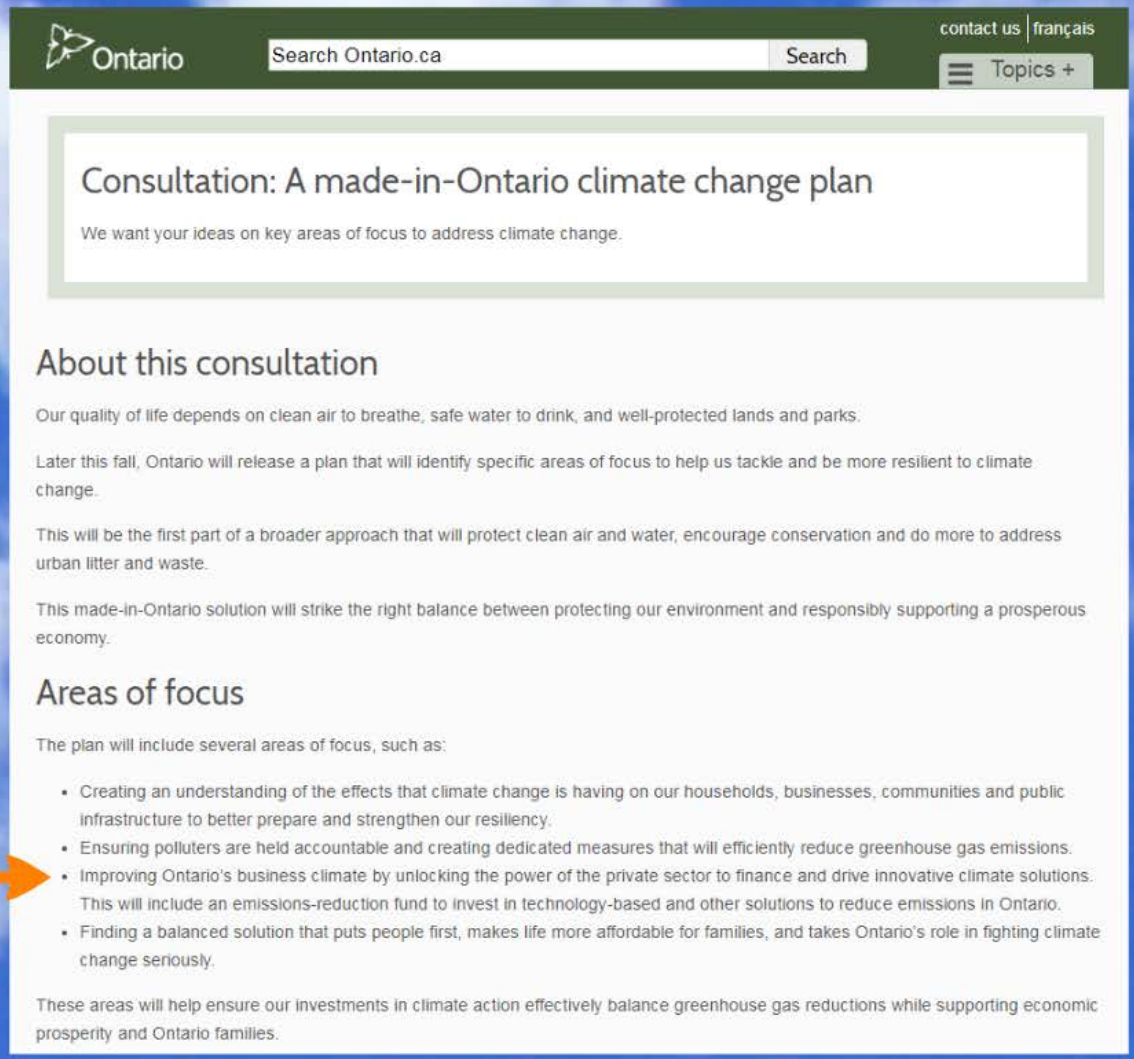
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Topics +
Consultation: A made-in-Ontario climate change plan
We want your ideas on key areas of focus to address climate change.
About this consultation
Our quality of life depends on clean air to breathe, safe water to drink, and well-protected lands and parks.
Later this fall, Ontario will release a plan that will identify specific areas of focus to help us tackle and be more resilient to climate change.
This will be the first part of a broader approach that will protect clean air and water, encourage conservation and do more to address urban litter and waste.
This made-in-Ontario solution will strike the right balance between protecting our environment and responsibly supporting a prosperous economy.
Areas of focus
The plan will include several areas of focus, such as:
• Creating an understanding of the effects that climate change is having on our households, businesses, communities and public infrastructure to better prepare and strengthen our resiliency.
• Ensuring polluters are held accountable and creating dedicated measures that will efficiently reduce greenhouse gas emissions.
• Improving Ontario's business climate by unlocking the power of the private sector to finance and drive innovative climate solutions. This will include an emissions-reduction fund to invest in technology-based and other solutions to reduce emissions in Ontario.
• Finding a balanced solution that puts people first, makes life more affordable for families, and takes Ontario's role in fighting climate change seriously.
These areas will help ensure our investments in climate action effectively balance greenhouse gas reductions while supporting economic prosperity and Ontario families.

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" 'Wastes' are substances or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law"
- Basel Convention (a fancy-schmancy UN treaty on waste and Hazardous wastes)

product (noun) \ˈprä-(ˌ)dəkt\

Something that is made or grown to be sold or used
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Conserve
More Efficient
Produce/Emit Less
Fuel Switching
Convert
Growing Biomass or RNG
Energy from Methane
Building Materials
Combine
Advanced Materials
Chemicals
Fuels (Energy Storage)

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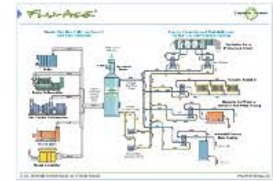
ArcelorMittal DOFASCO HAMILTON

resolute Forest Products



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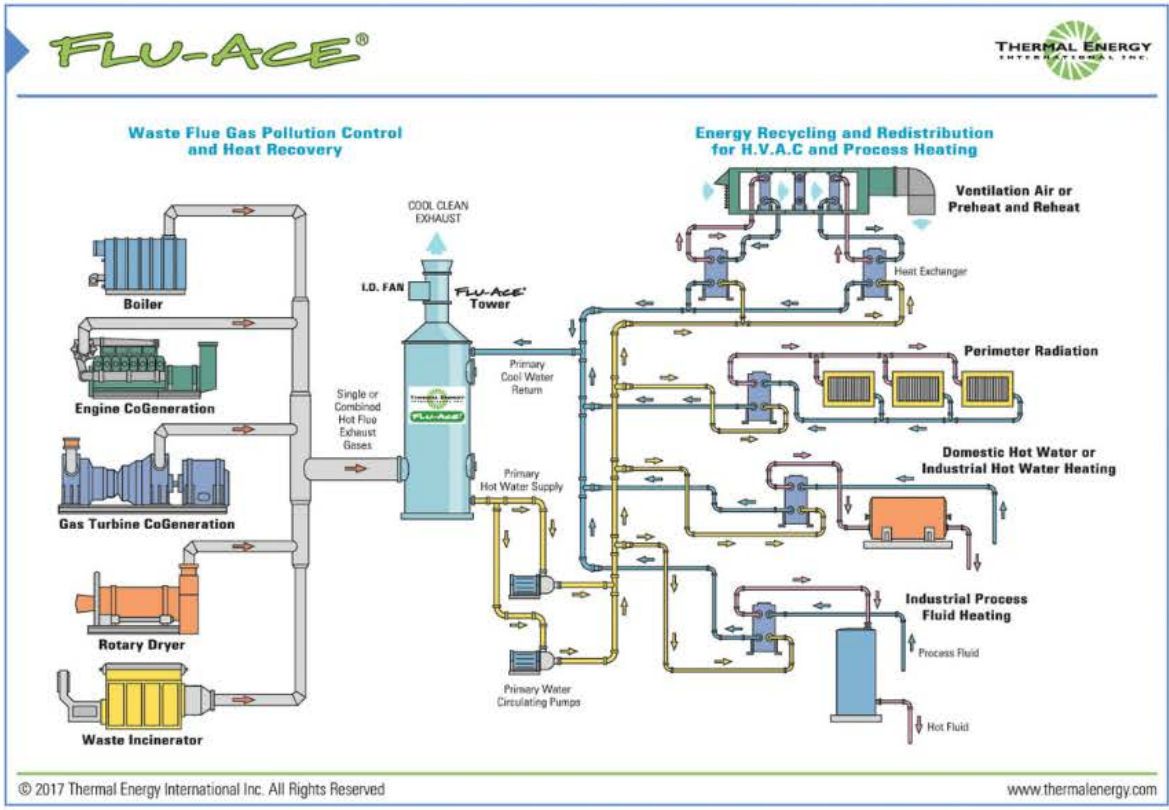

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More Efficient

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Growing Biomass or RNG

Energy from Methane

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Advanced Materials

Chemicals

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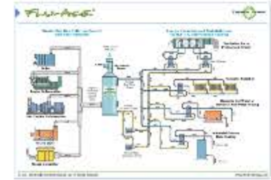

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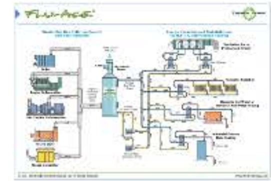

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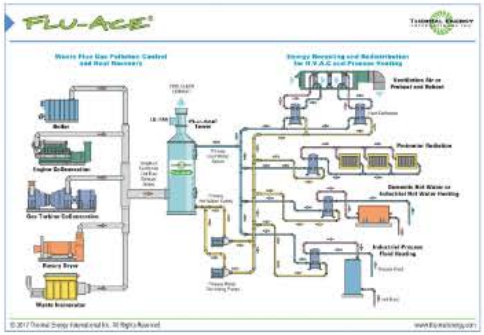

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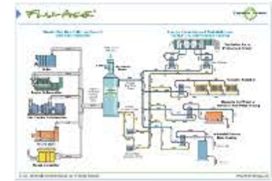

