ASSET-LEVEL DATA AND CLIMATE-RELATED FINANCIAL ANALYSIS: A MARKET SURVEY

2° Investing Initiative

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EXECUTIVE SUMMARY

The need for climate-related financial data. Policy processes across a range of countries (e.g. France, Switzerland, China, etc.), and at international level (e.g. G20, FSB Task Force on Climate-Related Financial Disclosures (TCFD), EU Non-Financial Reporting Directive) stress the importance of transparency on climate-related data and performance indicators in financial markets and public policy. At the same time, data completeness, quality, and consistency, notably the issue of non-disclosure (Fig ES-1), have emerged as key limiting factors in current climate-related assessments by investors, such as portfolio carbon footprinting (Kepler-Cheuvreux 2015).

Asset-level data: The solution? Some experts have questioned whether existing asset-level and market intelligence databases may hold the key to solving these issues, since they possess many of the characteristics necessary for climate-related assessments (Fig ES-2; 2ii and Oxford 2016; Caldecott & Kruitwagen 2016):

- **Geographic and technological detail**: Data are often geolocated—which is critical for assessing physical risk and country-level transition risks and policies—and also available with technological and economic detail in most sectors;
- **Completeness and consistency**—Due to their sources (see Section 3.2), such data are often universal or near-universal in coverage, eliminating non-disclosure bias and providing consistency across companies.
- **Forward-looking**: In some sectors, capital plans (i.e. planned assets) can help to show not only where a company is today but also its future capital planning, allowing forward-looking scenario analysis.

However, currently a significant information gap exists in the market on what data are already available and how they can be utilized by ESG data providers, investors and financial institutions, policymakers, and the broader public. Currently such climate data users must spend considerable resources seeking out data providers, reviewing sales pitches, etc. and may still miss the data most pertinent to their needs.

Report preview. This report surveys the current state of asset-level climate data in 9 sectors to fill this void. While only a sample of existing data across 9 climate-relevant sectors (see pg. 9-10), it answers critical questions like:

- Which climate performance data are already available in the market for the most important climate related sectors? (Sections 3.1-3.3)
- What are the key underlying sources for this data and what are the implications for data quality and reliability (Sections 3.1-3.2)?
- What are the key barriers for financial institutions and policymakers in terms of access (Section 4.3)?
- What is the way forward to create comprehensive and cost-effective access to climate data (Section 4.4)?

FIG. ES-1: CDP SURVEY RESPONSE RATE FOR GLOBAL SAMPLE (SOURCE: CDP 2016a)

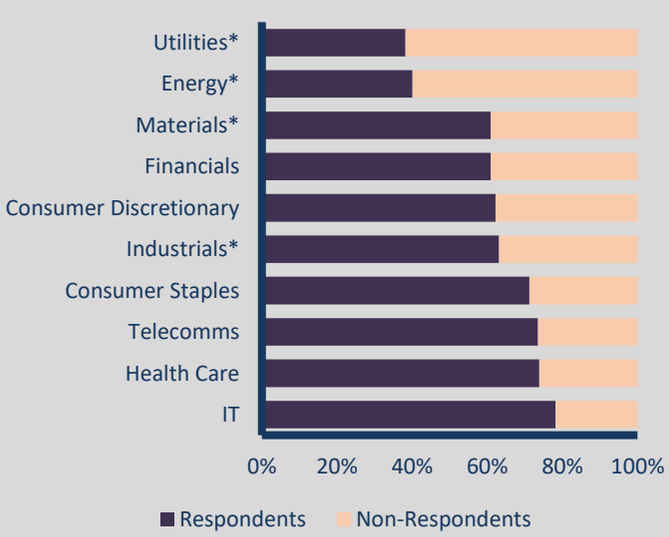


FIG. ES-2: NECESSARY DATA CHARACTERISTICS FOR CLIMATE AND ESG ASSESSMENTS (SOURCE: AUTHORS)

1. **Geography-specific:** Exposure to different national policies, markets, and physical risks.
2. **Forward-looking:** Exposure to future trends rather than past performance.
3. **Complete:** Global industrial coverage if possible.
4. **Disaggregated**: Nuanced at technology, cost, product class, etc. levels
5. **Practical**. Cost-effective and easily integrated into existing tools and analysis.

