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PROVA DE LÍNGUA ESTRANGEIRA: INGLÊS

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Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070

ABSTRACT

Fully decarbonizing global industry is essential to achieving climate stabilization, and reaching net zero greenhouse gas emissions by 2050–2070 is necessary to limit global warming to 2 °C. This paper assembles and evaluates technical and policy interventions, both on the supply side and on the demand side. It identifies measures that, employed together, can achieve net zero industrial emissions in the required timeframe. Key supply-side technologies include energy efficiency (especially at the system level), carbon capture, electrification, and zero-carbon hydrogen as a heat source and chemical feedstock. There are also promising technologies specific to each of the three top-emitting industries: cement, iron & steel, and chemicals & plastics. These include cement admixtures and alternative chemistries, several technological routes for zero-carbon steelmaking, and novel chemical catalysts and separation technologies. Crucial demand-side approaches include material-efficient design, reductions in material waste, substituting low-carbon for high-carbon materials, and circular economy interventions (such as improving product longevity, reusability, ease of refurbishment, and recyclability). Strategic, well-designed policy can accelerate innovation and provide incentives for technology deployment. High-value policies include carbon pricing with border adjustments or other price signals; robust government support for research, development, and deployment; and energy efficiency or emissions standards. These core policies should be supported by labeling and government procurement of low-carbon products, data collection and disclosure requirements, and recycling incentives. In implementing these policies, care must be taken to ensure a just transition for displaced workers and affected communities. Similarly, decarbonization must complement the human and economic development of low- and middle-income countries.

Keywords: Industry Emissions Technology Policy Energy Materials.

1. Introduction

To avert dangerous climate change, it is necessary to reduce greenhouse gas (GHG) emissions from every sector of the global economy. Modeled emissions trajectories that limit likely warming to 2 °C generally require reaching net zero emissions in the latter half of the 21st century and net negative emissions thereafter. To limit warming to 1.5 °C, emissions must reach net zero around 2050.

The industry sector was responsible for 33% of global anthropogenic GHG emissions in 2014. This figure includes emissions from on- site fuel combustion, emissions from manufacturing processes, and indirect emissions associated with purchased electricity and heat; without indirect emissions, the industry sector was still responsible for 19% of global anthropogenic GHG emissions (Fig. 1).

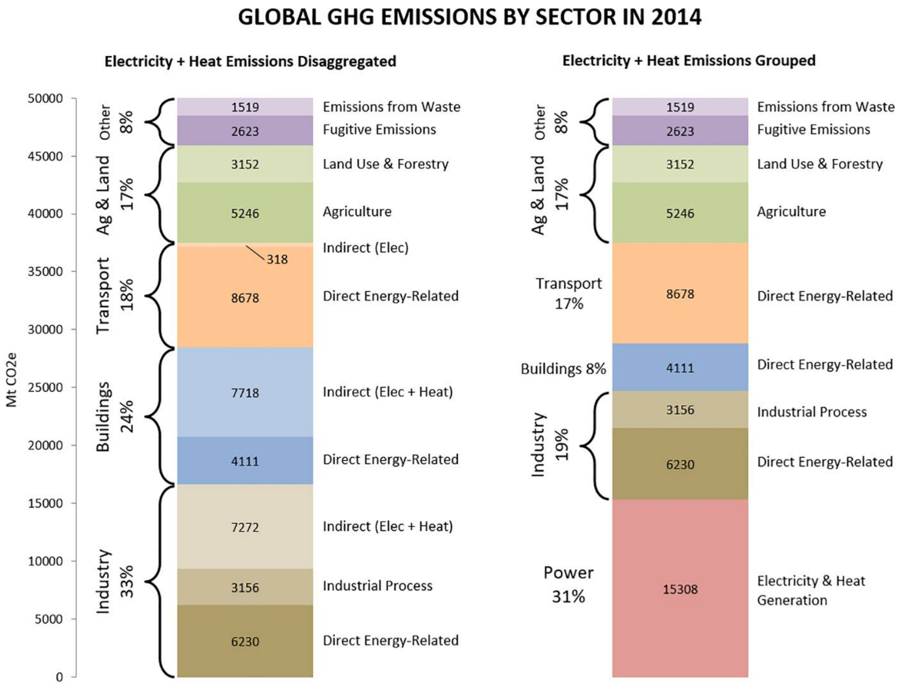

Fig. 1. Emissions by sector in 2014, displayed with indirect emissions (from the generation of purchased electricity and heat) assigned to the sectors that purchased that energy, or grouped into a single "power" sector. For more detail on which industries are included in the "industry" sector, see Fig. 2. Emissions from agriculture, from waste (e.g. landfills, wastewater treatment), and fugitive emissions (e.g. methane leakage from coal mines and natural gas systems) are not considered part of the industry sector in this paper.

Industry is at the core of developing low-carbon solutions: it is responsible for producing technologies such as renewable electricity generation facilities, clean vehicles, and energy-efficient buildings. Therefore, it is imperative to reduce emissions from industrial operations while industry continues to supply transformational technologies and infrastructure. These approaches should be compatible with a pathway to zero industrial emissions.

A variety of technologies, product design choices, and operational approaches can rapidly and cost-effectively reduce energy consumption and GHG emissions across a broad range of industries. Breakthroughs in areas such as 3D printing, improved chemical catalysts, and facility automation are transforming how we make everything from smartphones to aircraft. Meanwhile, techniques such as lightweighting and design for longevity/reuse offer ways to reduce material consumption while providing equivalent or better services. All of these technologies and practices can be enhanced by integrated systems design. Over 90% of GHG emissions are from about a dozen industries (Fig. 2), so very large reductions in industrial GHG emissions are possible by focusing on a limited set of product and process improvements.

