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The $2 Trillion Transition

Canada's road to Net Zero

Presentation to TABE

December 2021

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COP26 Take Aways

- Power remains concentrated, but divisions deepen
- Deadlock on coal
- The outlook remains cloudy for meeting warming goals
- Adaptation is ready for primetime
- There's a growing role for the private sector

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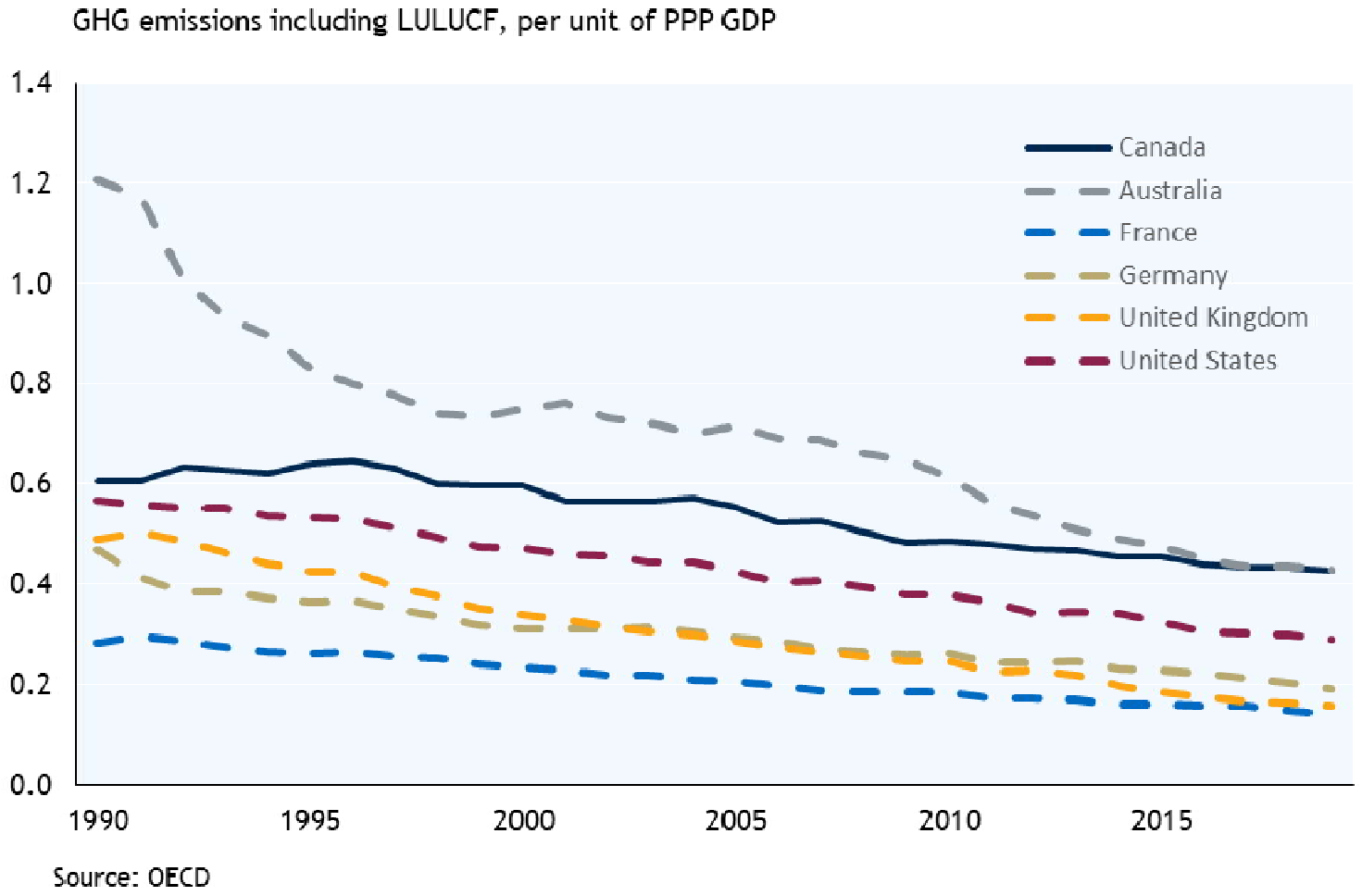
Canada has been slower to decouple growth and emissions



