THE ROLE OF DIGITALIZATION IN DRIVING DEMAND FOR INDUSTRIAL DECARBONIZATION

MARCH 2020

EC-MAP
ENERGY CONSUMER MARKET ALIGNMENT PROJECT

ABOUT EC-MAP

The Energy Consumer Market Alignment Project (EC-MAP) is a Washington, DC based non-profit seeking to align public policy with a digital energy future. EC-MAP envisions an energy future where digital technologies drive greater transparency, fair competition, and consumer choice—and where policy enables innovation instead of creating market barriers. EC-MAP is advancing a dialogue around the role of government in this new era of energy digitalization for the transportation, power, and industrial sectors.

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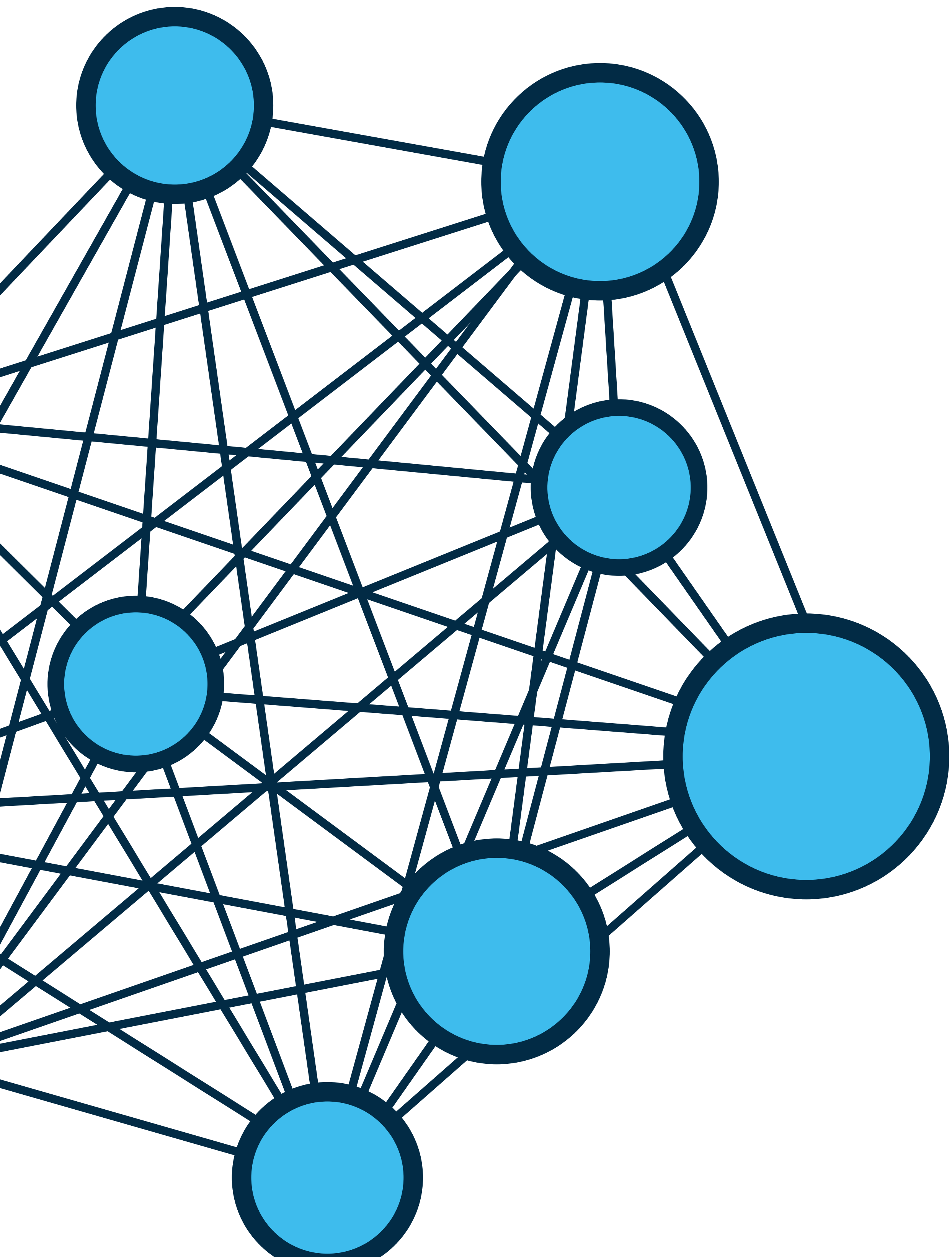
EXECUTIVE SUMMARY



Climate change is a systems problem, but most approaches to addressing it—while often resulting in meaningful progress—have nonetheless been insufficient in aggregate to match the scale and urgency of the problem. At the same time, the rise of the internet and digitalization has been a revolutionary driver of economy-wide systems change—transforming social relationships, global connectivity, science, communications, politics, and governance. Together, these symbiotic trends have the potential to usher in a new era of carbon transparency—one with the potential to drive change from the bottom up, with consumers playing a more significant role in meeting their energy needs and driving goals around cost, sustainability, and efficiency.