Technologies are only part of the picture. Enacting the right policies can make investment in cleaner industrial processes more profitable and dramatically accelerate emissions reductions. The right policies can even spread innovations through international supply chains, improving companies in countries that lack strong policies of their own. Companies that invest in improved technology will be positioned to be leaders throughout this century, when concern over climate change is likely to make inefficiency and high emissions increasingly serious business liabilities.

To help guide policymakers and businesses, this work develops a blueprint for action that addresses the inter-connected concerns of innovation, technical feasibility, cost-effectiveness, an enabling policy environment, and the need for social equity in delivering human wellbeing globally.

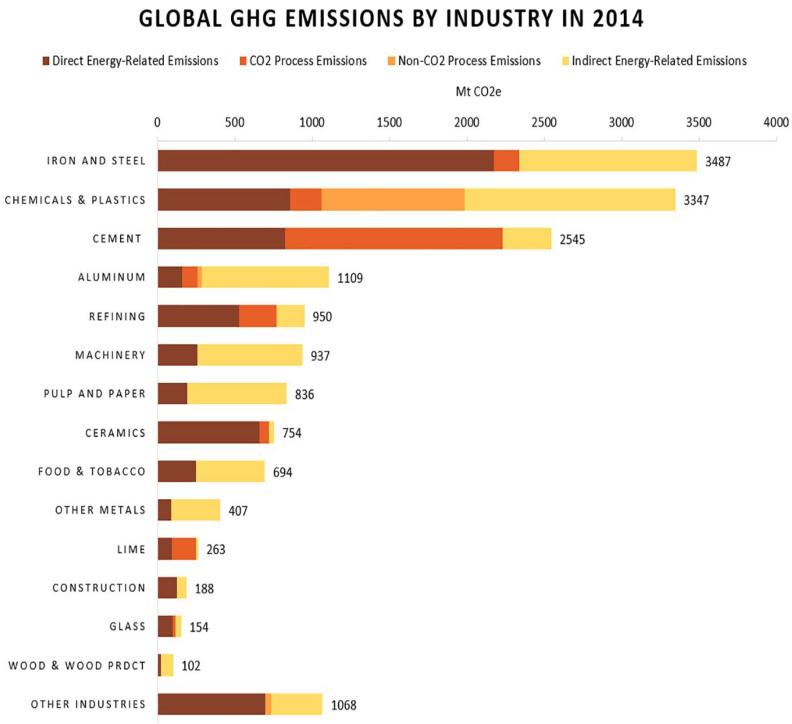

Fig. 2. Industry sector GHG emissions disaggregated by industry and by emissions type. Energy-related emissions are from fuel combustion, while process emissions are from other industrial activities. Direct emissions are from industrial facilities, while indirect emissions are associated with the production of electricity or district heat purchased by industry (not generated on-site). Emissions associated with transporting input materials and output products are considered part of the transportation sector and are not included in this figure. “Chemicals and plastics” includes all fluorinated gas emissions, even though most of those gases (e.g. refrigerants, propellants, electrical insulators) are emitted due to the use or scrappage of products. Chemicals production by refineries is included in the “refining” category, not the “chemicals and plastics” category. “Ceramics” includes brick, tile, stoneware, and porcelain. “Food and tobacco” includes the processing, cooking, and packaging of food, beverage, and tobacco products, not agricultural operations. “Other metals” includes copper, chromium, manganese, nickel, zinc, tin, lead, and silver. “Lime” only includes lime production not accounted for in another listed industry (e.g. cement). Total industry sector emissions do not match those in Fig. 1 due to differences in data sources [4–20].

2. Two-degree-compatible industrial decarbonization pathways

Holding global average temperature increase to well below 2 °C (the goal of the 2015 Paris Agreement) requires decarbonizing global industry in tandem with all other sectors. Direct industrial emissions, including energy and non-energy process emissions, rose 65% from 1990 to 2014. This was driven in part by industrialization in the developing world, and further industrialization is expected to raise the standards of living in developing countries.

Industrial decarbonization will be motivated by the declining costs of cleaner technologies, environmental regulation, and voluntary climate action. Numerical assessments of decarbonization potential can highlight critical knowledge gaps and research and development (R&D) opportunities.

The Shell Sky Scenario, the 2-Degree Scenario (2DS) and Beyond 2-Degree Scenario (B2DS) from the International Energy Agency's (IEA) Energy Technology Perspectives, and the pathway described in the "Mission Possible" report by the Energy Transitions Commission (ETC) are four scenarios that limit warming to below 2 °C. These scenarios present break-outs for global industry sector CO2 emissions, hydrogen use, and CCS use. The Sky Scenario shows projections to the year 2100 from a World Energy Model (WEM) framework. The IEA shows projections to the year 2060 from a technology-rich, bottom-up analytical "backcasting" framework. The ETC projections are based on modeling by the firm SYSTEMIQ, which ETC indicates will be described in forthcoming technical appendices. Though complete time-series data are not yet available from ETC, data are reported for the net-zero emissions system, which is achieved in 2050 by developed countries and in 2060 by developing countries. The graphs below show ETC results in 2060, as the results are global (and most of the world's industrial activity occurs in developing countries). All four scenarios consider only combustion and process CO2, not other GHGs.