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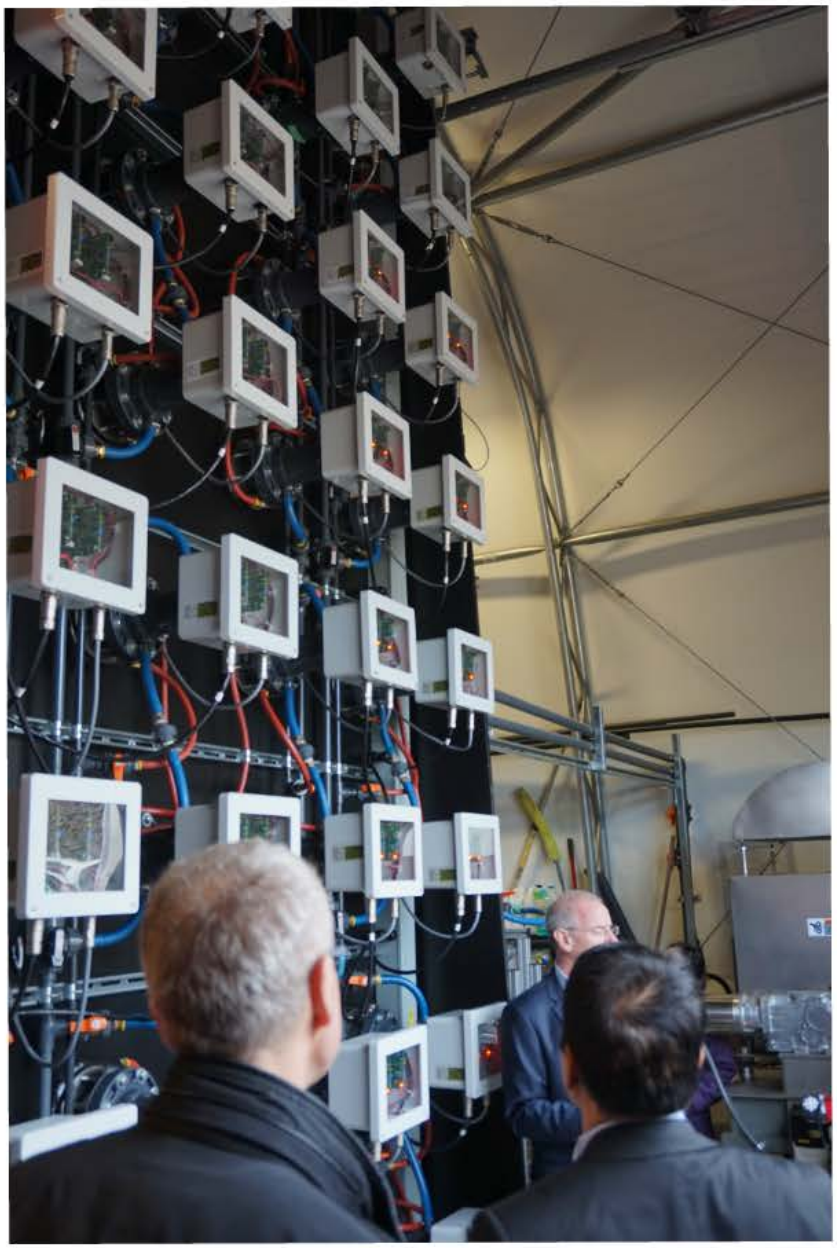

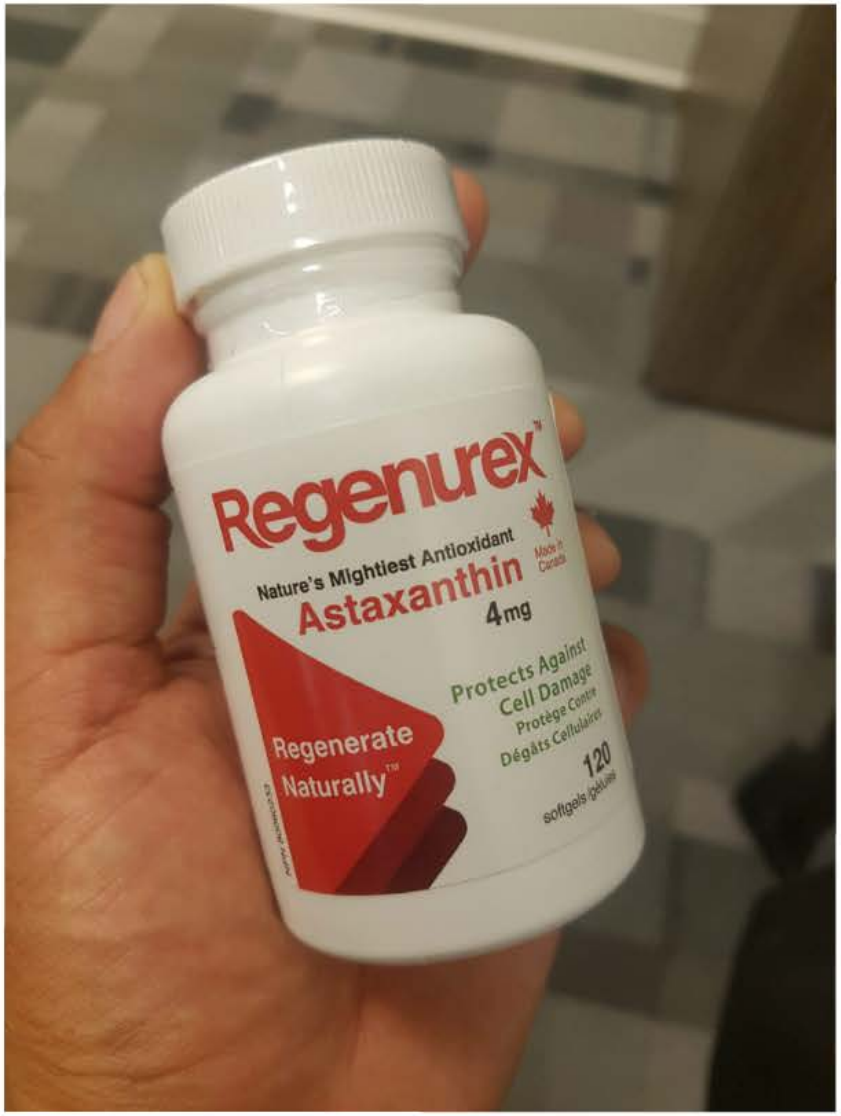
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Nature's Mightiest Antioxidant
Astaxanthin
4mg
Made in Canada
Protects Against Cell Damage
Protège Contre Dégâts Cellulaires
Regenerate Naturally™
120
softgels/gélules






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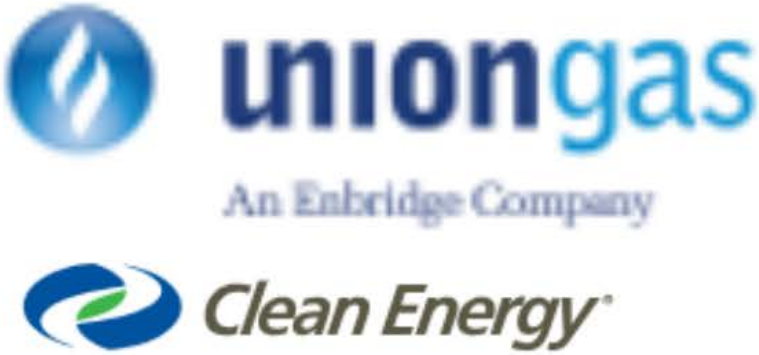
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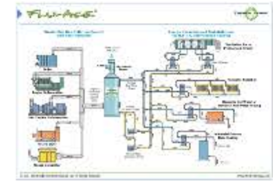

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General Motors of Canada Company
Welland Canal Service Rd
Seaway Haulage Rd
Thorold Townline Rd
Regent St
Mountain Rd
Taylor Rd
101
70
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Google Earth
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43°07'59.56" N 79°10'24.33" W elev 178 m eye alt 2.02 km

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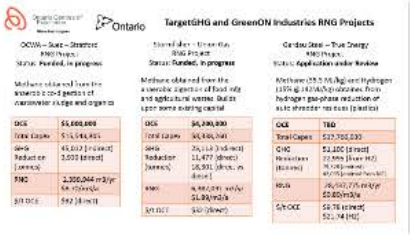

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Where Next Happens

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TargetGHG and GreenON Industries RNG Projects

OCWA – Suez – Stratford
RNG Project
Status: **Funded, in progress**

Methane obtained from the anaerobic co-digestion of wastewater sludge and organics

OCE	**$5,000,000**
Total Capex	$15,543,305
GHG Reduction (tonnes)	45,012 (indirect) 3,939 (direct)
RNG	2,359,944 m3/yr $8.70/m3/a
$/t OCE	$92 (direct)

Stormfisher – Union Gas
RNG Project
Status: **Funded, in progress**

Methane obtained from the anaerobic digestion of food mfg and agricultural wastes. Builds upon some existing capital.

OCE	**$4,200,000**
Total Capex	$8,338,260
GHG Reduction (tonnes)	25,113 (indirect) 11,477 (direct) 18,301 (direct vs diesel)
RNG	6,387,091 m3/yr $1.89/m3/a
$/t OCE	$32 (direct)

Gerdau Steel – True Energy
RNG Project
Status: **Application under Review**

Methane (55.5 MJ/kg) and Hydrogen (15% @142MJ/kg) obtained from hydrogen gas-phase reduction of auto shredder residues (plastics)

OCE	**TBD**
Total Capex	$17,760,930
GHG Reduction (tonnes)	51,100 (direct) 22,995 (from H2) 79,328 (emitted) 42,035 (emitted from NG)
RNG	28,437,775 m3/yr $0.80/m3/a
$/t OCE	$9.78 (direct) $21.74 (H2)

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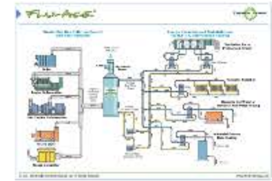

CO2 Utilization

CO2U: CO2 Utilization focuses on finding pathways and novel approaches for reducing CO2 emissions by developing beneficial uses for the CO2 that will mitigate CO2 emissions and generate significant environmental and economic benefits.