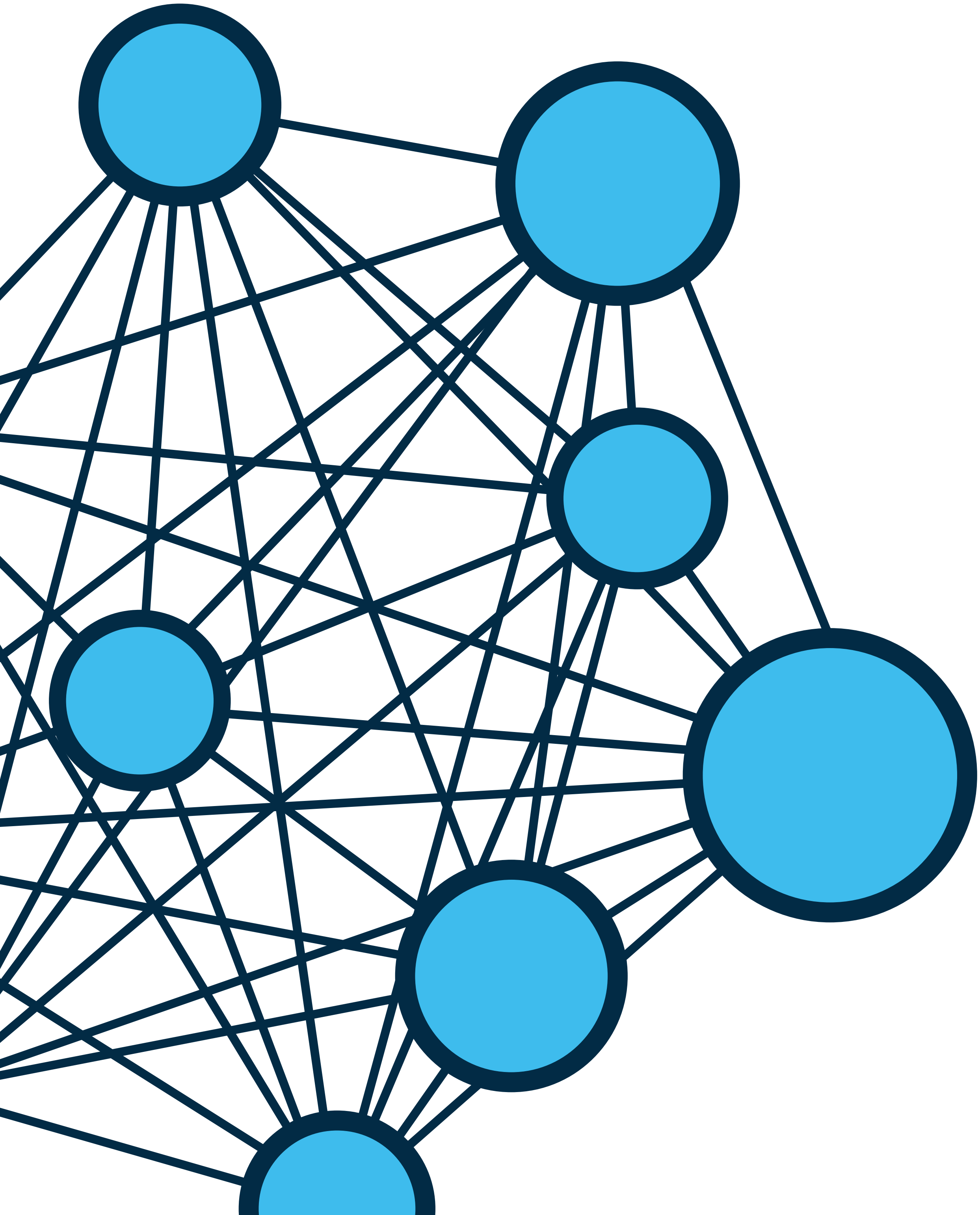
In general, the speed of digitalization (like climate change itself) is outpacing government's response. However, if digitalization can be appropriately harnessed and governed, it has enormous potential to drive climate policy. A key test area poised to benefit from digitalization is industrial decarbonization.

Industrial emissions—in particular from energy-intensive commodities like chemicals, cement, iron and steel, and aluminum as well as the extraction, production, and refining of oil and natural gas—represent a growing problem and one that is incredibly complex. Although technologies to help reduce industrial emissions are beginning to mature, there remains no clear and consistent way for the market to differentiate and value low-carbon industrial products in relation to higher polluting alternatives. This market challenge presents a new opportunity for industry and other climate stakeholders.

The key to unlocking this opportunity will be overcoming barriers to better data access and better data contextualization by deploying a new digital approach to measurement, reporting, and verification (Digital MRV) that quantifies emissions and environmental attributes in ways that are more granular, more accurate, and more actionable. By leveraging digitalization and advanced digital technologies like AI and blockchain, industrial companies can securely collect, store, and share real-time environmental data—and in turn, give consumers, investors, and governments a more complete, timely, credible, and trustworthy assessment of the climate impact of a particular product, facility, or company.

The promise of Digital MRV, however, is not guaranteed. Successfully implementing Digital MRV systems is an imperative that will require adherence to key principles including transparency, accuracy, replicability, predictability, and interoperability. Doing so will also require significant new stakeholder engagement and governance frameworks to build upon and convert existing standards, metrics, and methodologies into digital standards and benchmarks. EC-MAP is building an ecosystem of partners and allies to explore the role of digitalization in driving demand for industrial decarbonization.

DECARBONIZATION AND DIGITALIZATION: SYMBIOTIC TRENDS



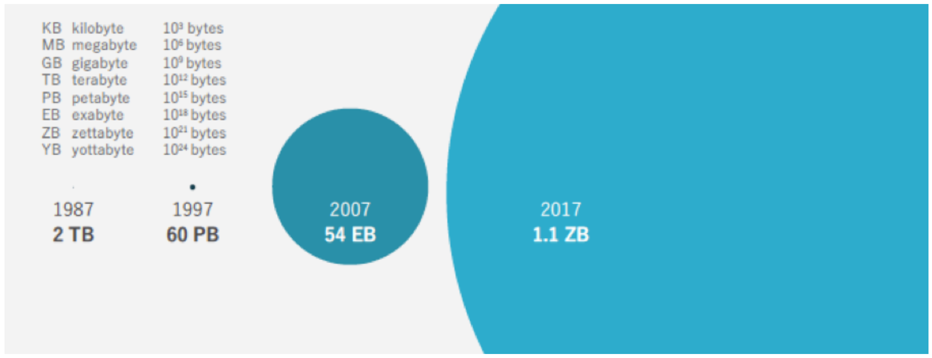
Climate change is a systems problem. The signatories to the 2015 Paris Agreement committed to keep global temperature rise under 2 degrees Celsius above pre-industrial levels, while seeking to achieve an aggressive target of 1.5 degrees Celsius.[1] Achieving this will require cutting greenhouse gas emissions in half by 2030 and reaching net zero emissions by 2050.[2]

However, to date, most of the approaches to address climate change have been incremental and pragmatic, in many cases due to political and economic constraints. Despite continued progress on renewables deployment, electric vehicle adoption, and the development of carbon capture utilization and storage technologies—and most recently a flattening of global emissions in 2019—climate policy has nonetheless been insufficient to match the scale and urgency of the problem.[3]

To date, climate policy has been insufficient to match the scale and urgency of the problem.

Concurrently, the rise of the internet and digitalization has been the biggest driver of economy-wide, systems change in our lifetime, resulting in transformational change in social relationships, global connectivity, science, communications, politics, and governance. Real-time access to the internet, broadband, and mobile devices has increased exponentially in each of the past four decades (see Figure 1). In the U.S., smartphone adoption has surpassed 80 percent.[4] As recently as the early 2000s, the world's largest companies represented a diversity of industries; however, today all of the world's largest companies are focused on information and communications technology.[5]

Figure 1
Growth in Global Internet Traffic



Source: International Energy Agency

The market for digital technologies in energy will reach $64 billion by 2025.

