

INTRODUCTION TO LIFE CYCLE ASSESSMENT

FNCI INFORMATION SHARING

December 2019

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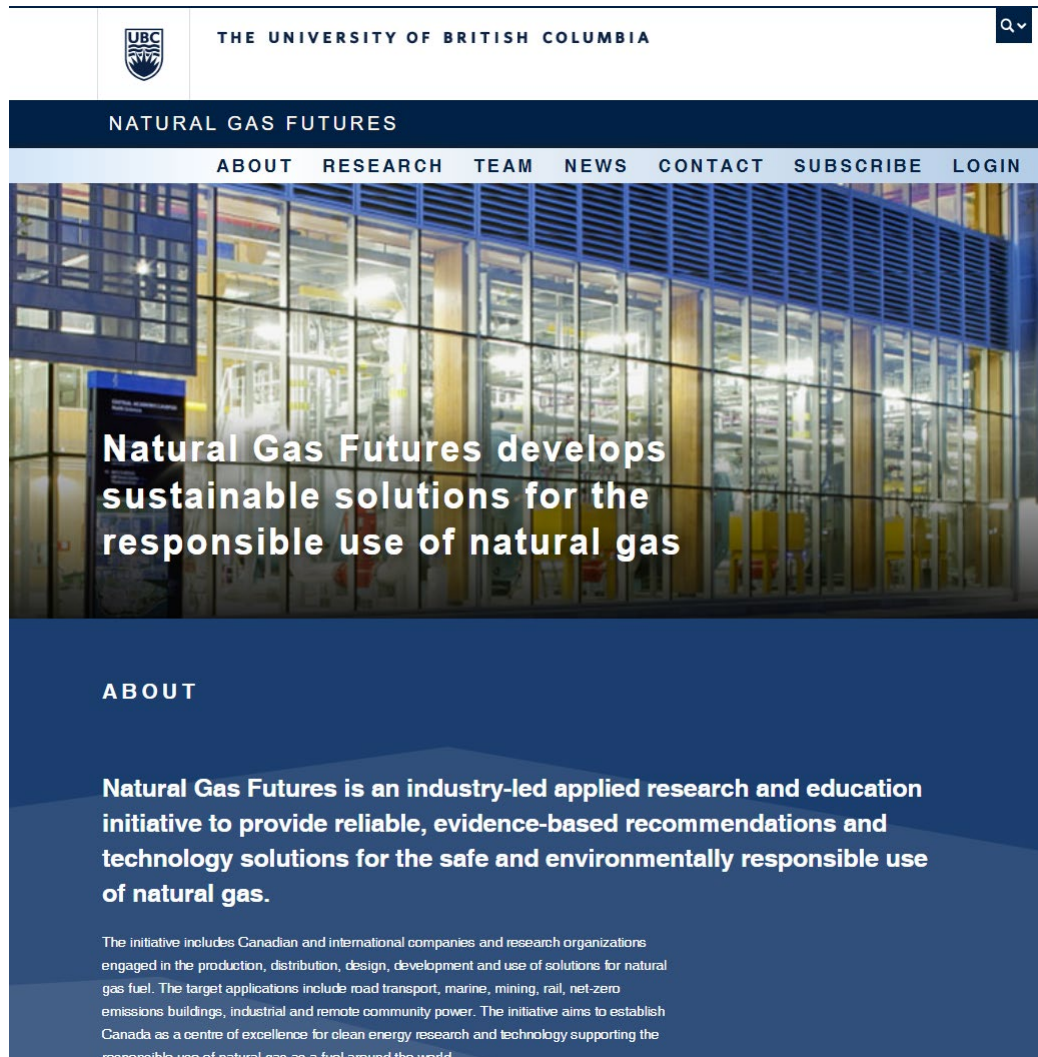


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DR. PAUL
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NATURAL GAS FUTURES



The screenshot shows the top portion of the Natural Gas Futures website. At the top left is the UBC logo and the text "THE UNIVERSITY OF BRITISH COLUMBIA". A search icon is on the top right. Below this is a dark blue navigation bar with "NATURAL GAS FUTURES" in white. Underneath is a light blue bar with navigation links: "ABOUT", "RESEARCH", "TEAM", "NEWS", "CONTACT", "SUBSCRIBE", and "LOGIN". The main content area features a large image of a modern industrial building with glass walls and blue accents. Overlaid on this image is the text: "Natural Gas Futures develops sustainable solutions for the responsible use of natural gas". Below the image is a dark blue section with the heading "ABOUT" and a paragraph: "Natural Gas Futures is an industry-led applied research and education initiative to provide reliable, evidence-based recommendations and technology solutions for the safe and environmentally responsible use of natural gas." A smaller paragraph follows, describing the initiative's scope and goals.

THE UNIVERSITY OF BRITISH COLUMBIA

NATURAL GAS FUTURES


ABOUT RESEARCH TEAM NEWS CONTACT SUBSCRIBE LOGIN

Natural Gas Futures develops sustainable solutions for the responsible use of natural gas

ABOUT

Natural Gas Futures is an industry-led applied research and education initiative to provide reliable, evidence-based recommendations and technology solutions for the safe and environmentally responsible use of natural gas.

The initiative includes Canadian and international companies and research organizations engaged in the production, distribution, design, development and use of solutions for natural gas fuel. The target applications include road transport, marine, mining, rail, net-zero emissions buildings, industrial and remote community power. The initiative aims to establish Canada as a centre of excellence for clean energy research and technology supporting the responsible use of natural gas as a fuel around the world.



