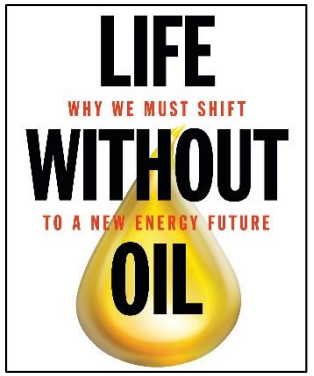
University of Victoria Retirees Association



Living Without Oil

Series Review

John Gunton

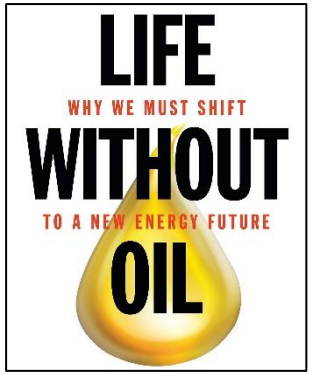
October 3, 2020

University of Victoria Retirees Association

AN ELDER ACADEMY EVENT

February Saturday Speaker Series

LIVING WITHOUT OIL? Part 1



FEB 8: "The Role of Hydrogen and the Fuel Cell in Future Energy Transition"

Presenter: Nicolas Pocard, MChem Eng, MSc, Director, Ballard Power.

FEB 15: "Nuclear Re-visited - Canadian SMRs (Small Modular Reactors)"

Presenter: John Stewart, Canadian Nuclear Association, Director of Policy and Research

FEB 22: "Wind Energy Opportunities: Terrestrial, offshore and airborne variants"

Presenter: Curran Crawford, BEng, SM (MIT), PhD, PEng, Professor Mech Eng, U. Vic.

FEB 29: "Cleaning BC: Wave Supplied Power in a Low-Carbon Energy System"

Presenter: Brad Buckham, PhD, PEng, Professor Mech Eng, U.Vic.

Hydrocarbons

FUELS/FEEDSTOCK

Coal	C
Propane	C_3H_8
Petroleum	C_8H_{18}
Biodiesel/Diesel	$C_{12}H_{23}$
Methanol	CH_3OH
Ethanol	C_2H_5OH
Natural Gas	CH_4

PRODUCTS/PLASTICS

Polypropylene	$(C_3H_6)n$
Polyethylene	$(C_2H_4)n$
Polystyrene	$(C_8H_8)n$
Polyvinyl chloride	$(C_2H_3Cl)n$

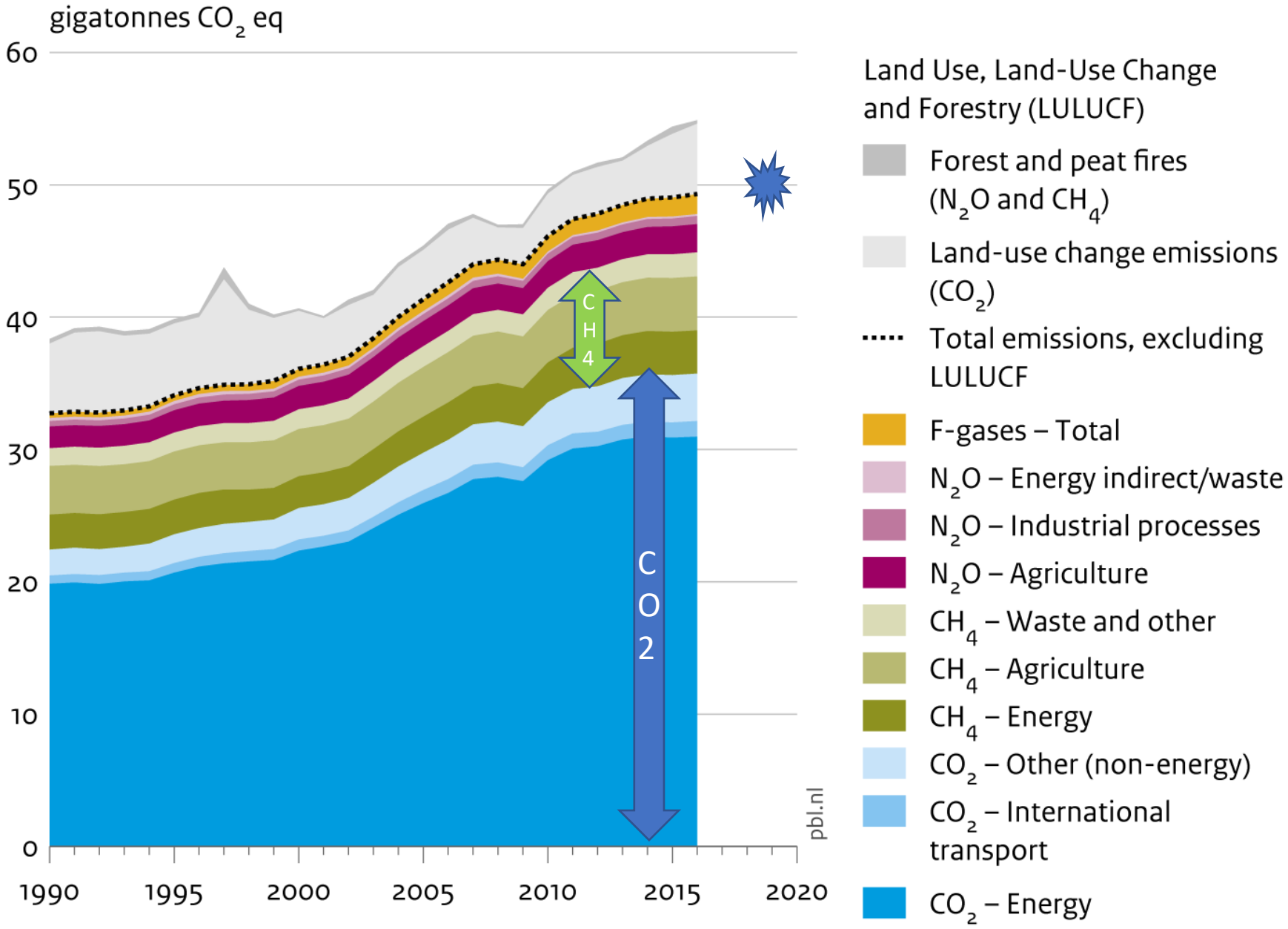
combustion

Perversely sequestering C; Plastics….pipeing etc (CCU)

$$C_{(n)} + H_{(n)} + O_2 = CO_2 + \text{energy/products}$$

Emitted to atmosphere or captured

Global greenhouse gas emissions, per type of gas and source, including LULUCF

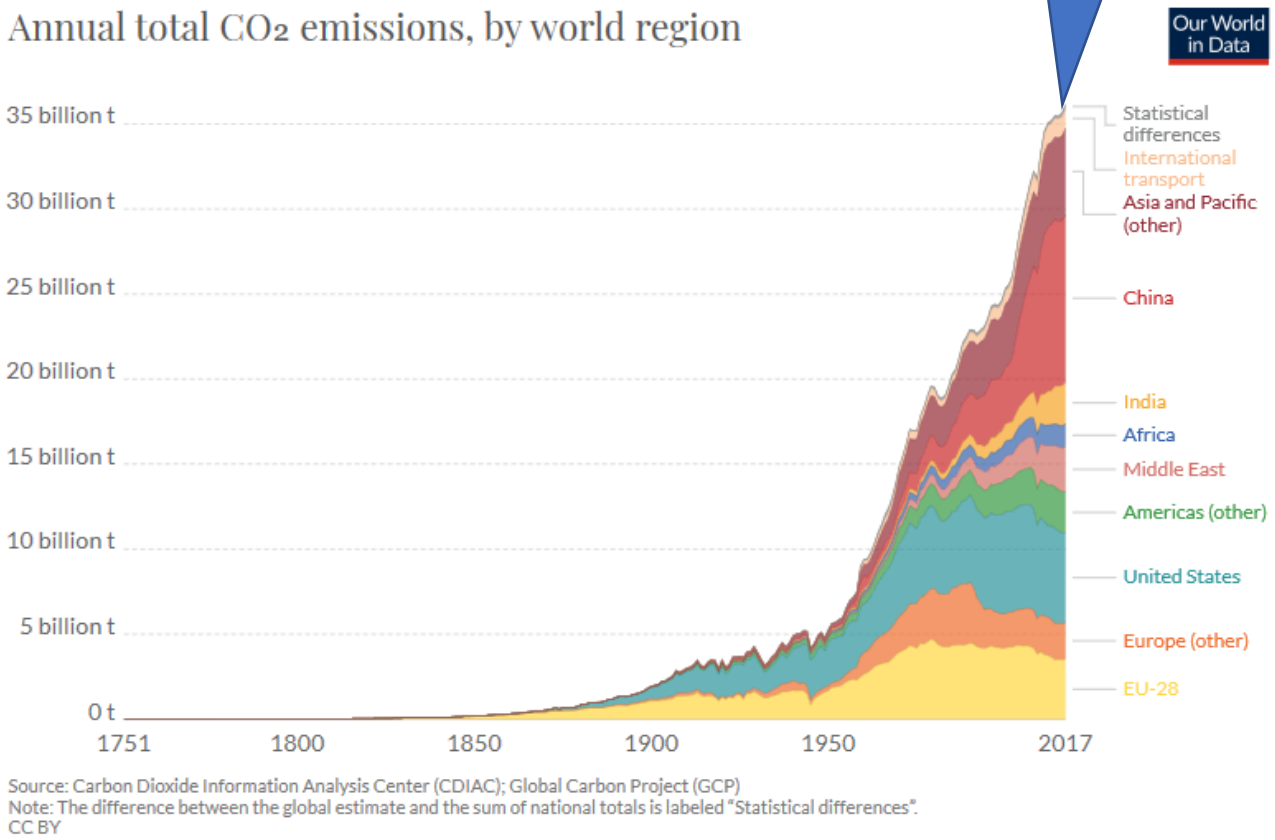


Source: EDGAR v4.3.2 (EC-JRC/PBL 2017); Houghton and Nassikas (2017); GFED 4.1s (2017)

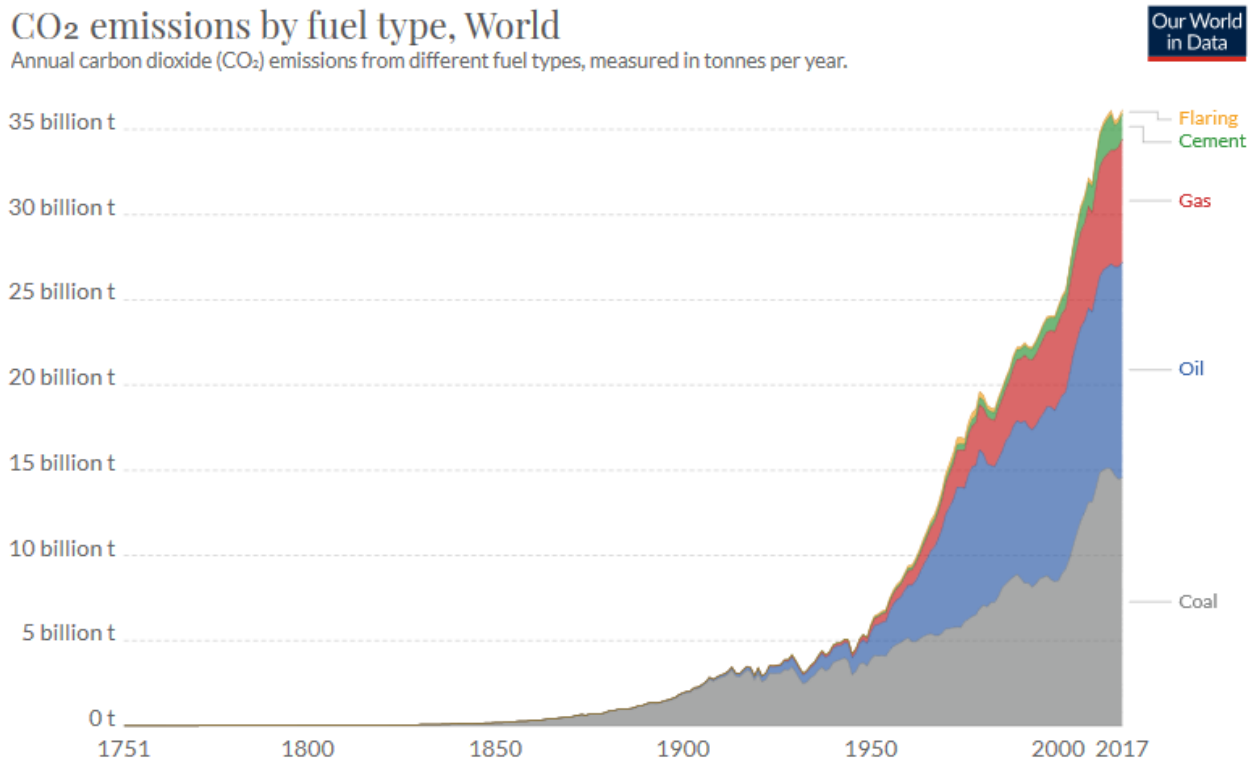
Carbon Dioxide Emission by Region and by fuel Type

https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

35+ billion tonnes CO_2 pa

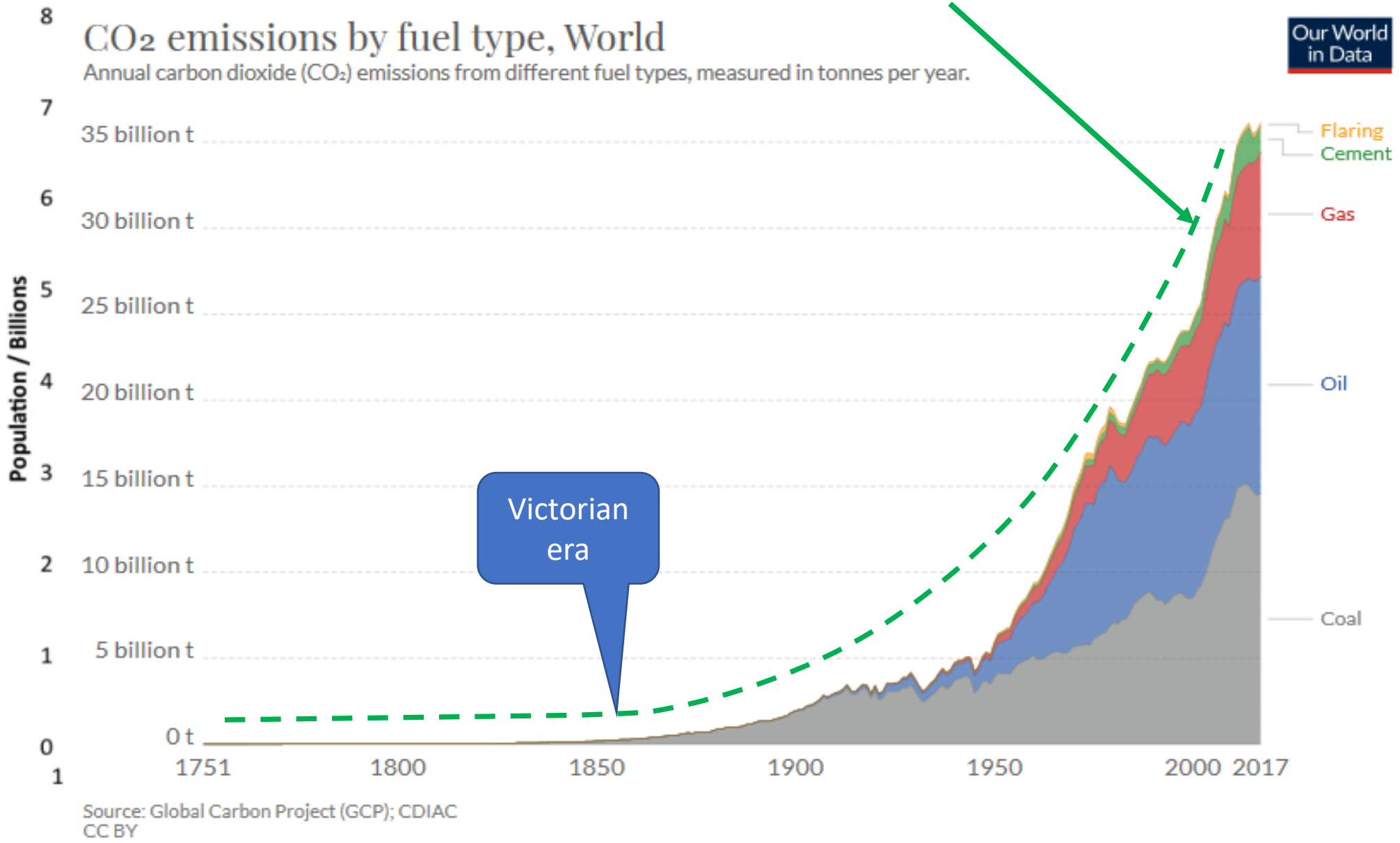


Source: Carbon Dioxide Information Analysis Center (CDIAC); Global Carbon Project (GCP)
Note: The difference between the global estimate and the sum of national totals is labeled "Statistical differences".
CC BY