Information and communications technologies are intersecting with the energy system in a variety of ways, including through data collection, data analytics, and real-time communications networks.[6] Advances in computing and machine learning have also enabled advanced functionality to be embedded within energy delivery systems and distribution networks.[7]

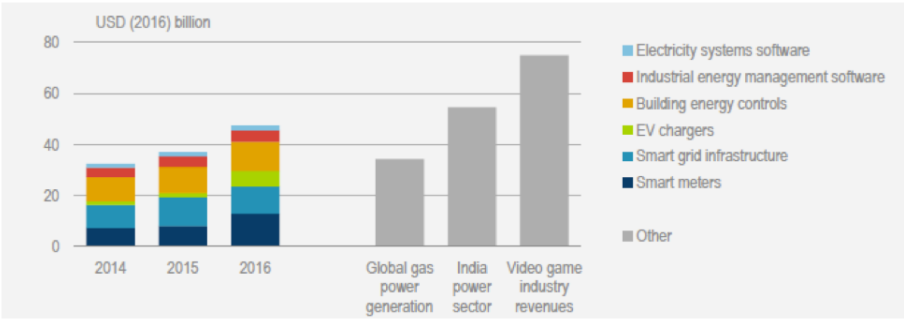
Unlike many energy and environment innovations of past decades, emerging digital innovations are not relegated to serving a single purpose. Rather, most are crosscutting digital tools and platforms that can be applied to the energy system in myriad ways. They include:

- Artificial intelligence (AI) and machine learning that enable increased automation;
- Blockchain technologies that enable secure, decentralized, peer-to-peer transactions;
- Crowdsourcing platforms that enable creative finance mechanisms and expose consumer preferences;
- The internet of things, which connects smart appliances, electronics, mobile devices, and sensors and enables them to communicate across a network; and
- Software and systems that enable new business models for energy services.

Although the intersection of information technology and energy is far from new, the pace of adoption is accelerating dramatically. Investment in digital technologies by energy companies grew by more than 20 percent between 2014 and 2016 (see Figure 2). Bloomberg New Energy Finance (BNEF) has projected the market for digital technologies in energy (including for fossil fuel production, renewable generation, and grid applications) will reach $64 billion by 2025.[8] Moreover, BNEF estimates that the benefits from digitalization of the energy sector will rise from $17 billion in 2017 to $38 billion in 2025.[9]

Figure 2

Recent Growth Trends in Digital Energy Infrastructure Invesment



Source: International Energy Agency

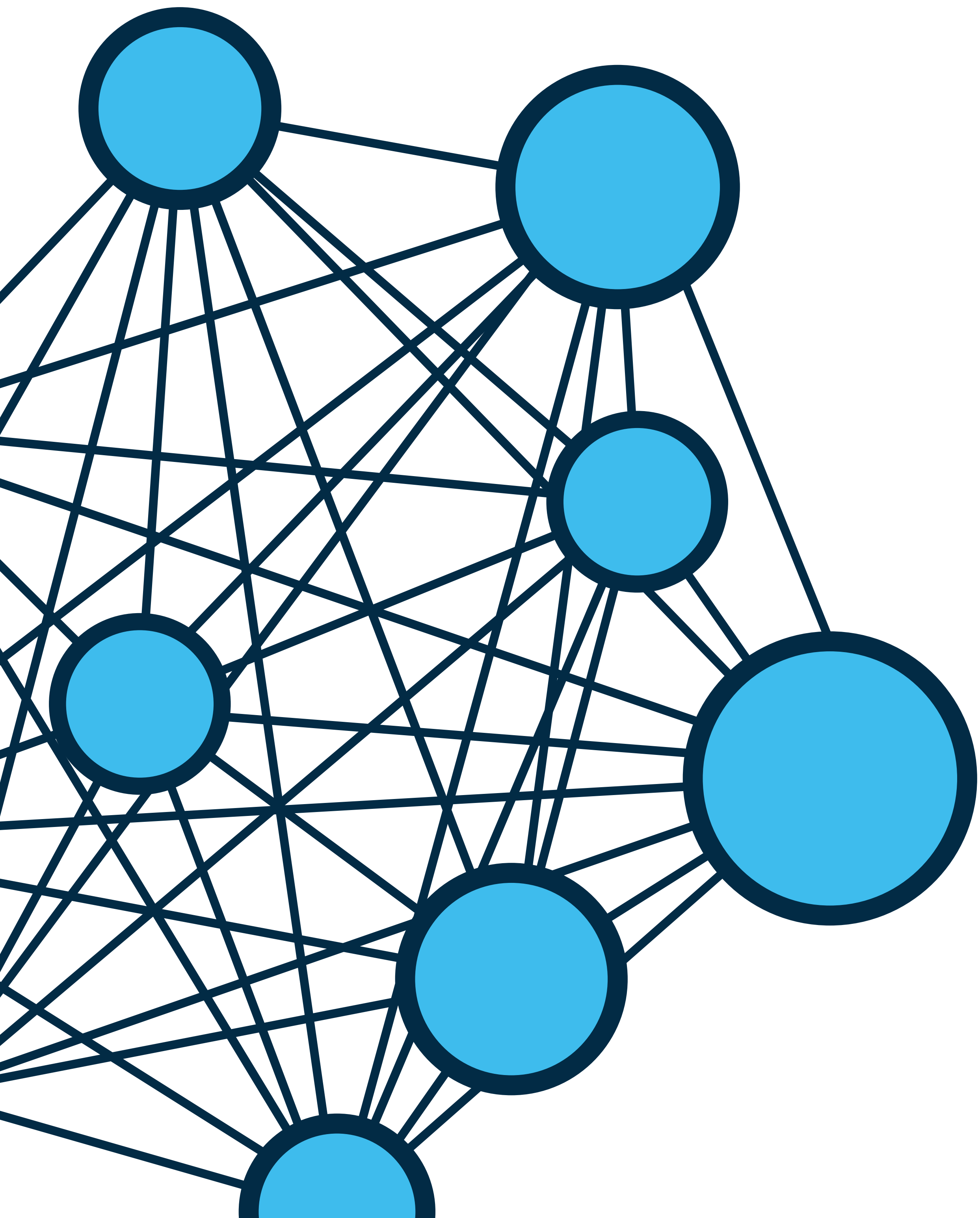
A NEW ERA OF CARBON TRANSPARENCY

Together, these symbiotic trends have the potential to usher in a new era of carbon transparency[10] — an era with the potential to transform sustainability and climate policy, driving change from the bottom up, with consumers playing a more significant role in meeting their energy needs and driving goals around cost, sustainability, and efficiency.

However, this potential will only be realized if digitalization is implemented and governed appropriately.[11] Some stakeholders are concerned that digitalization of the fossil fuels industry could "automate the climate crisis,"[12] while studies by PwC [13] and the Environmental Defense Fund [14] have highlighted the emissions reduction potential of similar digital technologies. Blockchain has been regularly criticized for its high energy requirements, but understanding its impacts on emissions will likely require a more nuanced understanding of where the energy-intensive data systems are located and the emissions profile of the electricity those systems use.[15]

In general, the speed of digitalization (like climate change itself) is outpacing government's response. However, if digitalization can be appropriately harnessed and governed, it has enormous potential to drive climate policy and reduce emissions not just within one sector, but across sectors; accelerate not only technology performance but market innovation at scale; and redefine the role of government in achieving policy goals —both emissions reduction and economic competitiveness. A key test area poised to benefit from digitalization is industrial decarbonization.