2.1 Modeled global industry emissions

The Sky Scenario projects a continued rise in heavy industry CO_2 emissions through the early 2030s, followed by a decline as CO_2 capture and hydrogen technologies are deployed. Emissions in light industry begin falling from the late 2030s, driven primarily by electrification. The IEA 2DS shows modestly rising industrial CO_2 emissions through 2025, followed by a linear decline, driven by efficiency and CCS technologies. The IEA B2DS includes steep cuts to Industry emissions beginning in 2014. ETC finds that global industry emissions can be reduced to net zero, except for "residual" emissions of 2 Gt CO_2/yr, consisting of "end-of-life emissions from chemicals (plastics and fertilizers) and the last 10–20% of industrial emissions" (Fig. 3).

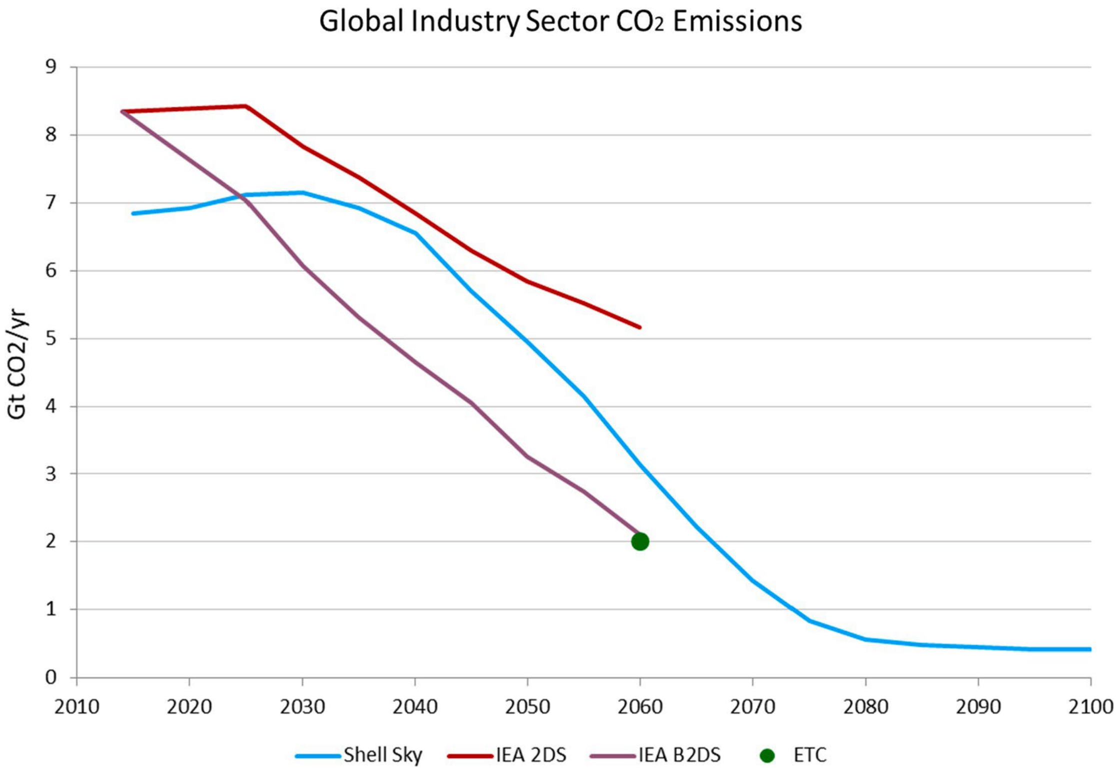

Fig. 3. CO_2 Emissions from Industry in the Shell Sky, IEA 2DS, IEA B2DS, and ETC scenarios. These scenarios include only direct emissions, not emissions from the production of purchased electricity or heat. This graph includes only CO_2 that reaches the atmosphere, not CO_2 that is captured and stored. The Sky scenario excludes fuels used as raw materials (such as petrochemical feedstocks) from the Industry sector, while IEA considers these fuel uses to be part of Industry. This might help to explain IEA's higher 2014 Industry sector emissions.

2.2. Modeled global hydrogen adoption

As the cost of renewable electricity continues to decline, there is growing interest in the role of renewable electricity-sourced hydrogen (i.e., via electrolysis) as a contributor to industrial decarbonization, both as a direct fuel and as a chemical feedstock.

Global industrial decarbonization scenarios that have explicitly considered zero-carbon hydrogen while differing in their technological and subsector scopes, have generally similar conclusions. Namely, renewable hydrogen can play a significant role in industrial CO2 mitigation in both light and heavy industries, but the high current costs of electrolyzers and hydrogen transport, competition with cheap natural gas, need for new process heating equipment (e.g., avoidance of hydrogen embrittlement of metals), and moderate technology readiness levels of some emerging solutions (e.g., hydrogen-reduced steel) pose challenges for large-scale market penetration in the absence of good policy. Smart policy can accelerate the uptake of renewable hydrogen in industry by making the required R&D and infrastructure investments more cost-effective, and/or by requiring emissions reductions from industries whose best emissions abatement option is hydrogen.