Source: Global Carbon Project (GCP); CDIAC
CC BY

Human Population Growth



BALLARD

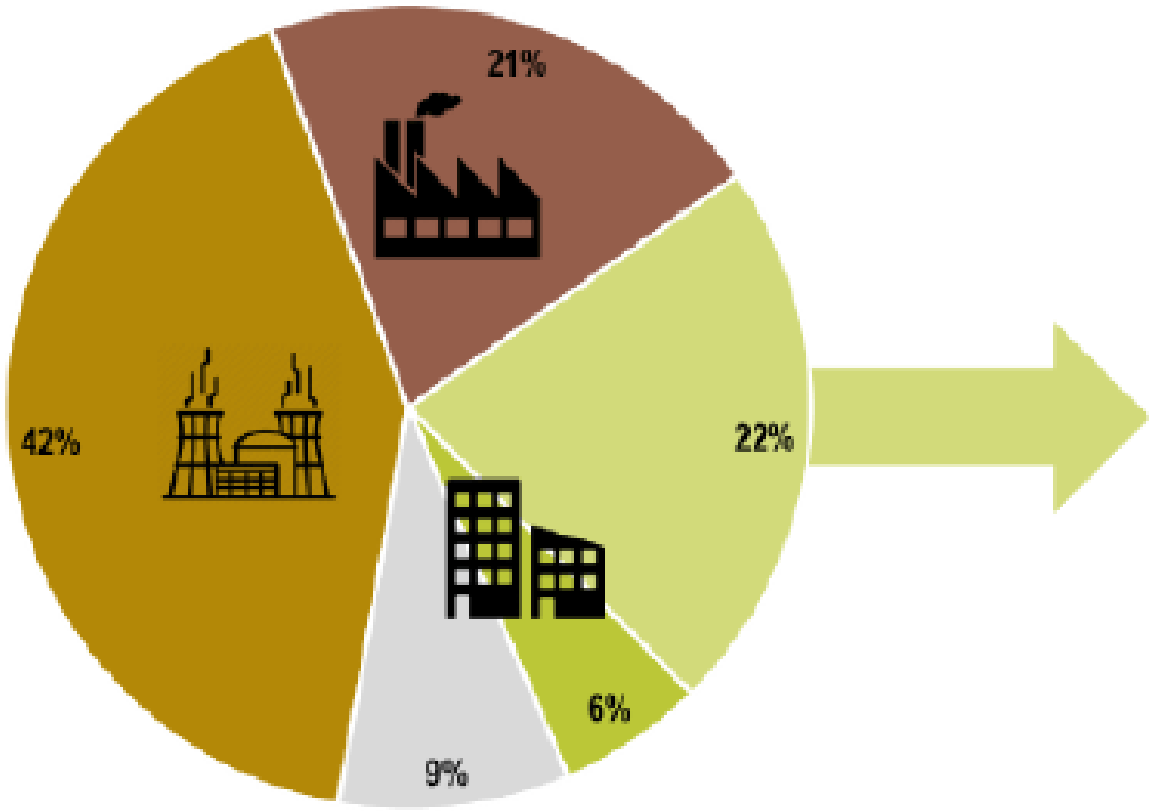
The Role of Hydrogen and the Fuel Cell in Future Energy Transition

Feb 2020

"The Role of Hydrogen and the Fuel Cell in Future Energy Transition"

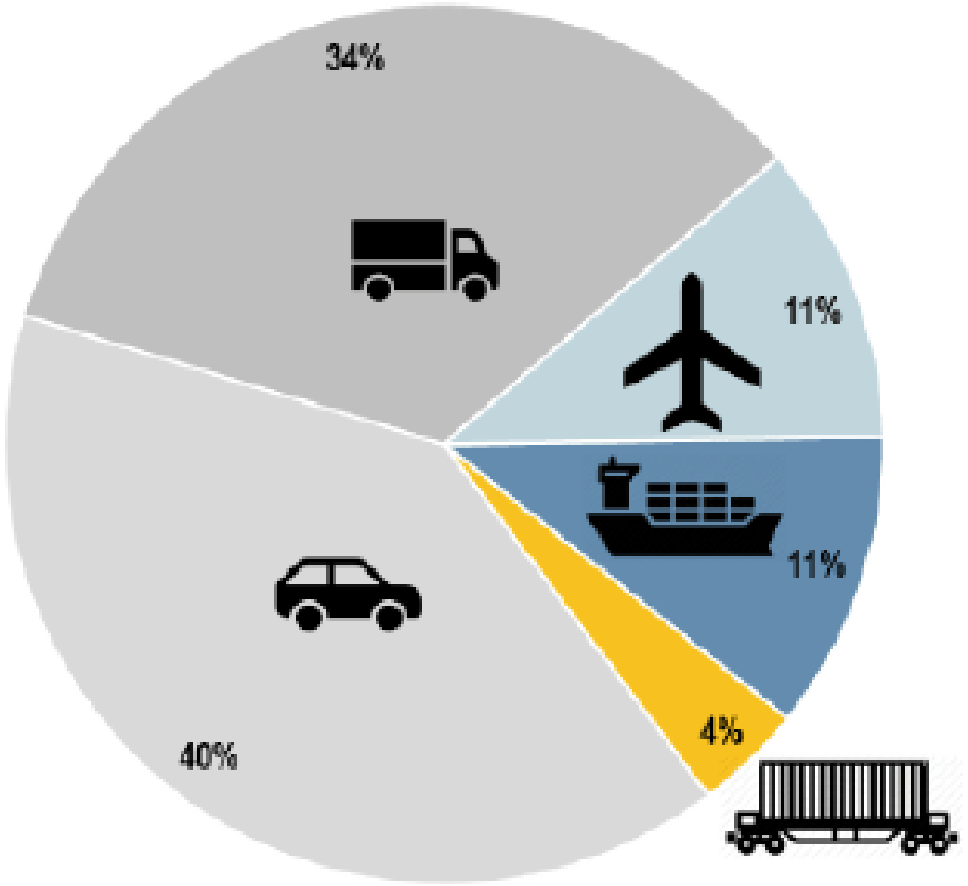
Nicolas Pocard
Director of Marketing
Ballard Power Systems

CO2 Emissions by Economic Sector



- Electricity and heat production
- Manufacturing and Construction
- Transport
- Residental
- Other

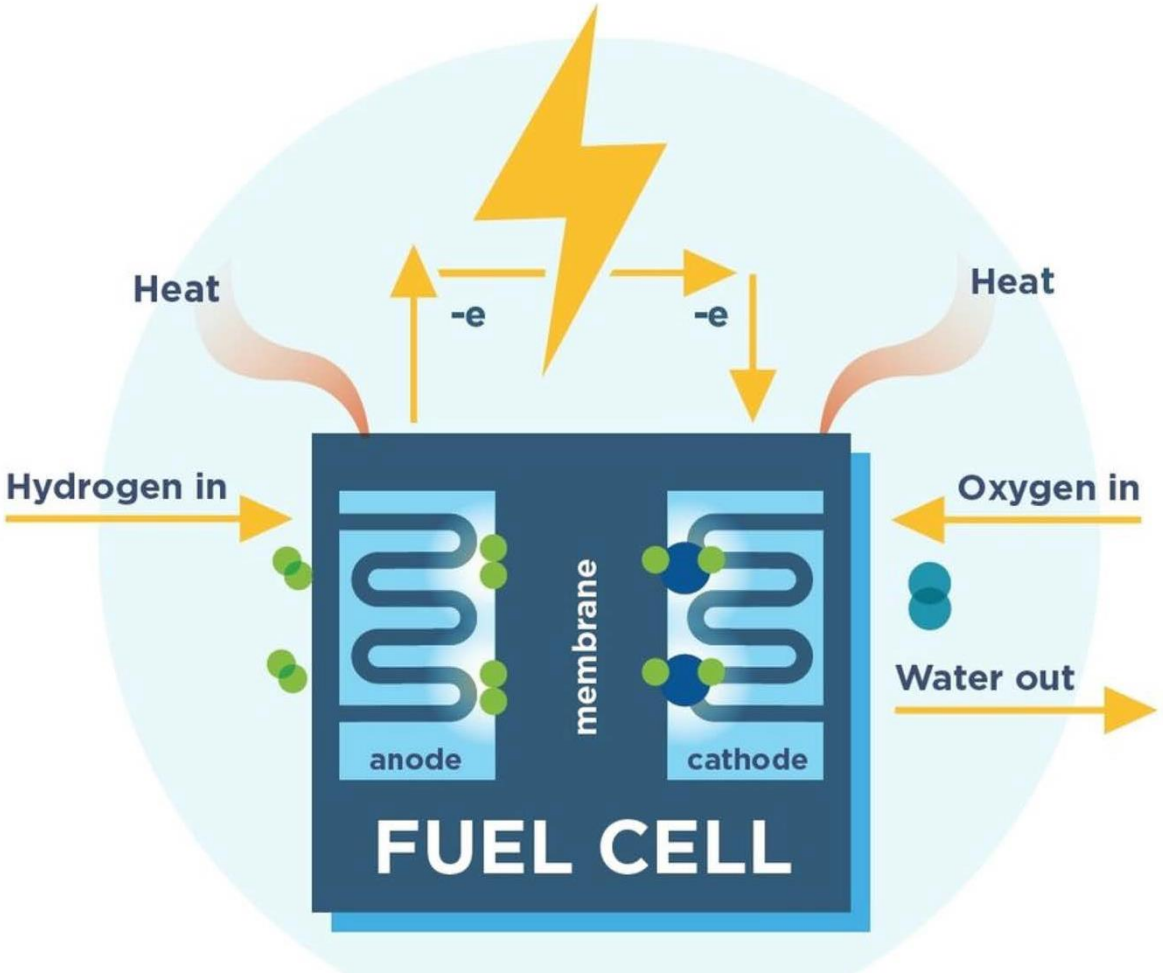
CO2 Emissions by the Transport Sector



- Automobiles
- Trucks
- Aviation
- Marine
- Railways

BALLARD

FUEL CELL (Ballard)



H2 +oxygen +catalyst = electricity + H2O
The reaction will work in reverse.

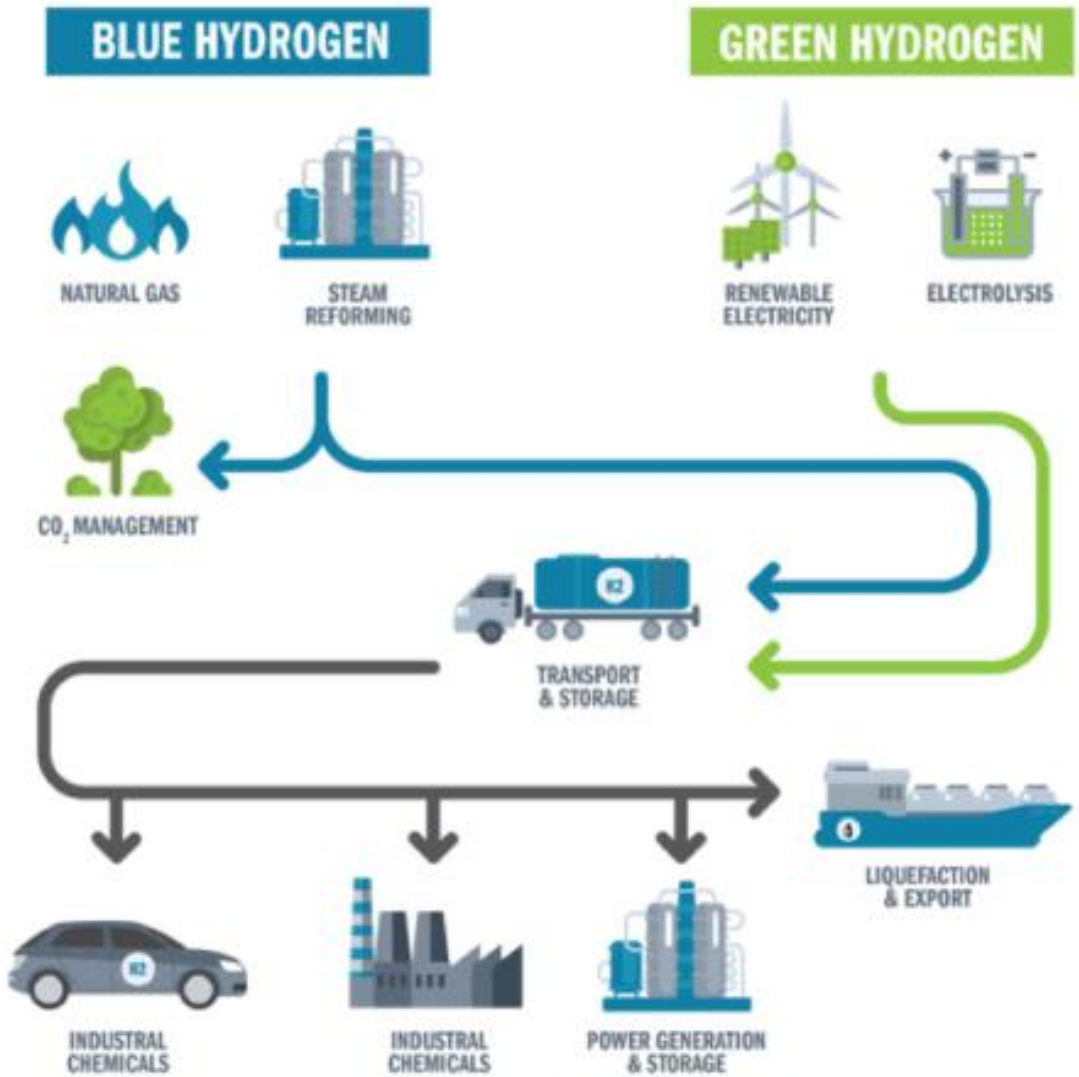
Can be viewed as a battery
rather than a fuel.
Produce hydrogen by electrolysis
(off-peak), store it and use on
demand to generate electricity

No combustion of hydrogen in a fuel cell.
This is an electrochemical reaction.