Two side-by-side portraits. On the left is Walter Mérida, a man with short dark hair, wearing a dark suit jacket over a light-colored shirt. On the right is Kevin Wei, a man wearing a white hard hat with "CMR" on it, glasses, and a grey work shirt.

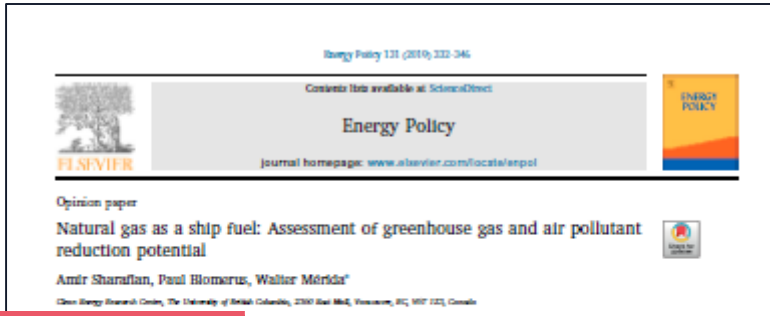
WALTER MÉRIDA
Professor, Associated Dean of Research and Industrial Partnership | Department of Mechanical Engineering

KEVIN WEI
Natural Gas Futures Project Manager | Clean Energy Research Centre



<http://naturalgas.apsc.ubc.ca/>

LIFE CYCLE ASSESSMENT PROJECTS



ABSTRACT

Shipping is a significant contributor to global greenhouse gas (GHG) and air pollutant emissions. This study uses a life cycle assessment to compare emissions from domestic and imported liquefied natural gas (LNG), and heavy fuel oil (HFO) or marine shipping. The findings show that only ship-proximal coal and (HFO) engines recently reduce well-to-wake GHG emissions by 10% compared with their HFO-related counterparts. The engine technology to only evaluate air cargo low-speed engines does not account for vessel (LNG). For marine vessels, such as ferries, the current deployment of medium speed low-pressure diesel (MS-LPD), and some other engine types (LNG) gas engines cannot reduce GHG emissions. This is primarily due to the high levels of methane slip from these engines. For air pollution reduction, gas engines are more so an effective means or reducing nitrogen oxides, sulphur oxides and particulate matter without any additional engine adjustments. The HFO engines, however, need adjustments or engine gas conversion to meet the International Maritime Organization (IMO) regulations. Sulphur control, such as the 2020 act, moves to diesel engine to 0.5% globally. However, this will increase the cost of the HFO used by most OGVs, reducing the economic case for natural gas use.

an increasingly important issue with greenhouse gases (GHGs) such as nitrogen oxides (NOx), oxides of sulphur (SOx), and particulate matter (PM), among others. However, progress in reducing air larger vessels has been modest, proving to be particularly

global CO₂ emissions (Diner et al., 2017). The primary global pollution control mechanism for shipping is the International Convention for the Prevention of Pollution from Ships (MARPOL), Annex VI which entered into force in 2005 and has been amended by countries around the world. The convention established limits to sulphur content of fuels and NO_x emissions inside and outside of the emission control areas (ECAs) shown in Fig. 2.

To control SO_x and PM emissions, the sulphur content of fuels should be less than 0.5% in SO_x ECAs and to currently in effect in North America and Northern Europe. The sulphur content of fuels outside the SO_x ECAs should not exceed 3.5% until January 1st, 2020 and 0.5% thereafter (sulphur oxides (SO_x) and particulate matter (PM), 2019).

heavy fuel oil (HFO) which accounted for 72% of all fuel consumed in 2015 (Diner et al., 2017). HFO is the residue product of crude oil in refineries and its combustion releases high levels of air pollutants. Natural gas has been suggested as an alternative transport fuel to decrease these emissions. However, there is some disagreement as to the potential for natural gas to provide significant improvements over emissions emerging from the current transport systems (Verbeek et al., 2011; Larsen, 2012; Lowell et al., 2012; Ramati et al., 2018). Liquefied natural gas (LNG) is currently estimated to make up just 2% of global shipping fuel, predominantly from LNG carriers (Diner et al., 2017).

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The prescribed NO_x emissions as a function of engine speed are shown

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Merrill.

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CAN NATURAL GAS REDUCE EMISSIONS FROM TRANSPORT?

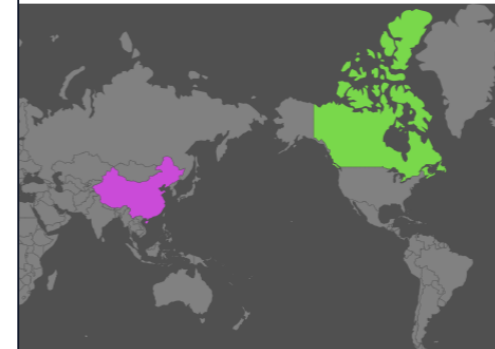
HEAVY GOOD AND SHIPPING

WHITE PAPER

Jamie Speirs, Paul Balcombe, Jasmin Cooper, Paul Blomerus, Nigel Brandon, Adam Hawkes