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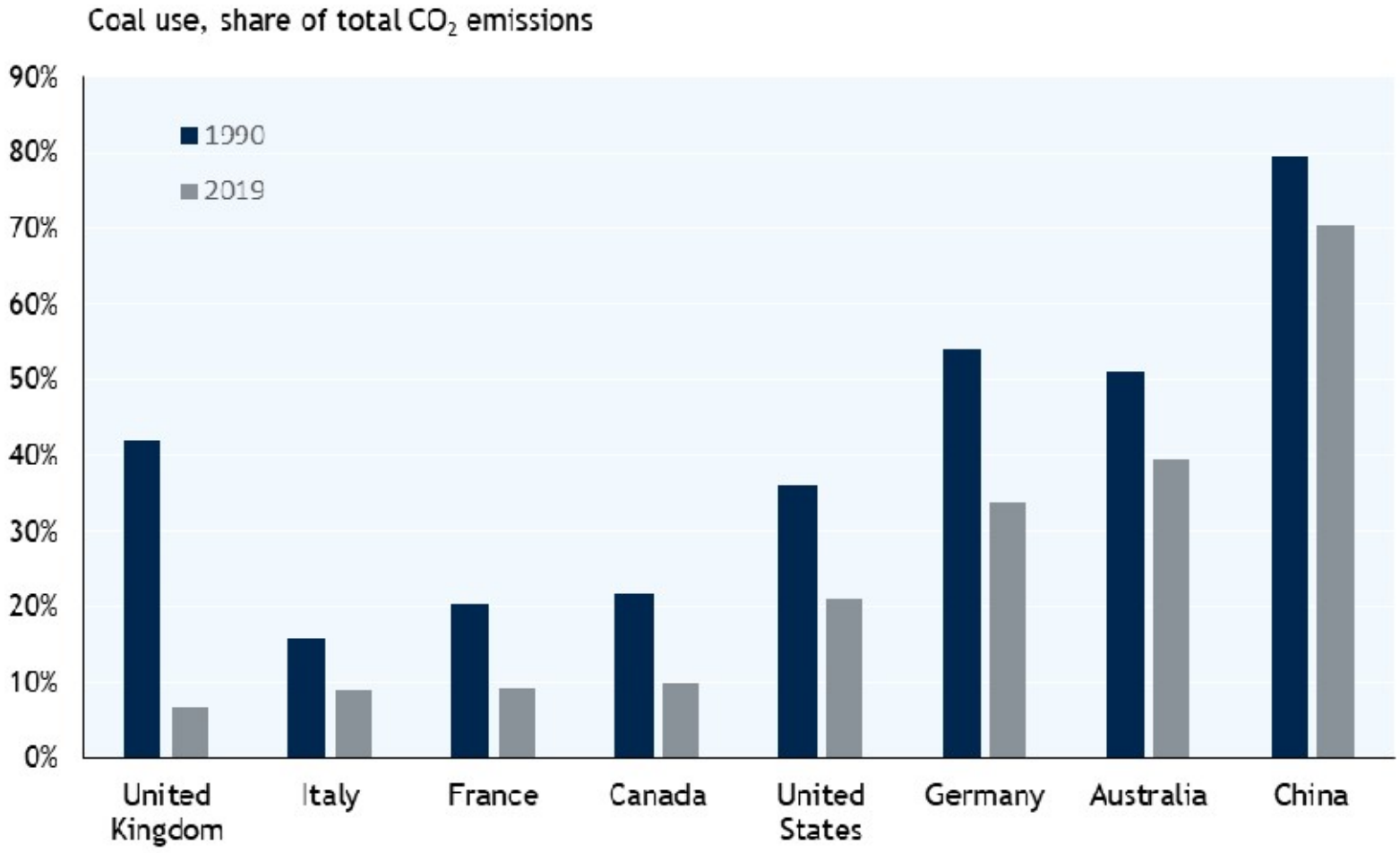
But international comparisons, and percentage-based targets lack context



Source: Our World in Data, RBC Economics

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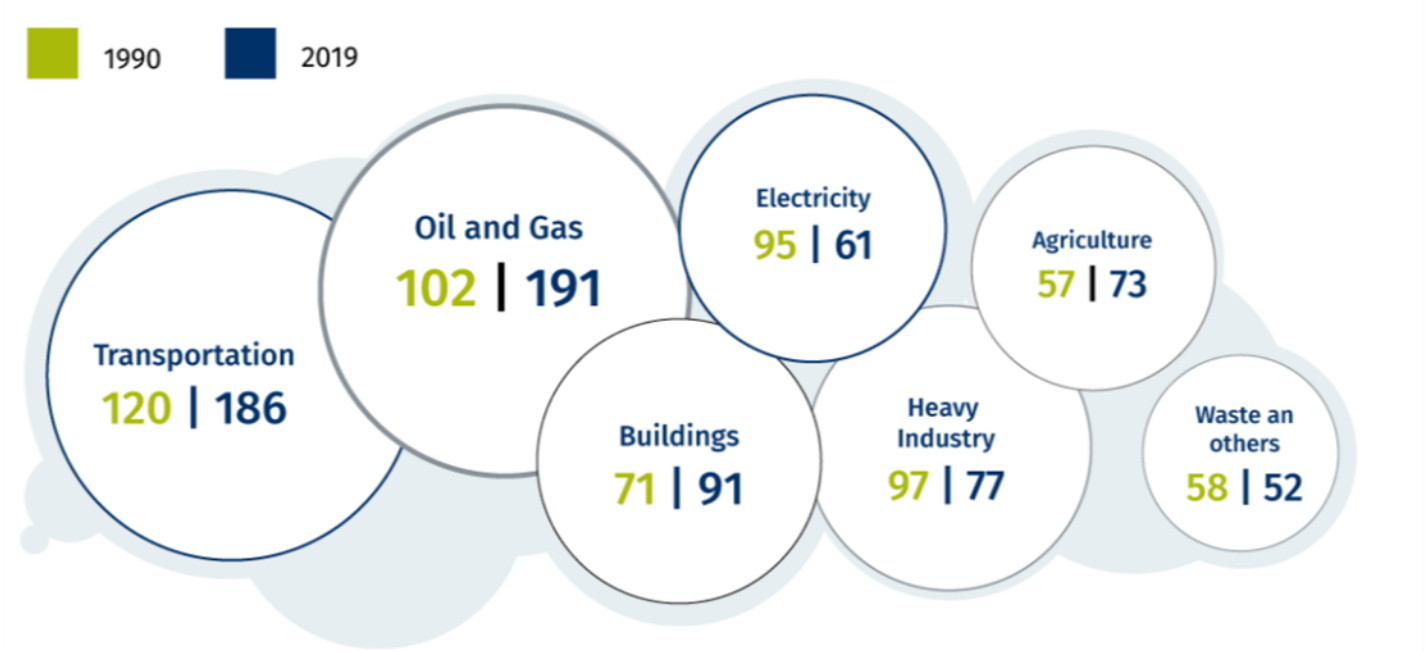
Despite ambition, progress has been slow



Source: Environment and Climate Change Canada, RBC Economics

- Growth in the fossil fuel sector, Canada's penchant for large autos, and our cold climate have worked to offset many of the energy efficiency efforts made elsewhere.
- The big emissions win in the last two decades has been largely in phasing out coal electricity.