There are applications where hydrogen is
used as a combustible fuel but they are not practical
(In an ICE modified hydrogen-diesel mix
Or as a rocket fuel)

DMFC Technology: Direct Methanol Fuel Cell
Methanol (Liquid) as a carrier of H2
is introduced into fuel cell
EFOY unit
Light low power applications: NASA

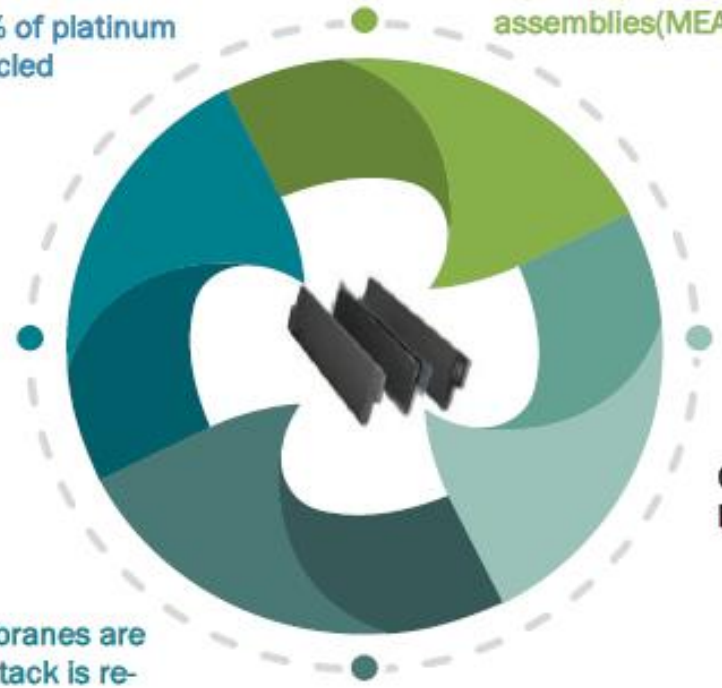
Hydrogen can be generated from various sources



Fuel cell have a lower environmental impact

More than 95% of platinum catalyst is recycled

Fuel cell stacks are refurbished by replacing the membrane electrode assemblies(MEA)



Carbon bipolar plates & compression hardware are re-used indefinitely

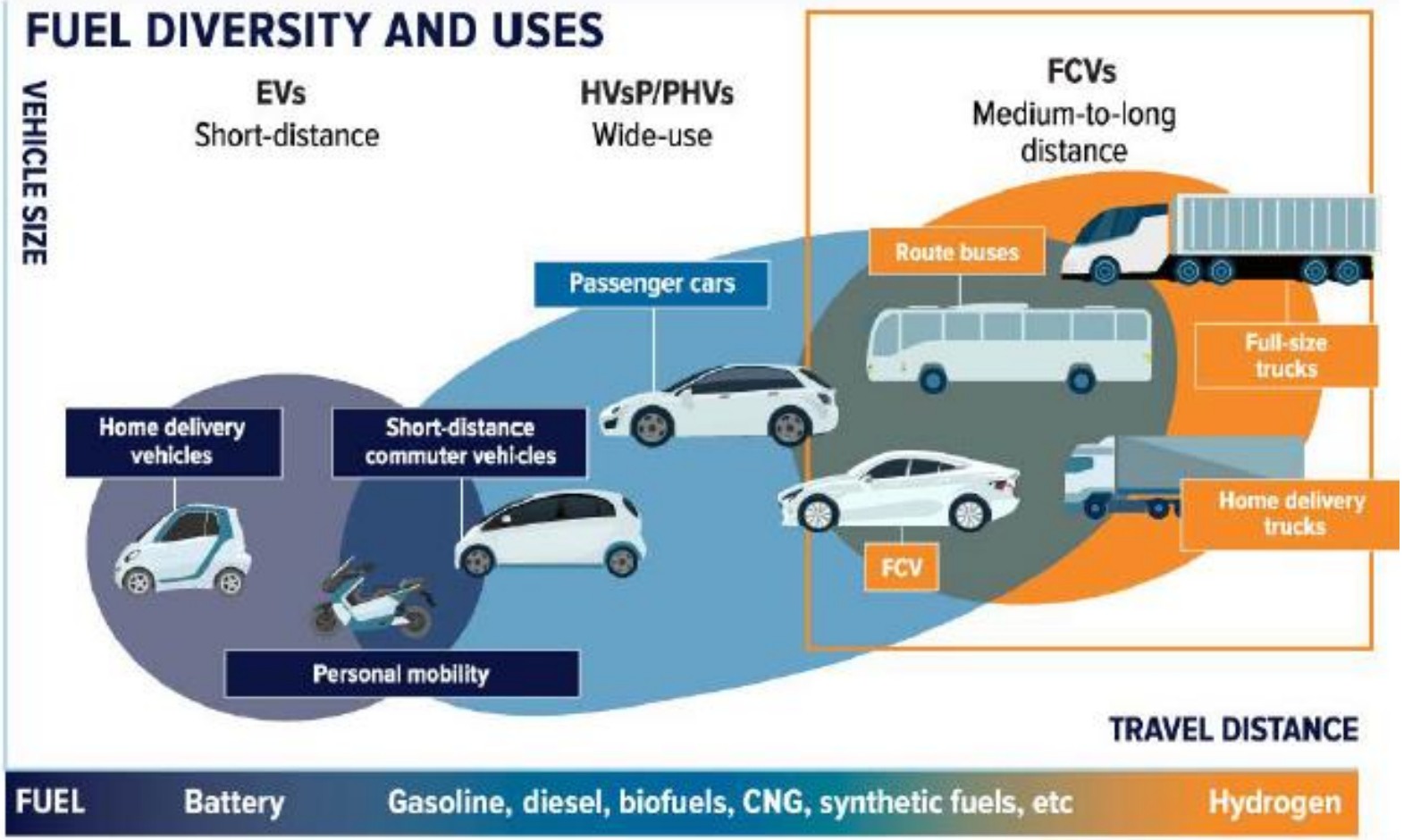
Fuel cell membranes are recycled and stack is re-conditioned

BALLARD

Fuel Cell Vehicles (FCVs)

powered by hydrogen, are no-compromise and emission-free, offering long operating range and fast refueling.

FUEL DIVERSITY AND USES



SOURCE: Green Car Reports

BALLARD

2030

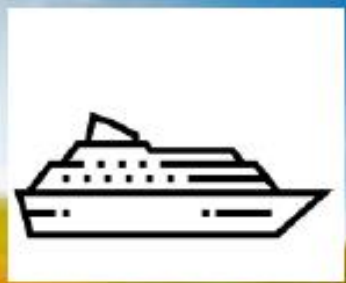
100% decarbonized hydrogen fuel for transport

H_2

Thousand's of fuel cell buses will be on the road.

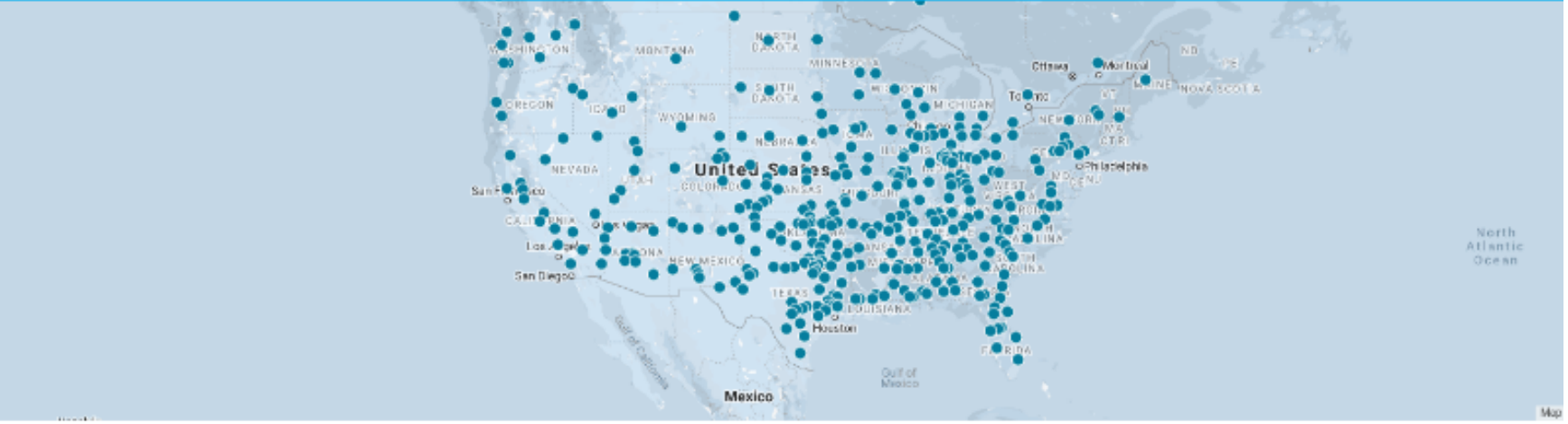
500,000 trucks will be powered by hydrogen .

1-10 trains sold for currently non electrified railways could be powered by hydrogen.



The first hydrogen powered cruise ships will be in service .

The vision of the Hydrogen Council is achievable



NIKOLA Motor Company

ZERO EMISSIONS

FROM ENERGY CREATION, TO ENERGY CONSUMPTION

RENEWABLE POWER GENERATION → ONSITE CONVERSION OF ELECTRICITY TO HYDROGEN VIA ELECTROLYSIS → ONSITE HYDROGEN STORAGE SUPPLY → FAST 70 MPA FUELING STATION → FAST 70 MPA HYDROGEN DISPENSER → HYDROGEN FUEL CELL VEHICLE

Nikola

https://nikolamotor.com/one

UP TO 2,000 FT LBS TORQUE*

UP TO 1,000 HP*

EST. 500-750 MILE RANGE*

10-15 MINUTE REFILL TIME

TESLA All electric (battery)Class 8 Highway Truck

Estimated pre-order 2000+

Production and availability for 2021

Range: 500 miles full charge and
400 miles after 30 minute charge

Battery weight 11,000 Kg (1/3 payload)

Cost: US$ 200,000

TESLA All electric (battery)Class 8 Highway Truck

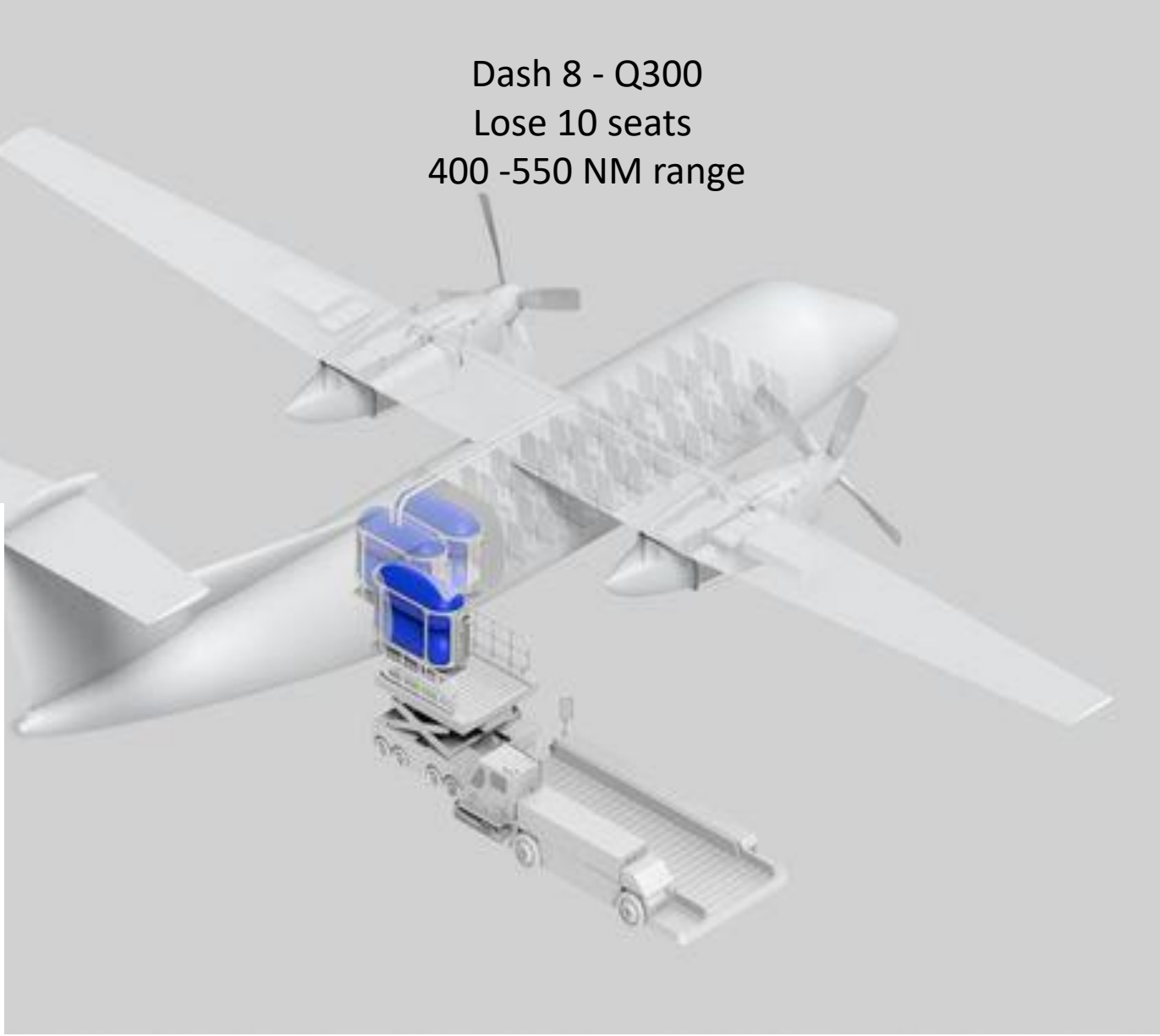
The quest for a carbon neutral airplane

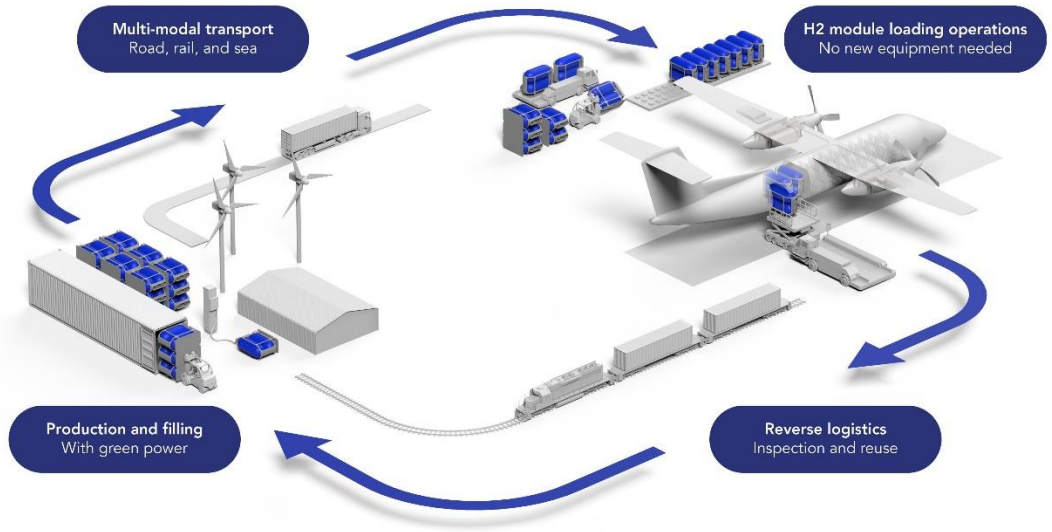
https://www.businessinsider.com/airbus-hydrogen-powered-airplane-photos-details-2020-9

Mark your calendar: 2035

Kevlar coated liquid H fuel pods
850- bar

Dash 8 - Q300
Lose 10 seats
400 -550 NM range





ZERO EMISSION H-FUEL CELL FLIGHT

https://www.aviationtoday.com/2020/09/14/universal-hydrogen-eyes-disruptive-new-concept-power-turboprop-aircraft-mid-2020s/

Hydrogen - The Fuel Cell Pros & Cons

- Negative
  - Source of H_2 = CO_2 emissions?
    - Blue not green
    - Direct Methanol Fuel Cell (DMFC)
  - Infrastructure lacking
    - Leakage, brittlization, corrosion
    - Refueling stations (only 337 worldwide)
    - Concede to BEV for cars, light trucks

- Positive:
  - Emission Free (if green H_2 & no methanol)
  - Off-peak electricity generation = H_2 storage
  - Fuel Cell: Simplicity, reliability, portability
  - Attractive power to weight ratio (eg: trucks)
  - Aviation developments
    - Fuel cell weight advantage over batteries
    - Direct combustion : Fanjet

"Nuclear Re-visited - Canadian SMRs (Small Modular Reactors)"

Canadian Nuclear Energy:

Moving from Mainframe to Laptop

Large Centralized Nuclear Plants (1000 MWe) to SMRs (<300MWe)

Living Without Oil – Part **1**

Victoria, BC -- February 15, 2020

cna canadian nuclear association

John Stewart
Director

SMRs – small modular reactors

- Traditional 1+GWe large centralized nuclear plants ($12B+)
  - These are difficult to finance
  - Extensive power distribution infrastructure required
  - Challenging public acceptance
- SMRs
  - Sized to specific application (300 – 15 MWe)
  - Financeable (lower risk)
  - Modular – economy in manufacturing, construction and operating (refueling)
  - Transportable components
  - Speed of construction & decommissioning is more practical (15 – 20 yr life)
  - Safe, Secure, Reliable
  - Greater public acceptance