JANUARY 2019

Refined Natural Gas Supply Chain in Canada: Greenhouse Gas Emissions



Rasoul Asaee
Paul Blomerus
Amir Sharafian
Walter Mérida

DISCUSSION OUTLINE



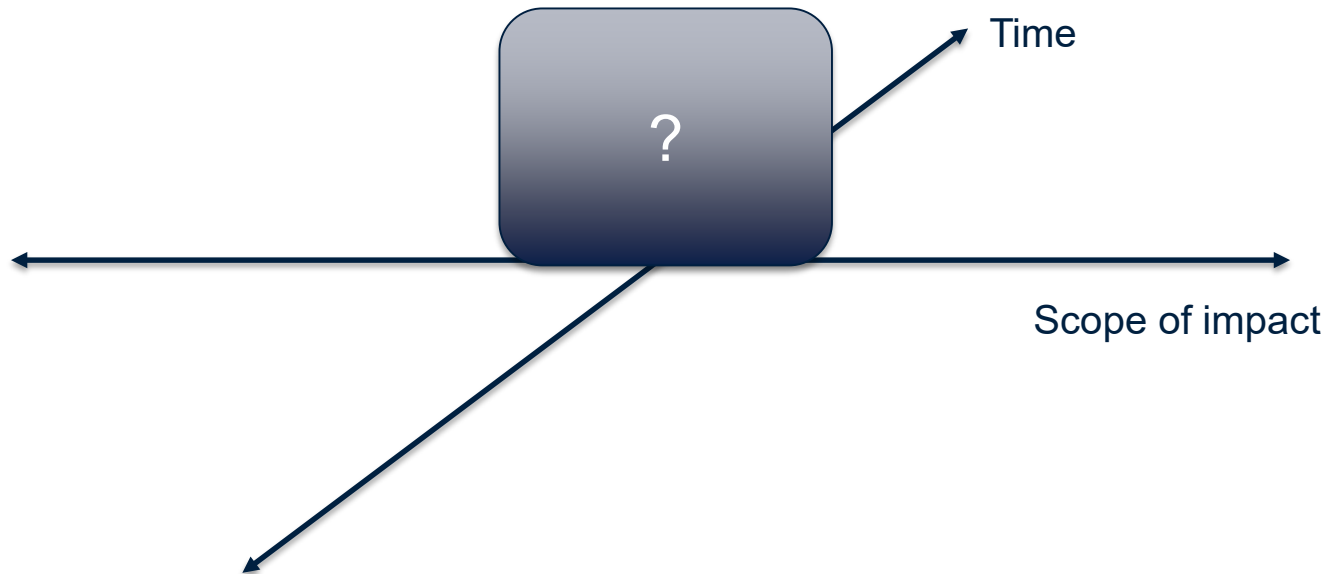
Life Cycle Assessments

1. Why do we need them?
2. What are they?
3. How do we use them?

MAKING BETTER DECISIONS

Which car is most economical to drive?

What should I build my house out of?