WHY INDUSTRIALS?



"Industrials" include a range of heavy industries, including a wide variety of manufacturing processes; the production of energy-intensive commodities including chemicals, cement, iron and steel, and aluminum; and the extraction, production, and refining of oil and natural gas. Industrial greenhouse gas (GHG) emissions are made up of direct emissions (Scope 1), indirect emissions (Scope 2), and value chain emissions (Scope 3) (See Table 1).

TABLE 1: THE LANGUAGE OF EMISSIONS

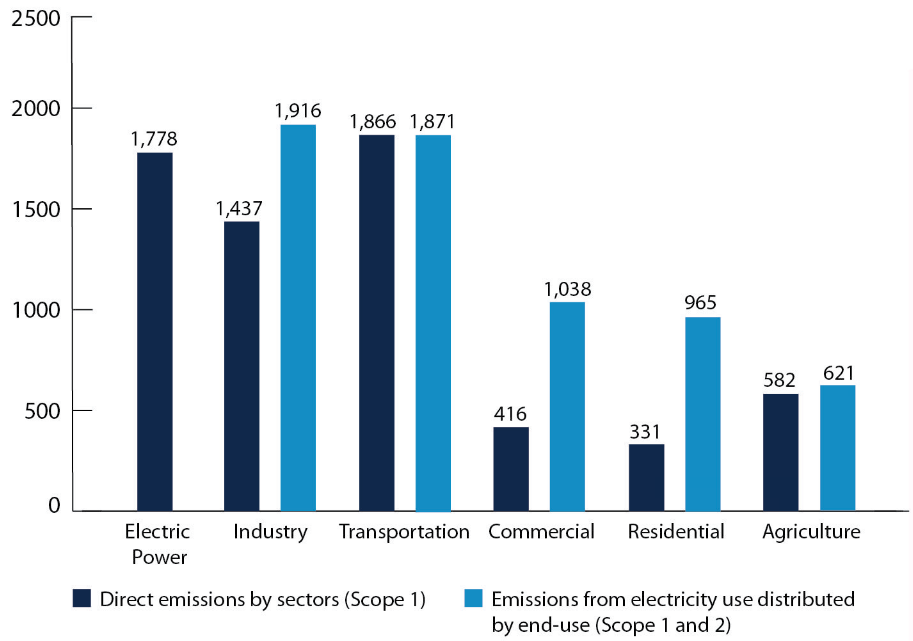
TERM	DEFINITION
Scope 1 Emissions	Direct emissions from owned or controlled sources
Scope 2 Emissions	Indirect emissions from generation of purchased energy
Scope 3 Emissions	All indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions
Product Life Cycle Emissions	All emissions associated with the production and use of a specific product, from cradle to grave, including emissions from raw materials, manufacture, transport, storage, sale, use, and disposal
CO2 Equivalent (CO2e)	A quantity of GHG can be expressed as CO2e by multiplying the amount of the GHG by its GWP (see below).
Global Warming Potential (GWP)	How much energy the emissions of 1 metric ton of a gas will absorb over a given period of time (usually 100 years), relative to the emissions of 1 metric ton of carbon dioxide (CO2). The larger the GWP, the more that a greenhouse gas warms the Earth compared to CO2 over that time period.

Sources: Greenhouse Gas Protocol, Ecometrica, and U.S. Environmental Protection Agency

Direct industrial emissions represent 22% of GHG emissions in the U.S.[16] and 24% globally.[17] However, if both direct emissions and indirect emissions are taken into account, the industrial sector represents the largest source of greenhouse gas emissions in the U.S.—1,916 million metric tons (MMT) of CO2e, or 29% of the U.S total in 2017 (see Figure 3).[18] Comparisons of value chain emissions can be challenging because accounting and reporting remain inconsistent across industry despite growing interest among companies and investors to understand and address them.

Figure 3

Comparison of 2017 U.S. Greenhouse Gas Emissions by Sector



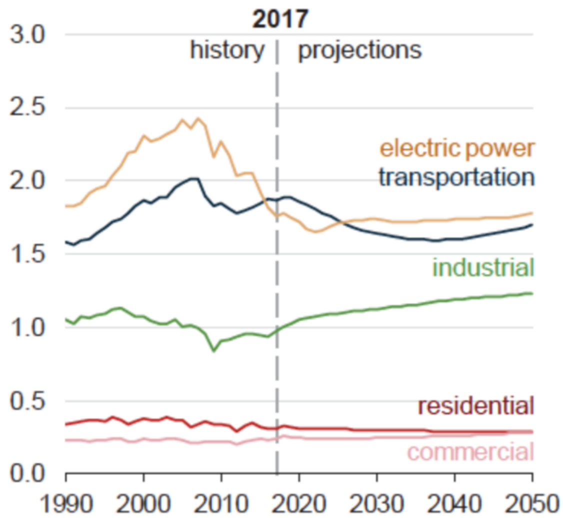
Source: U.S. Environmental Protection Agency (EPA)

Without new action, industrial emissions are projected to rise 23% by 2050.

The vast majority of direct industrial emissions are from the combustion of fossil fuels for process energy, with additional emissions from chemical reactions necessary to convert raw materials into products (such as melting iron ore to produce steel or calcination of limestone to make cement) and from the production and use of hydrofluorocarbons (HFCs), highly potent GHGs used in refrigeration, air-conditioning, aerosols, and foams. With regard to oil and gas production, the highest percentage of emissions come from methane emissions from natural gas systems.[19]

Without new action, these emissions are projected to rise. The Energy Information Administration has projected a 23% increase in industrial emissions by 2050 (see Figure 4).[20]

Figure 4
Energy-Related Carbon Dioxide Emissions by Sector (billion metric tons of CO2)



Source: U.S. Energy Information Administration

INDUSTRIAL EMISSIONS CHALLENGES AND SOLUTIONS

The industrial sector also represents one of our most complex emissions challenges. From a technology perspective, the diversity and complexity of industrial processes means there is no one-size-fits all solution. Moreover, there are currently very limited low-carbon alternatives for producing a key ingredient in industrial products: high-temperature industrial heat. In fact, 42% of industrial emissions come from combustion to produce large quantities of industrial heat for cement, steel, and chemicals.[21]

To date, the industrial sector has pursued a variety of approaches to Scope 1, 2, and 3 emissions reduction, including:

- Utilizing renewable electricity, bioenergy, or low-carbon hydrogen;
- Utilizing alternative raw materials;
- Minimizing process energy inputs and/or improving energy efficiency; and
- Integrating carbon capture utilization and storage (CCUS) technologies to offset emissions from fossil fuels.