SMR Technologies

- All Fission technologies
- Vary from well established to exciting new developments
- 4 main types based on moderating control systems and fuel type
  - Light water (conventional eg: PWRs)
  - Fast neutron (breeder)
  - Graphite moderated high temp (HTRs)*
  - Molten salt (MSRs)*

    * = Th fuel development
- Rapid pace of development
  - US, China, Russia, Argentina, Korea, Pakistan, Canada
- Canadian Roadmap (described by John Stewart)
  - Dec 1, 2019: Ont, NB, Sask, (Alta) Premiers sign a Commitment MOU
  - Govt. regulation, public acceptance, Aboriginal consultation and buy-in
  - Market opportunities
  - Cost competitive with FF and Alternative electricity generators

Multiple Canadian Markets for Small Reactors

29 coal fired
343 MWe

1. **On-grid** – likeliest on existing, licensed nuclear sites, or replacing coal-fired units in coal-mining towns

2. **Mining** – electricity (+ heat?) for remote but rich mining sites

SAGD
210 MWe

3. **Process heat** – e.g. melting bitumen from the oilsands

4. **Remote communities** – electricity (+ heat?) for hundreds of isolated towns now depending on diesel

79 communities
>1 MWe

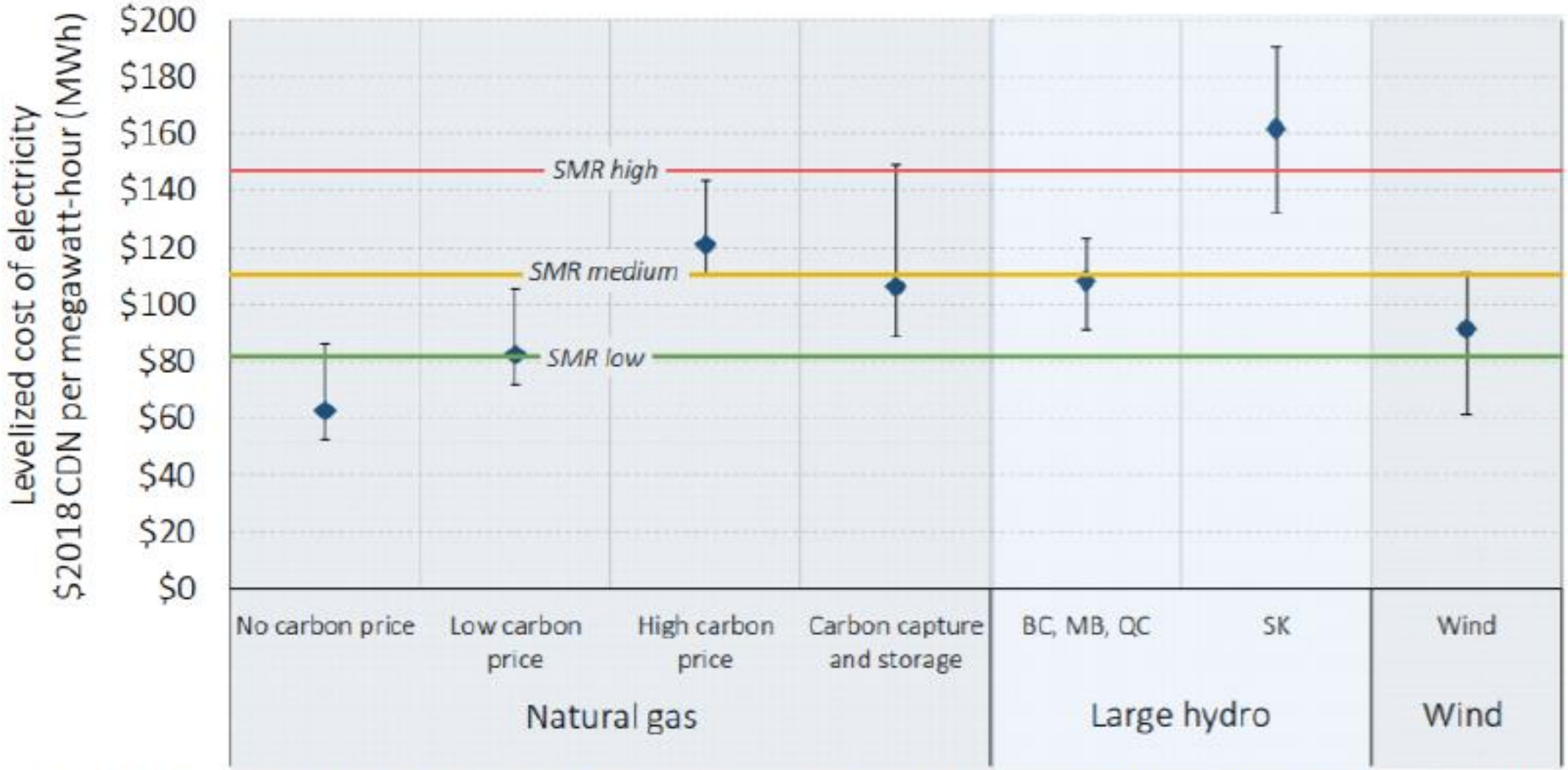


Figure 2. Comparison of levelized cost of electricity from on-grid SMRs with other options: Worst case (9% discount rate, less innovative technology)

Developments in Wind Turbines
Terrestrial to Offshore

Dr. Curran Crawford

Living Without Oil Lecture Series, Part One
An Elder Academy Event
February 22, 2020

University of Victoria | Institute for Integrated Energy Systems

SSDL Sustainable Systems Design Laboratory

PRIMED | Pacific Regional Institute for Marine Energy Discovery

Meteorology

- Origins of the Wind
- Characterizing the Wind
- The Earth's Boundary Layer

"Conventional" technology Overview

- Historical Development
- Basics of Wind Energy extraction
- Aerodynamics is Complicated!
- Improving Performance
- Structures and Drivetrains

Deployment & Economics

- Wind Resource
- Installed Capacity
- Decommissioning

Offshore Wind Energy

- EU Genesis
- Offshore Resource & Development
- Floating Offshore

Airborne Wind Energy Systems (AWES)

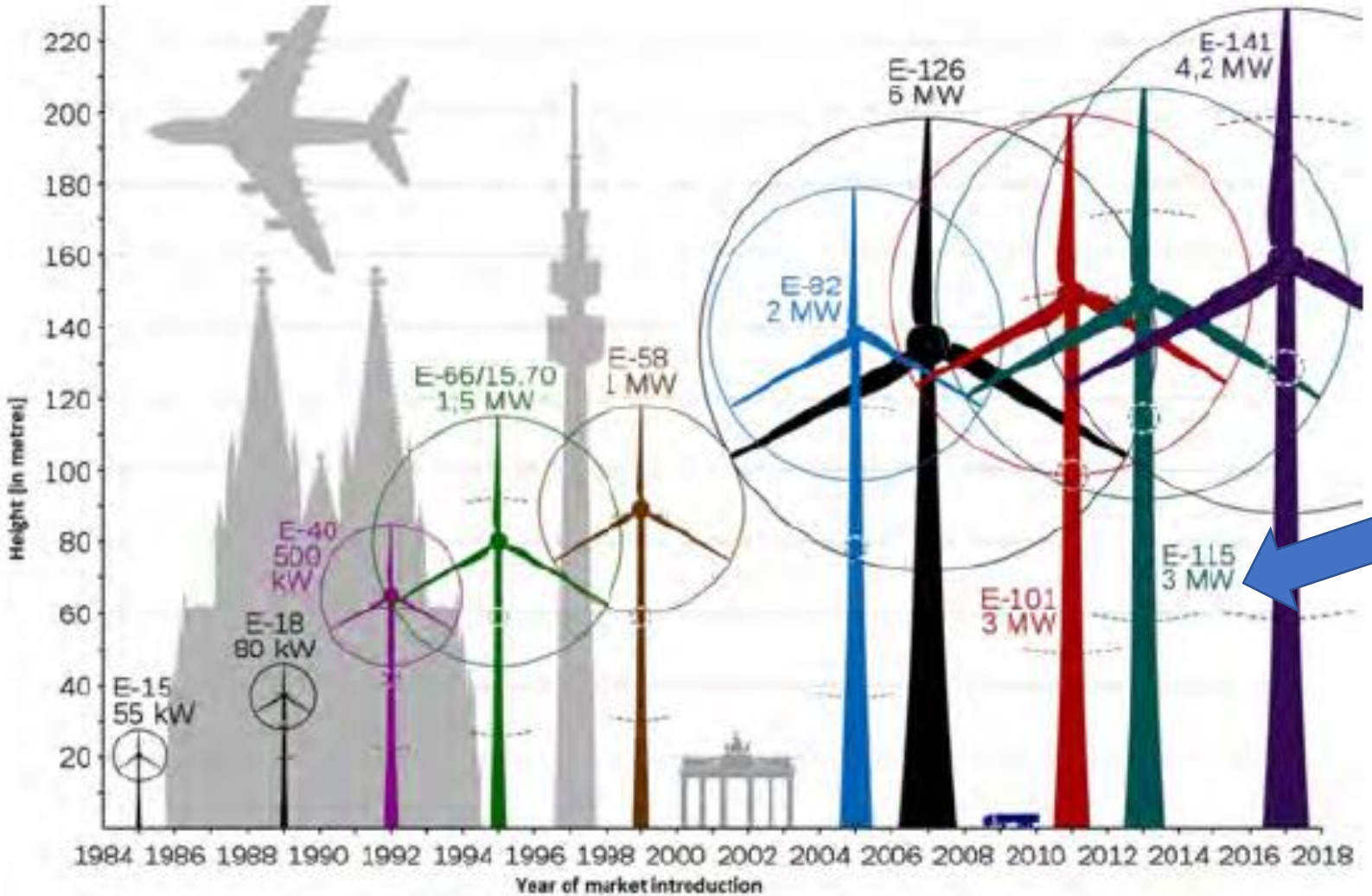
- AWES Advantages
- AWES Challenges
- Other AWES Markets

DR. CURRAN CRAWFORD'S PRESENTATION OUTLINE

The flow around a wind turbine rotor is complex and fundamentally governs the power capture and loads

(http://i.imgur.com/qruVcnu.jpg)

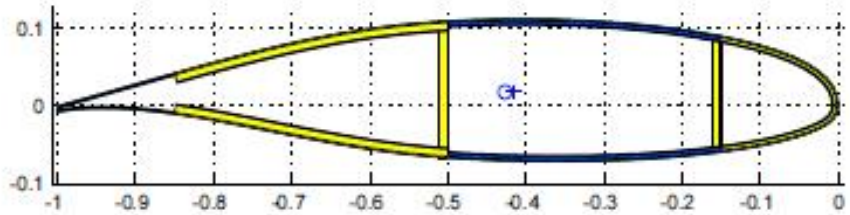
"Danish-concept" turbines continue to grow in size

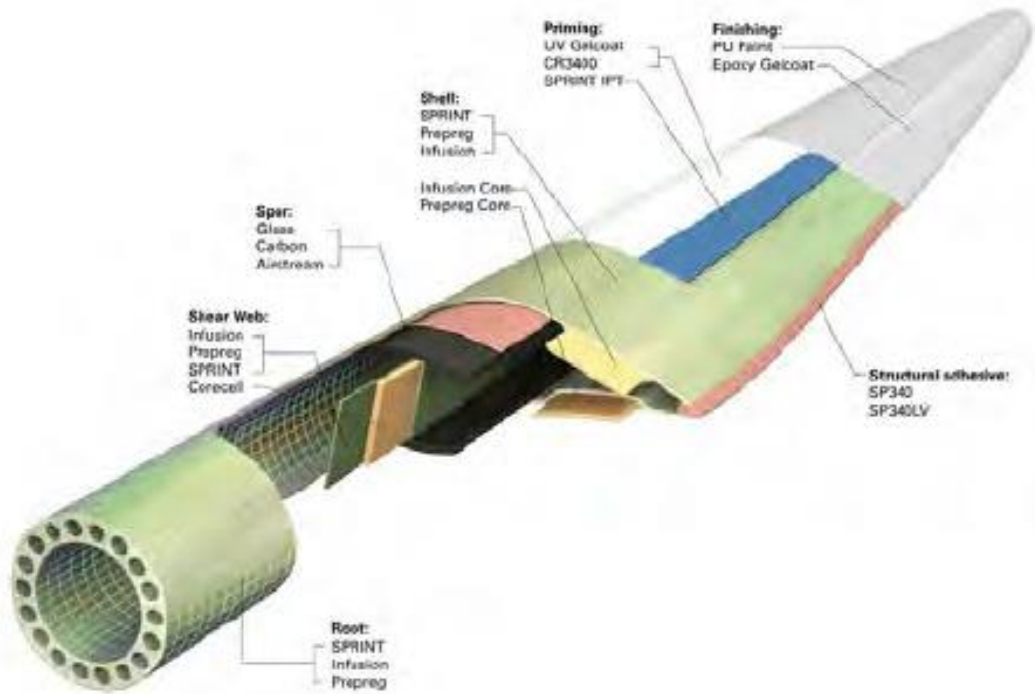


3 MW NAMEPLATE

Source:
https://www.cleanenergywire.org/factsheets/german-onshore-wind-power-output-business-and-perspectives

Blades are made up of composite layups





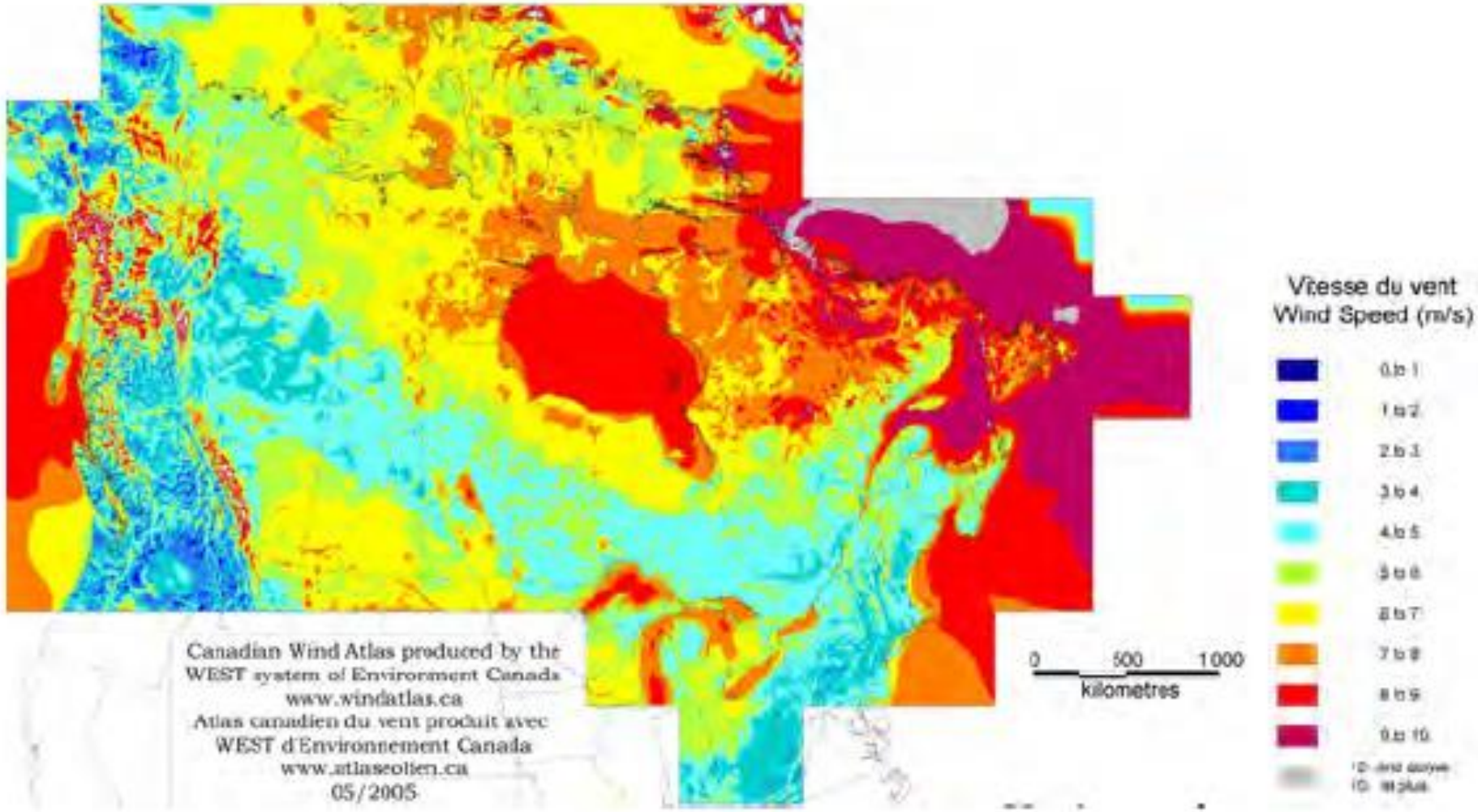
Towers are frequently manufactured locally in 3–4 sections and bolted together on-site

