

On Electrons and Molecules

Lux Research's short vision on the future of energy and chemicals

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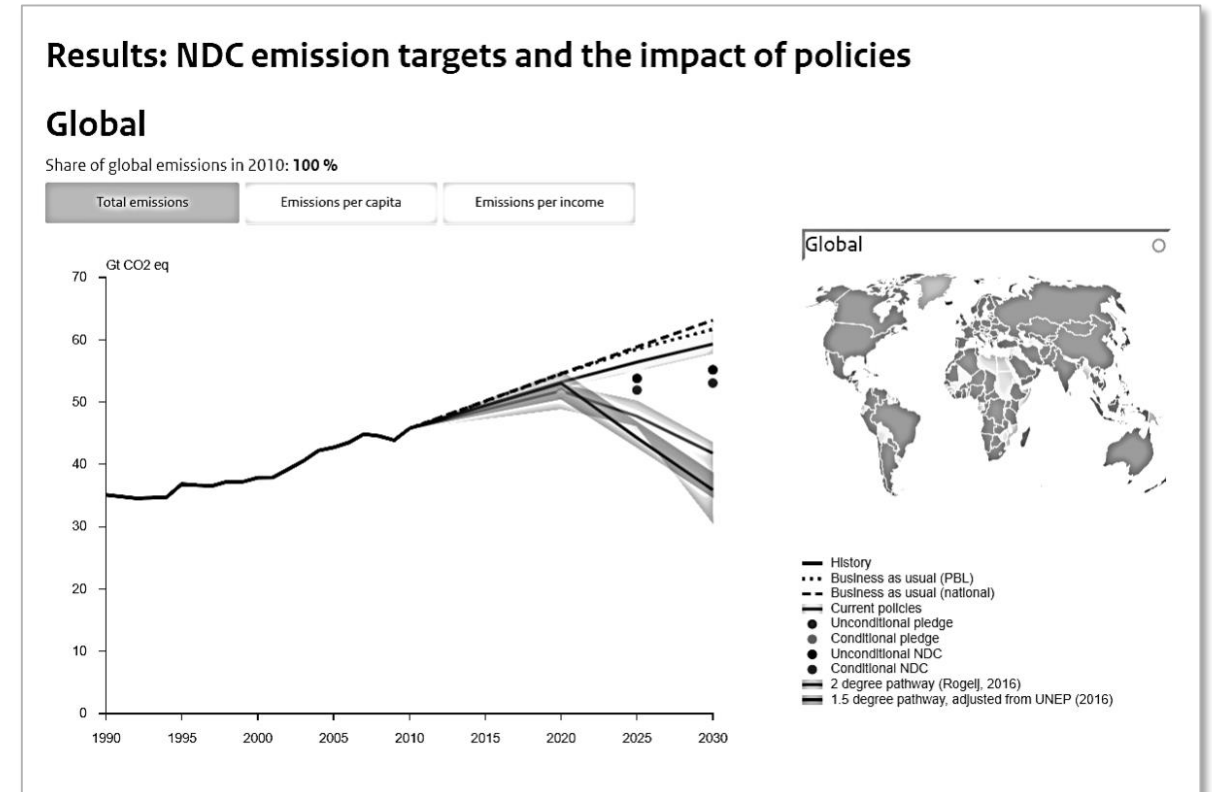
As NDC's of COP-21 materialize, the roadmap takes shape