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The cost of inaction

- Doing nothing to cut emissions could cost us some $40 billion annually in future disasters made worse by climate change.
  - That's heat waves, floods, and so on
  - Tipping points could as much as double those costs
- Moving to quickly shut-in oil and gas production has consequences too:
  - If oil and gas output falls by two-thirds, the industry would shrink from nearly 8% of GDP to just 1%, we'd lose nearly three-quarters of the jobs in the sector, and government revenue would fall by $8 billion each year.
  - Cutting emissions with falling production could cost $550/T

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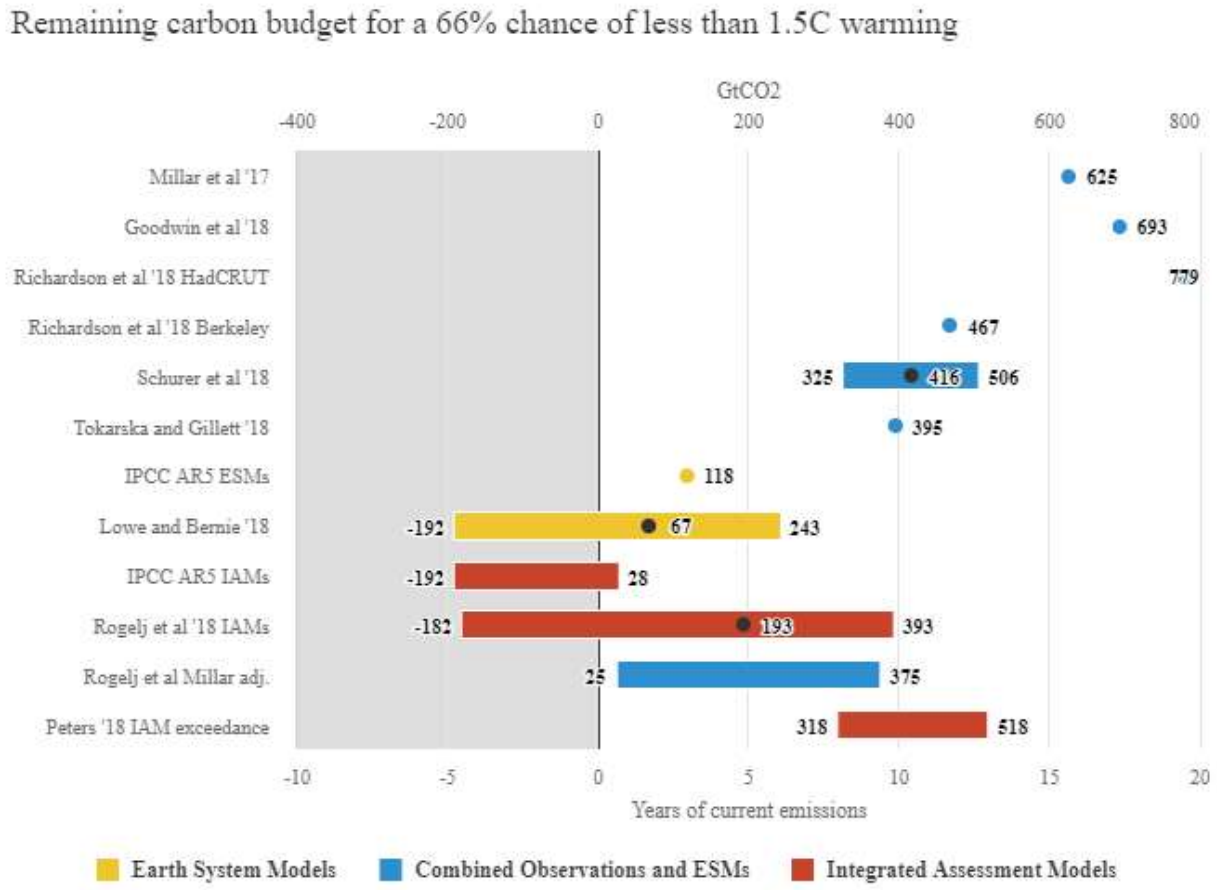
At the current pace, we have less than a decade to start deeply cutting emissions



Source: Carbon Brief

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What we set out to do

- Amid commitments and targets, subsidies and carbon taxes, one thing remained unclear to us: how we'd actually get from today's emissions to Net Zero.
- Many projections and analyses we've seen suggested future technologies were just around the corner, and just about to be affordable.
- We set out to answer a simpler question: with current technology, where could we get, and at what cost?
- In other words, this was a static assessment: we didn't project growth by sector, population, or technologies.
- If we had to get the current economy as close to Net Zero as presently feasible, what would it take?