However, even when these approaches are successfully deployed, there remains another significant challenge: There is no clear and consistent way for the market to differentiate and value low-carbon industrial products in relation to higher polluting alternatives—in other words, there is no real carbon transparency.

Today there is no clear and consistent way for the market to differentiate and value low-carbon industrial products.

Some companies and governments are seeking to assess the carbon impacts of various products and certify low-carbon and/or more sustainable industrials products and materials (see Box, Governments Seek to Buy Clean). However, global markets more broadly cannot currently access timely and accurate information about the environmental impacts associated with industrial commodities. This disconnect limits investment consistent with the scale and pace required to meet science-based climate targets and sustainable development goals.

This market challenge presents a new opportunity for industry and other climate stakeholders. The key to unlocking it will be finding innovative ways to differentiate low-carbon industrial products, drive consumer demand, and incentivize industry to accelerate emissions reductions.

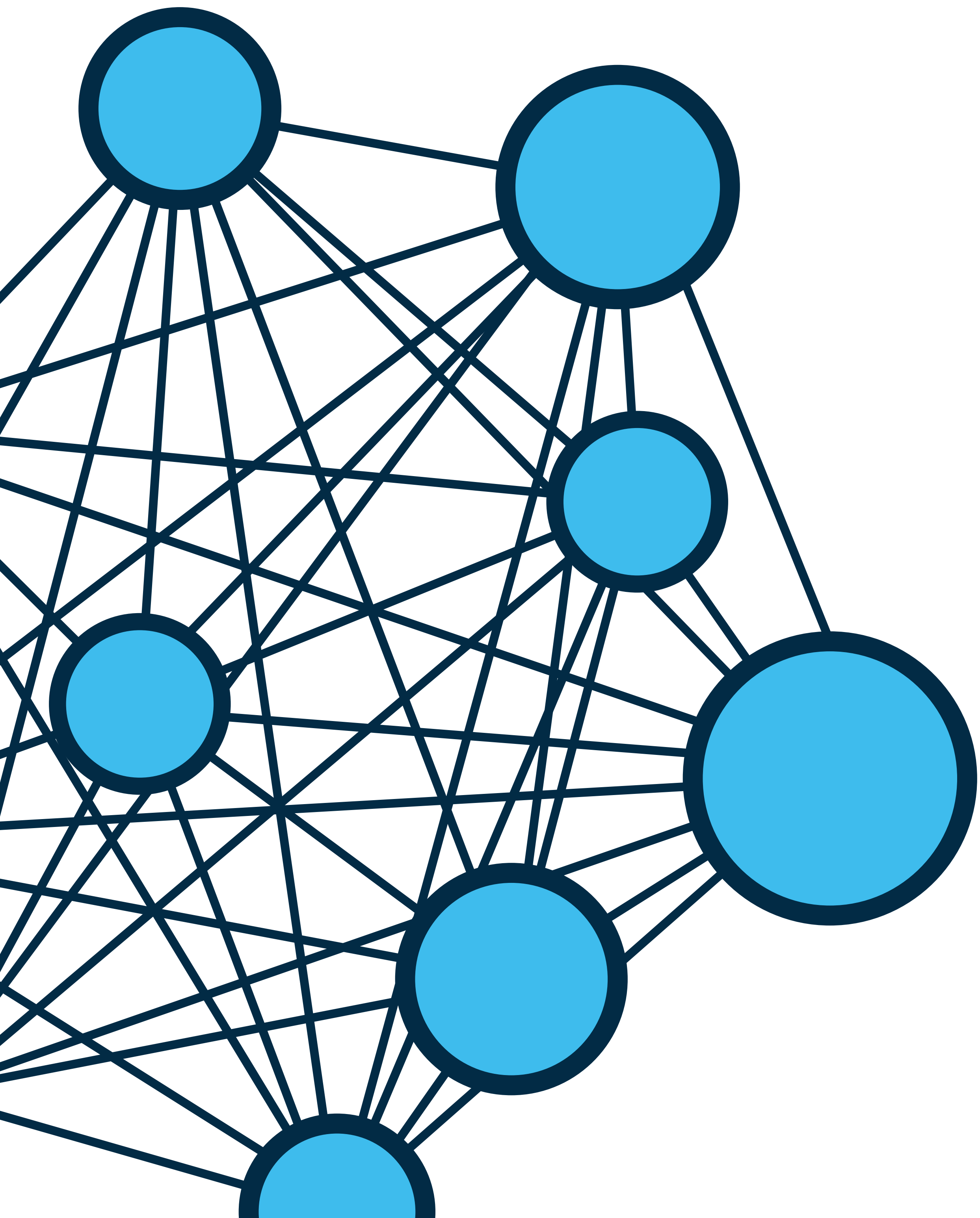
GOVERNMENTS SEEK TO BUY CLEAN

An emerging trend in government procurement has been to define and encourage the purchase of more sustainable, lower-carbon goods and services, in particular building materials and other products used in public infrastructure. Such programs are collectively referred to as green public procurement (GPP) or “Buy Clean” initiatives, and typically focus on materials such as steel, cement, asphalt, and glass.[22]

Twenty-two countries, as well as regional, state, and local government entities are developing and implementing Buy Clean programs, with the intent to improve competitiveness by attracting cleantech investment and incentivize producers of low-carbon products. Buy Clean programs typically assess the sustainability of products and services using lifecycle analysis (LCA), which examines the environmental impact of a product over its entire lifetime from production through transport, use, and disposal. Although many standards are still under development, programs often must rely on static tools and methodologies that use as inputs assumptions from regulatory reports or industrial studies[23] or data that has been directly measured but is incomplete (e.g. missing more granular process-specific or facility-specific data). In addition, LCA does not necessarily allow analysts to update inputs on a timely basis; for example, recent legislation introduced to create a U.S. Federal Buy Clean standard recommends updating environmental impacts every five years[24] —a timeframe during which significant emissions changes may occur but would not be captured by the LCA results.

Conversely, a market with full information—and by extension full investor confidence—will require Buy Clean programs to go further, incorporating a more accurate, real-time, trustworthy version of carbon transparency. Improved measurement, reporting, and verification (MRV) that leverages data and emerging digital technologies has the power to radically transform both public and private procurement of low-carbon industrial products.

THE PROMISE OF DIGITAL MRV



MEASUREMENT, REPORTING, AND VERIFICATION SYSTEMS TODAY

Measurement, reporting, and verification (MRV) systems, also known as evaluation, measurement, and verification (EMV), have been used for decades to assess compliance with energy efficiency programs and emissions reduction requirements and goals.

Generally, there are two components of MRV: 1) the technical component, defined as what is being measured; and 2) the contextual component, defined as how the measurement is used in a regulatory or investment context.