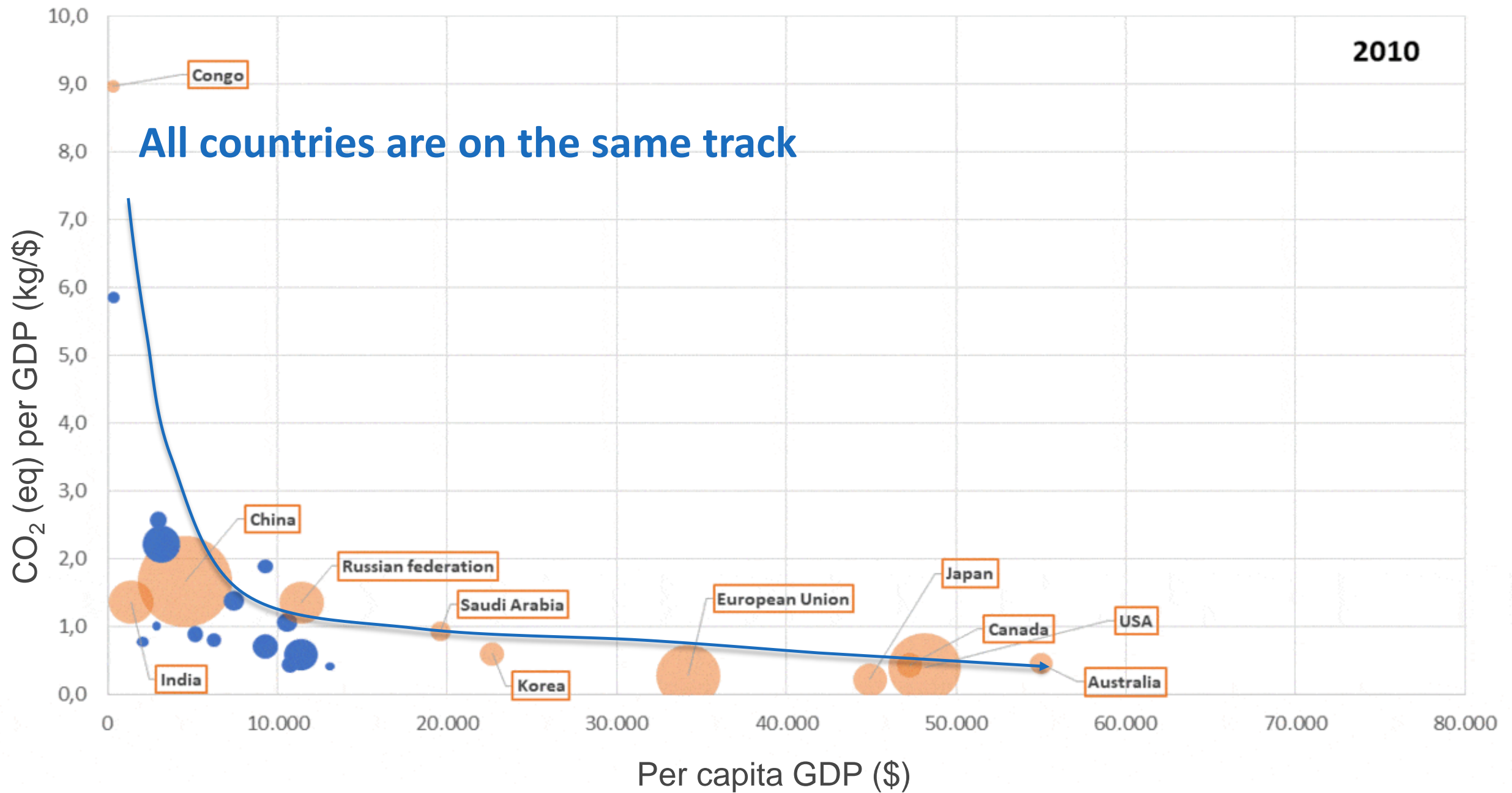
How COP-21 works

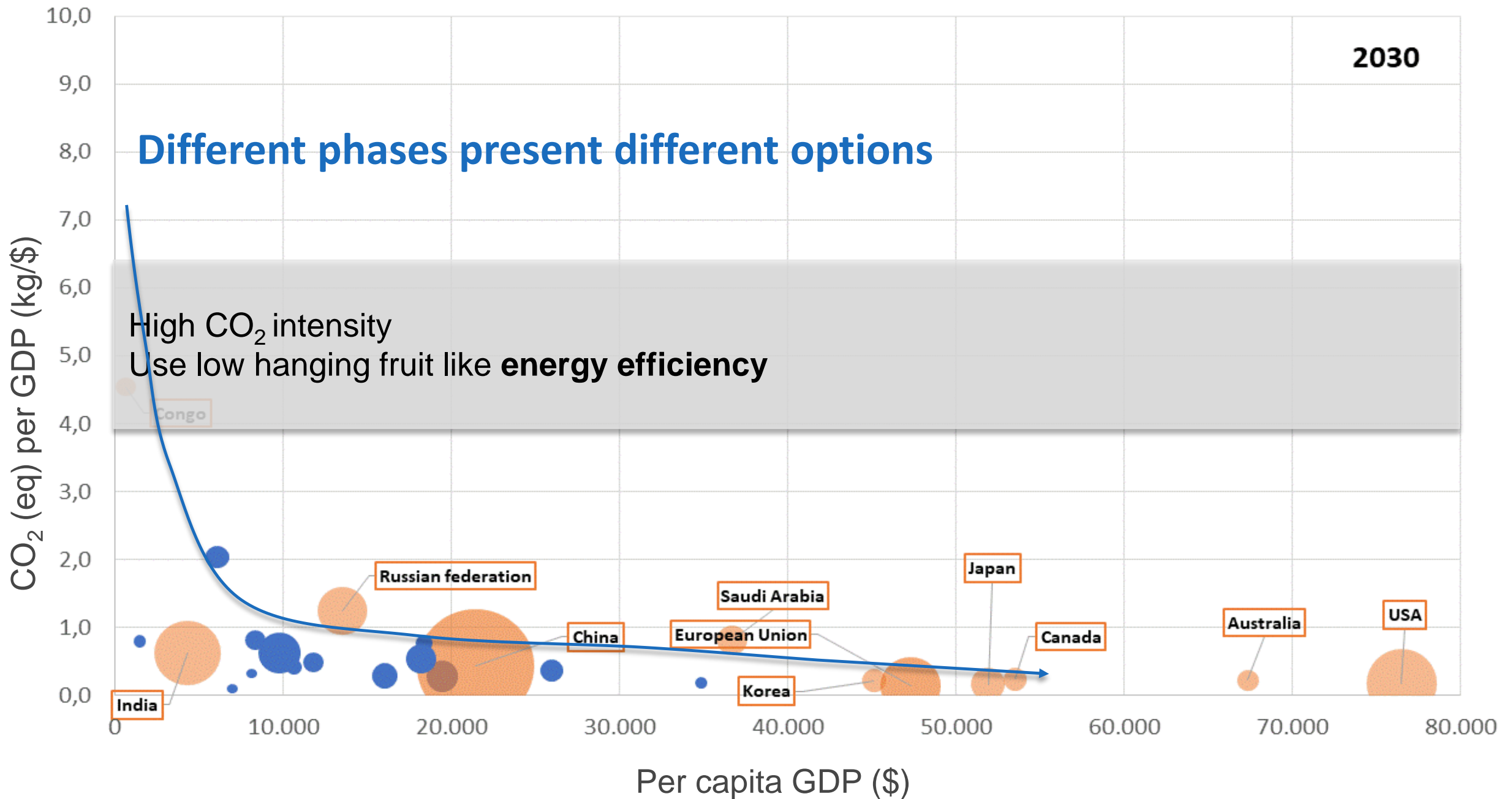
- Countries need to submit plans
- NDC: **N**ationally **D**efined **C**ontribution
- Most plans are in now, at least until 2030
- Acceleration will need to happen post 2030