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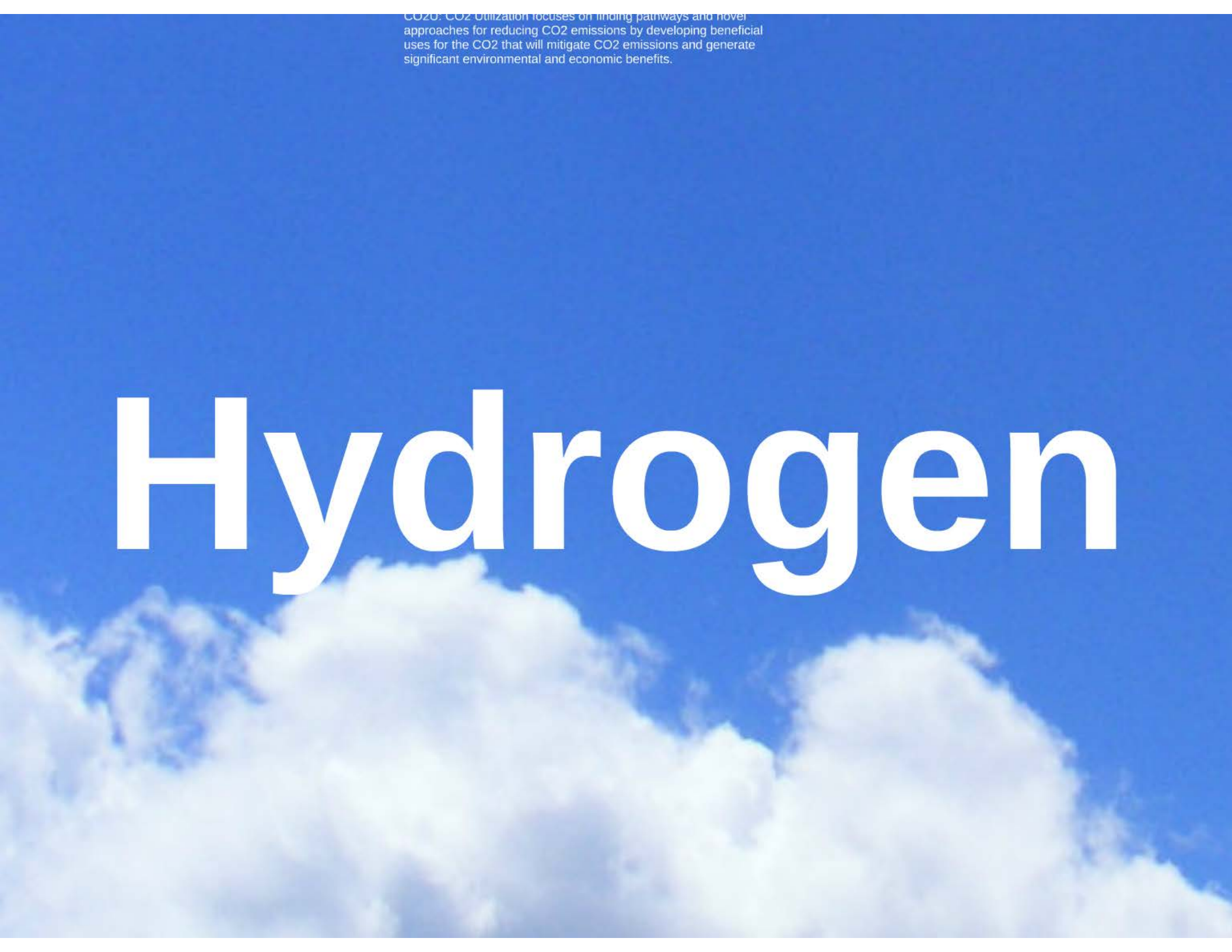
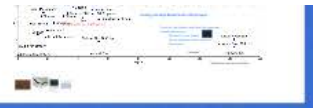
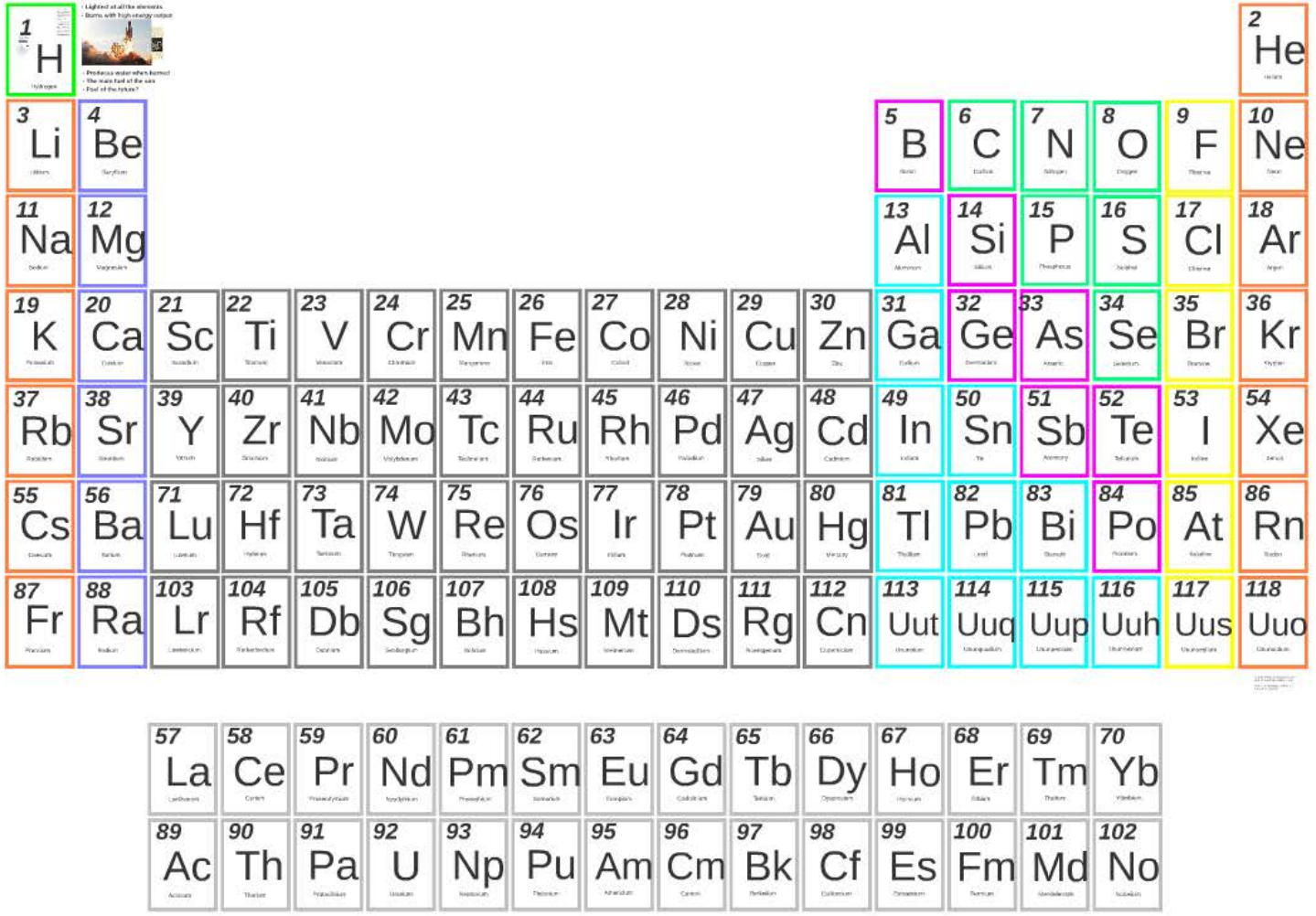
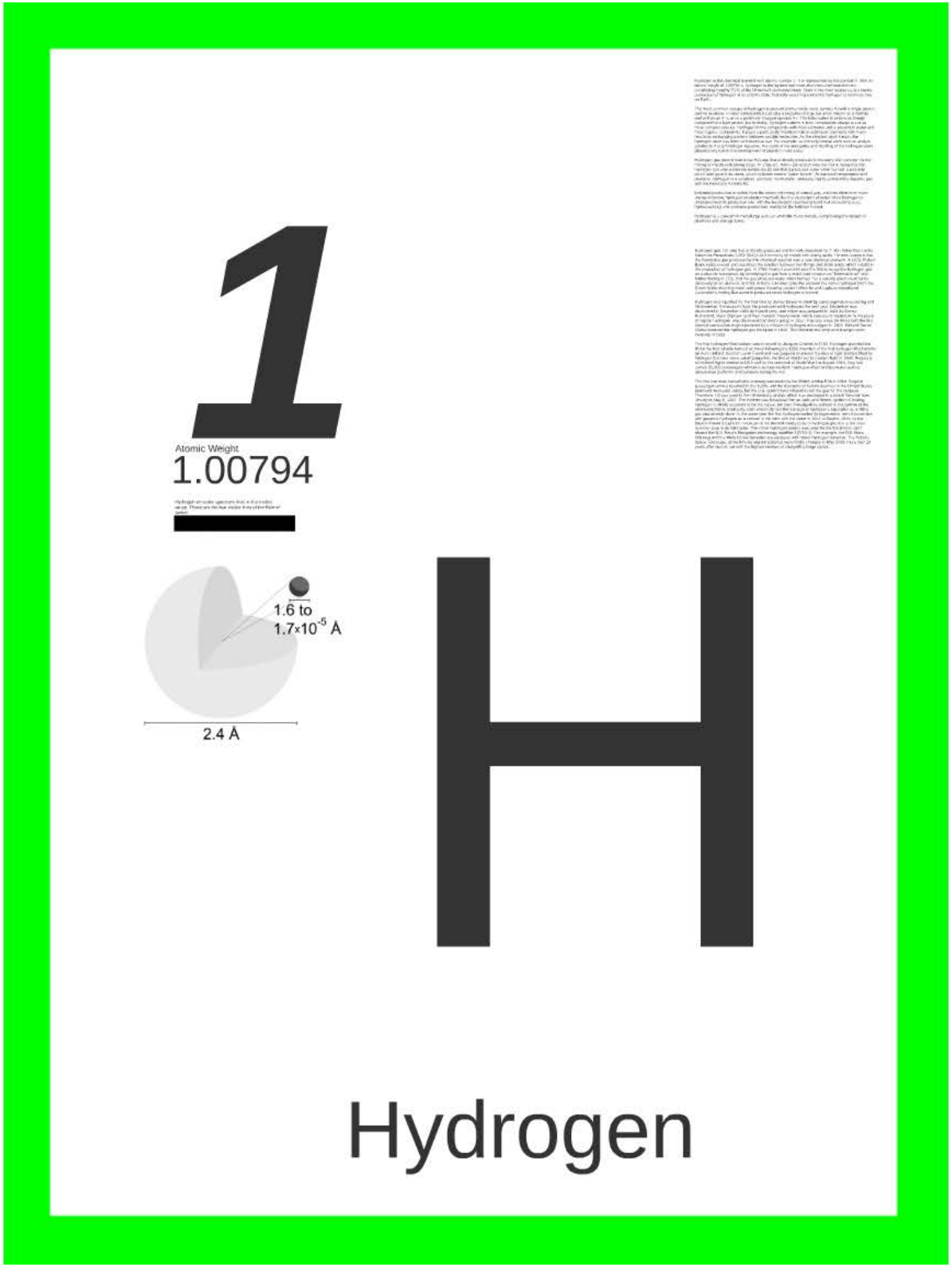


Hydrogen



The Periodic Table of Elements



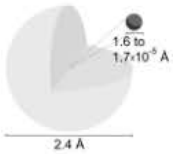


- Lighte
- Burns

- Produ
- The m
- Fuel c

1

Atomic Weight
1.00794



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Hydrogen

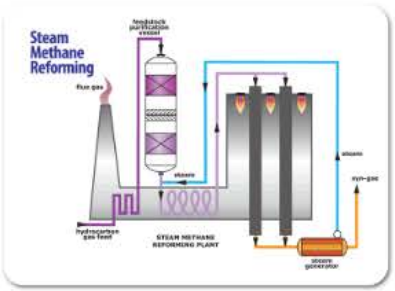
- Lightest of all the elements
- Burns with high energy output

- Produces water when burned
- The main fuel of the sun
- Fuel of the future?