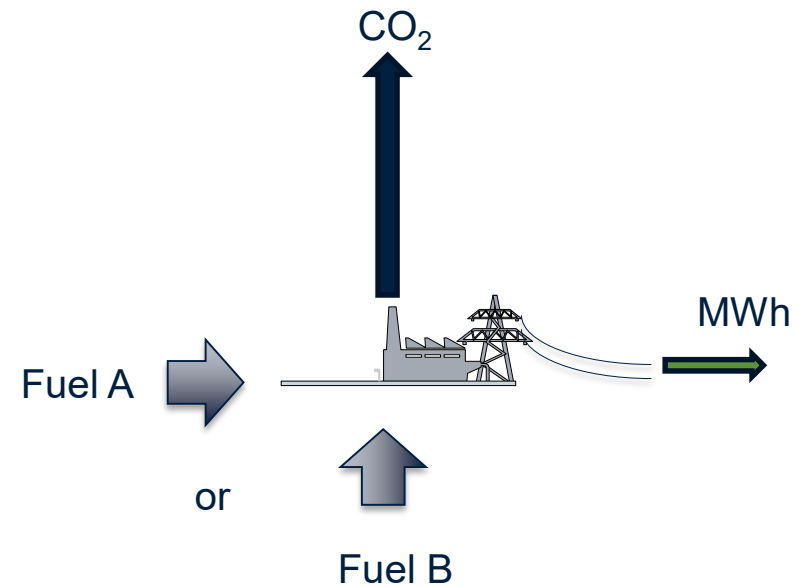


Life Cycle Assessment (LCA)
ISO 14040

LIFE CYCLE ASSESSMENT (LCA) APPLIED TO ENERGY AND FUEL



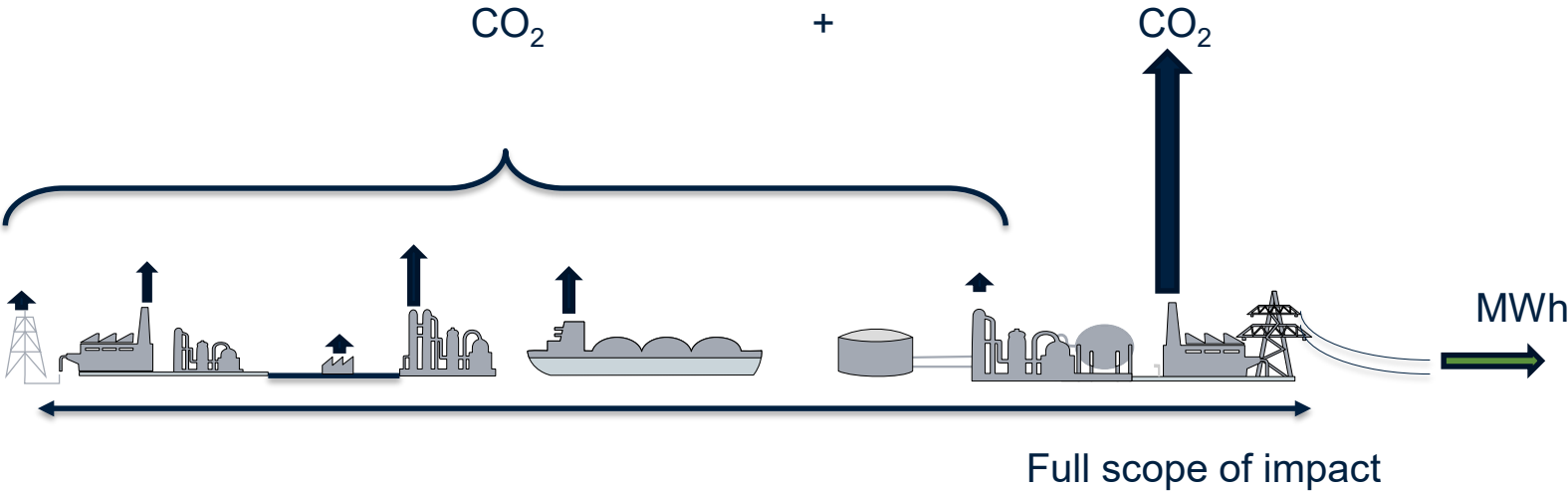
Which energy source has the lowest CO₂ emissions?



LIFE CYCLE ASSESSMENT (LCA) APPLIED TO ENERGY AND FUEL



Which energy source has the lowest CO₂ emissions?