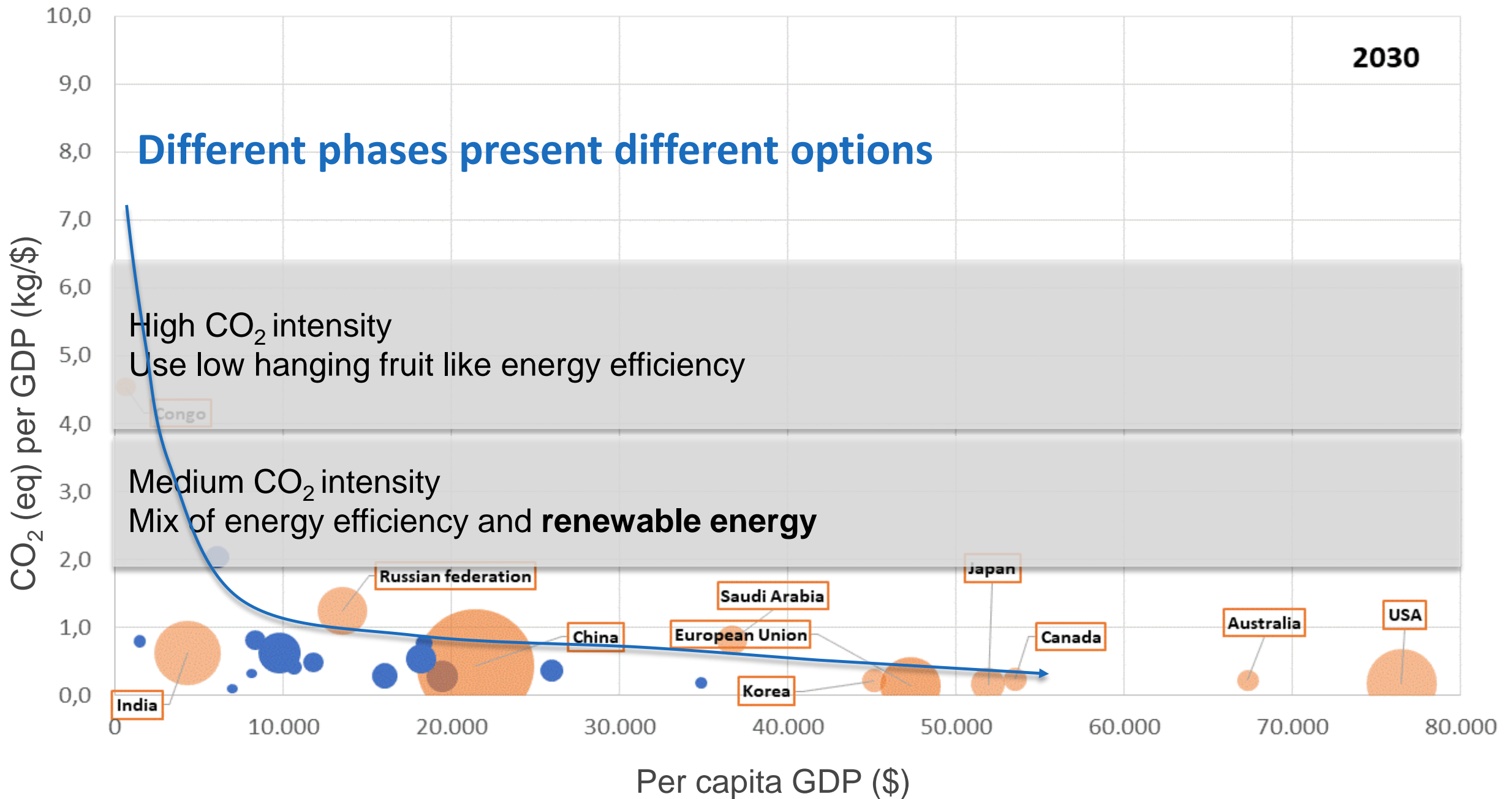
Take a look yourself, these people keep track:

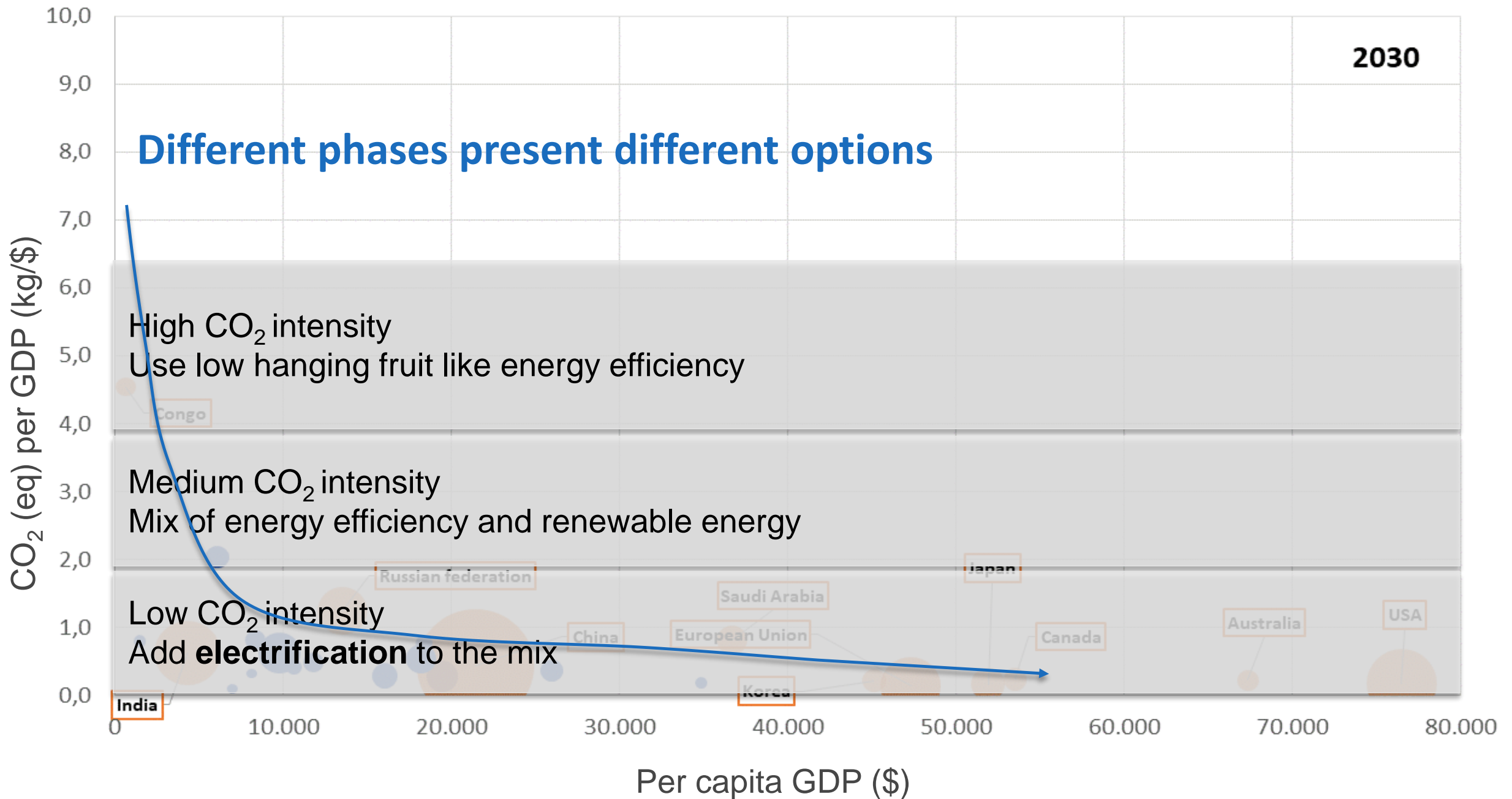
<http://themasites.pbl.nl/climate-ndc-policies-tool/>