The IEA, Shell, and ETC scenarios have different predictions regarding hydrogen usage. The IEA scenarios do not show any hydrogen use by industry and very little by the transportation sector, reaching just 0.59 EJ/yr (2DS) or 0.85 EJ/yr (B2DS) in 2060. (Note these IEA hydrogen projections are out-of-line with IEA's more recent work in The Future of Hydrogen and may no longer reflect the IEA's expectations regarding the importance of hydrogen in a decarbonized economy.) The Shell Sky Scenario includes steady growth of hydrogen use, from zero in 2020 to 69 EJ/yr in 2100. Hydrogen use by industry peaks in the early 2080s, as efficiency technologies reduce industrial energy consumption. The ETC scenario has the most aggressive numbers: 40 EJ/yr of hydrogen consumption by Industry and 38 EJ/yr by the rest of the economy (converted from mass of H2 using hydrogen's lower heating value, as recovery of the latent heat of vaporization of water vapor in the exhaust stream is unlikely in most high-temperature industrial contexts) (Fig. 4).

Rapid adoption of hydrogen by industry implies similarly rapid scaling of hydrogen production, distribution, and storage infrastructure. Large industrial facilities with access to cheap electricity may produce their own hydrogen on-site, while other industrial facilities may buy hydrogen, particularly if a robust hydrogen distribution system develops to accommodate transportation sector demand. The infrastructure required to produce and deliver 15 EJ of hydrogen (the Sky scenario's projected 2060 hydrogen use by industry) could be compared with the historical development of the liquid natural gas (LNG) industry. The first large-scale LNG facilities were built in the 1960s, and by 1990, the LNG industry had scaled to 2.5 EJ, or 1% of global energy supply. Today, global trade in LNG is some 15.5 EJ of final energy, accounting for roughly 2.5% of global energy supply. This "rapid" scale-up of the LNG industry nonetheless took 50 years. For global industry to decarbonize in line with these Paris-compliant scenarios, even faster hydrogen scale-up will be needed, illustrating the need for robust investments in hydrogen R&D and infrastructure to accelerate adoption.

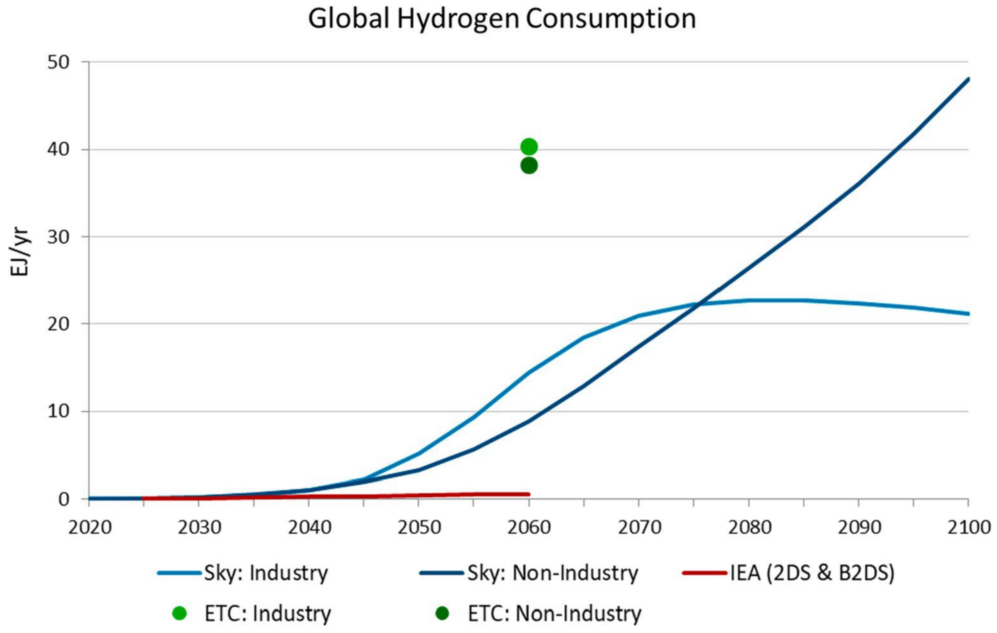

Fig. 4. Global hydrogen consumption in the Shell Sky Scenario, the ETC scenario (both disaggregated by end user), and in the IEA 2DS and B2DS (total). The IEA 2DS and B2DS are not identical, but their values are so close (0.59 vs. 0.85 EJ/yr in 2060) that their lines cannot be separately distinguished on this graph.

2.3. Modeled global carbon capture and storage

Carbon capture and storage (CCS) is also expected to play an important role in helping to decarbonize industry. The Shell Sky Scenario and IEA 2DS are largely in agreement about the magnitude of industry sector CCS, though the IEA projects scaling-up to begin roughly 5–10 years earlier. The ETC scenario closely agrees with the Sky scenario in total magnitude of CO2 captured annually, but ETC projects most carbon capture to occur in industry rather than in non-industry sectors. The IEA B2DS projects an industry CO2 capture rate falling between the Sky and ETC scenarios (Fig. 5).

