# Technology and Policy Pathways to Net-zero Heavy Industry

Dr. Chris Bataille

*Institut du Développement Durable et des Relations Internationales (IDDRI.org)*

July 15 2020

DEEP DECARBONIZATION PATHWAYS

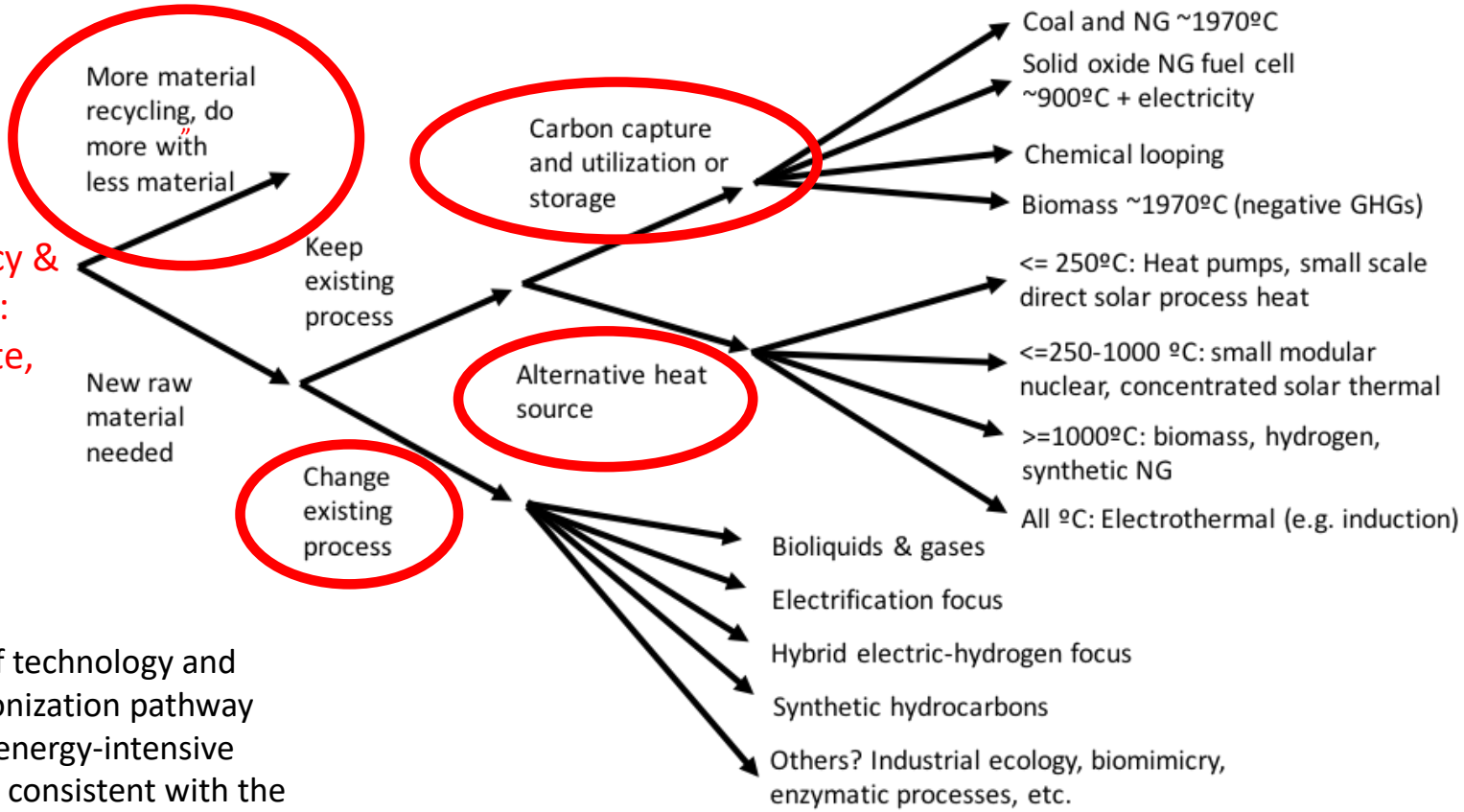
IDDRI

# While much of industry can be electrified, there are big sector specific challenges

- The “extract-use-throw away” model for most material use (steel & aluminum as exceptions)
- Maxed out thermodynamic efficiency of core technologies (but not systems)
- Low (<=250ºC), medium (250-1000ºC) & high (>1000ºC) process heat
- Steel iron ore “deoxidization” $CO_2$ process emissions (& melting heat)
- Cement lime calcination $CO_2$ process GHGs (and 850/1450ºC process heat)
- Hydrogen production for ammonia for fertilizers and other chemicals; coal & steam methane reforming $CO_2$ process emissions
- Non-ferrous metals & alloys (big progress in bauxite electrolysis, i.e. Elysis)
- Carbon feedstock needed for chemicals
- **Making sure new materials aren’t GHG combustion or process intense!**