3.2

What is asset-level data (Section 3.2)? Although different terminology with different meanings can be found (asset-level data, industry data, market intelligence data), in this report we define asset-level data as any type of quantitative or qualitative information regarding physical assets (tangible assets of economic value), including their characteristics/attributes, their ownership, and their operation. From a climate/energy and environmental risk standpoint, such assets can include energy producing assets (e.g. oilfields), stationary GHG emitting assets (e.g. power plants, cement plants), mobile GHG emitting assets (e.g. aircraft, vehicles), and infrastructure assets (e.g. airports, highways). Data about such assets is gathered in three primary ways: private data collection by industry groups, government surveys and statistical efforts, and by commercial data providers.

3.3

Where does asset-level data come from and who uses it Section 3.3)? As companies are the owners of a large majority of such assets, they are the primary data source of most asset-level data, which can be gathered by database providers through (in order of prevalence) web crawlers/press releases, government statistics and regulatory processes, surveys/meetings with companies, industry associations and sources, modeling/estimation, and corporate reporting. Traditionally commercial asset-level data is sold to and utilized by (in order of prevalence) industry companies, industry-focused financial institutions and investors, industry suppliers and consultants, and to a lesser extent governments and researchers. ESG data providers have not historically utilized asset-level data, focusing instead on corporate reporting, but interest is growing among some.

3.4

What type of information is available for different sectors (Section 3.4)? The following page and Table 3.2 in the report summarize key data available in asset-level databases for energy transition sectors. While industries (and thus available data) vary, databases generally databases track asset attributes such as location (often geolocational), age, technology/fuel type, production capacity, and in some sectors estimates of operational cost. Such data are usually available for both existing and planned/under construction assets, allowing forward-looking assessments. Notably lacking in many databases are emissions and ESG-relevant information, although ESG-focused asset-level data providers have emerged recently in some sectors (shipping, real estate), such information is privately collected in other sectors (steel, cement), and mandatory GHG reporting programs already collect over 11% of global GHG emissions (Table ES-1, pg. 21).

3.5

How are assets matched to companies and securities (Section 3.5)? Due to complex corporate structures in some sectors, a key question regarding asset-level data is the ability to connect assets to their owners and the ultimate parent company exposed to the local operating company. While knowledge of asset-level ownership and the ability to "roll up" exposures to ultimate parents can help to eliminate a key uncertainty in corporate GHG accounting (variable consolidation approaches, see pg. 23), only some (17 of 26) reviewed databases connect assets to ultimate parents. Further, only a smaller minority of providers (7 of 26) go the next step to connect parents to financial security identifiers (e.g. equity tickers, FIGIs/ISINs), a prerequisite for portfolio analysis usage.

3.6

How do users access asset-level data (Section 3.6)? Due to their high fixed costs and need for data security, the majority of asset-level commercial data providers currently operate on a subscription/license model granting users access to global asset-level data as well as market analysis and in some cases consulting services. Unfortunately, many users (diversified investors, sell-side research, government) often do not need such detail for all assets, instead focusing on a specific region, market, or set of global parents (e.g. utilities they own equity in). Serving such users would require high transaction cost/high volume product offer, one that roughly half of surveyed providers have attempted in some form (Fig 3.9). Interviews suggest such 'custom extracts' are a small portion of the current market.

FIG ES-3: COMMERCIAL ASSET LEVEL DATA AVAILABILITY ACROSS KEY ENERGY TRANSITION SECTORS

AUTOMOTIVE. Generally current and forecasted production data are available at detailed make/model level by region and in some regions by plant. Sales data and current fleets (i.e. registrations) are available for some regions, requiring fleet/survival curve models to assess current fleets globally. Fuel economy data are available but are generally limited to EU/USA and may be inconsistent due to different testing cycles used in these regions (ICCT 2014).

AVIATION. Asset-level airport and aircraft (existing and order book) data are widely available including details on seats/cargo space, engine type, and age/use cycles. Fuel consumption is generally not known, requiring modeling to assess energy use/emissions. Aircraft classes, but not individual aircraft, can be matched to specific airport to airport routes. Aircraft valuation models are available for financial analysis.

CEMENT. Most data is private, with only limited technology details (dry vs. wet kiln, clinker and/or cement capacity) and location known. Production levels are generally not available. Fuel type is known for some plants, allowing emissions estimates. Given the expense of plant-level data procurement, data are not generally available in machine-readable formats.