Foundation bolts ready for tower installation

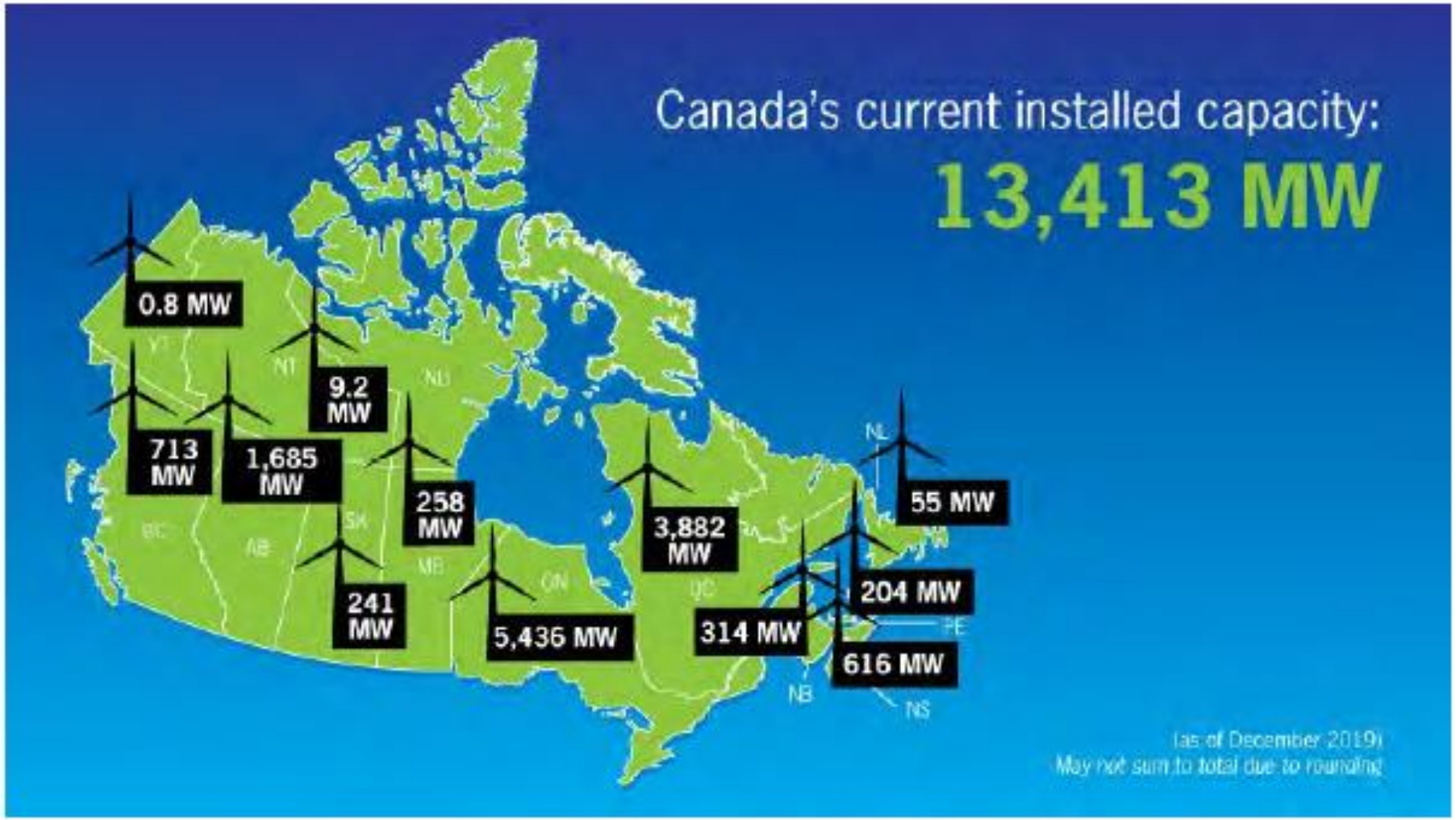
Principle Power WindFloat Atlantic (2020)

- 25 MW: 3x Vestas V164-9.0 MW turbines in 100 m water depth
- Grid-connected to Portugal
- Plans for 30 turbines, 150 MW total

Canada, and BC in particular, has a large offshore wind resource



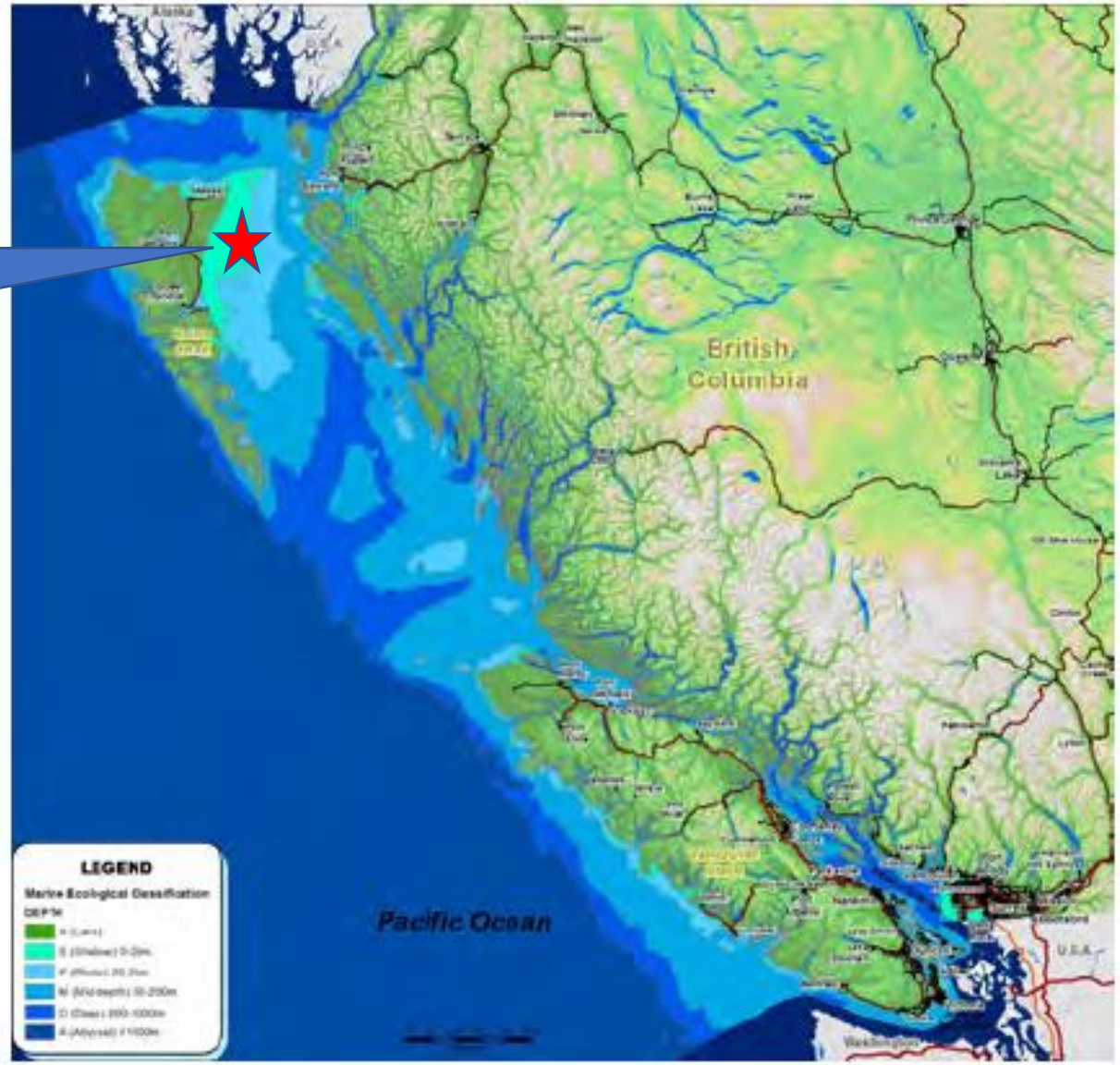
Installed wind capacity in Canada



Source: https://canwea.ca/wind-energy/installed-capacity/

BC's coastal remoteness and bathymetry motives the investigation of floating offshore wind

NaiKun
Or Northland Power



Doubly-fed induction generators with gearboxes have been the emergent norm for drivetrains

Growth of Wind Power over 10 yrs (2006-16)

	Hydropower	Solar[1]	Biomass	Wind	Geothermal	All Renewables	Renewable Generation (GWh)
2006	16.7%	0.1%	1.2%	1.1%	0.3%	19.4%	3,488,055
2007	16.4%	0.1%	1.3%	1.5%	0.3%	19.3%	3,644,173
2008	16.6%	0.1%	1.3%	1.7%	0.3%	20.0%	3,822,689
2009	17.2%	0.1%	1.5%	2.2%	0.4%	21.3%	4,064,206
2010	16.6%	0.3%	1.6%	2.6%	0.3%	21.3%	4,319,733
2011	16.4%	0.4%	1.7%	3.0%	0.3%	21.7%	4,582,578
2012	16.3%	0.6%	1.8%	3.4%	0.3%	22.4%	4,891,891
2013	16.2%	0.8%	1.8%	3.7%	0.3%	22.9%	5,161,742
2014	16.3%	1.0%	1.9%	4.2%	0.3%	23.6%	5,506,624
2015	15.9%	1.2%	2.1%	4.7%	0.3%	24.2%	5,830,656
2016	16.3%	1.6%	2.2%	5.3%	0.3%	25.8%	6,210,928

Source: https://www.nrel.gov/docs/fy18osti/70231.pdf

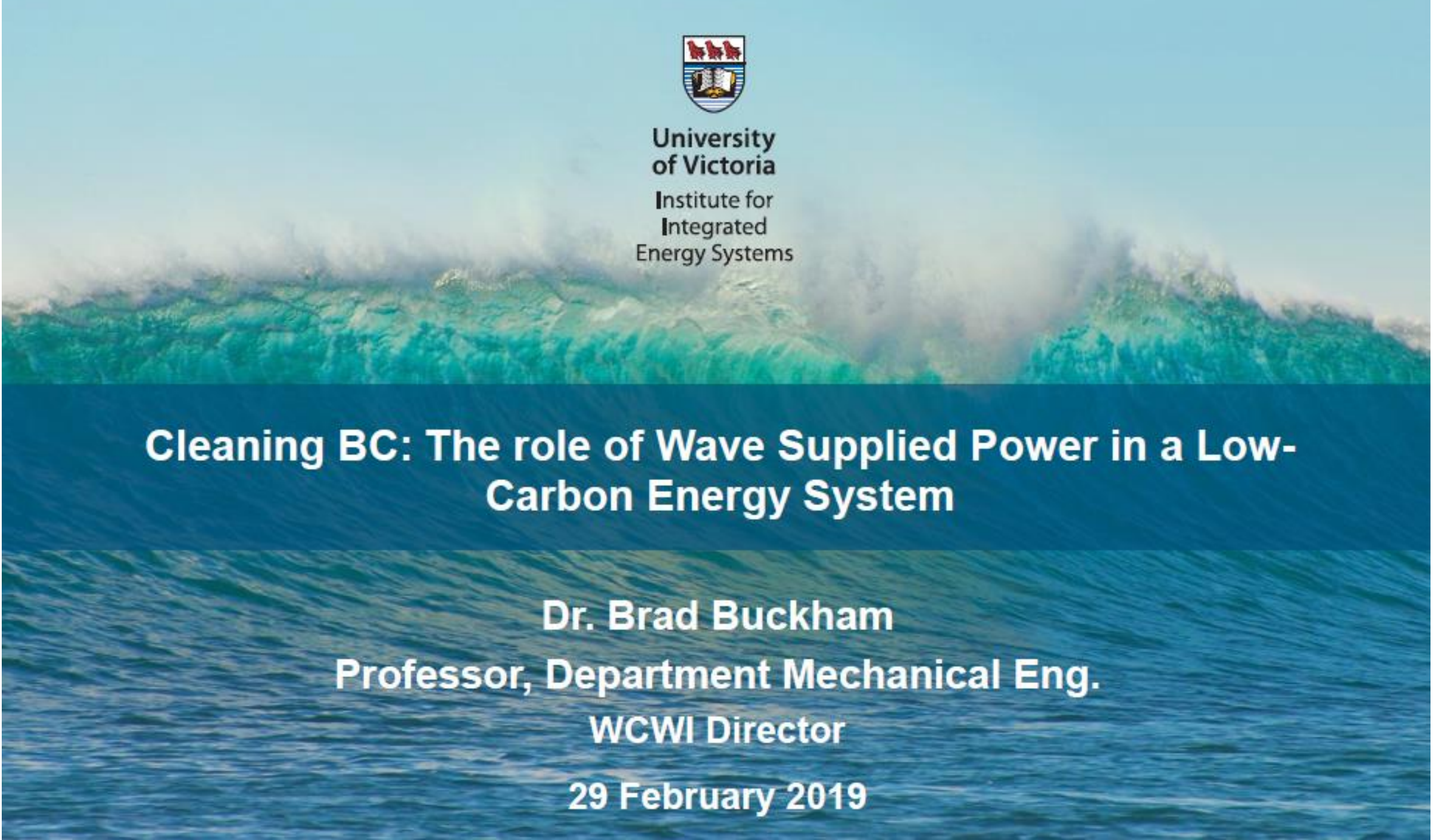
AWES (Airborne Wind Energy)

How crazy the idea of airborne wind sounds depends on what you're talking about

- There are a range of universities, companies and conferences on this topic!
- High-altitude vs. more realistic lower altitudes (< 1000 m)
  - High altitude jet stream looks good on paper
  - Airspace restrictions
- Drastically reduced structure for a very big capture area