3

4

Hydrogen Production



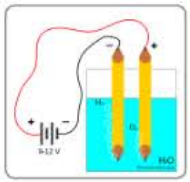
Made from Natural Gas

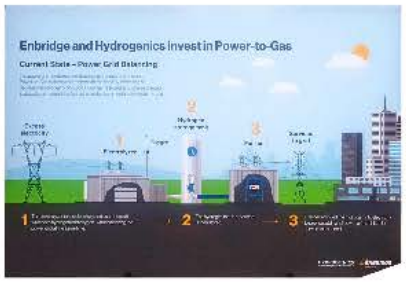
Steam Methane Reforming

Produces plenty of CO2

$CH_4 + H_2O \rightarrow CO + 3\,H_2$

$CO + H_2O \rightarrow CO_2 + H_2$





Electrical Splitting

Electrolysis

Needs low cost or surplus electricity

Thermo Chemical Splitting

Copper-Chlorine Cycle

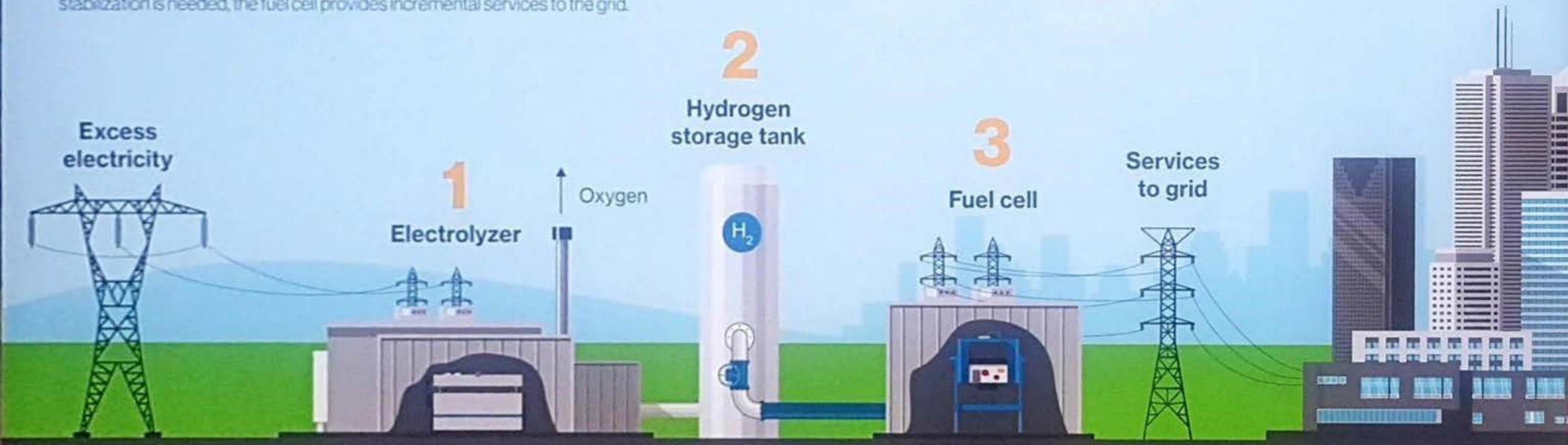
Needs 530C Heat Source

Electrical and Thermal Energy Storage Solutions?

Enbridge and Hydrogenics Invest in Power-to-Gas

Current State – Power Grid Balancing

The power grid needs real-time balancing of supply and demand. Power-to-Gas electrolyzers respond to this need by increasing or decreasing hydrogen production. Hydrogen is stored, and when more grid stabilization is needed, the fuel cell provides incremental services to the grid.



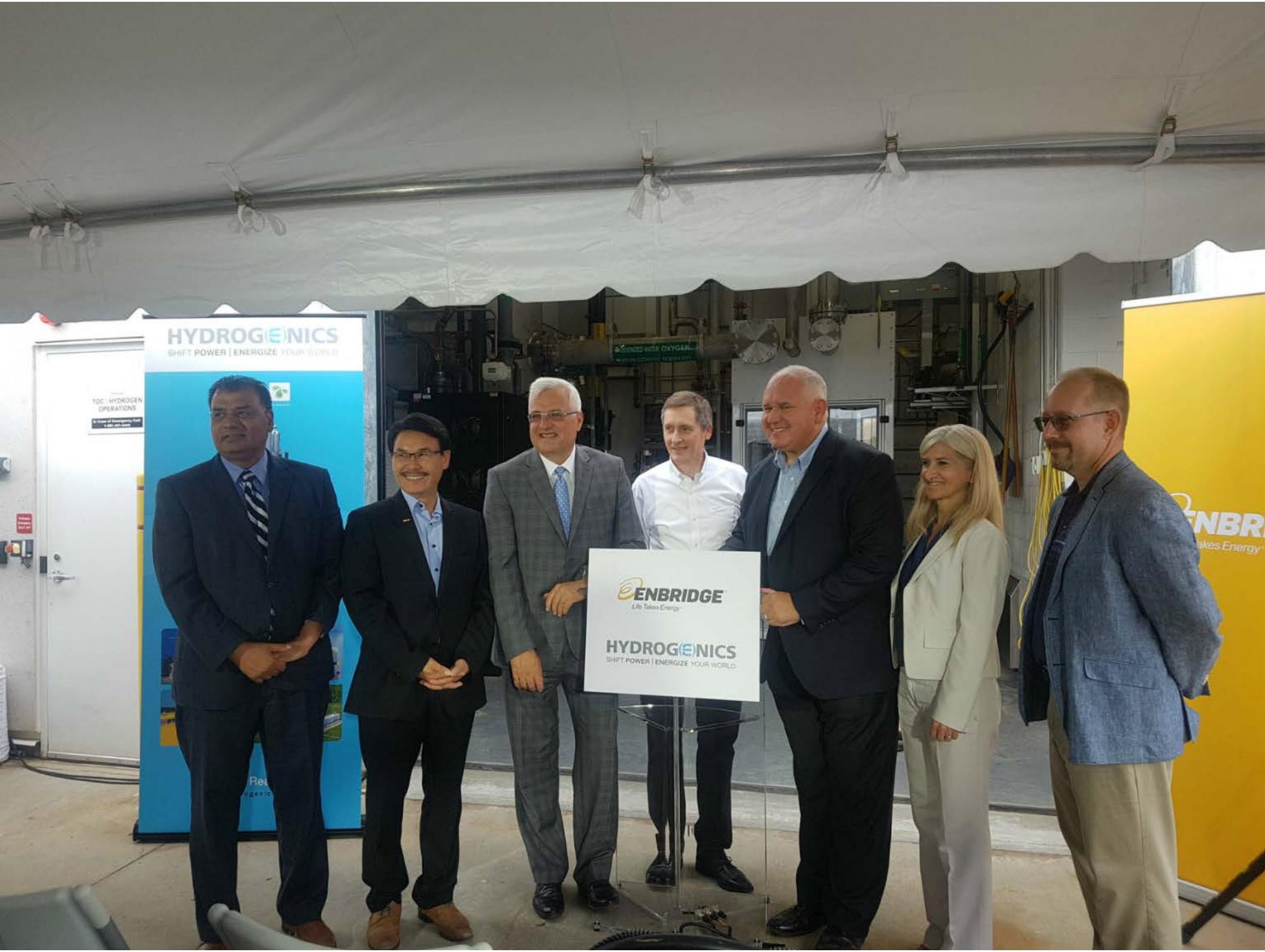
1 The electrolyzer takes electricity and uses it to split water into hydrogen and oxygen, while balancing the power grid at the same time.

2 The hydrogen that is produced is then stored.

3 Fuel cells convert the hydrogen into electricity to provide additional power grid stabilization services as needed.

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

ENBRIDGE
Life Takes Energy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Research

Thermochemical Hydrogen Production

Solar Based Hydrogen Production

Heat Engines/Pumps

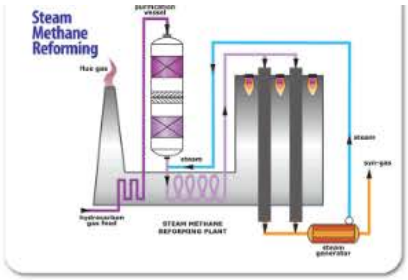
Wind Turbine Technology

THERMOCHEMICAL HYDROGEN PRODUCTION

Co-Principal Investigator: Dr. M. Rosen

Co-Principal Investigator: Dr. G. Naterer

Co-Investigators: Dr. K. Gabriel, Dr. Forest Wang, Dr. I. Pioro, Dr. Jurij Avsec (University of Maribor, Slovenia) Dr. M. Fowler (University of Waterloo, Ontario), Dr. I. Dincer, Dr. B. Easton, Dr. F. Gaspari, Dr. G. Goward (McMaster University, Hamilton, Ontario), Dr. S. Lvov (Pennsylvania State University), Dr. V. G. Papangelakis (University of Toronto), Dr. B. M. Ikeda, Dr. G. Rizvi, Dr. M. H. Kaye, Dr. J. Mostaghimi (University of Toronto), Dr. L. Lu, Dr. D. Zhang and Dr. J. Jiang (University of Western Ontario).