COAL MINING. Mine-level production and reserves data are available for almost all developed country mines, with gaps in developing nations (China in particular). Mines are geolocated and often matched to purchasers (power plants, steel plants, etc.) with contractual data. No emissions data are widely available.

IRON & STEEL. Substantial technical detail (capacity, equipment detail) is available by process (iron and steelmaking, finishing, sintering, etc.) for existing plants and to some degree planned plants. Plants are mapped to city/country but not geolocated. No emissions data are available except in privately held data from WorldSteel.

OIL & GAS. Field, lease, and well-level data are available for a nearly universal sample of existing and planned oil & gas fields worldwide. Current production, reserves, and production forecasts are available along with mostly estimated financial data (e.g. production costs). Emissions estimates are available from third party sources (Carnegie 2016; EPA 2016) but are not generally linked to commercial databases.

POWER GENERATION. Plant and generator detail by fuel and technology are available for existing and planned assets. Capacity is universally available but production is not always available or is estimated. Some providers offer CO_2 emissions estimates (e.g. EnerData) but most have only limited information on air pollution (e.g. SO_2) control technology. Limited data are available on power purchase agreements.

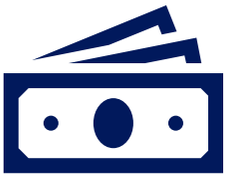
REAL ESTATE. Asset-level detail is available for buildings held and planned by real estate funds but is not universally available for all buildings. Energy use and emissions data are available for limited subsets from mandatory and voluntary reporting programs (below and pg. 21).

SHIPPING. Asset details (size/weight, engine type) are available for nearly all commercial ships globally, and geolocated route data from AIS (automatic identification system) are available for most in-use ships. Emissions estimates are becoming available, based either on AIS tracking data or ship attributes, though planned ships (order books) are more difficult to estimate.

TABLE ES-1: ASSET LEVEL ENERGY USE AND EMISSIONS DATA AVAILABILITY

Country	Number of Assets	Total GHG Emissions (Mt CO_2e)	Fraction of total GHG emissions	Company	Location	Sectors	Sector code
Australia	356	178	27%	Operator	State	Power	NA
Canada	574	264	37%	Operator	Lat/Long (96%)	See Annex 2	NAICS
EU	9941	1671	38%	Operator	Country	See Annex 2	IPCC Category
USA	8229	3033	49%	Parent	Lat/Long (99%)	See Annex 2	IPCC Category and NAICS
Cities	>66,000	NA	NA	Asset only	varies	Real estate	NA

Key challenges to overcome. The data availability and accessibility discussed above shows several key strengths of using asset-level data for climate analysis, notably the high level of detail, geographical specificity, forward-looking capital plans, and universal coverage. However, key challenges also emerge:

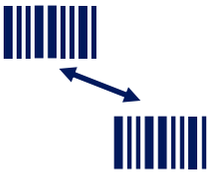


Cost. Most investors and ESG data providers (see pg. 18) report that the cost of asset-level databases are a major barrier to use. While any single industry database's costs may be manageable, the need to assess ESG- and climate-related issues across ***all*** (or at least all material) sectors makes purchasing high-resolution data for each sector cost-prohibitive. Search costs and training time compound these issues. This naturally leads to the desire for a single cross-industry solution (e.g. ESG scores, portfolio carbon footprint) that can achieve broader coverage of a diversified portfolio, even if the level of detail is not as high.

Asset Emissions/ESG Information: In general, asset-level databases were not designed for ESG and climate-related analysis and past/existing clients do not demand such information from commercial data providers. Thus, despite their increasing availability, asset-level emissions and ESG information are not broadly linked to commercial databases. The growth of asset-level data providers with some ESG focus (pg. 22) shows that at least some market players believe that adding such information could create a competitive advantage, but this is not yet widespread in the market intelligence data provider world.

Context: To be relevant for most analysis needs, asset-level data is not sufficient—it must be coupled to forward-looking transition/climate scenarios as well as company-level context on strategy, R&D, market positioning, and so on. Much of this data is in narrative form and disclosed by companies via traditional corporate disclosure channels (e.g. annual reports) or produced by investment and ESG research groups. Most asset-level data providers do provide analyst opinions and market research along with data, but this analysis may not always meet the needs of ESG-focused investors, regulators, etc.