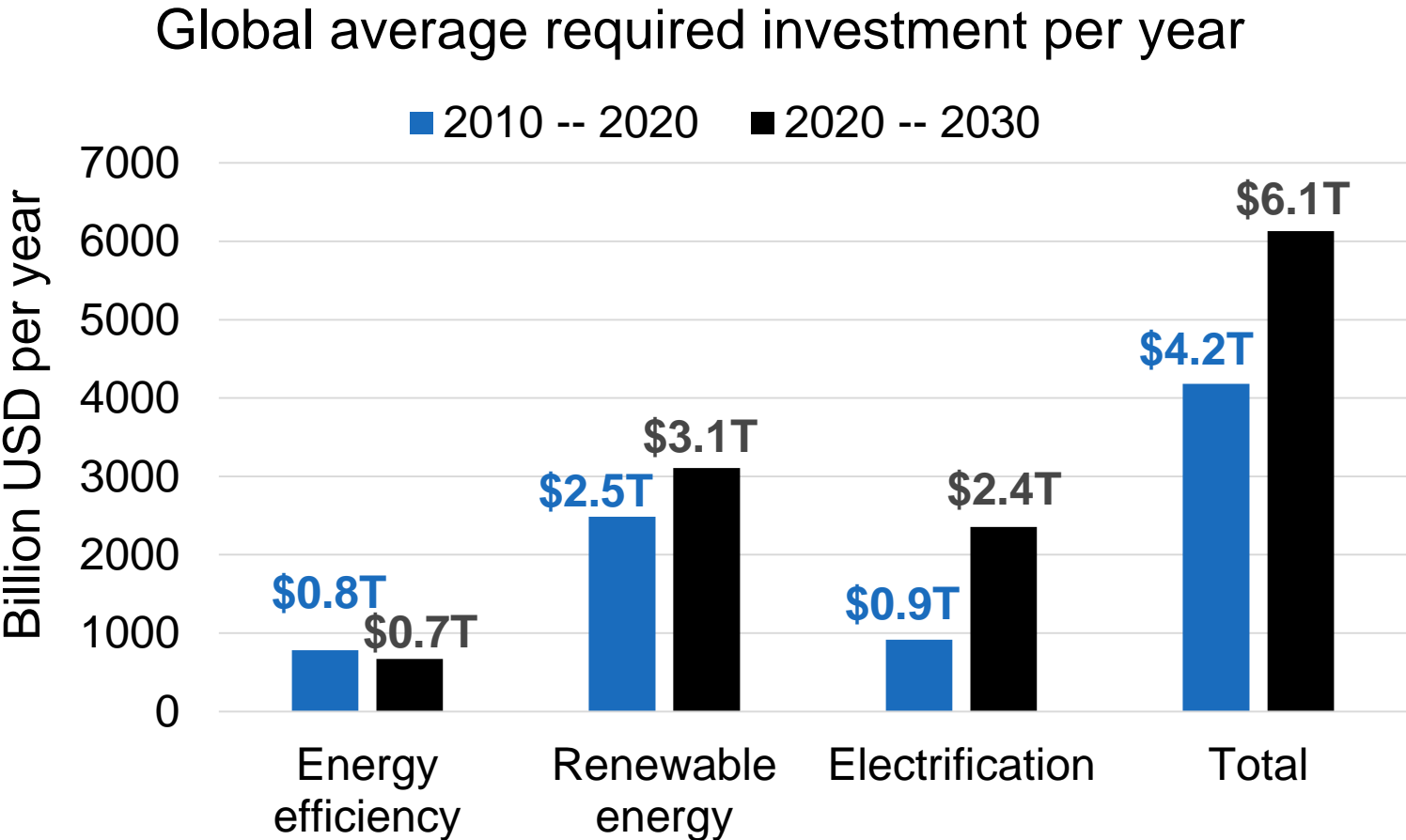








The roadmap defines a multi-trillion dollar market



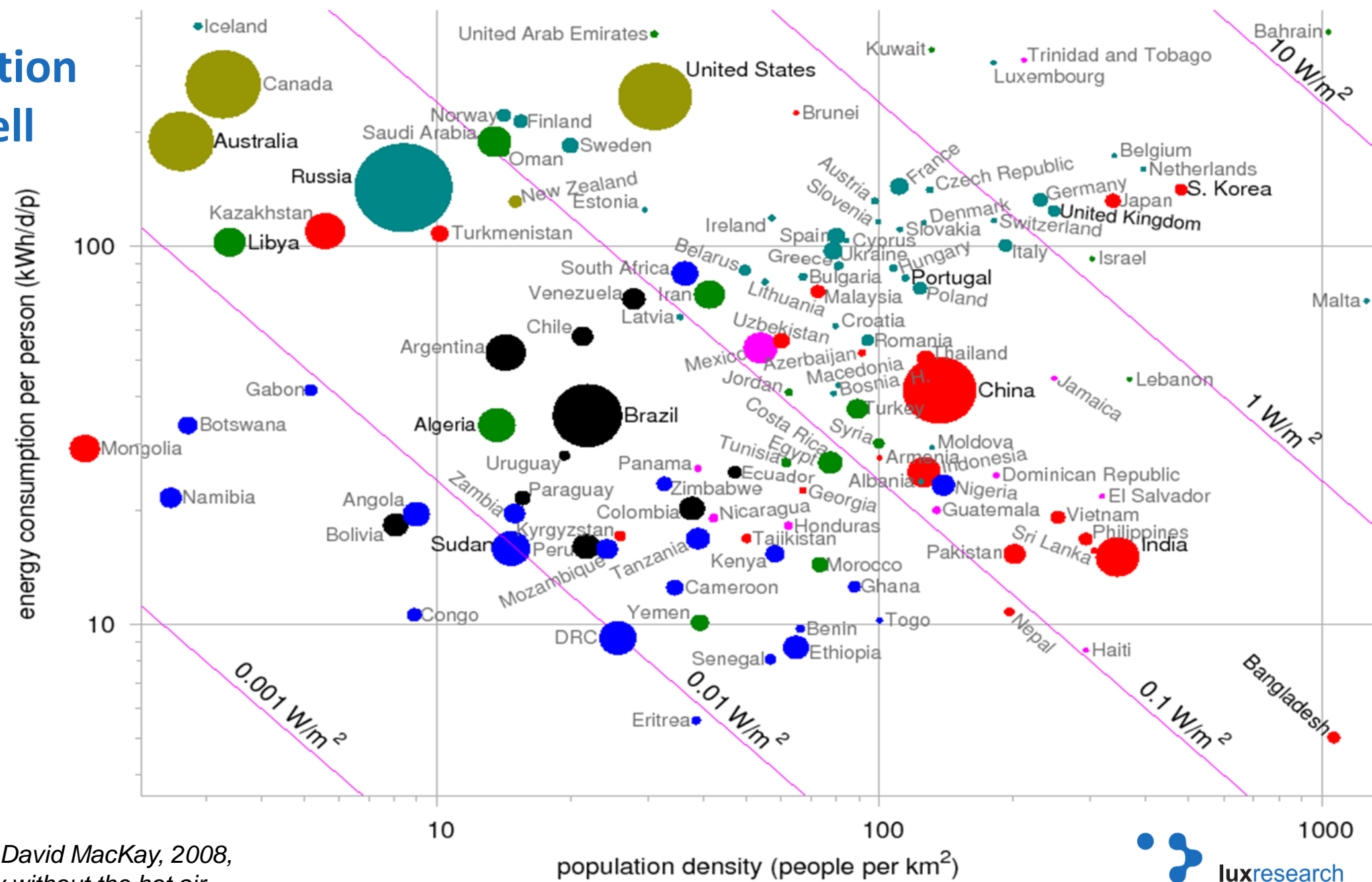
About 3% of global GDP

Varies by country; between 0.5% and 13% of GDP

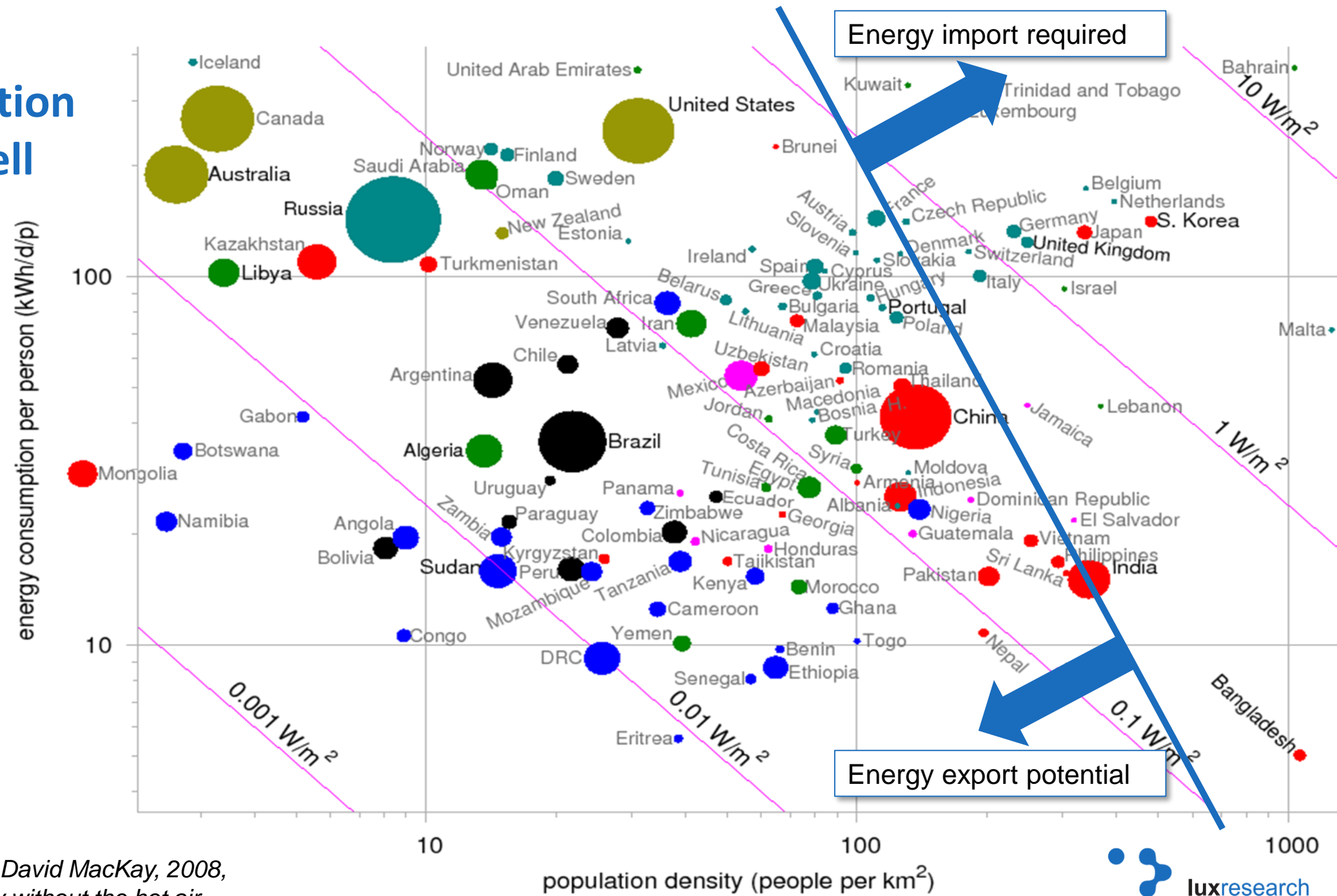
Based on the most aggressive promised reduction

Still a conservative estimate; **the most aggressive plans are not enough yet**

There is a
transportation
issue as well



There is a transportation issue as well



The long-range energy transportation options



LNG:

- Clean
- Existing infrastructure
- High energy density
- Available today
- Still CO₂



Electrolyte:

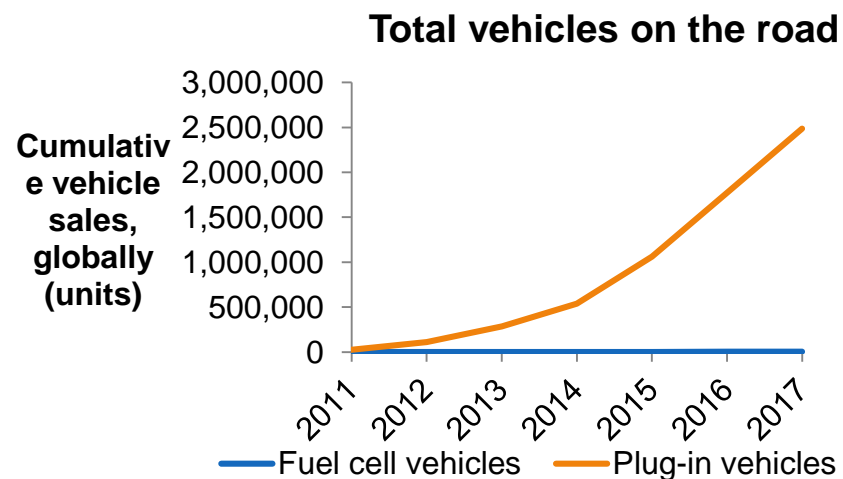
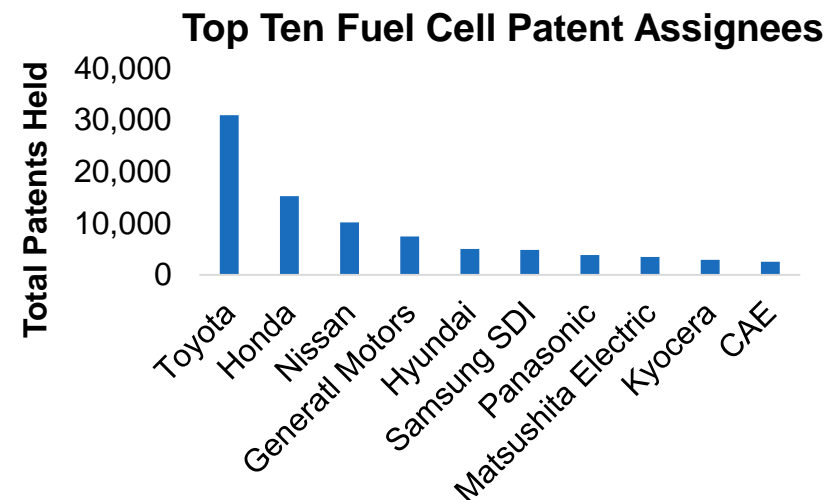
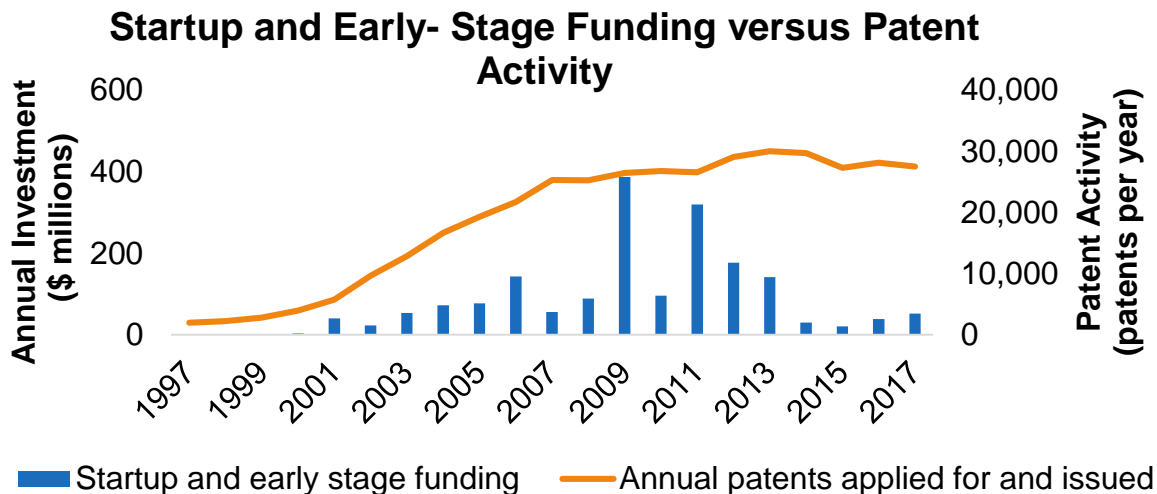
- Upcoming infrastructure
- New system
- Low energy density
- Electricity only



Hydrogen:

- Expensive infrastructure
- Versatile
- High energy density
- In development

Hydrogen is the most versatile option, but difficult to deploy



↑ Lots of activity

← Not a lot of result (yet?)