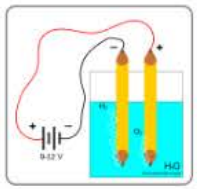
Made from Natural Gas

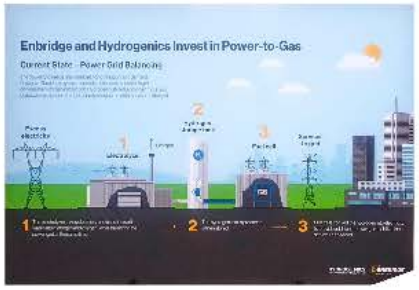
Steam Methane Reforming

Produces plenty of CO2

$CH_4 + H_2O \rightarrow CO + 3\,H_2$

$CO + H_2O \rightarrow CO_2 + H_2$





Electrical Splitting

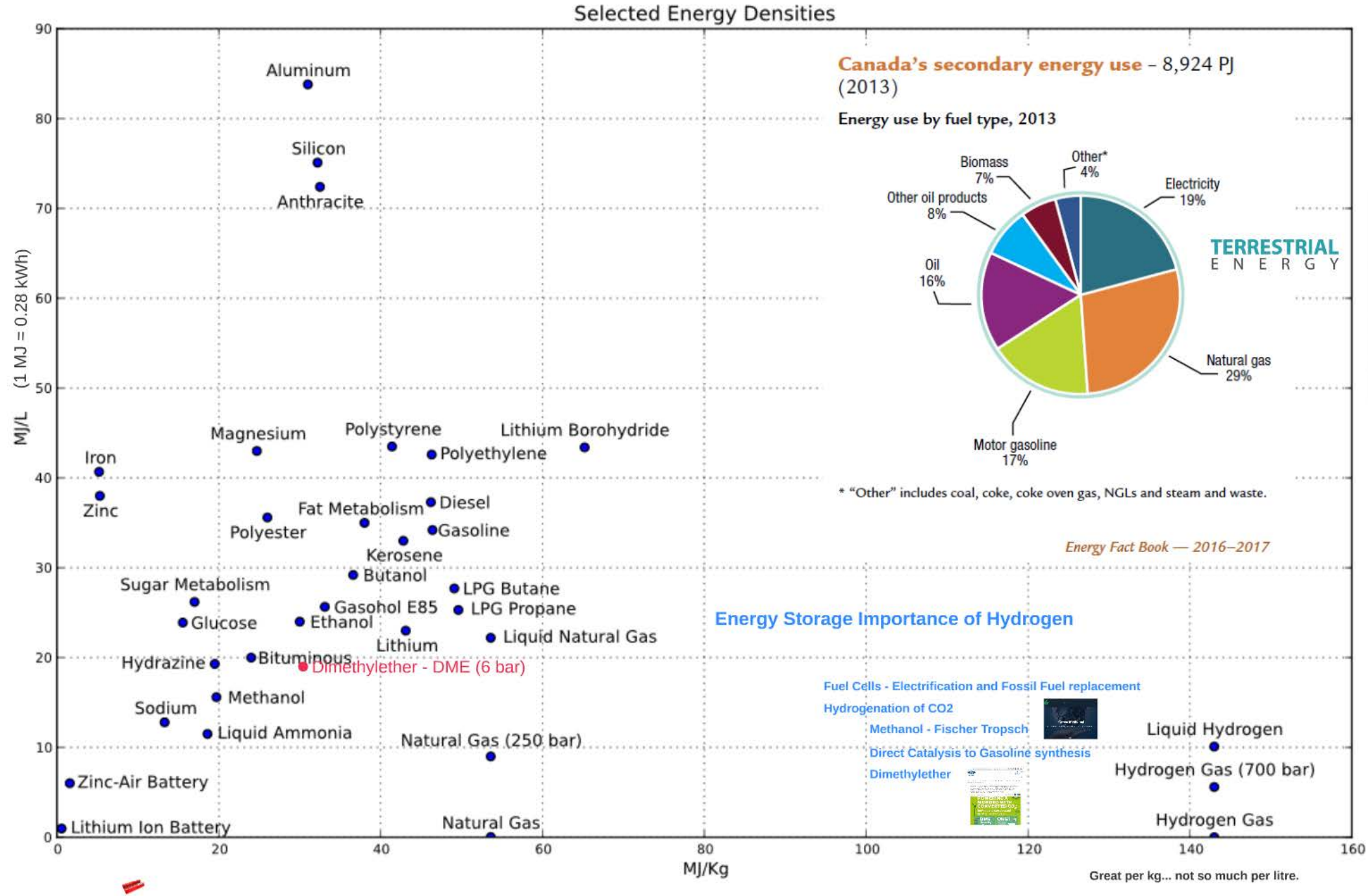
Electrolysis

Needs low cost or surplus electricity

Thermo Chemical Splitting

Copper-Chlorine Cycle

Needs 530C Heat Source


Selected Energy Densities
MJ/L (1 MJ = 0.28 kWh)
MJ/Kg
Aluminum
Silicon
Anthracite
Magnesium
Polystyrene
Lithium Borohydride
Polyethylene
Iron
Zinc
Fat Metabolism
Diesel
Polyester
Gasoline
Kerosene
Butanol
Sugar Metabolism
LPG Butane
Gasohol E85
LPG Propane
Glucose
Ethanol
Liquid Natural Gas
Lithium
Hydrazine
Bituminous
Dimethylether - DME (6 bar)
Methanol
Sodium
Liquid Ammonia
Natural Gas (250 bar)
Zinc-Air Battery
Lithium Ion Battery
Natural Gas
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Biomass 7%
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Other oil products 8%
Oil 16%
Natural gas 29%
Motor gasoline 17%
* "Other" includes coal, coke, coke oven gas, NGLs and steam and waste.
Energy Fact Book — 2016–2017
TERRESTRIAL ENERGY
Energy Storage Importance of Hydrogen
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Hydrogenation of CO2
Methanol - Fischer Tropsch
Direct Catalysis to Gasoline synthesis
Dimethylether
Liquid Hydrogen
Hydrogen Gas (700 bar)
Hydrogen Gas
Great per kg... not so much per litre.

* “Other” includes coal, coke, coke oven gas, NGLs and steam and waste.

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Dimethylether

Liquid Hydrogen

Hydrogen Gas (700 bar)

Hydrogen Gas

80 100 120 140 16

MJ/Kg

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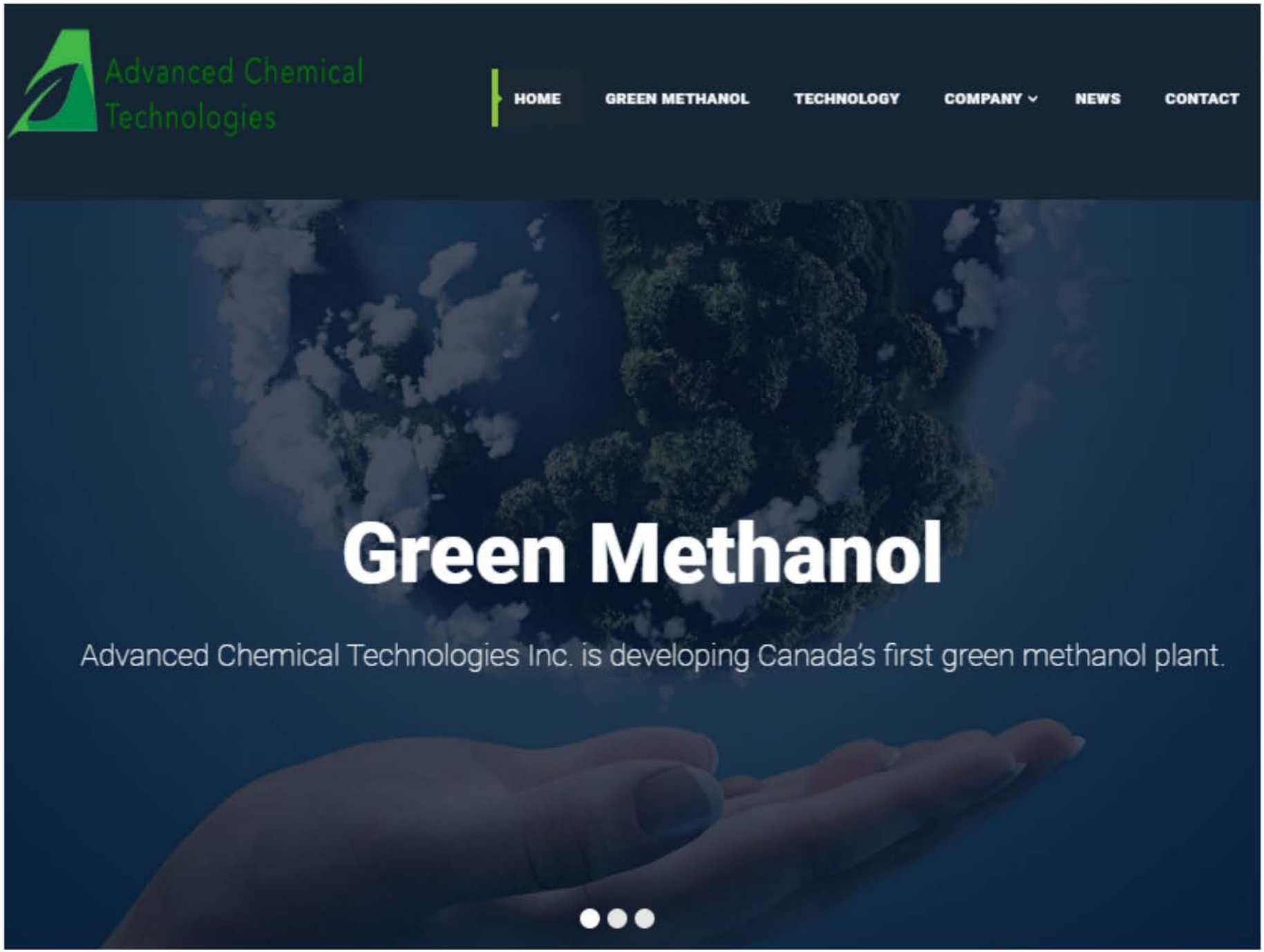
Advanced Chemical Technologies
HOME
GREEN METHANOL
TECHNOLOGY
COMPANY
NEWS
CONTACT
Green Methanol
Advanced Chemical Technologies Inc. is developing Canada's first green methanol plant.

* “Other” includes coal, coke, coke oven gas, NGLs and steam and waste.