Consolidation: In most cases, financial institutions invest in companies, not assets (exceptions are clear in private equity, project finance, etc.). Thus, these users require consistent ways to match individual physical assets to operating companies and the ultimate parent companies who own them at group level. Complicating the situation is the variability of consolidation rules applied in both financial and non-financial accounting practices (see pg. 3.8). While some asset-level data providers offer pre-consolidated (i.e. aggregated to ultimate parent) or information to perform consolidation (e.g. operating company-parent matching), this is not universal and requires further time and effort.



ID matching. Due to proprietary data standards for financial securities and lack of demand from industry users, many asset-level databases do not provide identifiers allowing users to match assets to financial securities. This in turn prevents financial institutions from directly assessing asset-level exposures with financial portfolios.

The Transition Capital Monitor: a long term vision for climate and financial data (Section 4.3). In the medium to long term, achieving the goals of the Paris Climate Agreement and monitoring climate-related risks will require a more permanent and systemic system tracking progress in both physical and financial terms. This envisioned system, a "transition capital monitor", represents a long term vision for how asset-level data could help to systemically track climate policy and energy transition progress:

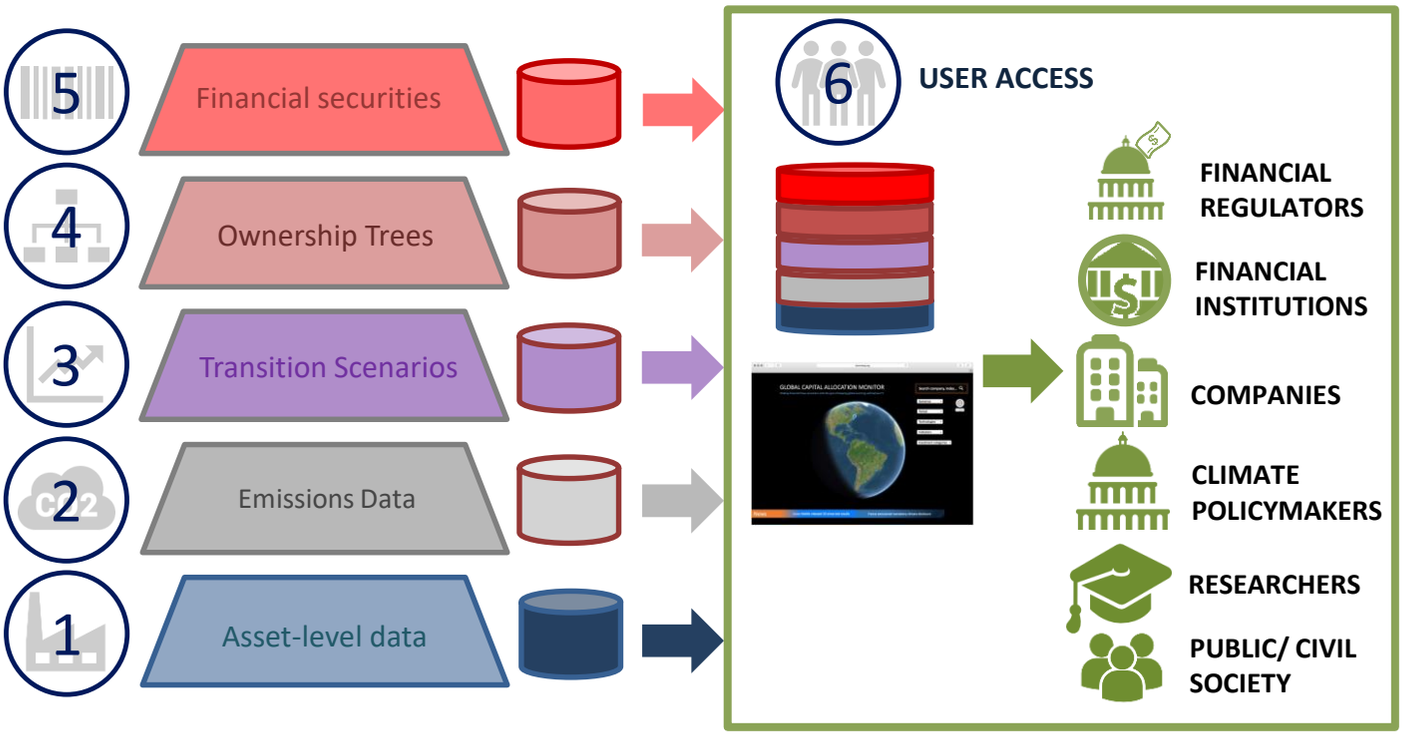


FIGURE ES-3: PROPOSED "TRANSITION CAPITAL MONITOR" (SOURCE: AUTHORS)