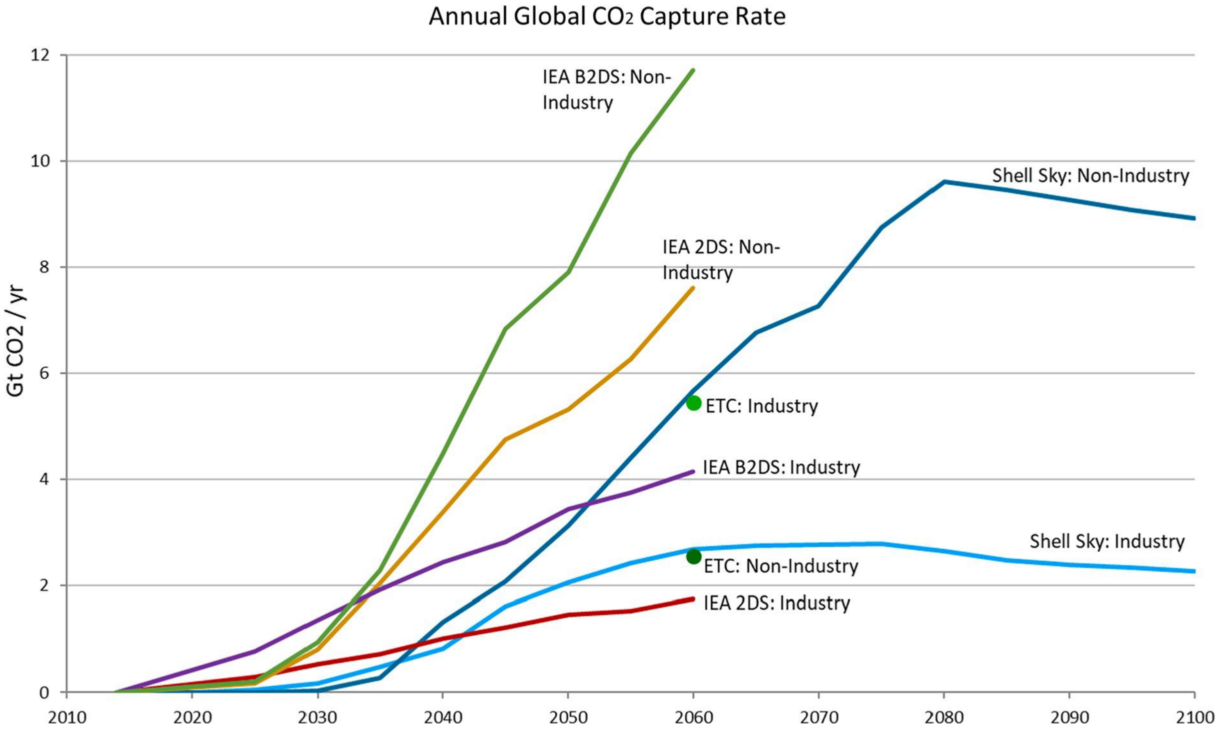

Fig. 5. CO_2 emissions from industry and non-industry sources captured in the Shell Sky, IEA 2DS, IEA B2DS, and ETC scenarios.

2.4. Three phases of technology deployment

Independent of the Paris Agreement, national and sub-national policies, economic forces, technology development, and voluntary corporate action will cause the industrial sector to substantially reduce its emissions over the coming century. But an outcome consistent with Paris requires net zero emissions within 30–50 years.

The European Commission has modeled a number of ambitious emission reduction scenarios for the EU that are compatible with 2- degree and 1.5-degree global trajectories. Projected energy intensity of EU industry (Fig. 6) may reflect technology and policy pathways also available to other developed economies and, with sufficient financial support and technical assistance, to developing economies. These intensity trajectories require a broad range of supply-side measures (electrification, energy efficiency, circular economy, hydrogen, etc.) and should be accompanied by demand-side measures (material efficiency, longevity, re-use, etc.).

In considering a rapid transition for industrial facilities worldwide, the following framework for change is proposed. Note the timing of proposed phases refers to a global average. In reality, developed countries likely would need to decarbonize more rapidly, to compensate for any developing countries that deploy technology more slowly. Also note that the "timeframe" specifies when each measure becomes widely used and begins delivering significant emissions reductions; R&D to improve technologies used in later phases must begin now, and measures started in earlier phases must persist in later phases.

This framework is informed by the phases of technology development and deployment commonly seen in large-scale energy systems. New technologies go through a few decades of high-percentage growth but from a very small base. Once the technology becomes 'material'—typically just a few percent of the system—growth becomes linear, then tapers off as the technology approaches its final market share. These deployment curves are remarkably similar across different technologies. As a result, there is often a lag of up to 30 years between initial testing of a technology and large-scale deployment. Two notes:

- Demand-side interventions, such as material efficiency, longevity, and reuse, may have less need for new physical technologies. However, they may involve more changes to social practices, business models, production location, etc. Like new energy technologies, demand-side interventions may need policy support and a multi-decade timeframe to achieve materiality.

- If political pressure to rapidly reduce emissions becomes acute (perhaps in response to accelerating climate damages), the investment cycle can be sped up through mandatory early retirement of the highest-GHG-intensity industrial facilities. This practice is already being used to phase out coal electricity generation in certain regions. For instance, Ontario completed a coal phase-out in 2014, and U.S. air quality regulations have accelerated the retirement of older coal units that would be too expensive to retrofit with pollution controls. The Chinese government has shut down highly polluting industrial facilities for air quality reasons.