Many concepts are being proposed

Sources: http://www.makanipower.com, http://www.kitepower.eu



University of Victoria
Institute for Integrated Energy Systems

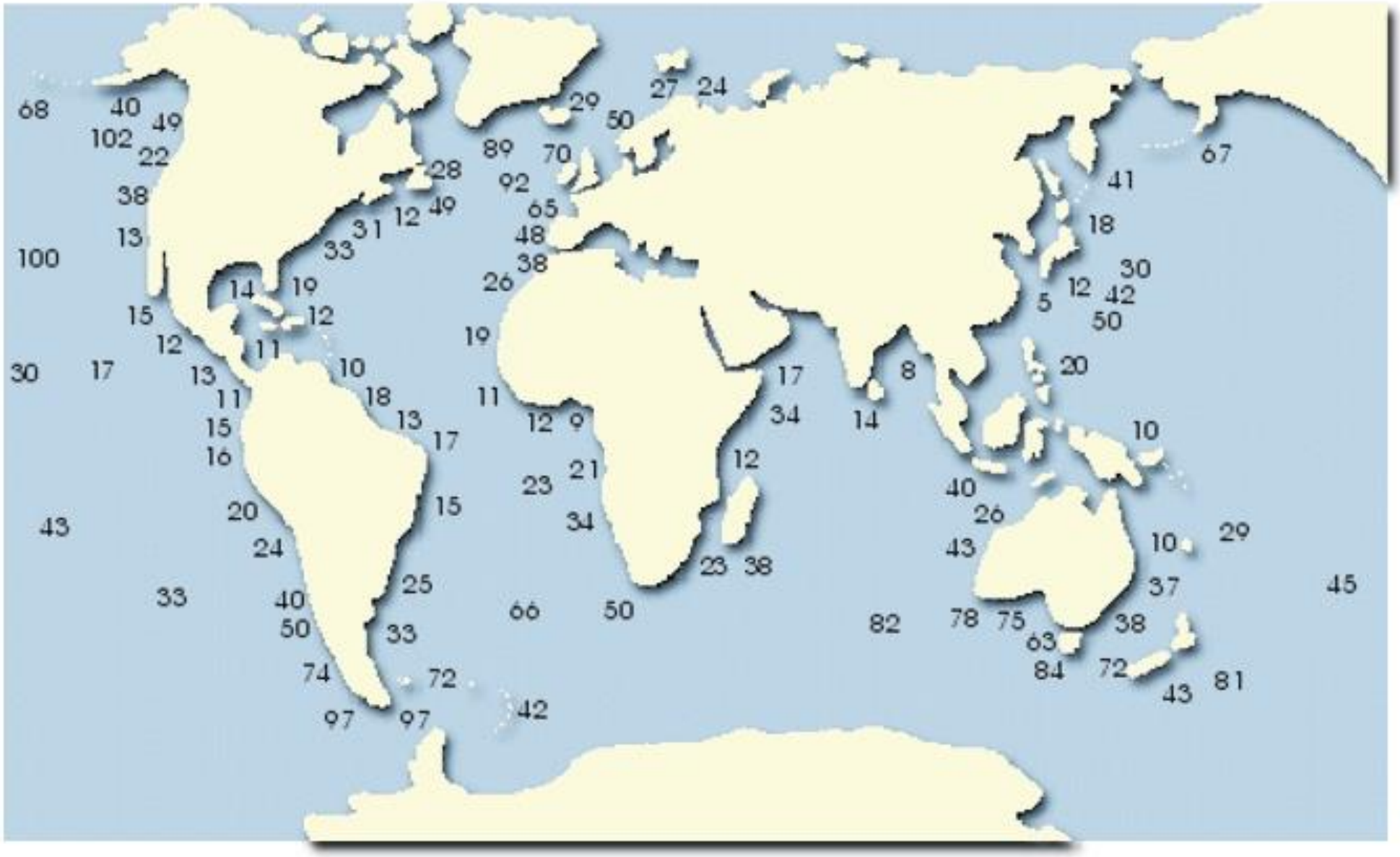
Cleaning BC: The role of Wave Supplied Power in a Low-Carbon Energy System

Dr. Brad Buckham
Professor, Department Mechanical Eng.
WCWI Director

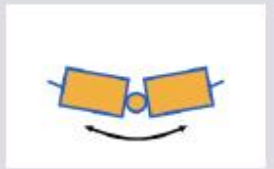
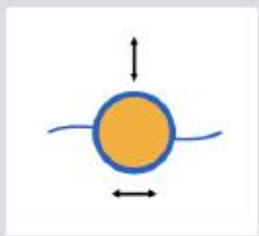
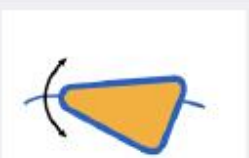
29 February 2019

Annual average wave power

in kW per metre of crest width



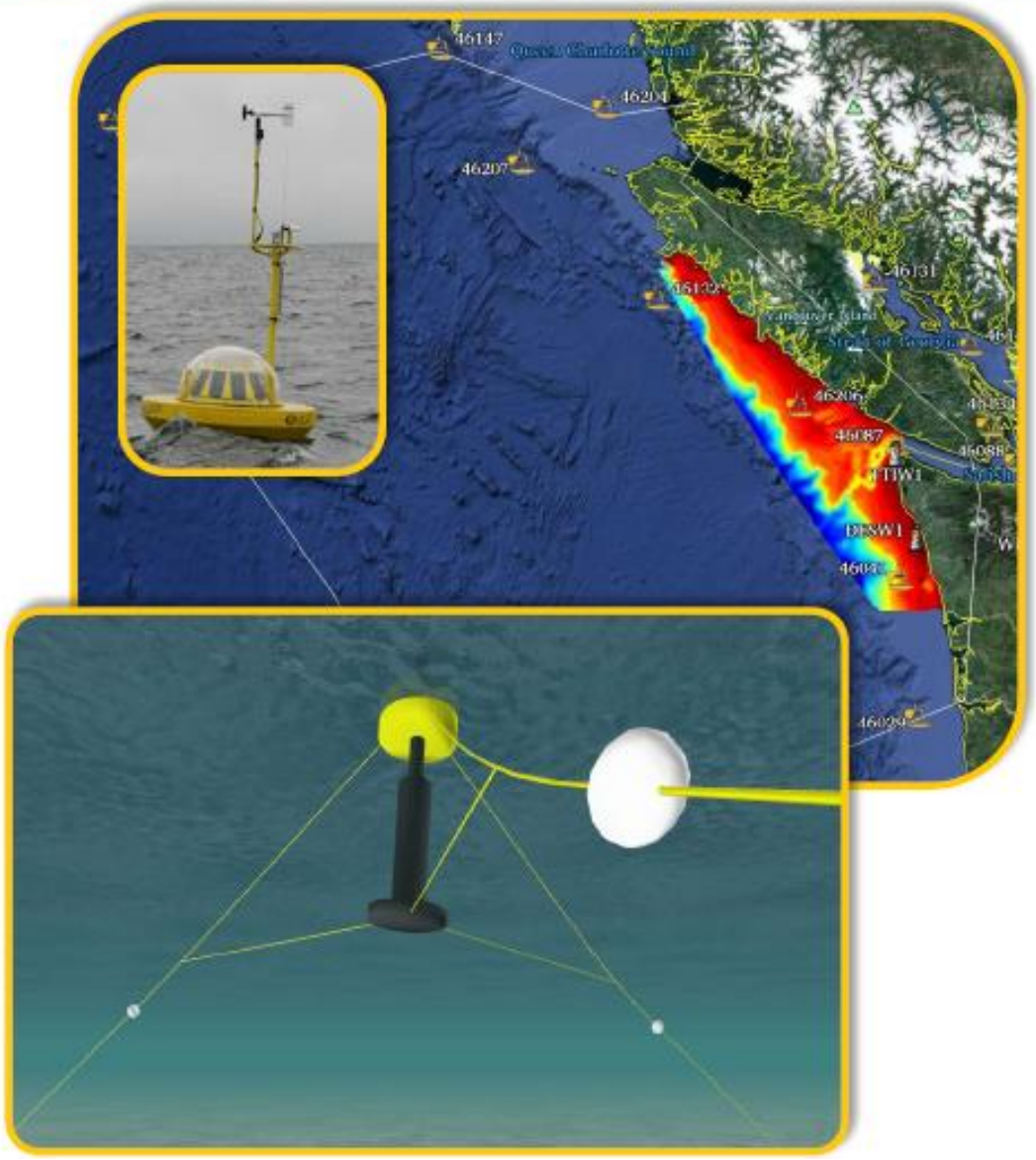
What is a Wave Energy Converter (WEC)?

	Definition	Example
Attenuators (Pelamis, Biopower)	• Aligned parallel to the direction of wave propagation.	 
Overtopping Devices (Wave Dragon, Limpet, Manchester Bobber, OceanLinx, ORECON, SEEWEC)	• Top of breaking wave used to drive low-head turbine.	 
Point Absorbers (OPT, WaveBob, AOE Canada)	• Omni-directional absorption – horizontal or vertical component of wave motion.	 
Terminators (AWS, OREC)	• Aligned perpendicular to the direction of wave propagation.	 

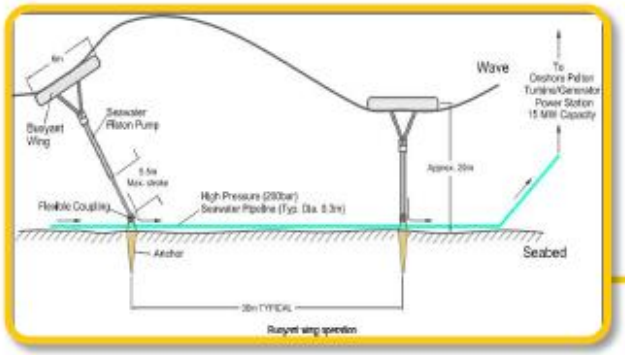
What is the West Coast Wave Initiative (WCWI)?

The WCWI is a comprehensive wave-to-wire-to-washing machine modeling study that includes:

- Detailed assessment of the wave energy resource in an important Canadian region – Vancouver Island.
- High fidelity time domain computer simulations of Wave Energy Conversion (**WEC**) technologies.
- Detailed integration studies that examine how wave energy should be used at kW, MW and GW scales.



Where can WECs be exploited in BC?



Hot Springs Cove is a community of the Hesquiaht First Nation.

Currently pursuing a combination of renewables to eliminate diesel fueled energy generation on site.

Barkley project group

University of Victoria | Institute for Integrated Energy Systems

WCWI

WEC technology & BC remote communities

- There still remains a lot of uncertainty in WEC technology
  - Concepts haven't converged.
  - CAPEX & OPEX.
- Advancement of the sector depends on motivated people who want to pursue transformational change.
- In BC, it is Indigenous communities that are taking the lead.
- IEA – OES:

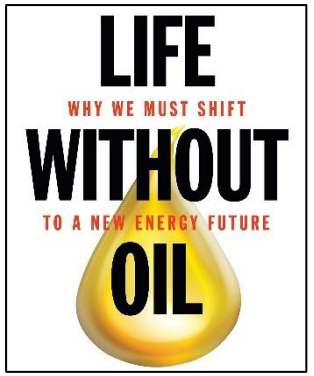
  "Ocean Energy is facing a dilemma: how to fund technological development and first deployments at sea oriented to gain experience, improve performance, limit risks and finally reduce costs in a challenging long-term scenario. The participation of public bodies committed to a clean energy future using indigenous sources is essential to help solve this dilemma. It can bridge the gap between a promising present and a profitable future".

University of Victoria Retirees Association

AN ELDER ACADEMY EVENT

February Saturday Speaker Series

LIVING WITHOUT OIL? Part 1



FEB 8: "The Role of Hydrogen and the Fuel Cell in Future Energy Transition"

Presenter: Nicolas Pocard, MChem Eng, MSc, Director, Ballard Power.

FEB 15: "Nuclear Re-visited - Canadian SMRs (Small Modular Reactors)"

Presenter: John Stewart, Canadian Nuclear Association, Director of Policy and Research

FEB 22: "Wind Energy Opportunities: Terrestrial, offshore and airborne variants"

Presenter: Curran Crawford, BEng, SM (MIT), PhD, PEng, Professor Mech Eng, U. Vic.

FEB 29: "Cleaning BC: Wave Supplied Power in a Low-Carbon Energy System"

Presenter: Brad Buckham, PhD, PEng, Professor Mech Eng, U.Vic.

Sources of Energy – World

Source: Shell SKY Scenario, 2019

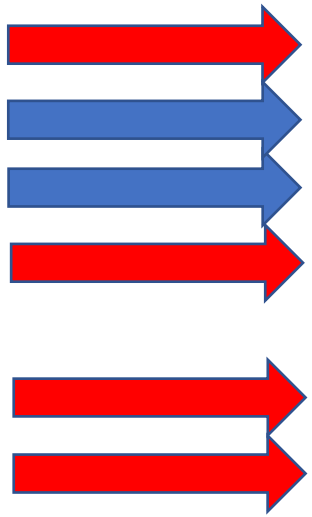
Hydrocarbons (90%)

- **Oil = 32%**
- **Gas = 22% (blue H_2)**
- **Coal = 27%**
- **Biofuel + Biomass = 9%**

Greenhouse Gas Emitters upon combustion

Non Hydrocarbons (10%)

- **Geothermal = 0.5%**
- **Nuclear = 5%**
- **Hydro = 3.0%**
- **Solar = 0.5%**
- **Wind = 0.6%**
- **Tide = <0.01%**
- **Wave = <0.01%**
- **Green Hydrogen = ?**



Zero Greenhouse Gas Emitters or "Alternate" energy sources

Hydroelectricity (Wikipedia, 2020)

Arrow Lakes Dam, BC
185 MW capacity
An average size of 68 dams in BC.

- Hydroelectricity provides 3% of world energy needs
- Hydroelectricity provides 17% of world electricity needs
- 10% of world supply provided by Canada
- Canada is the 3rd largest after China and Brazil

Quebec	38.4 GW
BC	14.2 GW
New/Lab	7.7 GW
Ont	7.4 GW
Man	5.7 GW
NB	0.9 GW
Alta	0.9 GW
Other	1.4 GW
TOTAL	76.8 GW

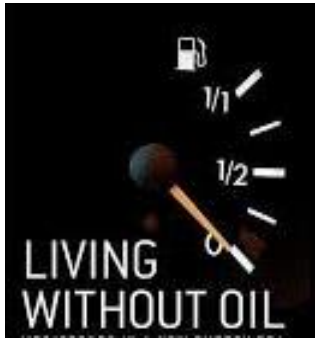
- Hydroelectricity accounts for 26% of Canada's energy needs

University of Victoria Retirees Association

AN ELDER ACADEMY EVENT

March/Oct Saturday Speaker Series

LIVING WITHOUT OIL? Part 2



MAR 7: "Are Big Hydro and Run of River Resources Maximised?"

Presenter: Heather Matthews: BC Hydro Power Group. Director Generation System Operations

At the last moment, the speaker was unable to present and BC Hydro was unable to provide a substitute speaker. Elder Academy was most fortunate to find replacement speakers as follows:

MAR 7: "Solar on Strata"

Presenter: Bruce Mackenzie (BCSEA):

"Low Carbon Electrification, the CleanBC Plan and BC Hydro"

Presenter: Thomas Hackney (BCSEA):

Many thanks to the BC Sustainable Energy Association (BCSEA) for providing Bruce and Thomas.

Following the March 7th presentations, the series was postponed until October and we are currently proceeding in a Zoom format.