ASSET LEVEL DATA. Harnessing data across sectors on existing and planned assets with both activity (e.g. production) and ownership data would allow systematic tracking of climate policy goals by industry, country/region, and non-state actor (company, locality, individual, etc.) as well as physical climate risk exposure via geospatial analysis.

GHG EMISSIONS DATA. A key component of climate progress tracking and transition risk assessment is the gross GHG emissions and emissions intensity (e.g. CO_2/MWh, CO_2/ton) of assets. Such data could be sourced from voluntary (pg. 16) and mandatory (pg. 21) reporting programs or estimated at asset-level and verified at company level (following similar consolidation approaches).

TRANSITION AND CLIMATE SCENARIOS. Understanding transition risk and assessing climate policy progress requires forward-looking scenarios capturing alternative futures for climate change and energy systems, including needs for R&D and innovation. However, such scenarios are not yet centralized or directly linkable to financial analysis, key areas for further research and engagement.

OWNERSHIP TREES. Connecting emissions and economic activity "on the ground" with financial markets requires consistent and transparent subsidiary-parent relationship matching, a key current limitation in both asset-level data and corporate reporting. A permanent monitor could utilize emerging open source corporate data (e.g. LEIs, see pg. 24) or commercial data.

FINANCIAL SECURITIES. Linking companies to financial security information allows the final level of usability in financial analysis, the connection to financial portfolios. As shown above, such connections are already common if not universal in commercial asset-level databases, though are severely limited in open governmental data and are not always complete.

USER ACCESS. Achieving cost-effective (possibly free for some users) and user/use-case specific access to the monitor is the key limiting factor and will likely require both new potential business opportunities for data providers and new potential research opportunities for the public, academia, and research organizations.

HOW DO WE GET THERE? NEAR TERM RECOMMENDATIONS

Achieving the vision described in the previous section is a multi-year, multi-step process, but initial steps by different actors will help achieve more cost-effective use of asset-level data in climate and ESG applications.

RECOMMENDATIONS FOR ASSET-LEVEL DATA PROVIDERS

1. MAKE ASSET-LEVEL DATA MORE USABLE FOR FINANCIAL ANALYSIS. As discussed in previous sections, for many data providers adding a range of asset attributes (e.g. open source financial and company identifiers (e.g. LEI, FIGI), ultimate parent company, geolocation, age) elements, where possible, will greatly enhance the usability for financial and climate/ESG assessments.

2. CONSIDER CUSTOM ASSET EXTRACTS. While transaction costs and fixed costs will limit this in some cases, developing sub-global product offerings may open new markets for users outside the sector of focus (who may not need global coverage). Partnering with ESG data providers, researchers, and environmental authorities may provide new opportunities for collaboration.

3. INTEGRATE GHG EMISSIONS AND OTHER ESG INFORMATION WHERE RELEVANT. While the market may be limited currently, climate policy, the energy transition, and climate change itself are likely to make such asset attributes a competitive product differentiator.

RECOMMENDATIONS FOR ESG DATA PROVIDERS AND RESEARCHERS

1. CONSIDER ASSET-LEVEL DATA FOR KEY MATERIAL SECTORS. The strengths of asset-level data, particularly coverage for poorly disclosing entities and ESG outlier assessment and forward-looking capital plans, strongly suggests a use case for forward-looking analysis and ratings.

2. DEVELOP RESEARCH COLLABORATIONS TO CLOSE EXISTING GAPS. The combined financial sector and ESG expertise of ESG providers represent a unique skill set for the use cases described above, and new collaborations may emerge in the near future with academia, environmental regulators and agencies, and NGOs. A particular focus could be open source matching from government emissions and asset data to issuers and voluntary disclosure data (e.g. CDP).