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Our Findings

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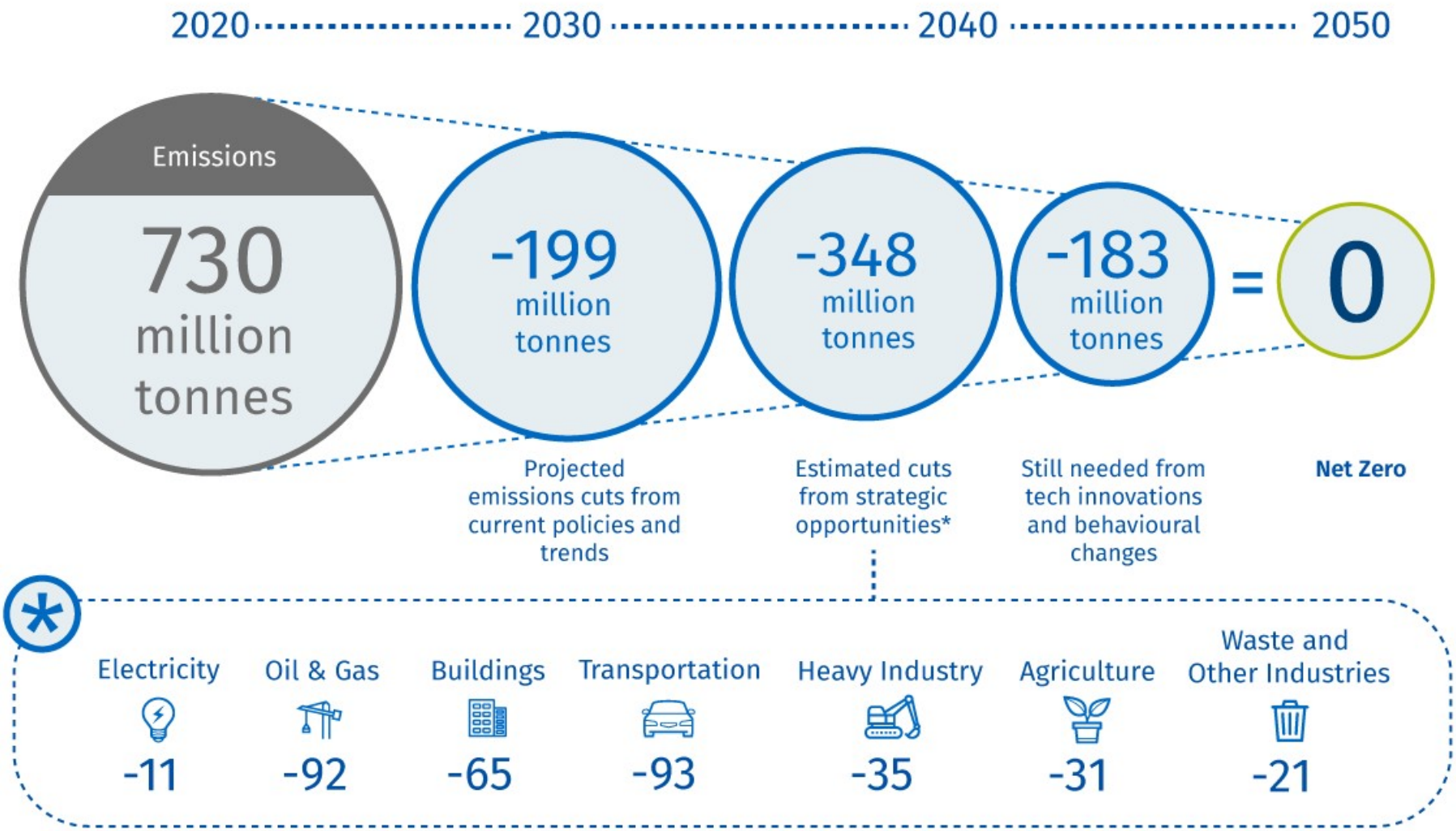
The Net Zero Equation



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How do we cut emissions?

- In our current energy system, we mostly take the chemical energy in fossil fuels, and burn it to create other forms of energy:
  - We burn it to generate heat for our homes; create steam, spin a turbine, and generate electricity; to melt ore and create metals; and to run a combustion engine and create kinetic energy to move vehicles
- Since the emissions come from the act of burning fuel, we can cut emissions in three ways :
  - Reduce the amount of energy it takes to do something
  - Reduce the lifecycle emissions from the fuel used (e.g., biofuel)
  - Substitute away from fuel altogether
- We'll do a combination of those three, and where we can't get away from fuels, we'll need to capture or offset the emissions

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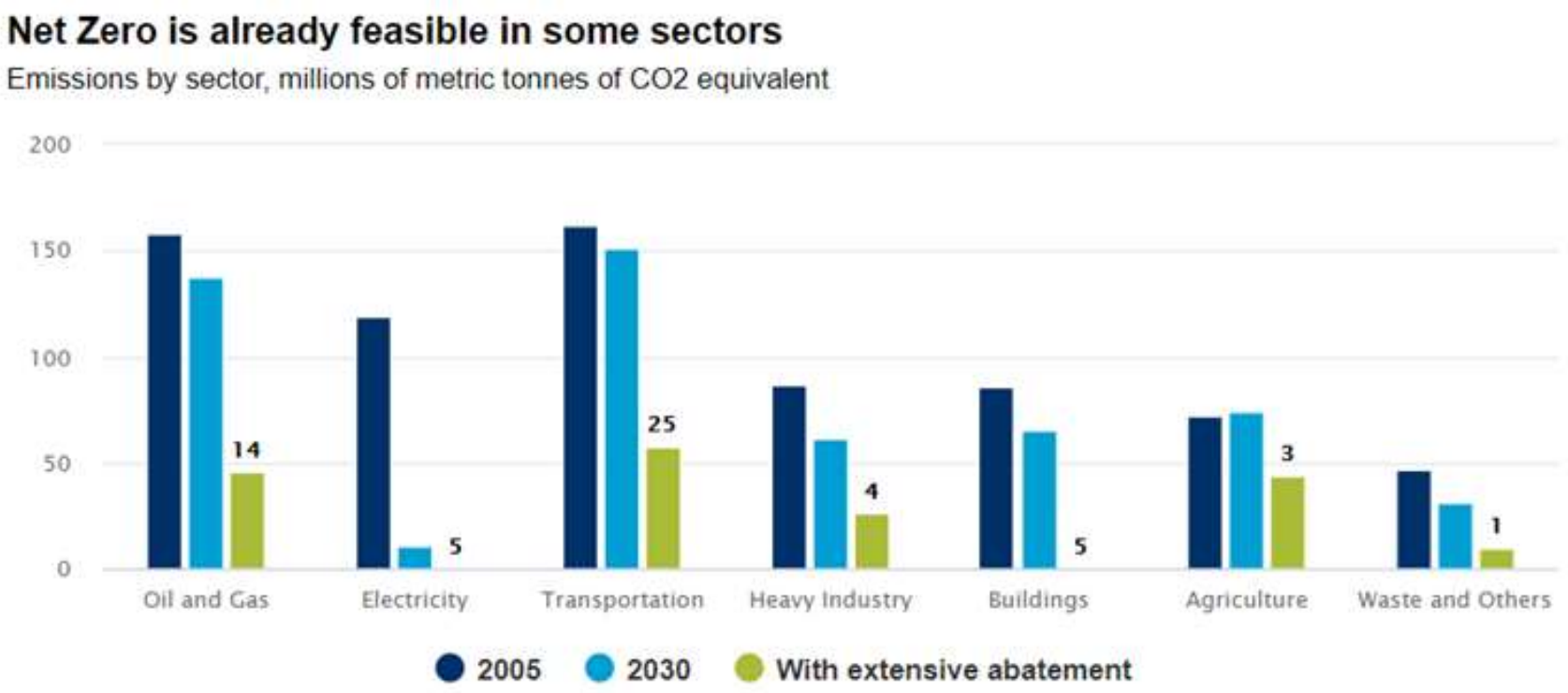
Some sectors' cuts are costly but feasible, others cheaper but limited