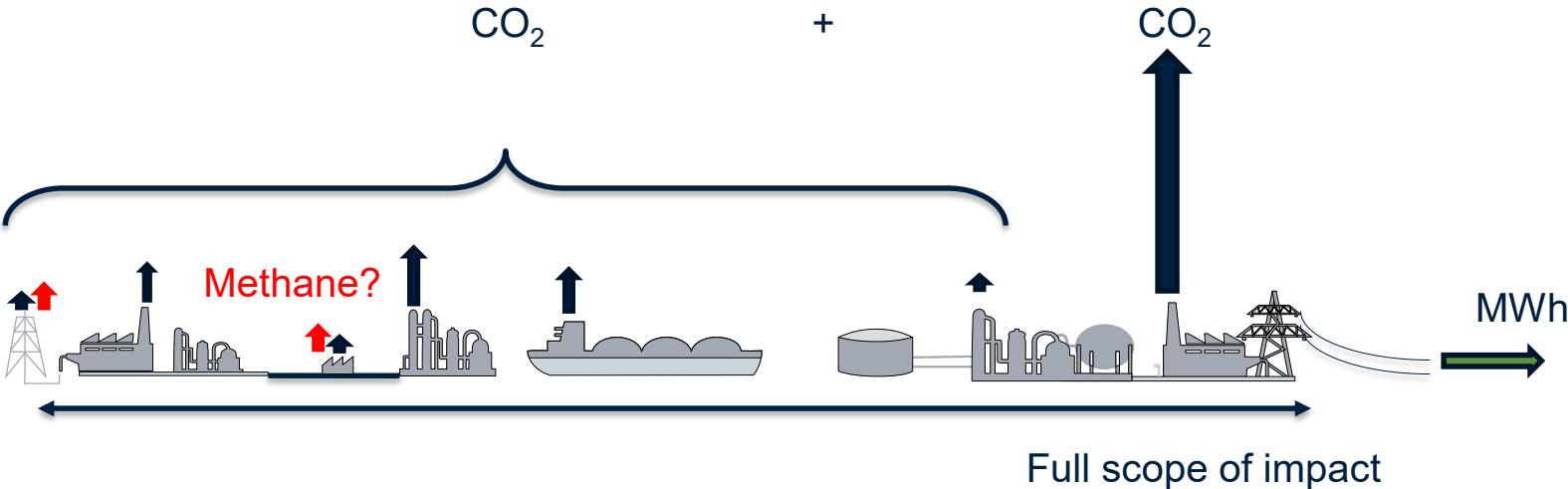


Well to wires

LIFE CYCLE ASSESSMENT (LCA) APPLIED TO ENERGY AND FUEL



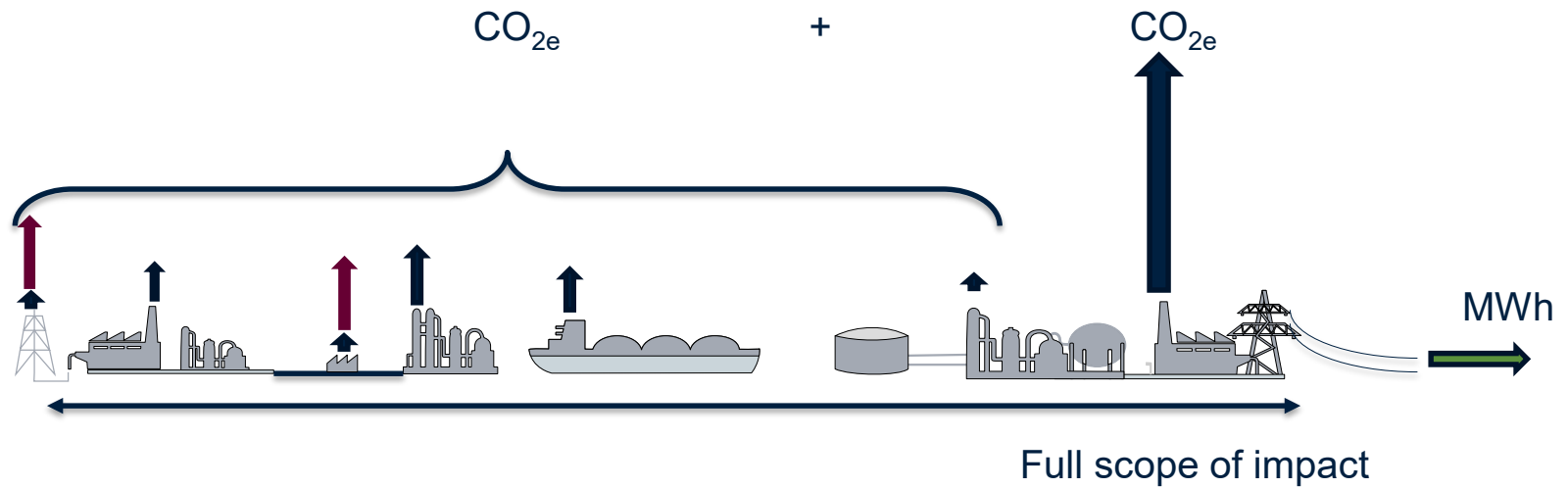
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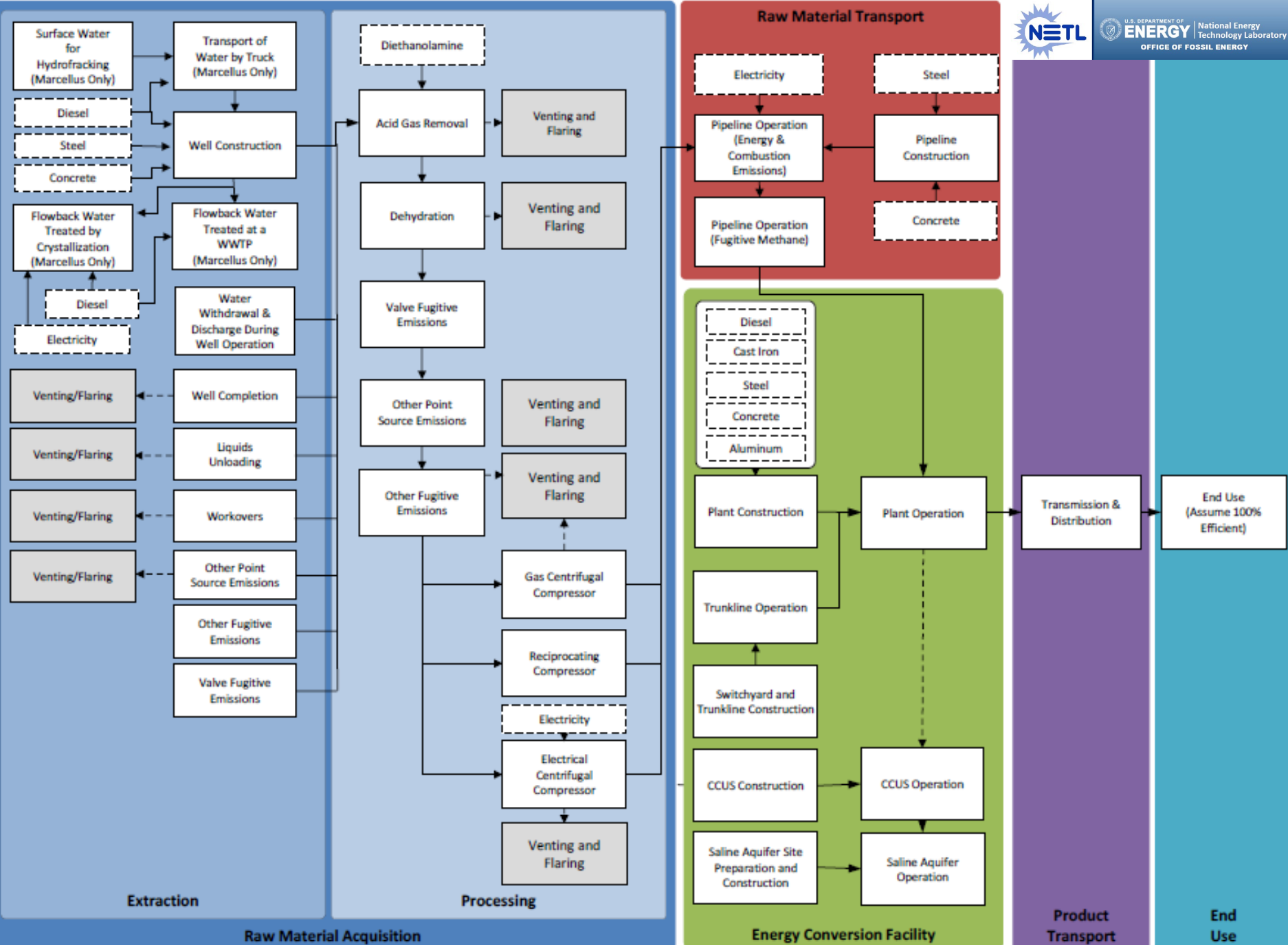
LIFE CYCLE ASSESSMENT (LCA) APPLIED TO ENERGY AND FUEL