# New literature has shown there are emerging and near commercial options to decarbonize all industrial sectors

Material efficiency & circular economy: Reduce, substitute, reuse, recycle

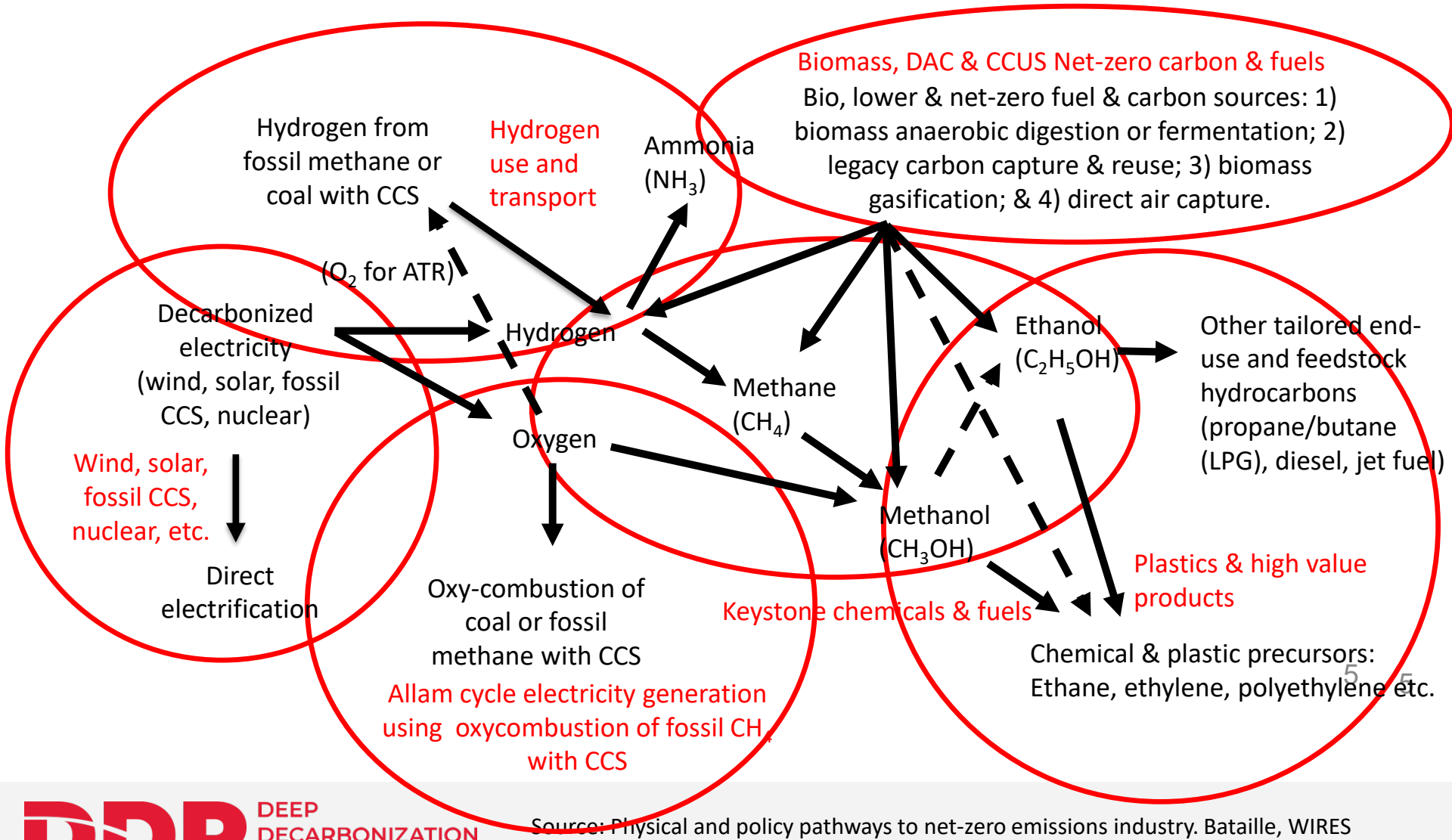



Source: "A review of technology and policy deep decarbonization pathway options for making energy-intensive industry production consistent with the Paris agreement", Bataille et al (2018) Journal of Cleaner Production

# Dynamic questions that have to be addressed

1. *Material efficiency & circular economy*: High potential, but what happens if it isn't easy, cheap, or fast?
2. *Electrification*: Capacity constraints matter and could be very expensive (electric steel example).
3. *Carbon capture, utilization, storage:* What happens if CCS reservoirs, CCUS opportunities in a given region are limited?
4. *Alternative heat sources:* Regional limits on biomass, solar, etc.
5. *What about long-lived legacy facilities?* e.g. Chinese BF-BOFs
6. *How can we build situation specific technology and policy hybrids to solve for all of the above?*

# One possibility for heat and feedstocks: Regionally tailored hybrids of electricity, hydrogen, biomass & synthetic hydrocarbons?