MRV today faces a variety of challenges that can affect both of these components and create uncertainty for consumers, investors, and governments. These challenges fall into two categories: data access and data contextualization.

MRV today faces a variety of challenges that create uncertainty for consumers, investors, and governments.

Data access begins with what is collected. Hardware and software—specifically sensors, communications capabilities, and cloud data storage—have grown significantly in recent years. However, not all industries and companies have deployed the hardware and software necessary to collect the quantity and quality of data necessary to assess the climate impact of its products. A recent survey of manufacturing professionals found that nearly half (48%) still rely on manual data inputs in spreadsheets and only 40% are collecting data through remote sensors.[25]

In some cases, companies have collected robust data sets, but they are locked within legacy systems and cannot be easily accessed or transmitted. Updating or replacing obsolete systems—or switching to new vendors or platforms—can be costly, and rarely are economic incentives clear.[26] Fears about data privacy and security—whether legitimate concerns or misconceptions about how technologies work—also creates barriers for companies.[27] Even companies that have implemented state-of-the-art, cloud-based systems often consider much of their data confidential business information and therefore are hesitant to allow access by consumers, investors, and governments.

Some companies have sought to address these issues by developing new, open source data tools. The Swedish construction company Skanska has partnered with Microsoft and others to launch the Embodied Carbon in Construction Calculator (EC3), a free, cloud-based, open source tool which gives buyers of building materials key emissions information they can use to make more informed purchasing decisions.[28] Salesforce has also launched a new carbon accounting product called Sustainability

Cloud, which leverages data sets from federal agencies like the U.S. EPA and intergovernmental bodies like the Intergovernmental Panel on Climate Change (IPCC). This system allows businesses to "track, analyze, and report reliable environmental data to help them reduce their carbon emissions."[29]

Similarly, in 2019, the U.S. government enacted the OPEN Government Data Act, which intended to improve public access and usability of government data. The new law requires government data to be machine readable and maintained in an "open" format not subject to licensing.[30] Although some environmental data sets are already in open formats, Federal agencies have only just begun to assess how to modernize MRV systems, and mandates in the law are currently unfunded.[31]

Investors seeking to assess environmental, social, and governance (ESG) attributes are faced with dozens of inconsistent standards.

Data contextualization is perhaps an even more complex issue. A critical issue for every industry is the need to establish data collection, formatting, and quality standards. Currently, there is no common or shared context for what sustainability or climate-related impacts of a given commodity or commercial activity means. Subjectivity and bias (intended or unintended), workforce training and knowledge, and resource intensity, i.e. the ability of companies to handle the volume of data in a timely manner, can all contribute to inconsistencies in data contextualization.

One well-documented result is that investors seeking to assess the environmental, social, and governance (ESG) attributes of companies are faced with dozens of inconsistent standards (see Box, The Many Faces of ESG). Moreover, in the U.S., the Securities and Exchange Commission (SEC) requires public companies to disclose climate risk, but companies are responsible for devising the standards by which they measure these risks. A recent paper found that in some cases, companies may use the SEC disclosures to minimize the impact of greenhouse gas emissions data they have reported under a different government requirement, the U.S. Greenhouse Gas Reporting Program (US GHGRP).[32]

The GHG Management Institute has also evaluated the ongoing growth (amount of data) and granularity of data sets (international, national, regional, state, and local; Scope 1, 2 and 3) related to greenhouse gas emissions. The group concluded that the limited number of experts combined with insufficient training and skills represent a significant limitation for stakeholders to process, contextualize, and use this data.[33]

A new digital version of measurement, reporting, and verification (Digital MRV) that leverages the growth in digitalization by collecting, storing, sharing, and securing key environmental data has the potential to address these challenges in significant ways and become an imperative for both industry and government.

THE MANY FACES OF ESG

The process of assessing environmental, social, and governance (ESG) performance has become central to identifying high-impact opportunities for climate action and business growth. An aggregate of more than 2,000 empirical studies related to ESG and financial performance gave evidence that ESG investing establishes long-term strategic benefits to firms.[34] In terms of mainstreaming ESG into conventional financial portfolios, researchers from MIT Sloan found that "an estimated $30 trillion of assets are invested worldwide that rely in some way on ESG information, a figure that has grown 34% since 2016."[35]

Demand for sustainable asset classes has created a "hyper-competitive landscape for ESG rating systems" and resulted in a multitude of different, competing standards that make it difficult for investors to make apples-to-apples comparisons.[36] In addition, methodologies behind various standards are often considered proprietary, which both stymies corporations attempting to improve their performance as well as investors seeking to make informed investments.[37]

This overall lack of uniformity often results in a company carrying vastly divergent ratings from different rating agencies simultaneously, with biases in favor of larger companies and companies with headquarters in certain geographies (such as Europe).[38] With no auditing process to verify reported data, investors are left to trust information that is subjective and far from trustworthy.

Without reform, the future of carbon transparency will be decidedly murky. But companies and investors can close the gap that exists between intention (goals to meet climate commitments) and action (executing on those commitments) by replacing inconsistent ESG systems with Digital MRV systems that use real-time, verified data to objectively quantify emissions and other environmental attributes.

KEY PRINCIPLES OF DIGITAL MRV

Digital measurement, reporting, and verification (Digital MRV) systems have the potential to significantly improve on current MRV systems today—and help turn carbon transparency into market-driven climate action.

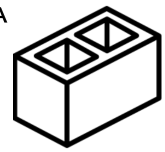
Digital MRV systems can securely collect, store, and share real-time data regarding emissions and other environmental attributes that can help give consumers, investors, and governments a more complete, timely, credible, and trustworthy assessment of the climate impact of a particular product, facility, or company (see Figure 5). Such assessments are critical for taking action on the investments and policy necessary to create markets for low-carbon products and ultimately accelerate emissions reduction.

Digital MRV systems can help turn carbon transparency into market-driven climate action.