Source: Environment and Climate Change Canada, Natural Resources Canada, RBC Economics | * Labels indicate annual abatement cost ($Bn)

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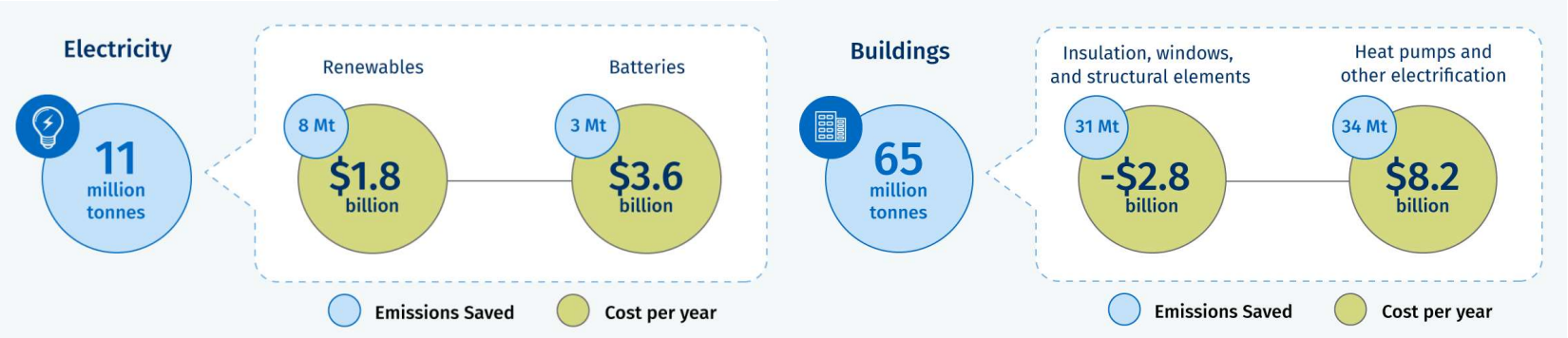
Where can we already cut emissions to zero?

Electricity

- The challenge here is not technical feasibility: renewables work, but they struggle to reliably generate electricity and storage is pricey. That may yet change.

Buildings

- Heat pumps and better insulation can mostly obviate natural gas or oil heat, but disruptive retrofits are a key challenge.



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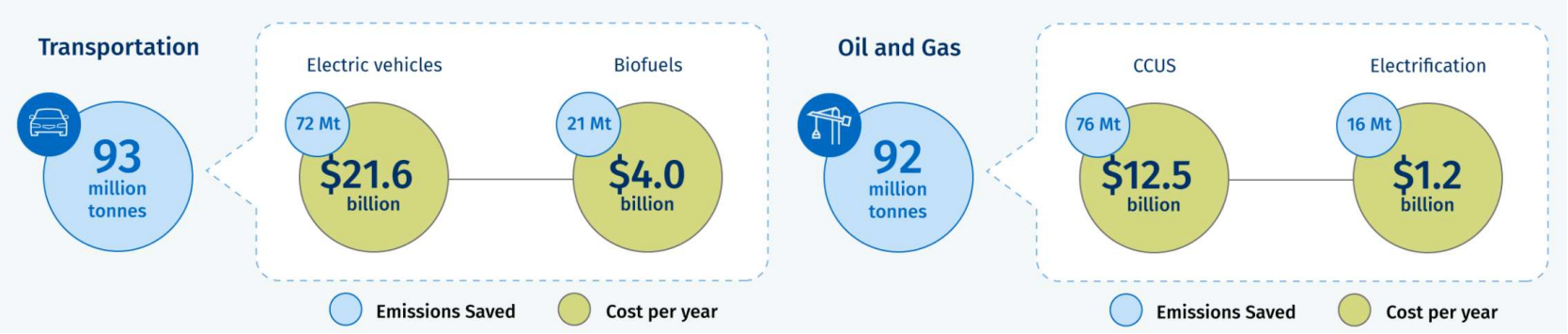
Where are deep cuts possible, but harder?

Transportation

- We have tools for passenger transport, but for heavy freight, marine, and air transport, batteries are currently too heavy and expensive.