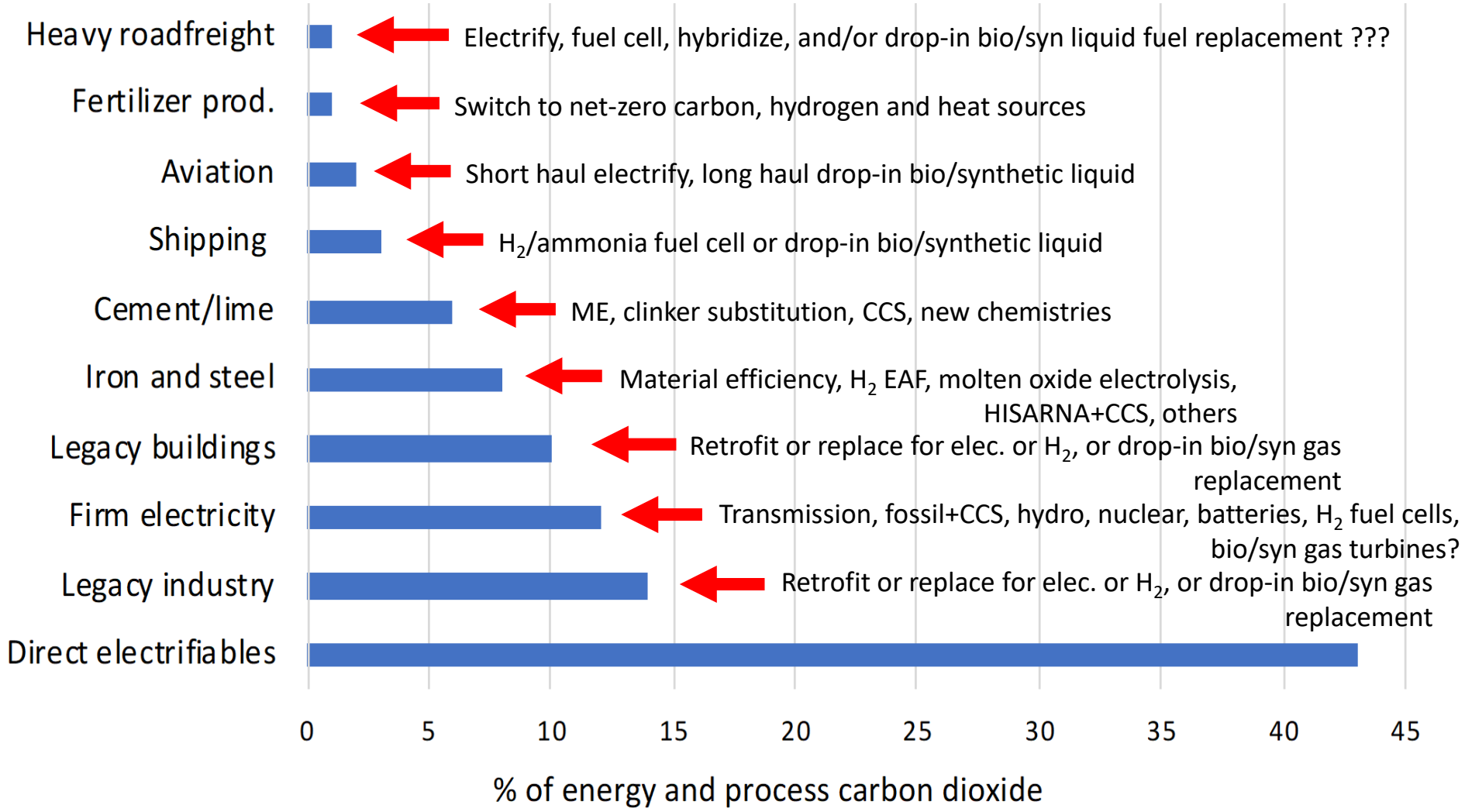





DEEP DECARBONIZATION PATHWAYS

Source: Physical and policy pathways to net-zero emissions industry. Bataille, WIRES Interdisciplinary Reviews, 2019.

# Potential hybrid actions to eliminate 2016 emissions




Source: Bataille, "Physical and policy pathways to low and zero emissions industry", WILEY Interdisciplinary Reviews, 2019

# To make this possible, we need a diversified portfolio (i.e. "toolbox") of tools to be used based on regional resources and needs

- "Only where necessary" design for cement and steel
- Aggressive clinker substitution -> alternative cement chemistries
- High temperature heat pumps
- Electrothermal technologies
- Electrolytic smelting & electric virgin steel production (DRI hydrogen EAF or molten oxide electrolysis EAF)
- Lower cost, more efficient electrolysis for hydrogen (alkaline to PEM or solid oxide fuel cells, cost/2, efficiency X2?); methane pyrolysis?
- Electro-catalytic and bio-catalytic instead of thermal processes
- Post-combustion and direct-from-air $CO_2$ capture
- Woody biomass gasification to commercialize bulk net-zero carbon sources, e.g. for methane & chemical feedstocks

# Simple carbon pricing and regulations are not enough: The challenges are more than technological

- While emerging tech exists, innovation will be slow because:
  - of low profit margins
  - competitive; they can’t pass on costs without losing market share
  - capital costs are focussed and upfront