Figure 5

Differentiation of Commodities with Digital MRV

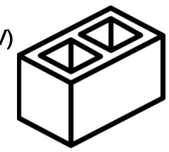
Product A (Today)



Basic data expected by the market	Sustainability information*
• Performance specifications • Region where it is manufactured • Legal and warranty information • UL or similar certifications	o Scope 1, 2, 3 and/or LCA information (if any) o ESG rating (if any)

*Static, imperfect information and assumptions with limited usefulness for consumers, investors, and government

Product B (Digital MRV)



Basic data expected by the market	Sustainability information*
• Performance specifications • Region where it is manufactured • Legal and warranty information • UL or similar certifications	✓ Full attributional profile, including materials and inputs used in production and their environmental impacts ✓ CO2e emissions for Scope 1, 2, and 3 based on timely and verified data, including for raw material acquisition, production and distribution, transportation, and packaging ✓ Additional environmental impacts based on timely and verified data, such as water use and land impacts ✓ Standardized, uniform ESG rating that can be used to compare similar products

*Real-time, dynamic information with high value for consumers, investors, and governments

Source: EC-MAP

Digital MRV can help turn environmental attributes into assets valued both for government compliance and in the market. The availability of trusted, real-time information could also help accelerate dynamic policymaking and enable common standards that better enable the market's "digital invisible hand"[39] to steer towards a net-zero carbon society. However, realizing the promise of Digital MRV will require adherence to five key principles:

- Transparency: The ability for consumers, investors, and governments to access machine-readable, open source data in real time.
- Accuracy: The ability for consumers, investors, and governments to trust the validity of the data they are accessing.
- Replicability: The ability for consumers, investors, and governments to compare similar products, facilities, and companies based on an accepted set of standards and practices that contextualize the data.
- Predictability: The ability for consumers, investors, and governments to more accurately forecast future scenarios (and potentially implement updated policy and regulation) based on analysis by automated or AI systems that are inherently more robust than human analysis.
- Interoperability: The ability for data (including metadata, ontologies, and vocabularies for the description and organization of data)[40] to be shared across systems regardless of geographic boundary, vendor, or organization and for Digital MRV systems to evolve with future technology.

These principles can serve as a point of departure for developing Digital MRV systems, including the robust physical infrastructure to collect, store, and share data as well as consistent standards for data contextualization. Several are already being implemented as companies and investors seek to define and market low-carbon industrial products (see Box, The Future is Now: Building Markets for Differentiated Commodities).

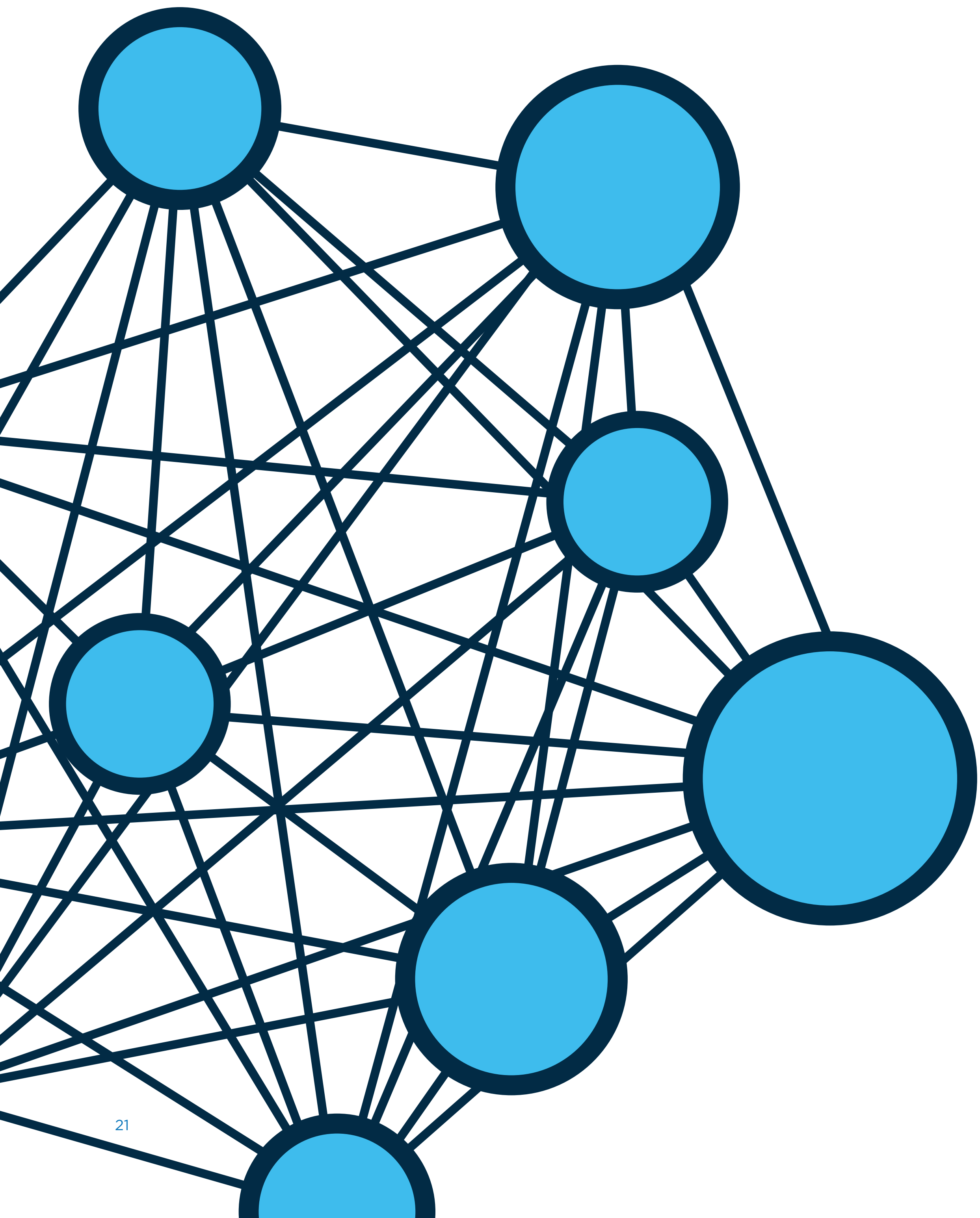
THE FUTURE IS NOW: BUILDING MARKETS FOR DIFFERENTIATED COMMODITIES

Although commodities are often thought of as inherently fungible and static, the reality is that industrial commodities vary widely in terms of their lifecycle environmental footprint. The source of raw materials, production configuration and process efficiency, and the characteristics of a given supply chain all impact a product's environmental profile. For example, before oil is refined into gasoline, plastics, and other finished products, the embodied carbon in a particular barrel of crude oil can vary by up to 80% depending on its origin, how it is produced, and how it is transported to for refining.[41] Similarly, a unit of natural gas produced using tight emission and methane controls will have a far lower carbon intensity profile compared to natural gas produced using limited controls.

One company seeking to illuminate these differences in the market is Xpansiv CBL Holding Group (XCHG). XCHG is a data refinery—a company that filters and processes raw data to create valuable information that enables commodity differentiation. XCHG processes real-time commodity production data using AI-enabled systems to create what the company calls "Digital Feedstock," a secure digital asset that contains an accurate, verified profile of the lifecycle environmental characteristics of a given commodity. The company leverages the power of remote sensing, digital monitoring, deep learning, and a distributed ledger platform (i.e. blockchain technologies) to reveal the specific environmental attributes (e.g. GHG intensity, water use, land disturbance) that differentiate a low-carbon commodity from a higher polluting alternative. These digital assets enable the market to more accurately contextualize environmental data and potentially accelerate procurement decisions aligned with sustainability and climate goals.