Oil & Gas

- Oil & gas is home to some of the cheapest cuts (methane) and some of the most expensive (CCUS). Many of these cuts will require a lot of engineering and infrastructure to be realized.



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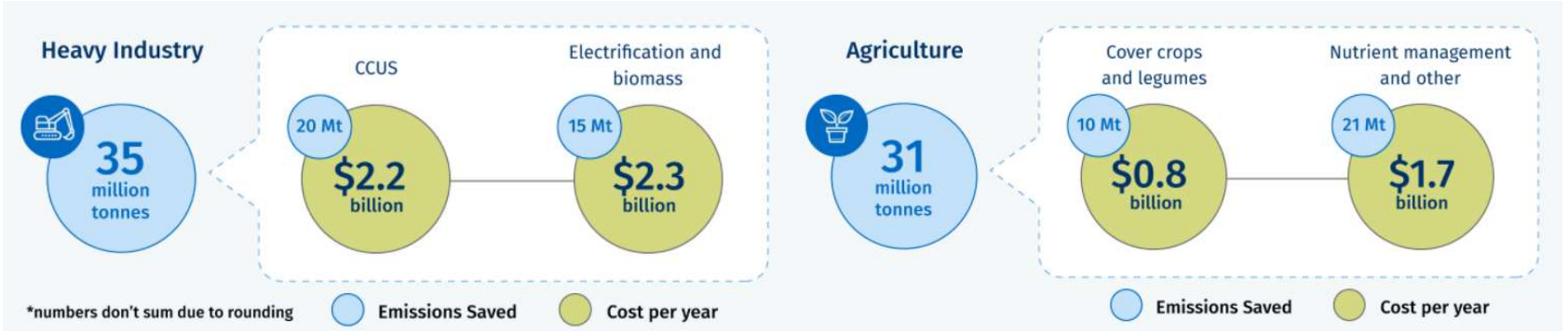
Where are cuts hardest?

Heavy Industry

- Emissions in some processes are inevitable (e.g., calcifying cement). These will likely require capture, but commercial scale is still being reached.

Agriculture

- While some agricultural emissions can be addressed, others are too diffuse to abate at all. And the sector has little ability to absorb added costs.



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What drives total decarbonization?

- At present, the only commercial fuel-switching option with the potential to cut end-use emissions to zero is electrification.
- In most cases, electrification also improves energy efficiency: EVs and heat pumps can be 3-4 times more efficient than their fossil fuel alternatives, cutting overall energy use
  - However, in most applications, they cost more because there are upfront costs to switching, and electricity is more expensive than natural gas.
  - In mobile applications, like EVs, we also need to store electricity, and batteries are expensive and heavy.
- Broadly, any place where electrons can replace molecules is one where full decarbonization is possible.

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Why are some sectors so hard and expensive to abate?

There are some major barriers to electricity replacing fossil fuel:

- High heat applications

  Commercially available heaters can't yet electrify all high-heat processes, like those in chemicals, cement, and steel

- Off-grid industry

  Where load requirements are high (kW not kWh), industry must be grid-connected. In some sectors, like mining and natural gas, that isn't practical.

- Weight-sensitive applications

  Batteries weigh too much to get a plane off the ground, and will challenge the economics of other sectors like freight transport and marine shipping

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Where electricity can't help, CCUS can

- Carbon capture systems are energy-intensive, complex to install, and expensive. That means, unlike electrification, they increase overall energy demand, reducing energy efficiency.
- They also can't solve the entire emissions problem: even the most reliable CCUS systems have residual emissions of 10-20%.
- But they can be deployed where electricity isn't an option, and where efficiency measures have been exhausted.
- They can also address process emissions from cement, steel, and chemicals.
- In our research, oil & gas and heavy industry are expected to rely heavily on CCUS unless other major breakthroughs come on things like hydrogen or new cement chemistries.

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The Road Ahead

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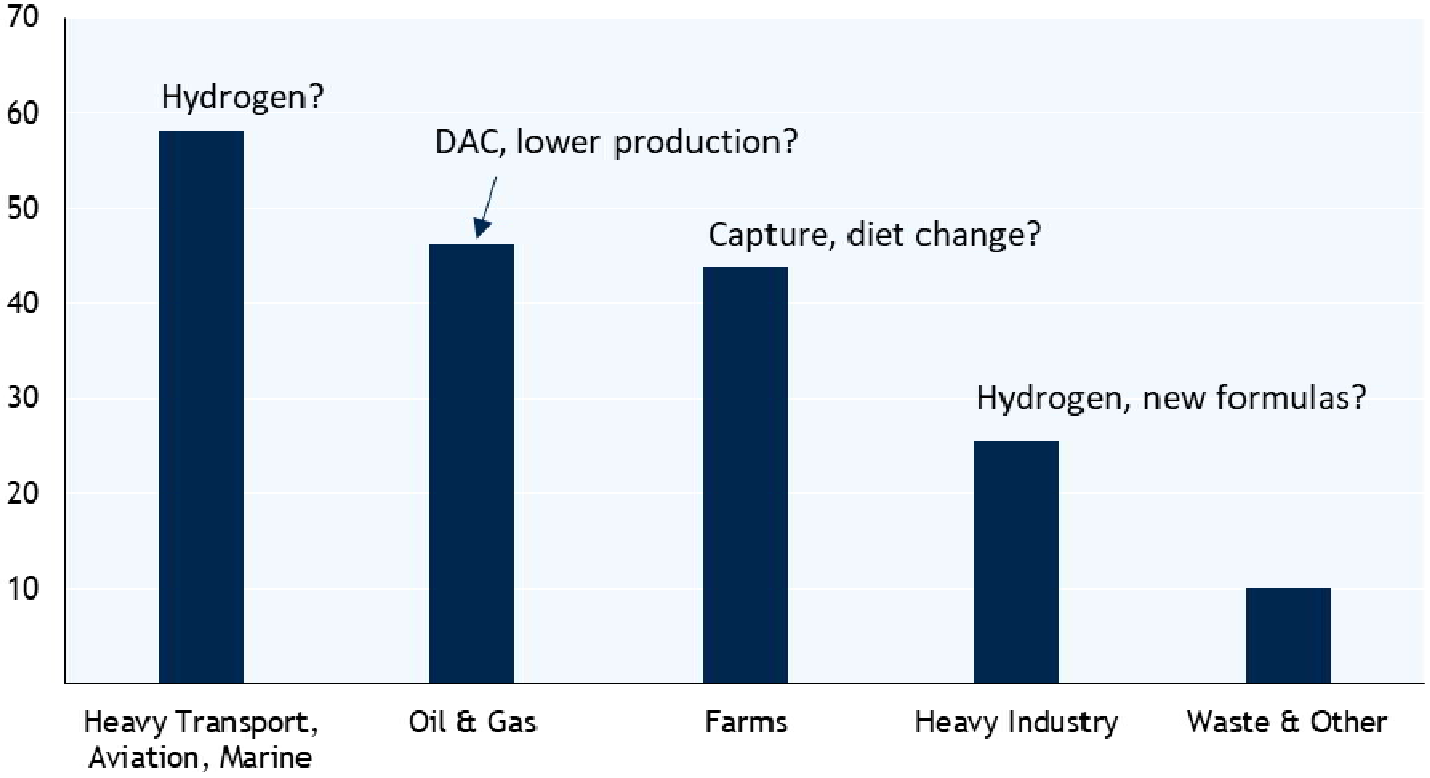
Keeping our options open…