  - they often can't capture the benefits of innovation
  - facility lives are long and turnover is slow
  - ***there is no market for more expensive low GHG materials***
- Policy for heavy industry needs to target these challenges directly
- Fundamentally, this is about reducing and controlling risk

# Combined strategies for a "local solution finding" policy package

- A multi-level **policy commitment** to transition to net-zero GHG industry
- Building code, design & recyclability policies for material efficiency/circularity
- A transition pathway planning process including all key stakeholders to assess strategic & tech options, competitive advantages, and uncertainties
- Accelerated R&D and commercialization; create lead markets to build economies of scale w/ green procurement, content regs, supply chain branding, guaranteed pricing & output subsidies (e.g. CfDs)
- Eventual exposure of all sectors to **full GHG pricing** with competitiveness protection, e.g. border carbon adjustments, to "mine" material efficiencies
- Early retirement if necessary for long lived, highly GHG intense facilities
- **Supporting institutions**: Just transition; monitoring; electricity, $H_2$ & CCS infrastructure; lifecycle accounting; education; regulatory backdrop

DEEP DECARBONIZATION PATHWAYS

In summary: net-zero industry is possible, but will require planning as well as subtle, staged, & stringent policy

Please send questions to:

Email: chris.bataille@iddri.org Twitter DM:@chris.bataille

DDP-INITIATIVE.ORG