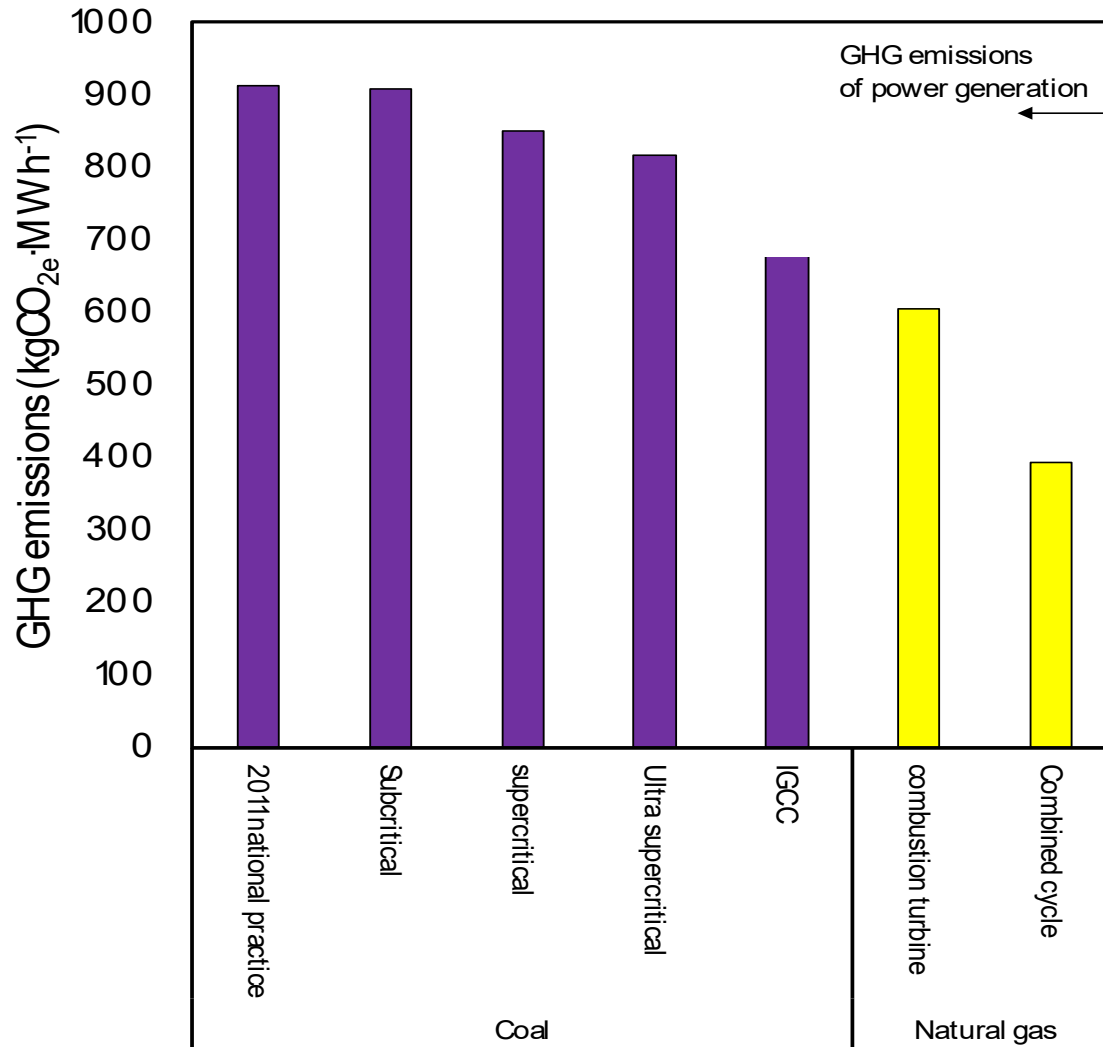
Which energy source has the lowest Greenhouse Gas (GHG) emissions?



Carbon Dioxide Equivalent:
 $\text{kg CO}_2 \times \text{Global Warming Potential (GWP) of methane} = \text{kg CO}_{2e}$