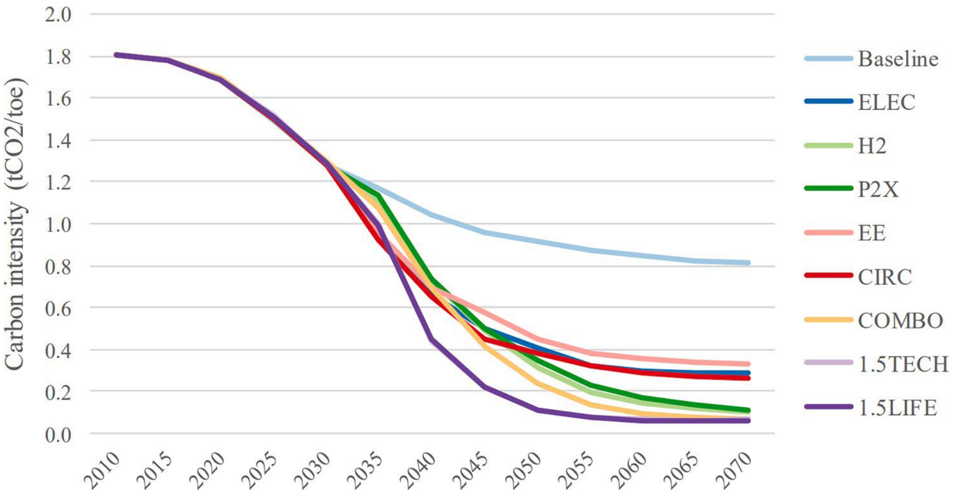

Fig. 6. Carbon intensity of EU industry under nine scenarios appearing in the European Commission's long-term plan. Image CC BY 4.0 (permission).

3. Circular Economy

The term Circular Economy (CE) contrasts with the idea of a "linear economy," the predominant value chain structure today, in which goods are produced, consumed, and discarded. In a CE, every end-of-life product is considered a resource that can be put to valuable use. Rather than being a single type of activity (such as "recycling"), CE is a cascade of options that put each product, component, or material to its highest or best use, minimizing value loss. The first option is for a product's original user to keep it for longer, share it with others, and prolong its service life through proper maintenance and repair. When this is not possible, the next best option is to transfer the product to a new user. The third best option is to refurbish or remanufacture the product. (Remanufacturing is dis-assembling and re-using the components of the product.) The fourth-best option is to recycle the raw materials that make up the product (Fig. 15).

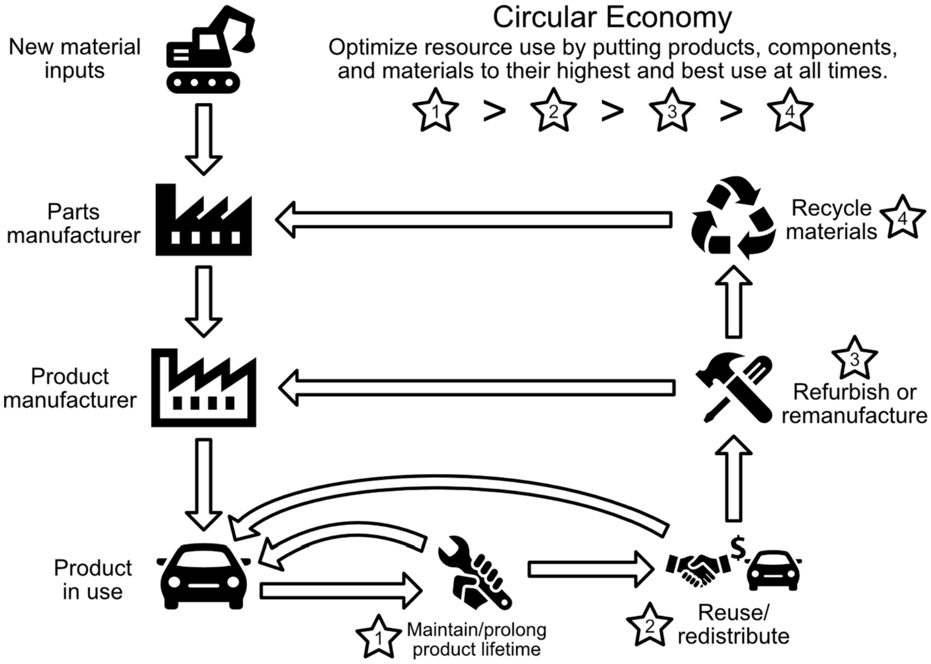

Fig. 15. A schematic overview of material flows within a circular economy. Products, components, and materials are put to the best possible use, minimizing value loss.

Assessments of the techno-economical potential of increased circularity vary widely and can be difficult to compare, due to different units and assumptions. For example, Cooper et al. find CE has the potential to save 6–11% of worldwide energy used for “economic activity”, while Material Economics finds that CE could reduce 2050 CO_2 emissions from steel, plastics, aluminum, and cement in the EU by 56% relative to a 2050 baseline scenario (a 59% reduction relative to 2015 emissions levels). There is, however, broad consensus that CE potential is held back by limited ability to achieve comparable performance with virgin material, driven by the challenges of separating blended or assembled materials. For example, the copper content of recycled steel is generally higher than is allowable for the most common steel end uses, unless the recycled steel is diluted with primary steel. New separation technologies may help to improve the quality of recycled metals.

One key barrier to high-quality secondary materials is that information about the material is lost over the course of its service life. For example, structural steel is usually in fine condition for reuse when a building is demolished, but its alloy content and specifications are no longer known. This means that expensive testing is required to determine its composition before it could be reused, and it is often more cost-effective to put it in poorly-differentiated waste streams for recycling at a lower grade. The standard categories for steel scrap do not specify the copper content, even though copper will prevent the recycled steel from being used in many high-value applications, like sheet metal for vehicles. Policies that ensure sufficient information follows the materials and components throughout their life, whether through low-technology interventions like indelible marking or higher- technology options like blockchain, facilitate first reuse then higher-value recycling of product components and materials.