RECOMMENDATIONS FOR GOVERNMENTS AND DISCLOSURE ORGANIZATIONS

1. ENCOURAGE ASSET- AND CORPORATE LEVEL DISCLOSURE WITH CONSISTENT CONSOLIDATION. As both voluntary and mandatory disclosure programs advance, ensuring their consistency will become increasingly important. Encouraging both asset- and corporate-level disclosure will maximize the key strengths of both models.

2. REQUIRE ACTIVITY DATA DISCLOSURE. Where not limited by CBI concerns, requiring or encouraging the disclosure of asset-level activity information (alongside emissions) greatly enhances the meaningfulness and usability for many use cases. Tools like US EPA's eGrid (EPA 2015) that combine both emissions and activity data are more useful than emissions data alone.

RECOMMENDATIONS FOR INVESTORS

1. EXPLORE THE USE OF ASSET-LEVEL DATA IN ENGAGEMENT. Engagement activities represent a key potential first use case for asset-level data, particularly for forward-looking engagement on energy transition plans and scenario analysis (TCFD 2016a; Ceres 2016).

2. WORK WITH EQUITY AND CREDIT ANALYSTS TO ACCESS ASSET-LEVEL DATA. Some ESG or sustainable investment officers may have indirect access to market intelligence data through analysts. This represents an important collaboration point with sector analysts.

1. INTRODUCTION

1.1 OVERVIEW

The need for climate-related data. Policy processes across a range of countries (e.g. France, Switzerland, China, etc.), and at international level (e.g. G20) reflect the importance of transparency on climate-related data and performance indicators in financial markets. The Financial Stability Board's (FSB) Task Force on Climate-Related Financial Disclosures (TCFD) has recently released their draft recommendations (TCFD 2016a). The G20 has set up a Green Finance Study Group focusing in part on climate risk. Mandatory reporting laws such as Article 173 of the French Energy Transition Law expand reporting requirements for companies and investors (2ii 2016a). At EU level, Directive on Non-Financial Reporting will be implemented at member state level in the course of 2017 and an expert group on sustainable finance has been established. Finally, the Paris Climate Agreement calls for aligning financial flows with climate goals (Art. 2.1c).

While there is a growing emphasis on climate data in financial markets, there are few comprehensive overviews of the cost and availability of investor-ready climate data. In their first report the TCFD highlighted over 400 different climate-related data standards and metrics (TCFD, 2016a), yet comparative studies have generally been limited to one reporting channel (e.g. climate data reported to CDP, Fig 1.1. and pg. 16) or broad reviews of climate metrics for financial institutions (Fig 1.1; e.g. Portfolio Carbon Initiative 2015; MSCI 2015; Kepler-Cheuvreux 2015).

Completeness and quality—can they be solved? Moreover, data completeness and quality, notably the issue of modeling for non-disclosers, have emerged as key limiting factors in current climate-related assessments by investors, such as portfolio carbon footprinting (Kepler-Cheuvreux 2015). Some experts are questioning whether existing asset-level and market intelligence databases may hold the key to solving these issues (2ii and Oxford 2016; Caldecott & Kruitwagen 2016). However, there is currently a significant information gap in the market on what data are already available and how they can be accessed. Currently investors interested in benchmarking their investees' climate performance must spend considerable resources seeking out data providers, reviewing sales pitches, etc. and may still miss the data most pertinent to their needs.

Report preview. This report assesses the current state of climate-related data, specifically focused on market intelligence and data at the physical asset-level. It seeks to answer the following questions:

- Which corporate and asset-level climate performance data are already available in the market for the most important climate related sectors?
- What are the costs for financial institutions to access this information and through what channels?
- What are the key underlying sources for this data? (e.g. CSR reports, surveys, regulatory reporting, national statistics) and what are the implications for data quality and reliability?
- What are the key barriers for financial institutions and policymakers in terms of access?
- What is the way forward to creating comprehensive and cost-effective access to climate data?