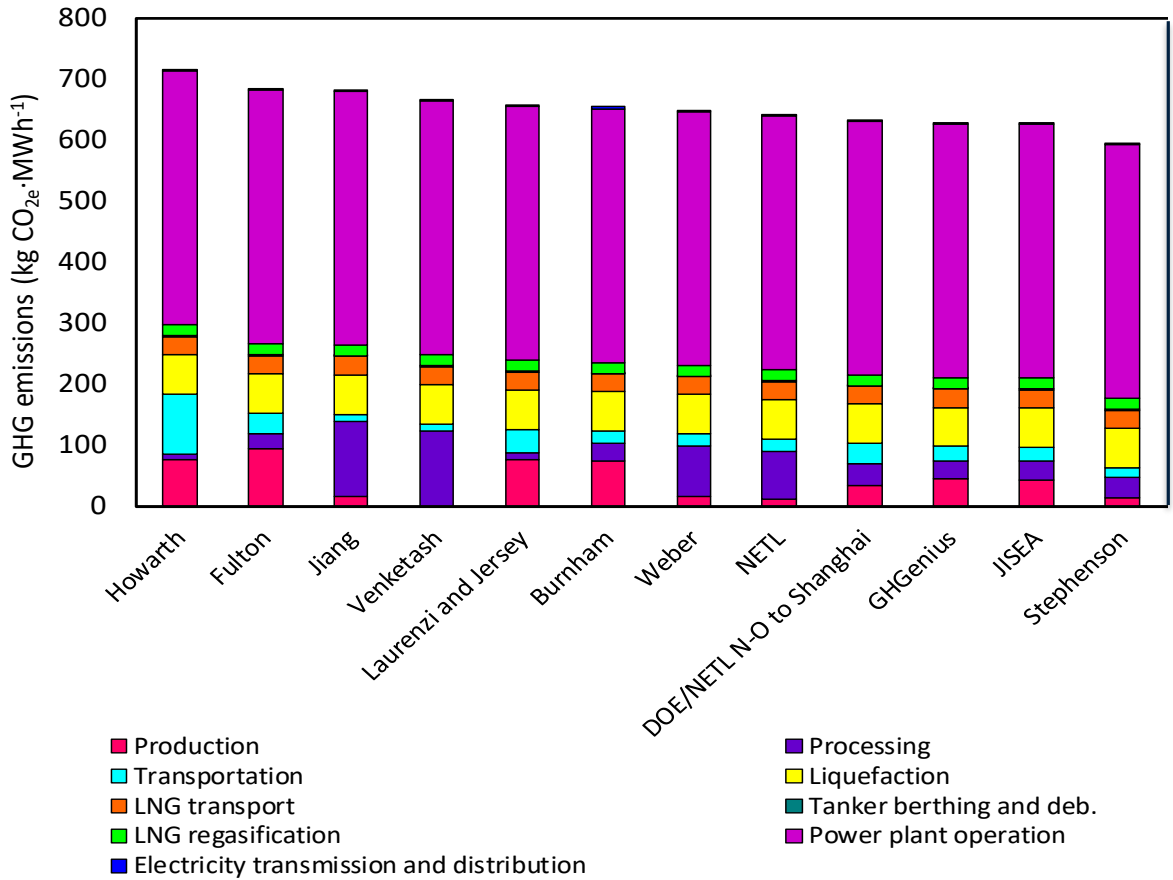


EMISSIONS FROM COMBUSTION ONLY



The GHG emissions of coal- and gas-fired power generation
(Chang 2015)

LIFE CYCLE ASSESSMENT (LCA)



Life cycle GHG emissions of electricity generation in China from LNG imported from North America (Coleman 2015, Kasuma 2018)

LCA MODEL CONSTRUCTION FOR LNG



Key Assumptions:

- Liquefaction plant energy source and efficiency
- Acid gas venting
- Pipeline compressor energy
- Fugitive methane emissions
- LNG tanker engine emissions
- Global Warming Potential (GWP) of methane

Converting units:

LNG production:

tonnes CO₂ / tonne LNG

Electricity:

x number of tonnes of LNG to make 1 MWh of electricity

- power plant efficiency
- energy content of the LNG
- Losses along the way

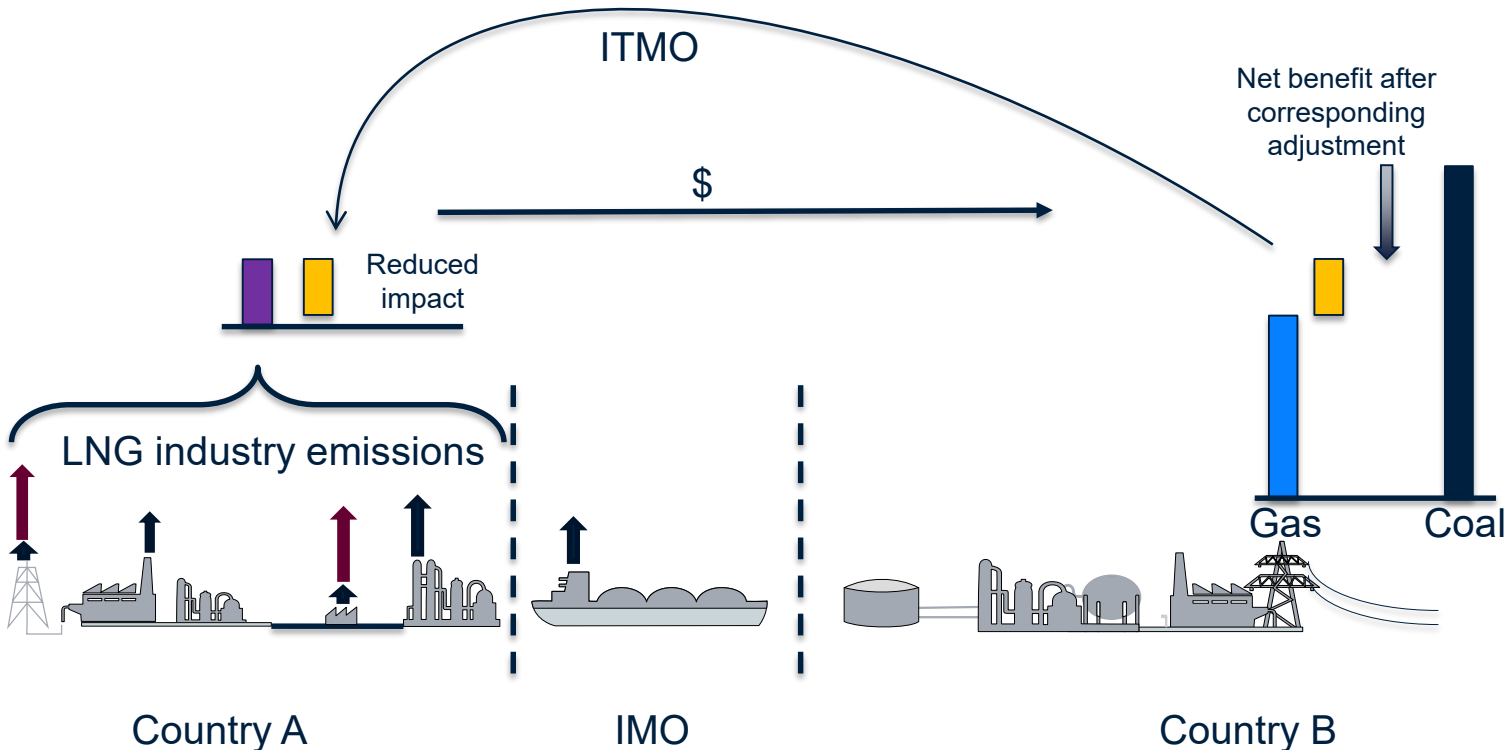
= kg CO₂e / MWh

Country emissions:

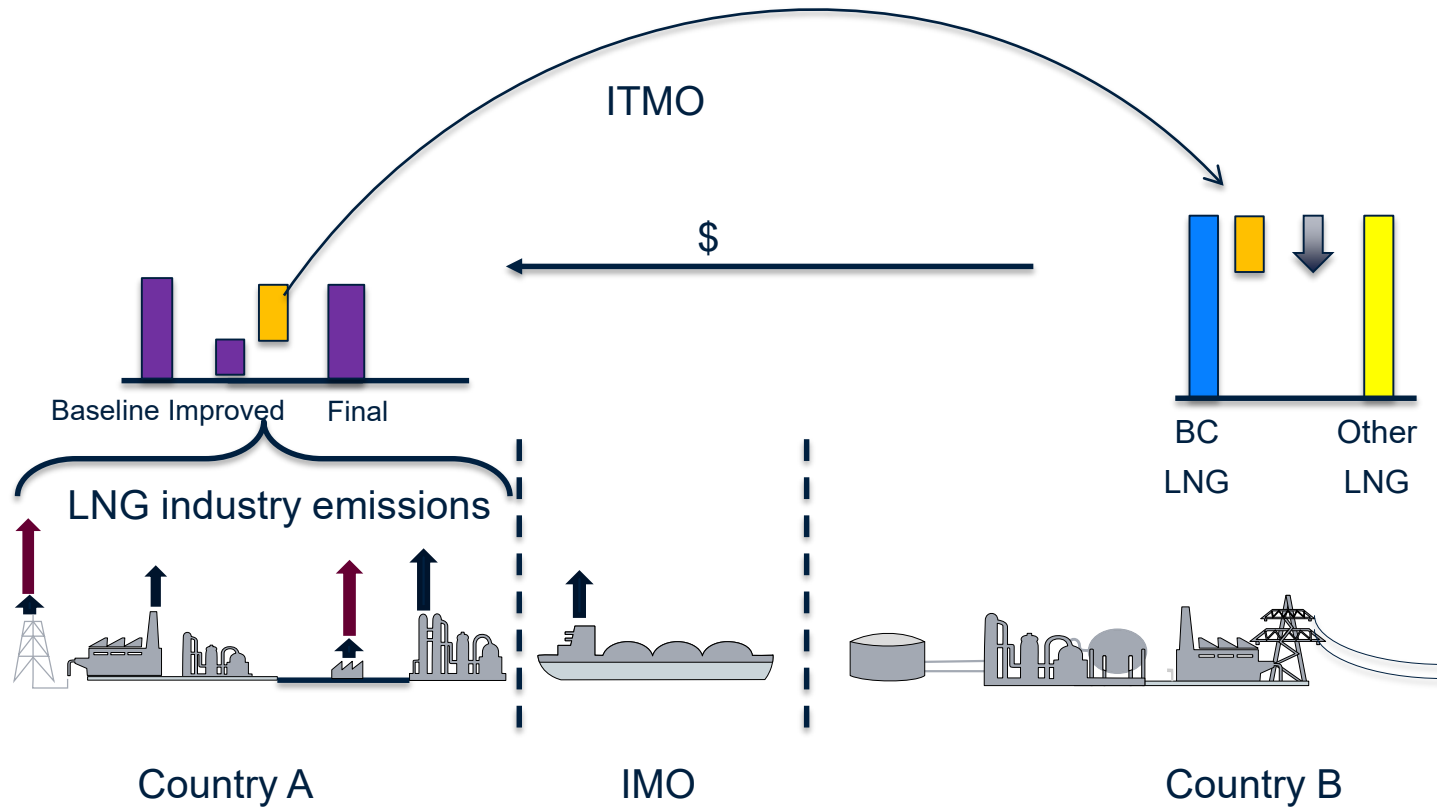
x annual LNG production

= Mt CO₂e per year

SIMPLIFIED ITMO SCENARIO



A DIFFERENT ITMO SCENARIO



COUNTRY LEVEL ITMO SCENARIO