Design for reuse and recycling takes this one step further, not just providing information but modifying the products to encourage reuse and recycling. Approaches include modular design, reversible attachments, and material standardization. Again, using the example of structural steel, reversible joints like ConX joints standardize the mounting and disconnecting of beams, making it easier to reuse them. The primary policy mechanism that has been used to encourage these types of design changes is Extended Producer Responsibility (EPR), where the manufacturer or retailer is required to take physical or financial responsibility for discarded products. However, EPR has not yet been widely applied in the contexts that would have the greatest impact on industrial emissions, namely building materials and commodity metals.

Increasing the circularity of our economy may require the creation of business models around secondary materials, which can be facilitated by supporting policies. Leasing models can require products be returned at the end of the lease period for refurbishment and subsequent lease or sale to another consumer. While such business models exist for certain products (e.g. cars) and are easy to imagine for durable consumer goods (e.g. large appliances), they are less intuitive for short-lived consumer goods, public infrastructure, or the built environment. Some nations and regions are beginning to implement supporting policy, such as China's Circular Economy Promotion Law of 2009 and a CE package implemented by the European Commission.

Ultimately, to limit global warming to acceptable levels, significant decreases in carbon-intensive material consumption will be required. CE can help to achieve this decrease without lowering countries' standard of living or hampering their development. The opportunity of CE leads to an imperative for policy action (and may result in significant business opportunities). Key areas for policy intervention are:

- Ratchet up performance requirements in building codes at defined intervals to drive innovation.
- Include the implications of shared mobility solutions in zoning and urban planning.
- Build out reverse supply chains for collection of used products for repurposing or recycling.
- Regulate requirements for disassembly of products (e.g. batteries in electronics must be removable).
- Establish tools and information infrastructure to track and monitor material flows to enable new business models and improve material recapture.

Fonte: Rissman, J. et all. Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070. Applied Energy 266 (2020) 114848. Adapted.

Marque a opção correta.

1. De acordo com o *abstract*, quais fatores tornam políticas específicas indispensáveis para viabilizar a transição para emissões líquidas zero?

a) Os altos custos de P&D e as limitações tecnológicas atuais.

b) A ausência de consenso internacional e o aumento do consumo energético global.

c) O papel das externalidades negativas e a necessidade de incentivos econômicos robustos.

d) A segurança e a falta de materiais alternativos adequados para setores emissores.

2. Na frase, "strategic, well-designed policy *can* accelerate innovation and provide incentives for technology deployment.", qual é o efeito discursivo do modal "*can*" nesse contexto?

a) Demonstrar uma capacidade ou potencial realista.

b) Indicar uma recomendação cautelosa.

c) Expressar uma possibilidade condicional.

d) Propor uma solução hipotética.

3. O que é destacado como necessário para garantir a transição justa na descarbonização?

a) Aumento da automação industrial. b) Eliminação de subsídios governamentais para combustíveis fósseis.

c) Investimentos exclusivamente no setor privado.

d) Criação de políticas de apoio para trabalhadores deslocados e comunidades afetadas.

4. Qual é a conclusão do *abstract*?

a) A descarbonização industrial depende exclusivamente do investimento privado.

b) Apenas países de alta renda podem implementar políticas de descarbonização eficazes.

c) A descarbonização completa da indústria é possível por meio de intervenções tecnológicas e políticas integradas.

d) A neutralidade de carbono será alcançada automaticamente com o avanço tecnológico.

5. No trecho: ″These core policies should be supported by labeling and government procurement of *low-carbon* products, data collection and disclosure requirements, and recycling incentives.″, como funciona o termo "*low-carbon*":

a) Adjetivo composto qualificando " products ".

b) Advérbio composto qualificando "policies".

c) Substantivo qualificado pela expressão "low-carbon".

d) Preposição qualificada pela palavra "products".

6. No trecho, "To limit warming to 1.5 °C, emissions *must reach* net zero around 2050, qual é o efeito da estrutura modal "*must reach*" na frase?

a) Sugerir que alcançar emissões líquidas zero depende de acordos internacionais.

b) Indicar uma previsão baseada em suposições científicas.

c) Apontar uma habilidade a fim de atingir o objetivo proposto.

d) Expressar uma forte recomendação.

7. Qual porcentagem das emissões antropogênicas globais de GEE em 2014 foi atribuída diretamente ao setor industrial?

a) 19%

b) 25%
c) 33%
d) 50%

8. Qual é o papel estratégico do setor industrial no contexto da descarbonização global descrito no artigo?
a) Reduzir emissões exclusivamente através de fontes renováveis.
b) Implementar tecnologias de baixo custo em setores emergentes.
c) Produzir tecnologias essenciais para outras áreas e reduzir suas próprias emissões.
d) Concentrar esforços em países desenvolvidos para compensar emissões globais.

9. No trecho, ″Industry is at the core of developing low-carbon solutions: it is responsible for producing technologies *such as* renewable electricity generation facilities, clean vehicles, and energy-efficient buildings″, a expressão "*such as*" é usada para:
a) Introduzir uma comparação.
b) Exemplificar tecnologias mencionadas previamente.
c) Contrastar ideias no texto.
d) Indicar uma conclusão.