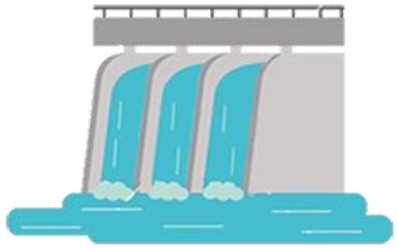
BC Electricity Generating Capacity - Total

http://www.energybc.ca/, 2017

	EXISTING (2016)		PLANNED (2016)	
	MW	#	MW	#
Dams	12,984	68	1,100	1
ROR	950	33	336	14
Wind	488	5	245	5
Solar	1	1	0	0
Biomass	349	17	40	1
Natural Gas	**1,464**	**5**	**nil**	**nil**
Diesel	**46**	**9**	**nil**	**nil**
TOTAL	**16,281**		**1,721**	

Power Generating Equivalencies

(Modified after EnergyBC)



1

Hydroelectric Dam

Site C
1,100 MW

=

12

Natural Gas Plants

McMahon Co-Generation
120MW

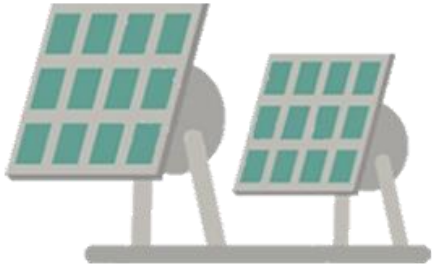
=

990

Wind Turbines

Leitwind LTW77-1500
1.5 MW

=



2,200,000

m^2 of Solar Panels

Canadian Solar
500 W

EnergyBC

3

Nuclear SMRs

330 MW

After Applying Avg Capacity Factors

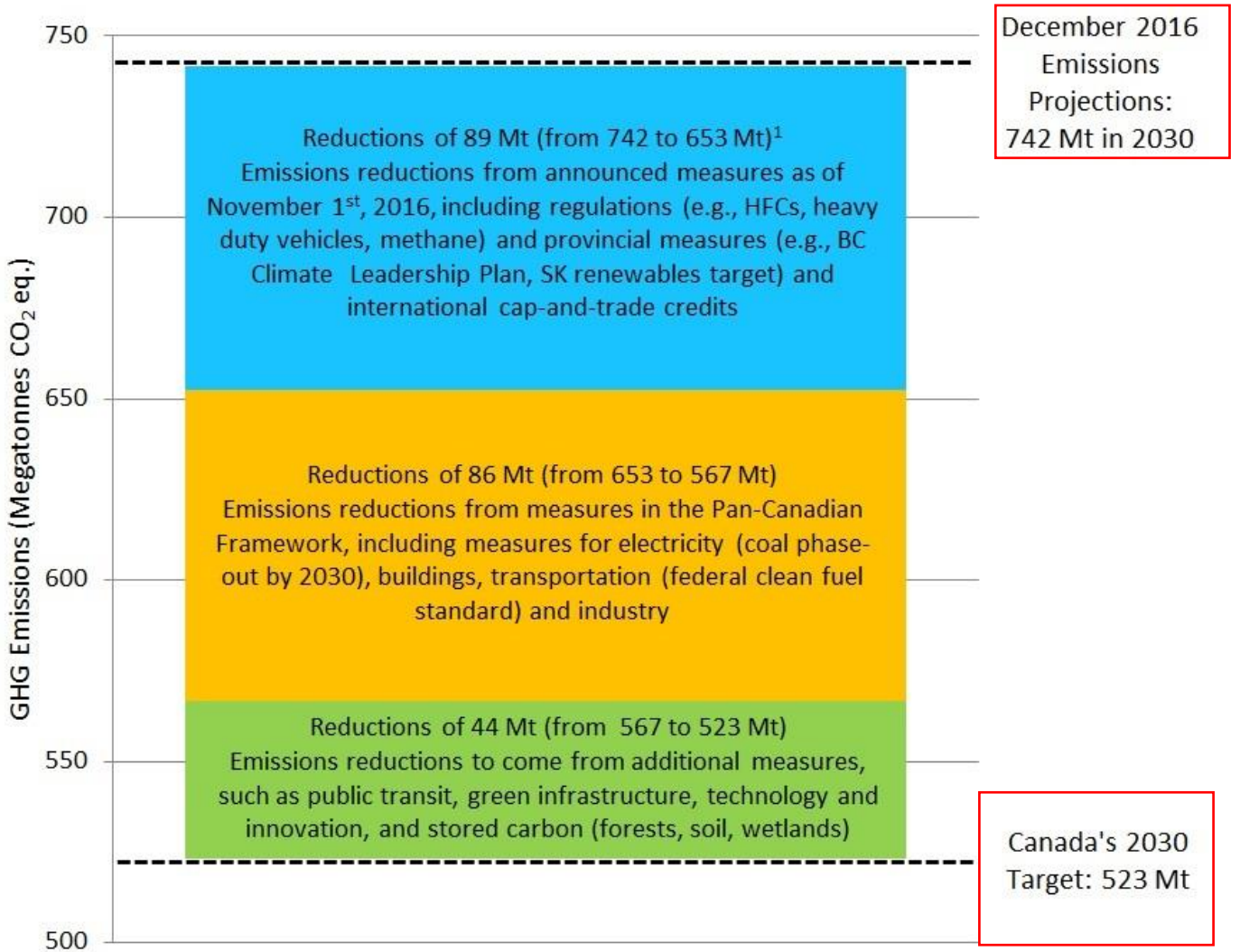
13 1466 12,000,000 2.9

Capacity Factors:

Hydro = 80%: NG = 60%: Wind Turbines = 40%: Solar panels = 12 -15% : nuclear = 90%

CleanBC

- BC has to be complemented when it comes to planning and setting targets to reduce emissions and respond to concerns over global warming and climate change
- BC was first out of the gate of all provinces with the Climate Change Accountability Act of 2007.
- This was followed in 2018 by the formation of CleanBC
- Clean BC made a commitment to reduce GHG by 25.4 Mt by 2030 (10% of the Pancanadian Framework federal commitment) and by 63.5 Mt by 2050 to reach net zero emissions.



Note: Reductions from carbon pricing are built into the different elements depending on whether they are implemented, announced, or included in the Pan-Canadian Framework. The path forward on pricing will be determined by the review to be completed by early 2022.

[1] Estimates assume purchase of carbon allowances (credits) from California by regulated entities under Quebec and Ontario's cap-and-trade system that are or will be linked through the Western Climate Initiative.

Pathway to meeting Canada's 2030 target

Canada continues with the incremental implementation of its Pan-Canadian Framework on Clean Growth and Climate, its overarching strategy for reducing emissions, adopted in 2016; often in the face of provincial pushback. The Government is implementing its coal-fired power plant phase-out, but it clearly needs to take more climate action, as emissions are projected to still be above 1990 levels beyond 2030, far from its Paris Agreement target and nowhere near a 1.5˚C-compatible pathway.

The Climate Action Tracker (CAT) for CANADA, 2019

https://climateactiontracker.org/countries/canada/

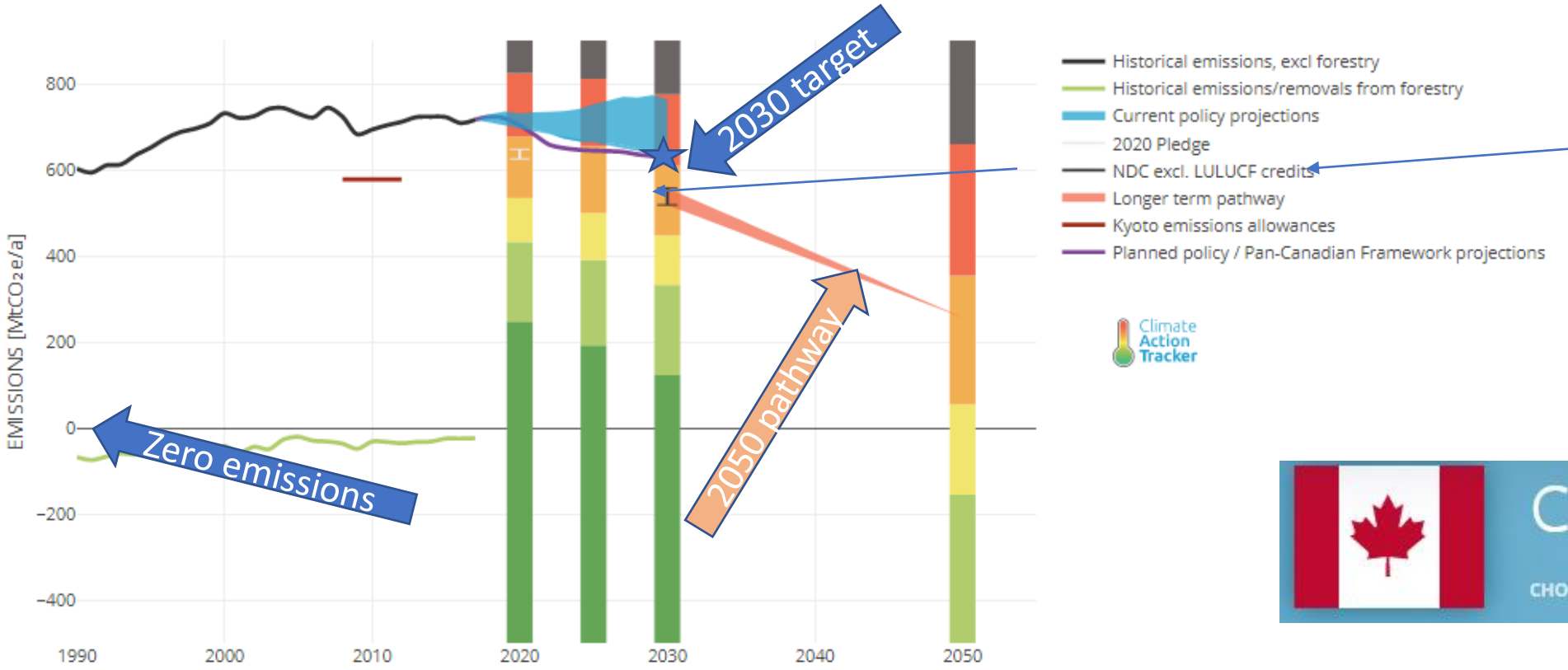
4°C+ WORLD | < 4°C WORLD | **< 3°C WORLD** | < 2°C WORLD | < 1.5°C WORLD | << 1.5°C WORLD

CRITICALLY INSUFFICIENT | HIGHLY INSUFFICIENT | **INSUFFICIENT** | 2°C COMPATIBLE | 1.5°C PARIS AGREEMENT COMPATIBLE | ROLE MODEL

NDCs with this rating are in the least stringent part of a country's "fair share" range and not consistent with holding warming below 2°C let alone with the Paris Agreement's stronger 1.5°C limit. If all government NDCs were in this range, warming would reach over 2°C and up to 3°C. For sectors, the rating indicates that the target is consistent with warming over 2°C and up to 3°C if all other sectors were to follow the same approach.

Country summary

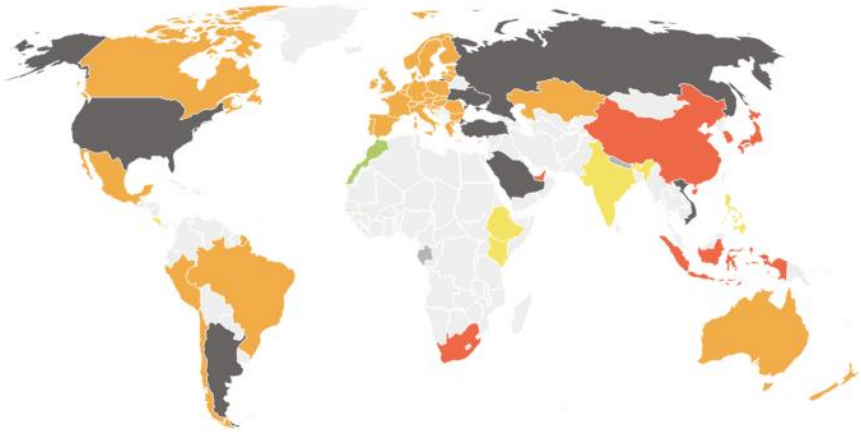
SUMMARY | PLEDGES AND TARGETS | FAIR SHARE | CURRENT POLICY PROJECTIONS | ASSUMPTIONS | SOURCES

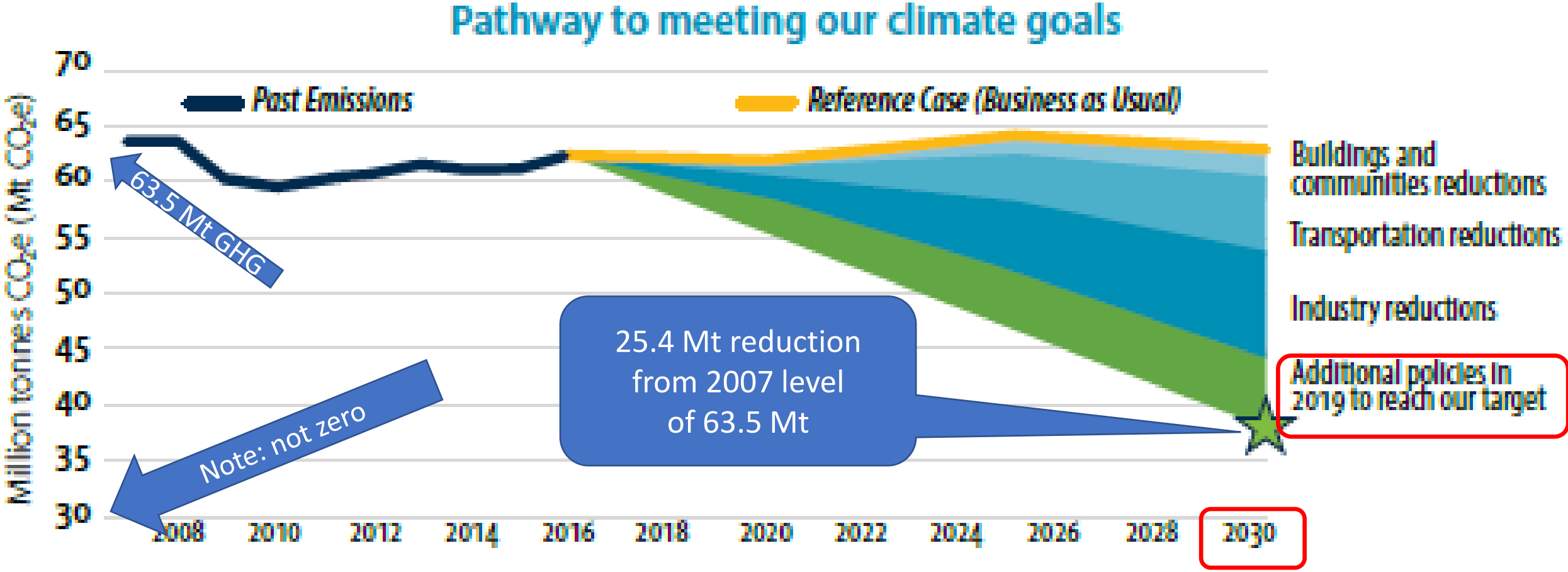


LULUCF= Land use, land use change, forestry accounting

https://climateactiontracker.org/countries/

CRITICALLY INSUFFICIENT	HIGHLY INSUFFICIENT	INSUFFICIENT	2°C COMPATIBLE	1.5°C PARIS AGREEMENT COMPATIBLE	ROLE MODEL
4°C+ WORLD	*< 4°C WORLD*	*< 3°C WORLD*	*< 2°C WORLD*	*< 1.5°C WORLD*	*<< 1.5°C WORLD*
ARGENTINA	CHINA	AUSTRALIA	BHUTAN	MOROCCO	
RUSSIAN FEDERATION	INDONESIA	BRAZIL	COSTA RICA	THE GAMBIA	
SAUDI ARABIA	JAPAN	CANADA	ETHIOPIA		
TURKEY	SINGAPORE	CHILE	INDIA		
USA	SOUTH AFRICA	EU	KENYA		
UKRAINE	SOUTH KOREA	KAZAKHSTAN	PHILIPPINES		
VIET NAM	UAE	MEXICO			
		NEW ZEALAND			
		NORWAY			
		PERU			
		SWITZERLAND			





Clean BC, 2018

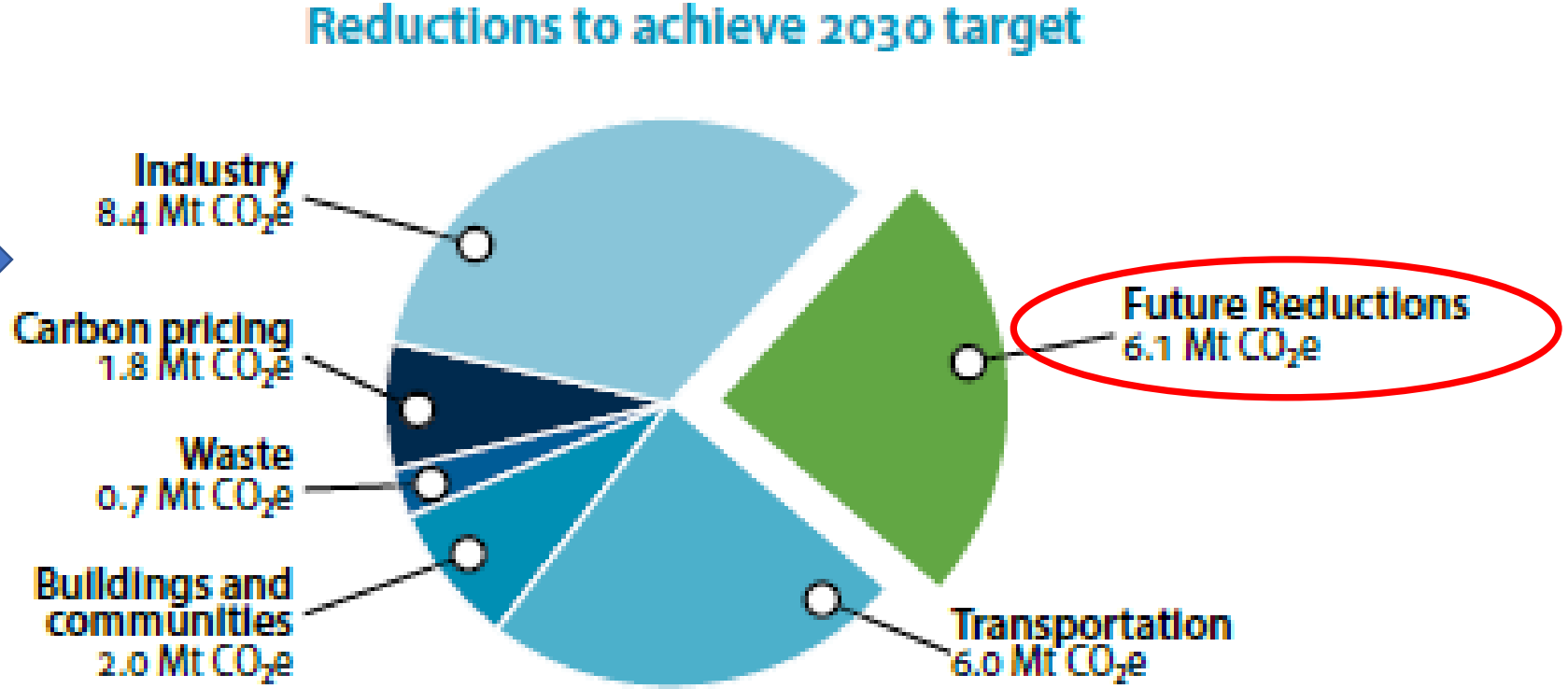
Clean BC, 2018 – Progress?