Remaining emissions are concentrated, but hard

Emissions remaining after current technologies, Mt CO_2e



Source: RBC Economics

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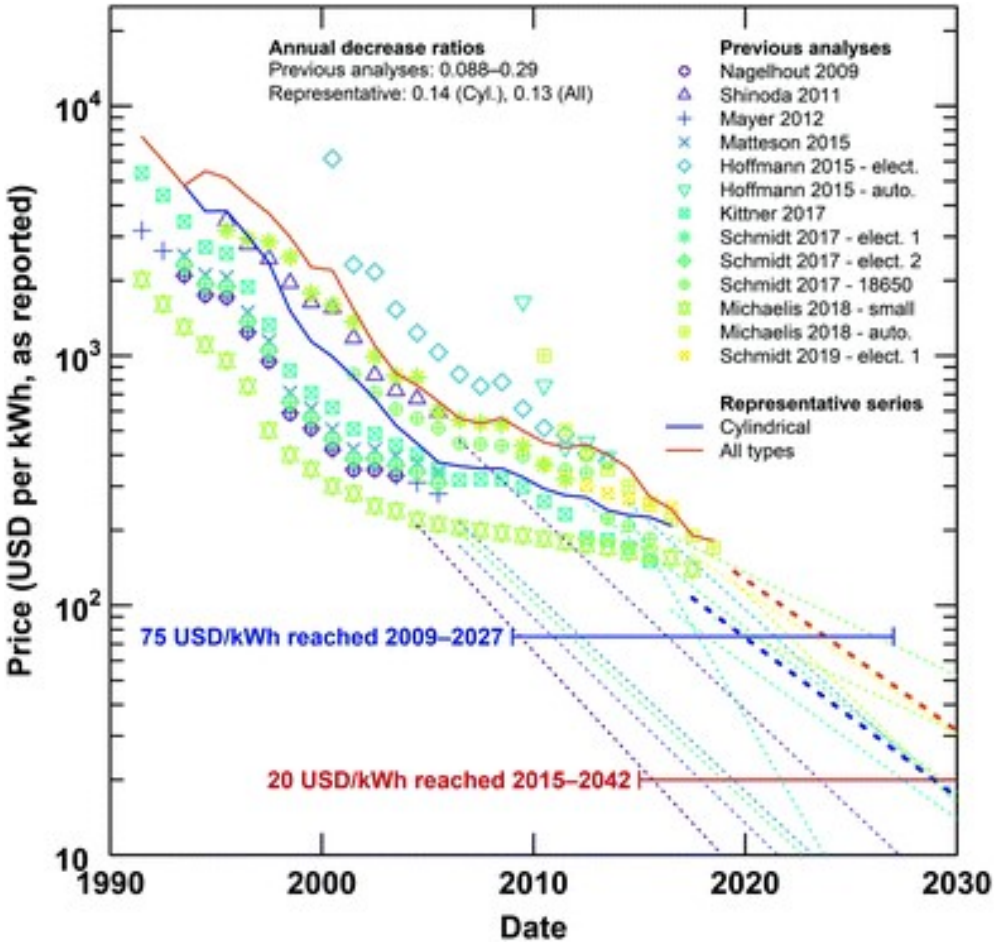
But acting quickly, if not decisively

- Acting now is a critical part of the equation for technology
- There is a well established relationship between adoption and cost-savings in energy tech.
- But this thinking must be risk managed