XCHG also owns CBL Markets, the leading environmental spot exchange where buyers and sellers can participate in the emerging marketplace for differentiated commodities. XCHG is engaged with producers and standards organizations across multiple sectors to generate and transact certified digital assets tagged to commodities produced with low-carbon intensity and other ESG attributes, including sustainable aviation fuel, low-methane-emissions natural gas, and low-carbon cement.

INDUSTRIAL COMPETITIVENESS AS CLIMATE COMPETITIVENESS: HOW DO WE GET THERE?



KEY BARRIERS

Digital MRV has the potential to improve industrial competitiveness while creating a new category of differentiation: climate competitiveness. However, as described above, to achieve this promise, stakeholders must address a variety of technical, market, and policy barriers. Table 2 summarizes key barriers to implementing Digital MRV to drive emissions reduction.

TABLE 2: KEY BARRIERS FOR DIGITAL MRV

Key Barriers for Digital MRV		
Technical Barriers	**Market Barriers**	**Policy Barriers**
• Digital technologies are nascent. **Use cases and implementation issues** are not yet well understood by key actors, including many industrial companies which will be responsible for deploying them. • Legacy systems that operate on **outdated standards and protocols** can create barriers for first movers seeking to implement Digital MRV. • Companies and governments often collect and store data in **proprietary formats**.	• There are currently **no uniform standards** for benchmarking or rating the emissions impact of industrial products. • Companies are legitimately concerned that historically invisible environmental data will reveal **confidential business information**. • There are **few incentives or requirements** for companies to make data accessible or use it to differentiate their products. • No one has yet **quantified the market opportunity** for low-carbon industrial products.	• There are **few forums for stakeholder education, discussion, and collaboration** across climate and data sectors. • **Open access to government data** is a work in progress. • Governments are significant buyers of industrial products, but there are limited/ nascent **incentives or requirements for government procurement** of low-carbon industrial products. • The necessary **legal frameworks** for low-carbon industrial product certificates that could drive investment have not yet been developed. • **Cybersecurity and data privacy regulations** are nascent and must be adopted in a manner that protects consumers but does not stifle the promise of Digital MRV.

RECOMMENDATIONS FOR ACTION

EC-MAP and our partners have identified three areas for near-term action: 1) Cross-Sector Stakeholder Engagement; 2) Research Agenda; and 3) Policy Development. Each of these seeks to address barriers described above.

1. CROSS-SECTOR STAKEHOLDER ENGAGEMENT

Critical to the success of Digital MRV will be discussion and dialogue across multiple sectors, specifically heavy industries that will deploy Digital MRV systems; internet and communications technology providers that offer Digital MRV hardware, software, and systems; customers for industrial products (individuals and organizations—including governments) that procure industrial commodities; and investors seeking to better quantify and understand climate risk.

Critical to the success of Digital MRV will be discussion and dialogue across multiple sectors.

Stakeholders should develop forums for these critical players to engage in discussion about education and communications around Digital MRV; sharing of use cases and best practices to date; development of standards and methodologies for data contextualization; and recommendations for policy development and governance. Such forums should bring together buyers and sellers across commodity value chains with industry; data scientists; digital platform technology partners; energy, climate, financial policymakers; standards bodies; and other technical experts. Together these stakeholders can build upon and convert existing standards, metrics, and methodologies into uniform digital standards and benchmarks, as well as explore use cases, pilot projects, and new market applications to align with customer demand.

2. RESEARCH AGENDA

Additional research and surveys can help stakeholders better quantify the opportunity for Digital MRV to drive industrial emissions reduction; illuminate the current state of technology deployment and key barriers; and inform policy discussions and the role of government in supporting Digital MRV. Stakeholders should support development of research focused on topics such as:

- Quantifying the overall market for low-carbon industrial products and market potential for specific products.
- Identifying and assessing current approaches to Digital MRV and best practices for turning the key principles described above into actions that can be taken by consumers, investors, and governments.
- Identifying and making accessible a database of Digital MRV use cases and/or pilot programs currently undertaken by industry and governments.
- Assessing the implementation of the OPEN Government Data Act and outstanding policy or funding gaps.

3. POLICY LEADERSHIP

Policymakers are seeking new ideas for climate policy with renewed urgency. Stakeholders should seek to educate and build policy champions for approaches that leverage the promise of digitalization to transform carbon transparency and incentivize action by consumers, investors, and governments to accelerate emissions reduction.

With the continued deployment of internet-connected computers and devices that gather and analyze data, perform complex operations, automatically adapt based on experience, and communicate with other similar systems, there are potentially vast opportunities to transform the regulatory frameworks that promote climate responsiveness.[42] Defining and prioritizing the most effective approaches and activities represent a significant need and undertaking for policymakers and other stakeholders.

EC-MAP seeks to ensure that this decade's emerging climate policies have a digital architecture—one that enables more nimble and responsive governance models as well as frameworks for markets to drive decarbonization from the bottom up. Stakeholders should consider:

- Briefing series for Federal and state policymakers focused on digitalization, carbon transparency, and implementing Digital MRV.
- Development of a cross-industry coalition(s) to educate and advocate for digital climate policy.
- Building expertise among existing caucuses and/or building a new bipartisan, Digital Climate Policy Caucus for policymakers to learn and lead on these issues.

In addition, stakeholders should consider the development of bipartisan, consensus legislation to define the Federal government role in leveraging digital technologies to drive carbon transparency and demand for low-carbon industrial products. Such legislation may include provisions related to:

- Ensuring relevant government databases are accessible to the public.
- Assessing how existing government databases can help address gaps in data needed to differentiate industrial products.
- Incentivizing reporting of data needed to differentiate industrial products (e.g. as part of existing voluntary GHG reporting or through financial regulation).
- Accelerating efforts to expand open access to high-value energy and environmental datasets.
- Developing standard methodologies for defining industrial product categories and measuring environmental attributes of industrial commodities.
- Incentivizing the adoption of standards by regulatory agencies.
- Establishing legal frameworks for clean product certificates.
- Developing heightened public, hybrid, and private governance mechanisms to regulate equitable open access to data and to reduce or avoid biases in public data used as inputs to algorithms.
- Establishing a "Buy Clean" procurement program for government agencies.

Stakeholders should develop bipartisan, consensus legislation to define the Federal government role in leveraging digital technologies to drive carbon transparency and demand for low-carbon industrial products.

CONCLUSION

Climate change is a systems problem; climate solutions require a systems architecture. The growth in decision-useful data and deployment of digital technologies present a new opportunity to accelerate reductions in the climate impacts of industrial processes and products. With the right policy and governance framework, transforming data transparency and uniformity in data contextualization can accelerate the complex yet critical task of industrial decarbonization. EC-MAP will continue working with its partners and allies to explore, educate, and promote new ways to convert carbon transparency into robust, market-driven climate action.

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