Hydrogen is *almost* competitive for high-utilization vehicles



Ballard fuel cell bus in Vancouver

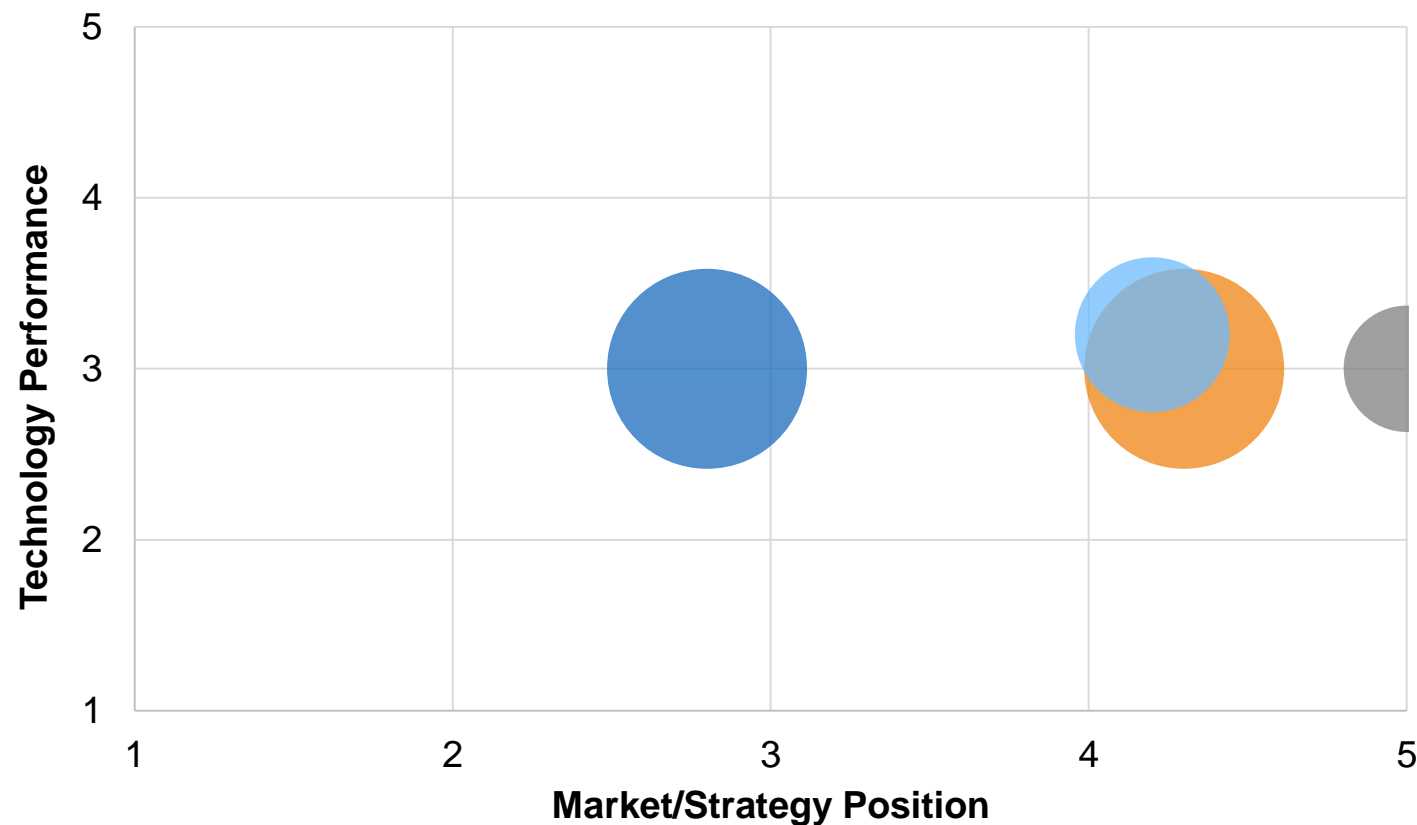
Source: Ballard



Proterra electric bus

Source: Proterra

Intra-City Bus Powertrain Competitive Matrix



● Diesel-hybrid ● Compressed natural gas ● Fuel cell ● Li-ion

CO₂ utilization is the other driver for hydrogen

Concrete	     
Chemicals	        
Fuels	      
Polymers	       
	<div>Laboratory</div> <div>Development</div> <div>Commercial</div>

Only a coordinated approach will build a hydrogen economy

- Every application of hydrogen on its own merits is too expensive
- When there is a hydrogen commodity market and infrastructure, this picture changes
- All hydrogen applications must mature in the same timeframe
- Coordination (governments) is essential

The collage features six overlapping screenshots of Lux Research articles, each with a 'Very important' tag and an 'Edit' button. The articles are:

- Shell and Anglo American invest in Hydrogen startup HyET Hydrogen** (Harshit Sharma, April 16, 2018). The article mentions that Shell Technology Ventures and Anglo American have each acquired a minority stake in Dutch startup HyET Hydrogen, who is developing an electrochemical solution for hydrogen compression and purification.
- SSAB invests \$250 million in CO₂-free steel production** (Anthony Schiavo, February 3, 2018). The article states that SSAB is set to become the first major steelmaker to build a hydrogen reduction steel plant – a technique for primary steel production that releases no CO₂.
- Germany approves the world's first train powered by hydrogen fuel cells** (Chloe Holzinger, July 12, 2018). The article reports that two pilots of the approved train, Alstom's Coadia iLint, are set to operate in Germany and start carrying passengers by the end of the summer.
- South Korea to invest \$2.3 billion in hydrogen fuel cell vehicle ecosystem by 2023** (Chloe Holzinger, June 25, 2018). The article discusses public-private partnerships in South Korea, aiming to install 310 hydrogen refueling stations to support 16,000 fuel cell electric vehicles by 2023.
- Audi renews commitment to CO₂-fuels by announcing second e-diesel facility** (Runeel Daliah, November 8, 2017). The article notes that Audi announced plans for a second CO₂-to-diesel facility together with INERATEC and Energiedienst Holding due for 2019 in Switzerland.
- Nouryon, Tata Steel, and Port of Amsterdam collaborate on feasibility study of 100 MW hydrogen production facility** (Anthony Schiavo, October 19, 2018). The article highlights that this announcement is notable for multiple reasons, including it being the biggest proposed PEM electrolysis facility.

Each article snippet includes a 'Project' tag, a 'Further reading from Lux Research' link, and a 'Partnership' tag. The Lux Research logo is visible in the bottom right corner of the collage.



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