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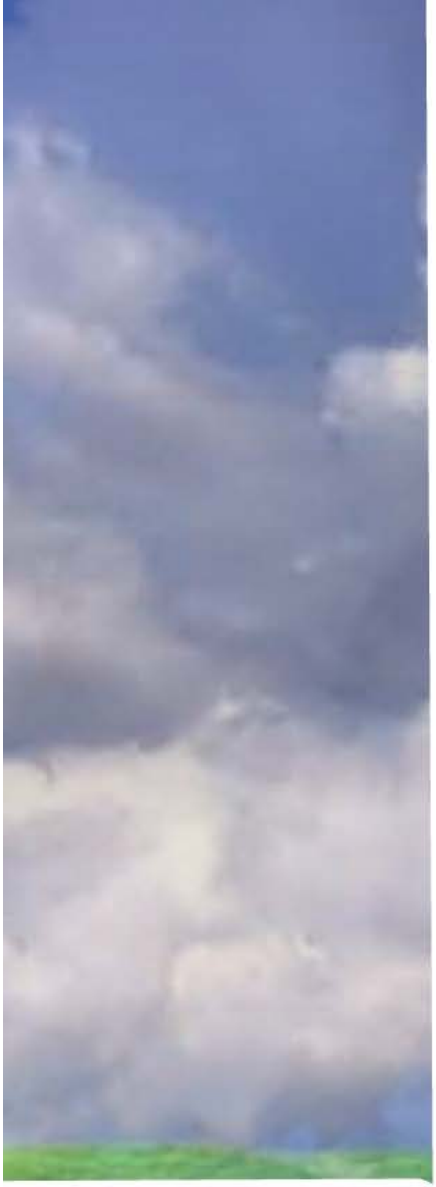
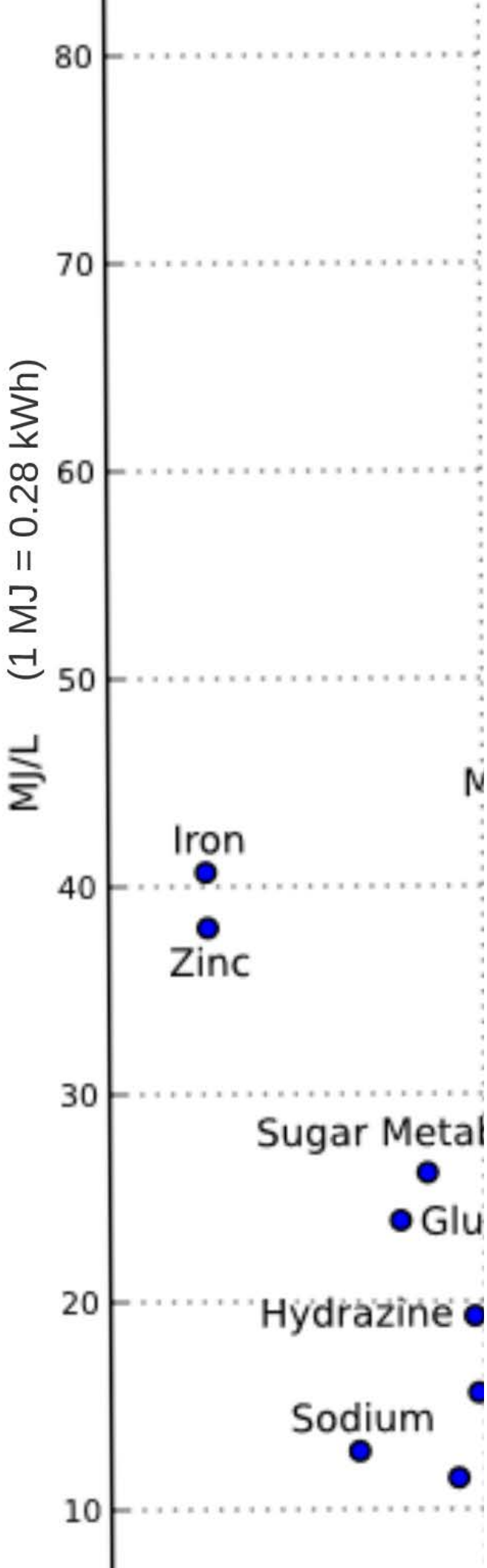
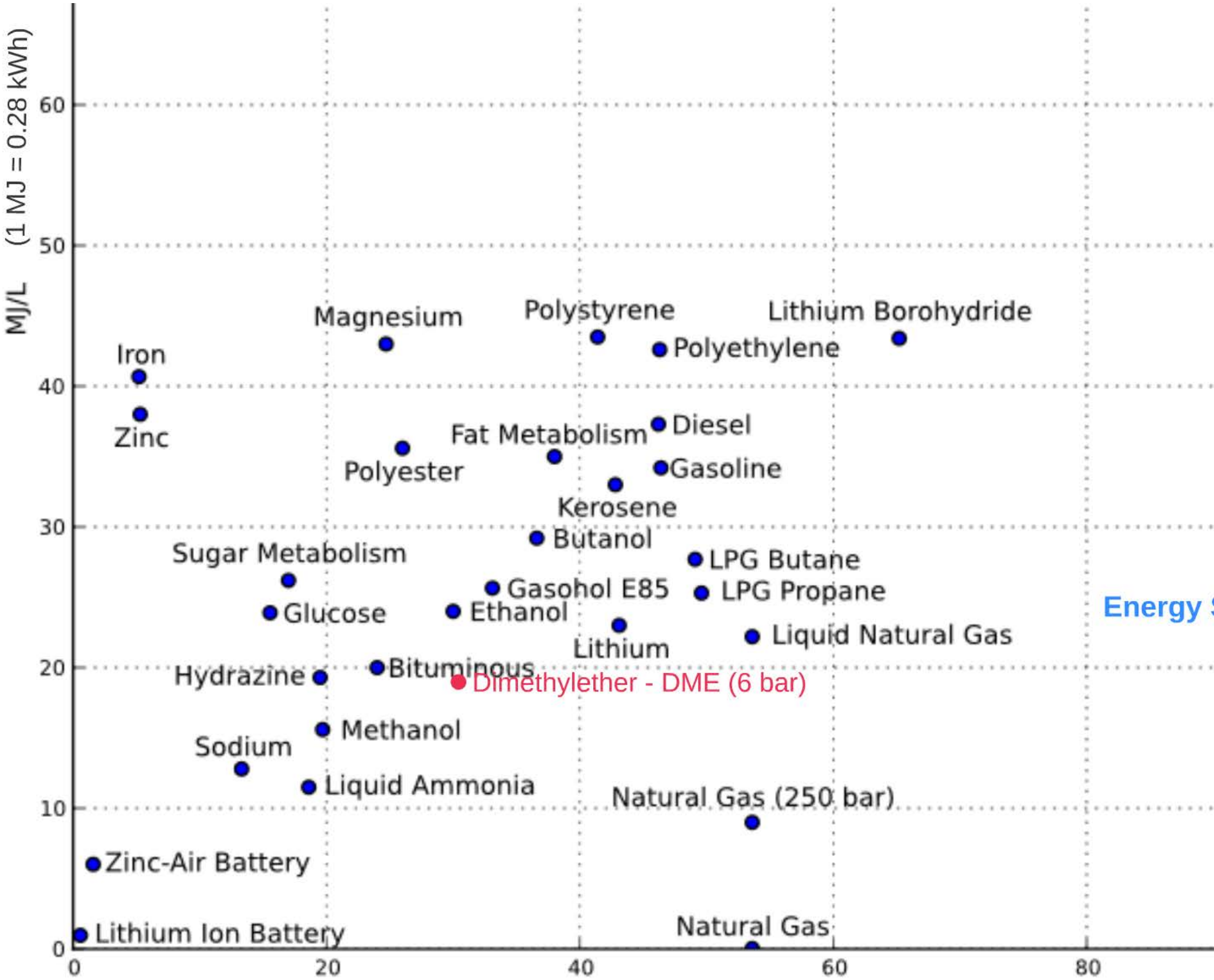



MJ/L (1 MJ = 0.28 kWh)
80
70
60
50
40
30
20
10
Iron
Zinc
Sugar Metal
Glu
Hydrazine
Sodium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60
50
40
30
20
10
0
0
20
40
60
80
Magnesium
Polystyrene
Lithium Borohydride
Polyethylene
Iron
Zinc
Diesel
Fat Metabolism
Polyester
Gasoline
Kerosene
Butanol
Sugar Metabolism
LPG Butane
Gasohol E85
LPG Propane
Glucose
Ethanol
Lithium
Liquid Natural Gas
Hydrazine
Bituminous
Dimethylether - DME (6 bar)
Methanol
Sodium
Liquid Ammonia
Natural Gas (250 bar)
Zinc-Air Battery
Lithium Ion Battery
Natural Gas
Energy

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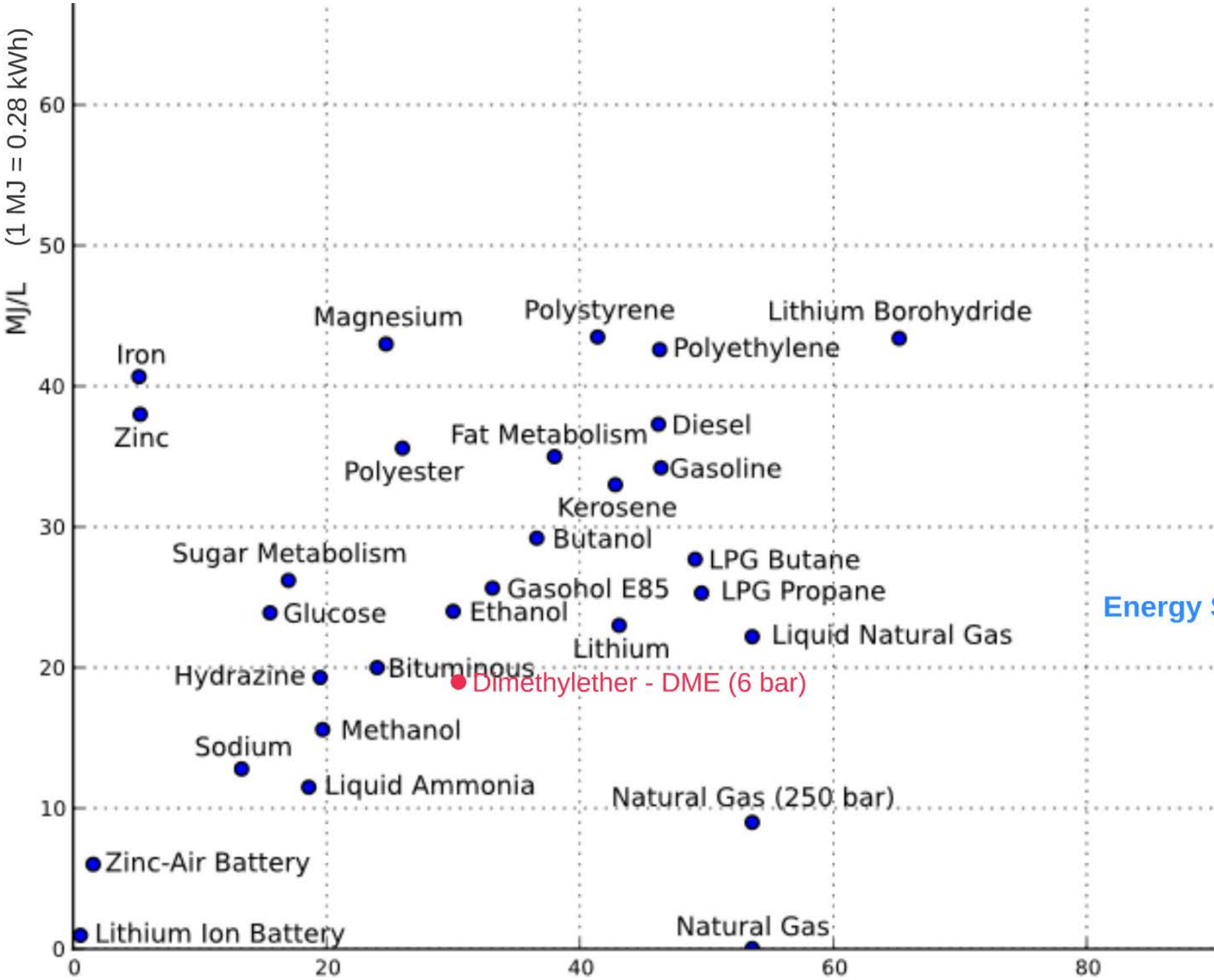
Go Further

FORD LEADS PROJECT TO DEVELOP NEAR ZERO PARTICULATE EMISSION DIESEL CARS THAT COULD RUN ON CONVERTED CO2

11-Sep-2015 | AACHEN, Germany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Natural Gas
Energy