FIG. 1.1: CDP SURVEY RESPONSE RATE FOR GLOBAL SAMPLE (SOURCE: CDP 2016a)

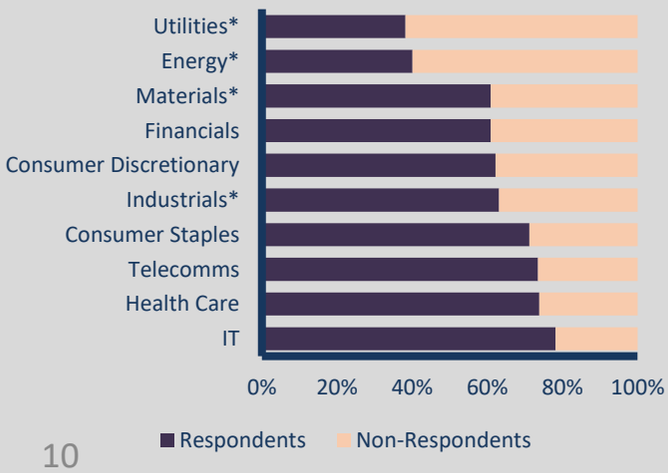


FIG. 1.2: ISSUES IN CLIMATE DISCLOSURE (SOURCE: 2II & Oxford 2016)

1. Equities Only
2. Non-reporters
3. Too Aggregated
4. No Benchmark
5. Backward-looking
6. Difficulty in tracking 'Green'

2. CLIMATE-RELATED DATA NEEDS

2.1 USE CASES FOR CLIMATE DATA

Before assessing the state of climate-related data, it is important to review why it is used in the first place and how these use cases define data needs. Key stakeholders such as the financial community and policy-makers are generally concerned with corporate climate-related data for three reasons: first, in order to assess climate-related financial risk (physical, transition, and legal risks; TCFD 2016a); second, to assess companies' contribution to the low-carbon future; and third, to support climate policy implementation (e.g. emissions trading schemes, regulations, and voluntary climate action programs) (Table 2.1). Each use case has different data needs with some commonality:

- **Physical risk.** Physical risk acts on specific physical assets (real estate, forest tracts, power plants) and can be both chronic/long term (e.g. sea level rise) or episodic/event-related (e.g. extreme weather) (IPCC 2014; CISL 2015; Mercer 2015). Analyzing its exposure requires *forward-looking* and *location-specific* information on physical assets plus adaptation and risk mitigation strategies and insurance coverage.

- **Transition risk:** Transition risk is largest in several energy producing or energy-intensive sectors (extractives, heavy industry, automotive and their low-carbon competitors; TCFD 2016a, WRI/UNEP FI 2015). Modeling transition risk requires assessing how companies perform in the transition, including their existing and planned asset characteristics and company strategy, R&D, and capex (2ii 2016).

- **Legal risk**: Legal risk is perhaps the least developed use case due to the variety of potentially impactful legal theories. Generally data needs will be qualitative and are thus outside the scope of this report.

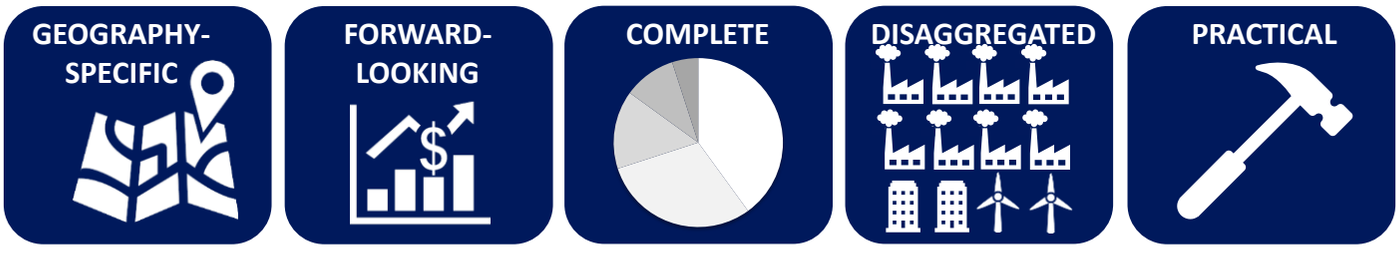
- **Climate 'contribution'/alignment with the energy transition:** The data needs for assessing climate 'contribution' are similar to transition risk plus the inclusion of other climate-relevant sectors like food, agriculture, and forestry. Data needs for physical and transition risk and climate contribution in energy-relevant sectors are discussed in this report while agriculture and forestry sectors will be covered in a forthcoming report.