Source: Ziegler & Trancik, 2021

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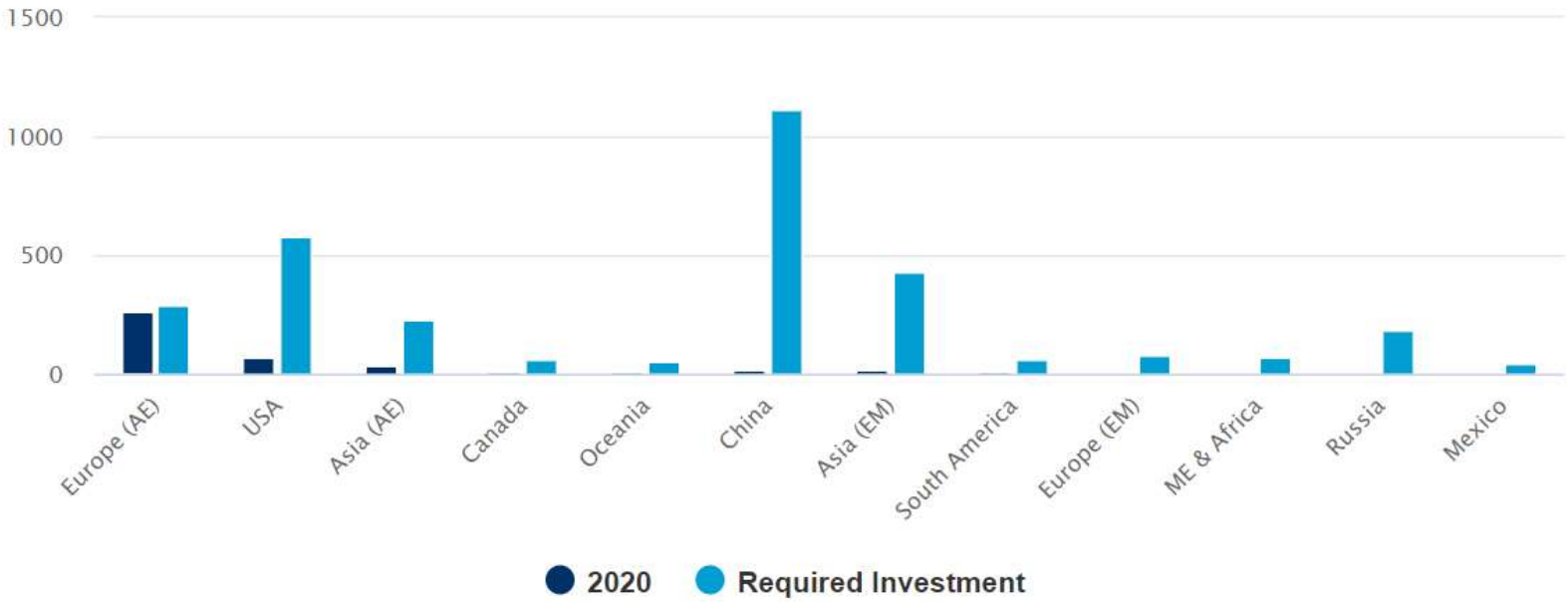
Green finance is concentrated globally

- ~$850 Bn through October 2021 in green finance globally, up 4x from 2017 levels
- But only Europe is really spending what they need to, and issues a disproportionate share of sustainable finance

Few regions are making sufficient climate investments

Estimated annual clean investment required and 2020 flows, top 40 countries, US$ billions



Source: Bloomberg, Our World in Data, RBC Economics, IEA | AE = Advanced economies, EM = Emerging economies

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How to proceed? Think about more than just carbon pricing

- The theoretical elegance of the carbon pricing regime comes in part from its universal application
  - This is a critical, and incorrect, assumption in modern regimes
- It also lends itself nicely to MAC curve thinking: cutting emissions incrementally and cheaply. But faced with our 2050 ambition, perhaps we should aim at full decarbonization efforts more.
- To progress towards our near-term climate goals, then, we need both broader and higher carbon pricing, and acceleration on efforts in a few key sectors: buildings, passenger transport, and CCUS.

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The Plan

- The report outlines 8 action items for policy makers:
  - **A national policy on electrification** to (at least) double generation
  - **A national strategy on green skills** to train the next generation of Canadian workers
  - **Long-term commitment to carbon pricing** to lay the groundwork for clean decisions
  - **Leveraging climate to enhance U.S. trade** to support domestic industry and supply chains.
  - **An industrial strategy for CCUS** to make projects easier and faster.
  - **A national action plan for sustainable agriculture** to help farmers store more carbon in our land
  - **Super-charging electric vehicles** to more quickly adopt the most viable electrification technology and develop the next generation of electric mobility
  - **Rapid retrofitting** to bring down energy waste

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Non-fiscal policies can be equally important

- Changing behaviour is a critical component to addressing the ~183 Mt of residual emissions by 2050.
- How do we get consumers riding e-bikes instead of driving, eating alternative proteins, and adopting heat pumps?
  - Solving information problems is key
  - Financial innovation can help accelerate change
  - Focus on amenities to make the green option better

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Questions to ask ourselves

- **Electricity –** will new capacity added be non-emitting? How can we make it so?
- **Oil & Gas –** do regulations reflect the different risk profile of CCUS projects vs. oil and gas development?
- **Buildings –** do owners have enough information? Can we aggregate projects like we do with NHA MBS?
- **Transportation** – early adopters tolerate inconvenience, but will the masses?
- **Heavy industry** – as an export-focused economy, competitiveness is key. Are there easier policies than BCAs?
- **Agriculture** – How can we rethink the ability of farmers to sequester? Can we find ways to generate cashflow rather than add debt?

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Key Takeaways

- Getting to Net Zero will be challenging, but we think it's doable.
- Canada needs a plan as the whole world jockeys for position in the Net Zero economy, lest we get left behind.
- Working to spur uptake of clean technologies in industry, electric vehicles, and pivot to more sustainable practices across the economy is critical.
- Effort to spur action in some sectors, like electricity, buildings, and passenger transport, may yield the fastest near-term emissions cuts.
- But we must remember to coordinate with trading partners to help our traded sectors transition, to ensure we cut emissions deeply even in trickier sectors.
- If we get it right, Canada could be heading into a new age of innovation and economic growth.