- In May 2018 – recognizing the impacts of a growing economy and population – the BC NDP government set new targets for GHG emissions.
- "These new targets reflect the fact that early progress to meet our commitments has stalled in recent years – we are not on track to meet our goals if we don't change the way we use energy across key sectors."
- Compared to 2007 levels (63.5 Mt), commitments were made to reduce emissions of:
- 40 per cent by 2030, (25.4 Mt)
- 60 per cent by 2040, (a further 12.7 Mt)
- 80 per cent by 2050. (a further 12.7 Mt) Total 50.8 Mt
- (12.7 Mt shortfall)

Clean BC, 2018: How will BC achieve its 2030 target?

The industry, buildings and transportation initiatives laid out in this plan combine to reduce our emissions by 18.9 Mt, getting us 75% of the way to our 2030 climate targets.

$45/T as of Sep 30, 2020



CleanBC, 2018: Expectations for 2030

1. Cleaner transportation and better air quality (6.0 Mt)

- Almost 500,000 new light duty zero-emission vehicles (ZEVs) and 140,000 plug-in hybrids on the road.
- 15% of the passenger vehicles could be all-electric, 4% plug-in hybrid, and 33% hybrids. That means less than half (48%) would be conventional gas-powered vehicles.
- Over 40% of diesel and 10% of gasoline comes from biofuels.

2. Healthier, more energy-efficient buildings (2.0 Mt)

- 160,000 new residential heat pumps for space heating instead of natural gas furnaces – a 60% increase covering 600,000 m^2 or more floor space each year from 2019 -2030.
- 53 million m^2 of commercial floor space heated by heat pumps, that's fifteen times as much as today.
- For heating water - 150,000 new residential heat pumps in place of natural gas appliances.
- NO residential and condo solar panel incentive scheme

3. Cleaner industry that cuts pollution (8.4 Mt)

- 60 large industrial operations using heat pumps instead of natural gas.
- Over 55% of natural gas compressors in the oil and gas sector are electric.
- **Emissions from 580,000 tonnes of CO_2e are prevented because of innovative technology like carbon capture and storage.**

4. Waste (0.7 Mt)

- **????**

5. Carbon Pricing (1.8 Mt)

CleanBC, 2018:Electrification Goals for 2030

So far, we have seen how Clean BC is focussed on setting and achieving emission reduction targets. But what about the increased power demands from a growing Province: What are the plans?

It is estimated that BC will require an additional 4,000 gigawatt-hours of electricity (500 MW capacity approx. 50% of Site C) over and above currently projected demand growth.

This is equivalent to increasing BC Hydro's current system-wide capacity by about 8 per cent, or about the demand of the City of Vancouver.

"We can meet this increased electricity use with existing and planned projects that harness B.C.'s vast wealth of clean, renewable power."

(Not quite so! I question there is sufficient planned capacity and let's recognise 10% is HC generated)

"Meeting our targets beyond 2030 will require substantial additional volumes of new clean electricity to further electrify transportation, industry, and buildings." **This is a key acknowledgement. Where's the plan?**

On March 6, 2020, BC Hydro published an Interim Report (Phase2). Disappointingly nothing new, it was very generic and non specific. Note: this is BC Hydro trying to implement CleanBC's electrification goals.

The next IRP (Integrated Resource Plan…a major defining BC Hydro document) is scheduled to be filed on Feb 28th, 2021. Hopefully we will then learn about the plan to take us to 2050

Electricity Generating Capacity - Total

http://www.energybc.ca/, 2017

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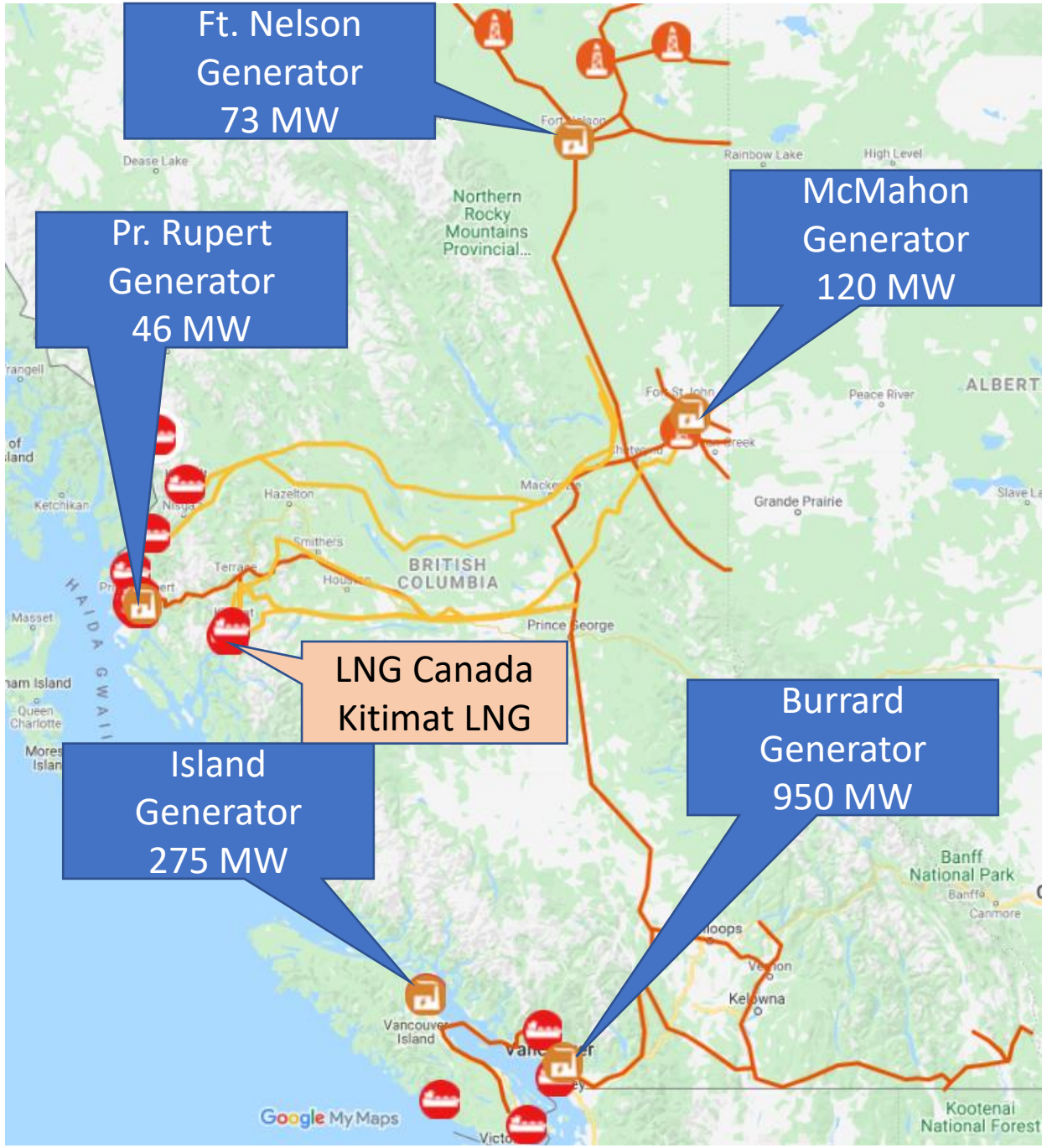


NG Infrastructure in BC

Red pipelines = approved/existing

Orange pipelines = potential/proposed

Gas Resources under development

Liard Basin	167 Tcf
Horn Basin	78 Tcf
Cordova Embayment	67 Tcf
Montney Formation	271 Tcf

LNG Plants

Approx 12 applications for a total capacity of 180 Mta.

Most now cancelled

LNG Canada at Kitimat proceeding 24 Mta (3.1 Bcfd or 1.1 Tcfa). No liquefaction electrification but still requires 700 MW capacity (3245 Gwha) or 2/3rds of Site C

Kitimat LNG proceeding 18 Mta. Full electrification of liquefaction requiring 700 MW or another 2/3rds of Site C.

Electricity Generating Capacity - Hydro

http://www.energybc.ca/ , 2017

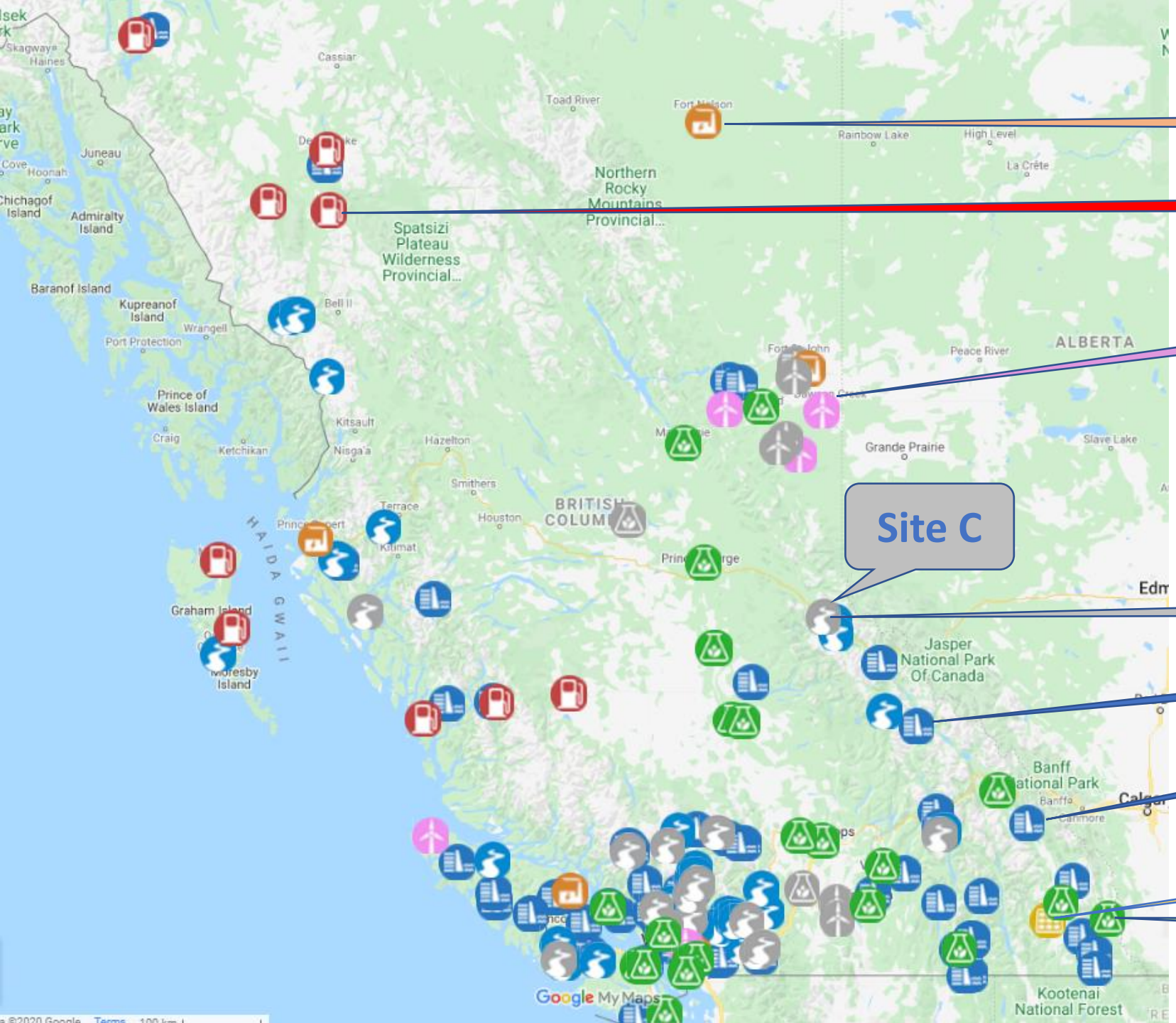
	EXISTING (2016)		PLANNED (2016)	
	MW	#	MW	#
Dams	12,984	68	1,100	1
ROR	950	33	336	14
Total	14,938	101	1,436	15

DAMS

Average size 460 MW (20% over 200MW all built pre-1980)
Total Sites = 68. 25% built post 2000 and all small
Only 1 site planned (Site C) 1,100 MW. Est. completion date 2024
BC Hydro (BCH) operates 72% of capacity and services 94% of province

ROR (Run of River)

Average size 85 MW
Total Sites = 33. 4 built before 2000
Planned sites =14 for a total capacity of 336 MW
BC Hydro (BCH) does not operate any of 33 sites (Innergex most common)



HC N.Gas (3)

Diesel (9)

Wind (5)

Distribution of BC's Electrical Power Generating Facilities

http://www.energybc.ca/, 2017

Planned (21)

ROR (33)

Dams (68)

Solar (1)

Biomass (17)

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AN ELDER ACADEMY EVENT

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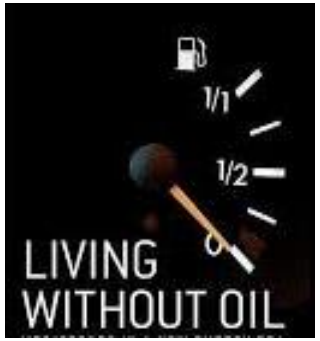

OCT 3: "Review of Presentations Given Prior to Postponement in Mid March",

Presenter: John Gunton, UVRA EA series organizer/coordinator

OCT 17: "Energy Storage and Electrification"

Presenter: Andrew Rowe, BEng (RMC), MASc., (UVic), Ph.D. (UVic), PEng. Prof Mech Eng.

OCT 24: "Solar: Cost and Limiting Efficiency of Silicon Solar Panels"

Presenter: Tom Tiedje, BASc, MSc, PhD, FRSC, PEng, Professor ECE Dept, U.Vic.

Oct 31: "Impact on Society of Life Without Oil",

Presenter: David Yager, Energy Policy Analyst and Author

University of Victoria Retirees Association

AN ELDER ACADEMY EVENT

November Saturday Speaker Series

Climate Change Anxiety:

Causes, Consequences, Solutions and Costs

TIME: 10:00am to noon

Nov 7: **"Key Climate Research Activities in the Canadian Centre for Climate Modelling and Analysis, CCCma",**
Presenter: Dr. Ellie Farahani, Manager CCCma. **Zoom**

Nov 14: **"Climate Change an Earth Scientist's Perspective",**
Presenter: Tom Gallagher, Explorationist & Researcher. **Zoom**

Nov 21: **"The Importance of Oceans to Climate Change",**
Presenter: Dwight Owens, ONC **Zoom**

Nov 28: **"Is Geoengineering the Naloxone for our Fossil Fuel Addiction",**
Presenter: Dr. Hadi Dowlatabadi, Professor UBC. **Zoom**

Dec 5: **"Tackling the Adaptation Imperative: International Best Practices",**
Presenter: Dr. Hannah Teicher, Researcher, PICS. **Zoom**

Thanks to Everyone for Attending

- Questions?

- I am happy to receive questions or to receive any comments on this presentation or on the material presented.

Please email directly at:

geogunton@shaw.ca

Don’t forget a video of the presentation and a pdf of the slides used will be made available to registrants shortly.