Zinc-Air Battery

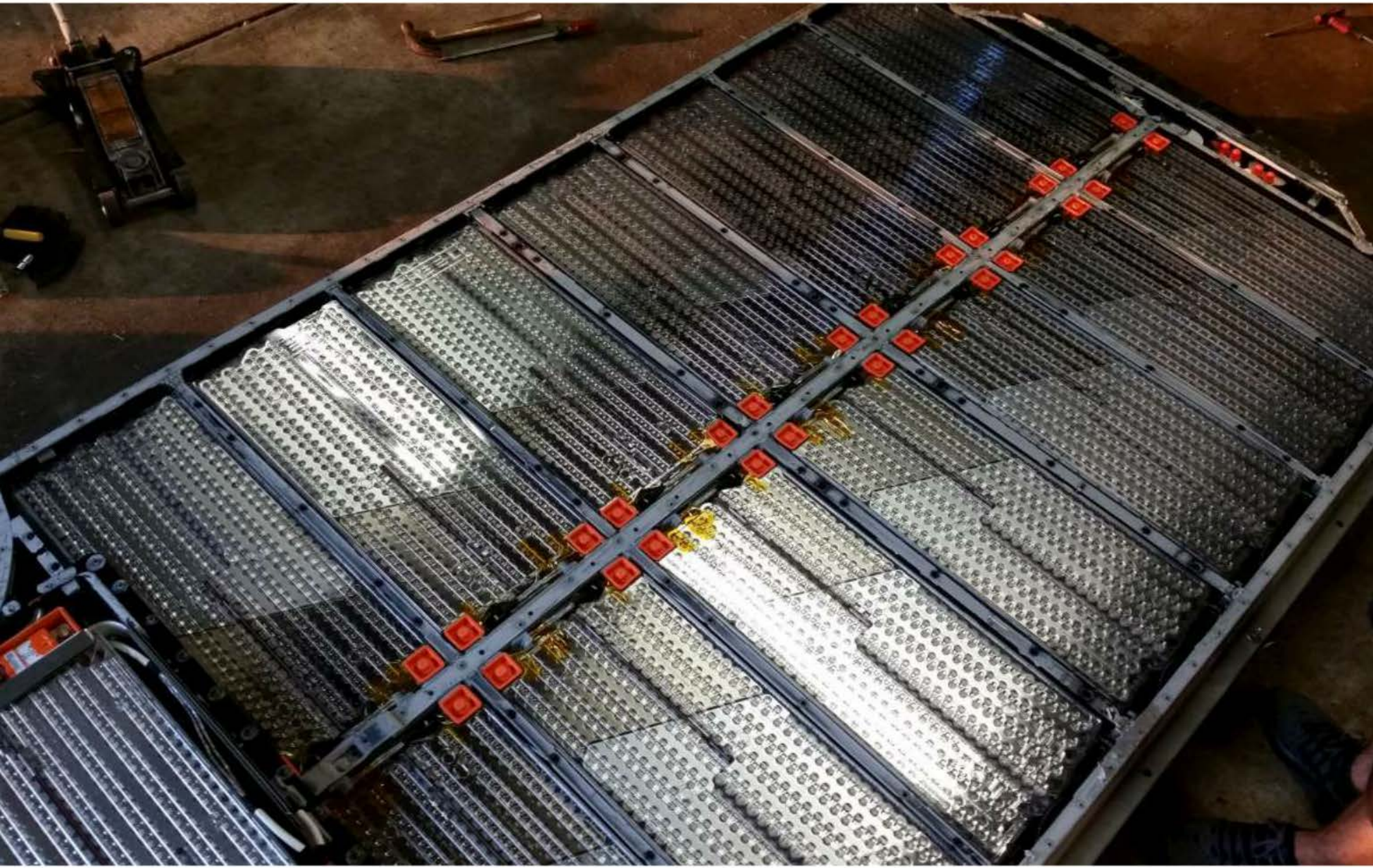
Lithium Ion Battery

0

0

20


BRC 18650 6800mAh
3.7V Li-ion
Low Discharge rate, No memory effect,
BRC 18650 6800mAh
3.7V Li-ion
Low Discharge rate, No memory effect,
Low reoccuring operation cost, Short-circuit

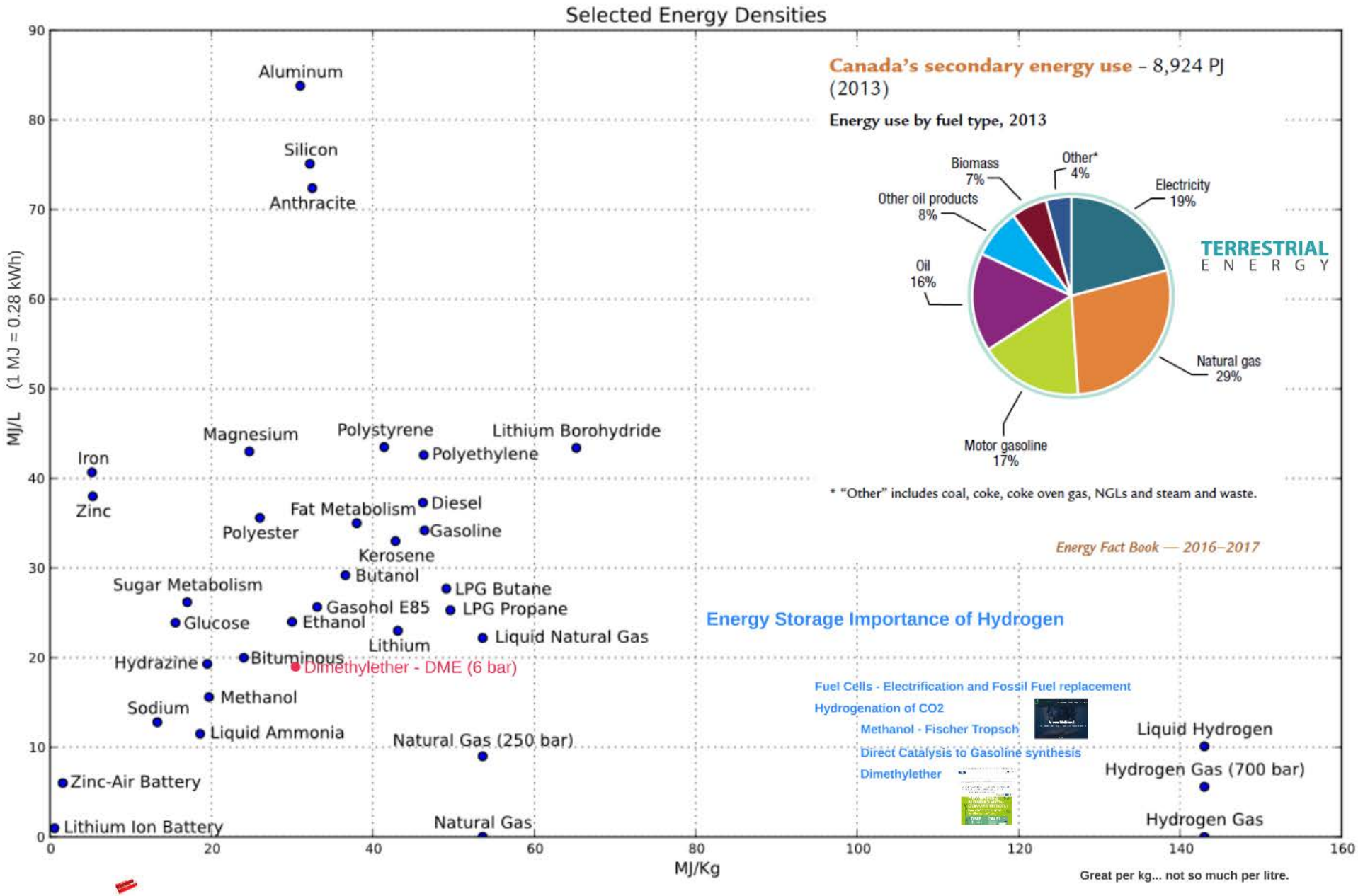


2% GHG Worldwide from aviation
420 grams of CO2 per tonne-km

DME?

Hydrogen-Electric Fuel Cell?

2.2% GHG Worldwide from Shipping
10 grams of CO2 per tonne-km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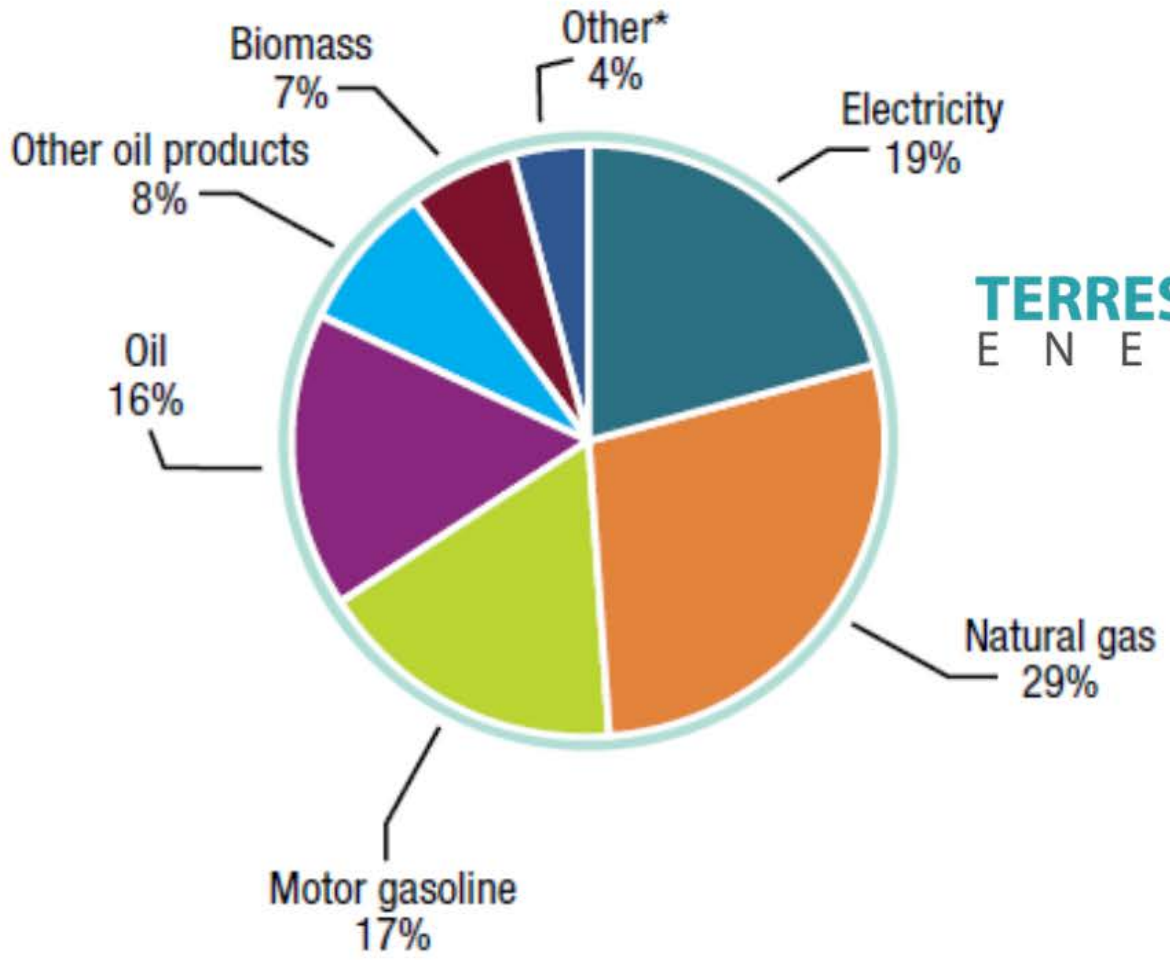
Energy use by fuel type, 2013