10. Qual das seguintes tecnologias NÃO foi citada como uma solução para reduzir emissões no setor industrial?
a) Impressão 3D
b) Catalisadores químicos avançados
c) Energia nuclear
d) Automação de instalações

11. Qual cenário citado no texto enfatiza o uso da captura de carbono (CCS), principalmente na indústria?
a) Cenário Sky.
b) Cenário B2DS.
c) Cenário IEA 2DS.
d) Cenário ETC.

12. Por que o setor de cimento é descrito como um dos mais difíceis de descarbonizar?
a) Pela falta de tecnologias avançadas disponíveis atualmente.
b) Devido à combinação de emissões de processos e alta demanda global.

c) Pela dependência de combustíveis fósseis para a fabricação de misturas químicas.
d) Pela indisponibilidade de matérias-primas em países industrializados.

13. O que é necessário para as economias em desenvolvimento reduzirem suas emissões industriais, conforme mencionado no texto?
a) Apoio financeiro e assistência técnica adequados.
b) Apenas a implementação de tecnologias de captura de carbono.
c) Um aumento no uso de combustíveis fósseis mais baratos.
d) O fechamento de fábricas industriais para reduzir as emissões.

14. No trecho, *"This framework* *is informed* *by the phases of technology development and deployment commonly seen in large-scale energy systems"*, qual é a função da voz passiva na frase?
a) Dar ênfase ao sujeito da ação.
b) Destacar o agente que realiza a ação.
c) Focar no processo ou no resultado da ação.
d) Indicar uma ação obrigatória.

15. Qual a relação entre a eletrificação e a redução das emissões industriais nos setores leve e pesado?
a) A eletrificação é eficiente em ambos os setores, mas enfrenta barreiras relacionadas à infraestrutura existente.
b) Nos setores leves, a eletrificação já se encontra amplamente implementada, enquanto nos pesados ela depende de tecnologias complementares.
c) Nos setores pesados, a eletrificação substitui integralmente os combustíveis fósseis, enquanto nos leves sua contribuição é limitada.
d) A eletrificação é mais promissora em setores leves, enquanto os setores pesados dependem de tecnologias como captura de carbono e hidrogênio.

16. No trecho "New technologies go through a few decades of high-percentage growth *but* from a very small base", qual é a função da conjunção "*but*" na frase?
a) Introduzir uma contradição ou contraste.
b) Adicionar uma ideia complementar.
c) Indicar uma causa.
d) Explicar uma consequência.

17. O texto menciona o uso de misturas minerais e químicas na indústria do cimento. Quais implicações essas práticas têm para a sustentabilidade e o desempenho do concreto?
a) Essas misturas aumentam a durabilidade do concreto, mas reduzem sua capacidade de reciclagem.
b) Promovem a redução de emissões de CO_2, mas podem alterar propriedades fundamentais do concreto.
c) Eliminam a necessidade de combustíveis fósseis nos processos de produção de cimento.
d) Melhoram a eficiência térmica do cimento, mas não apresentam vantagens ambientais significativas.

18. O que o texto sugere sobre o processo de implementação de novas tecnologias no setor industrial?
a) As novas tecnologias devem ser implementadas sem qualquer atraso para garantir a redução das emissões.
b) O uso de novas tecnologias deve ser evitado até que se prove sua total viabilidade econômica.
c) As tecnologias emergentes são implementadas de maneira linear, sem variações no crescimento.
d) Há frequentemente um atraso de até 30 anos entre os primeiros testes de uma tecnologia e sua implementação em larga escala.

19. O que é necessário para acelerar a transição industrial para uma economia de baixo carbono?
a) Implementação de medidas restritivas sem considerar os impactos econômicos.
b) Apenas o fechamento de fábricas com alta emissão de GHG.
c) Um conjunto abrangente de medidas de fornecimento e demanda, incluindo apoio financeiro.
d) A eliminação gradual das políticas de energias renováveis em favor dos combustíveis fósseis.

20. No trecho *"...the investment cycle* *can* *be sped up through mandatory early retirement…"*, qual é o significado gramatical de "*can*" nessa frase?
a) Expressar habilidade física.
b) Indicar possibilidade ou permissão.
c) Demonstrar uma obrigação legal.
d) Mostrar uma suposição improvável.

21. O que é a Economia Circular (*CE*)?
a) Um modelo de economia linear.
b) Um modelo onde produtos descartados são considerados recursos.

c) Um tipo de reciclagem.

d) Um sistema de produção de bens descartáveis.

22. Qual é a primeira opção na Economia Circular para prolongar a vida útil de um produto?

a) Reciclar o produto.

b) Transferir o produto para um novo usuário.

c) Manter o produto por mais tempo.

d) Remanufaturar o produto.

23. Em "Assessments of the techno-economical potential of increased circularity vary widely and can be difficult to compare, due to different units and assumptions", qual é a relação expressa por "*due to*"?

a) Causa.

b) Contraste.

c) Adição.

d) Condição

24. Qual é um dos principais obstáculos para a utilização de materiais secundários de alta qualidade?

a) A falta de demanda por materiais reciclados.

b) A perda de informações sobre o material ao longo de sua vida útil.

c) A dificuldade em encontrar compradores para materiais reciclados.

d) A falta de tecnologia para reciclagem.

25. O que é necessário para melhorar a qualidade dos metais reciclados?

a) Aumento da demanda por metais reciclados.

b) Menos regulamentações sobre reciclagem.

c) Aumento da produção de materiais virgens.

d) Novas tecnologias de separação.