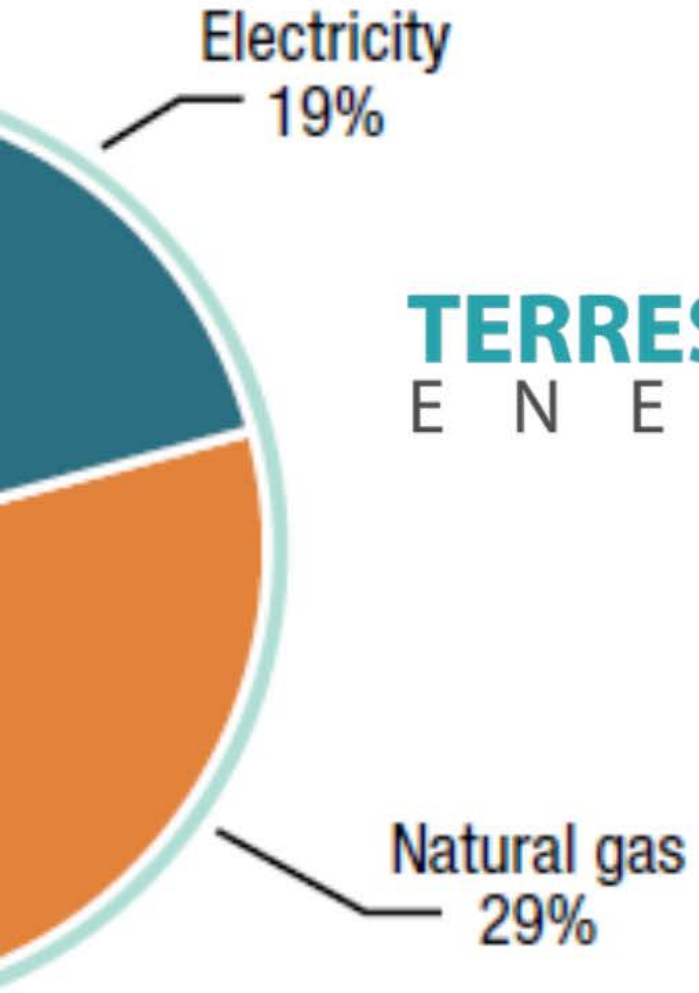


TERRESTRIAL ENERGY

* "Other" includes coal, coke, coke oven gas, NGLs and steam and waste.

Energy Fact Book — 2016–2017

Storage material
Deuterium (in Fusion reactor
Uranium (in breeder)
Thorium (in breeder)
Plutonium 238
Tritium
Hydrogen (liquid)
Hydrogen (compressed at 70
Methane or Liquefied natural gas(compressed)
Diesel
LPG (including Propane / Bu
Gasoline (petrol)



TERRESTRIAL ENERGY

Storage material	Energy type	Specific energy (MJ/kg)
Deuterium (in Fusion reactor)	Nuclear fusion	87,900,000[3]
Uranium (in breeder)	Nuclear fission	80,620,000[5]
Thorium (in breeder)	Nuclear fission	79,420,000[5]
Plutonium 238	Nuclear decay	2,239,000
Tritium	Nuclear decay	583,529
Hydrogen (liquid)	Chemical	142
Hydrogen (compressed at 700 bar)	Chemical	142
Methane or Liquefied natural gas(compressed)	Chemical	55.5
Diesel	Chemical	48
LPG (including Propane / Butane)	Chemical	46.4
Gasoline (petrol)	Chemical	46.4[2]

Regulatory Tools

Funding Models

Price on Carbon
Revenue for Capital

Ontario: 100% > 25kt = 49 Mt
China: 8% > 50 kt = 3.7 Gt

Innovation and Cleantech Investment and Development

2% of Cleantech IP Created in Canada
60% to 90% of Cleantech IP owned by China

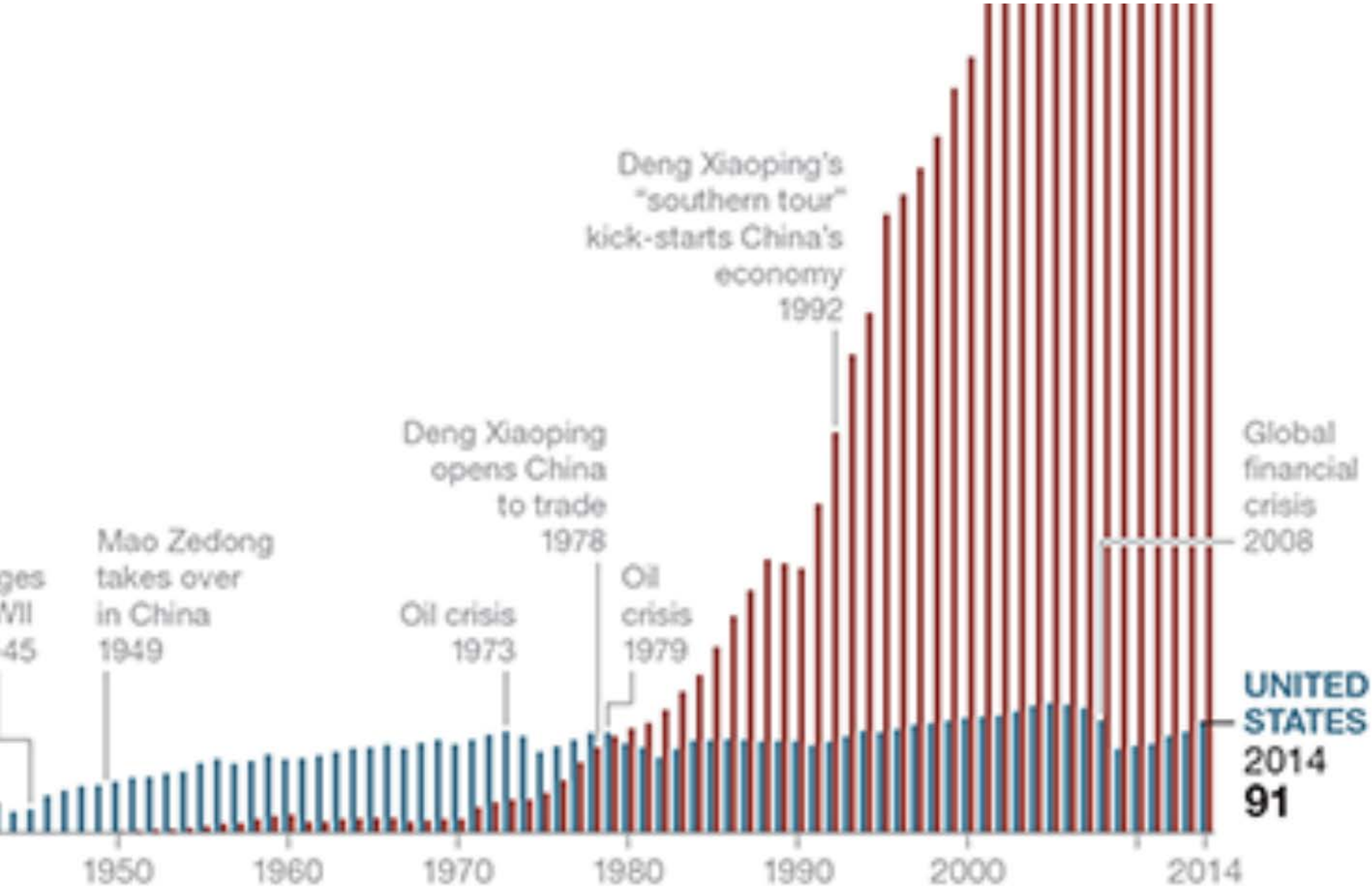
U.S. and China: Cement production

Millions of tons

Cement production tends to reflect political and economic shifts. Wars, revolutions, and financial crises have resulted in slowdowns.

GRAPHIC: MATTHEW TWOMBLY,

NATIONAL GEOGRAPHIC



GRAPHIC: MATTHEW TWOMBLY, NGM STAFF. SOURCES: USGS; ORVILLE SCHELL, ASIA SOCIETY

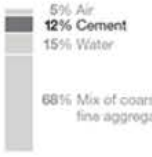
EXPLORE
Us

Towering Above

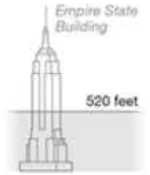
The foundation of China's 21st-century growth is concrete. Literally. The country's cement production has spiked 3,000 percent since 1980. Since 2012, China has made more cement than the U.S. has since 1900.

Where is it all going? Mass urbanization, says USGS geologist Hendrik van Oss: "When you consider large new cities and highways, [the Chinese are] building faster than anyone before." Cement, which tends to be a cheaper construction material than wood or steel, has been used for China's most ambitious building projects. One of the biggest—the Three Gorges Dam—required 12 million tons of cement, more than the United Kingdom produces in a year.

But there's a downside. Cement production, especially in antiquated plants, emits large amounts of CO_2—about five percent of all anthropogenic emissions, reports a U.S. study. China's cement contributes as much toward that tally as all other countries combined. *—Daniel Stone*



Cement to concrete
Cement is a small fraction of concrete, which is made with water plus other ingredients like rock, sand, or gravel. Too many additives can weaken it.



How much concrete?
In 2014 China produced enough cement to make 330 billion cubic feet of concrete. That's enough to cover the entire island of Manhattan with a block 520 feet thick.

U.S. and China: Cement production
Millions of tons

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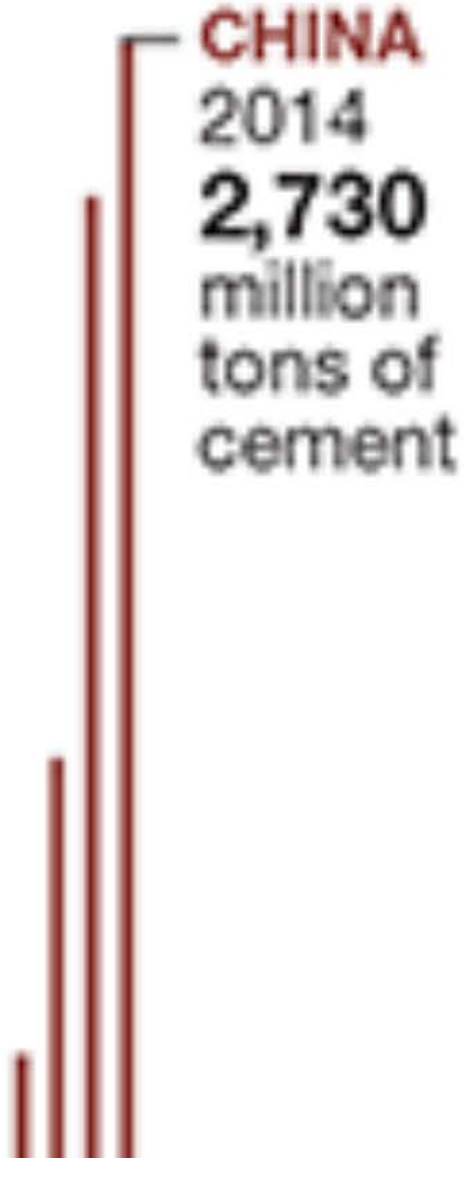
NATIONAL GEOGRAPHIC

Canada: 13 Mt



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Seed Financing/Start-ups • Demonstration/Adoption
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