TABLE 2.1: DATA NEEDS ACROSS CLIMATE-RELATED ASSESSMENT TYPES (SOURCE: AUTHORS; 2II 2016b)

Use Case	Time Horizon	Geography	Modeling approach	Asset Level Information	Security/Company level information
Physical Climate Risk	Forward-looking	Geolocation-specific	Physical climate / integrated assessment model	• Location and asset-related revenues • Climate sensitivity of own assets + upstream / downstream	• Insurance coverage • Adaptation strategies / company level risk mitigation strategies
Transition Risk	Forward-looking	Country/ market-specific	Techno-economic and risk / cash flow models	• Location • Cost of production & revenues • Capacity/ production • Emissions intensity	• Asset-specific capex / retirement strategy • Climate-relevant R&D • Market positioning
Legal / Liability Risk	Backward-looking	Depends on legal theory	Legal theories	• Asset-level data similar to transition risk relevant for asset-specific litigation	• Historic GHG emissions • Historic disclosures • Exposure to 'risky' jurisdictions
Alignment with 2°C Goal	Forward-looking	Country / region specific	Techno-economic/ investment models	• Location • Cost of production • Size / capacity/ production • Emissions intensity	• Asset-specific capex / retirement strategy • Climate-relevant R&D

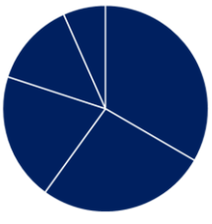
2.2. COMMON PRINCIPLES OF MATERIAL CLIMATE DATA

As discussed above, assessment of climate-related risks, opportunities, and contribution have different data requirements, but some common principles apply across all use cases:



Geography-specific: Data should be designed specific to each geography, measured both in terms of the location of the company and its assets. Geography-specific benchmarks are important to reflect the different financing and investment challenges of different regions and exposures to different risk factors. For example, the 2°C compatible fractions of coal and renewables investment will be starkly different in China and the EU given different development levels and incumbent technologies. Even within the EU, geographical contexts vary considerably (e.g. Poland vs. Denmark). Metrics must thus be specific to geographies of physical activity (e.g. power plant location) and financial activity (e.g. country of listing, revenue segmentation, etc.).

Forward-looking: With the exception of some categories of legal risk, climate assessments require long-term analysis, which in turn requires forward-looking information on existing and planned assets and their lifetime, location, and economic competitiveness. For this reason the TCFD recently called for the prominence of scenario analysis in managing and disclosing on climate-related risks (TCFD 2016b).



Complete: Within the current voluntary corporate reporting paradigm, a significant issue is non-reporters. After almost 20 years of pressure, reporters represent only around 63% of the highest impact sectors, and this further represents only listed companies (CDP 2016b). The problem is particularly acute for small caps and developing markets. When considering product-related and Scope 3 emissions, this shrinks further. Non-reporting also affects mandatory disclosure regimes, usually by design—such programs generally target larger companies to limit reporting burden (WRI/World Bank 2015).

Disaggregated: Carbon accounting standards (GHG Protocol, ISO 14064), designed for tracking of organizational performance over time, allow reporters to use different consolidation rules (equity share, operational control, financial control), making comparisons between seemingly similar reporters difficult (CDP 2015). Such approaches also aggregate physical assets exposed to policy or technology risk (e.g. power plants) with 'irrelevant' assets (e.g. corporate auto fleets, headquarters buildings) and tend to aggregate over key indicators (e.g. geography of assets, age). Detailed, disaggregated data at physical asset-level can solve these issues by zeroing in on the distribution of a company's relevant assets and their profile (location/geography, cost structure, age, etc.).

Practical. Depending on the use case, being 'practical' can mean different things, but include elements of cost and accessibility. The ability to connect data to other data is key, requiring "unique identifiers" at company and asset-level. In financial circles this means tickers and security IDs (ISIN, FIGI, CUSIP, SEDOL). In climate policy circles it might instead mean being able to link the data in question to GHG inventories. In all cases cost is relevant, and the ability to get "just the data you want" is important to avoid excessive budgetary requirements for analysis.

FOCUS: TODAY'S CLIMATE-RELATED DATA ECOSYSTEM

Types of climate-related data. Three types of information--primary data, secondary data, and performance metrics—are often used in climate assessments at company or portfolio level (Fig. 2.1). Each level of information has financial components and nonfinancial components (examples below) and are collected through three avenues: companies' (as the owners of physical assets) reporting and announcements, government agencies collecting information at either the asset-level (see pg. 21) or company level, and data & metrics providers who aggregate and often sell data aggregated data from the other two sources.

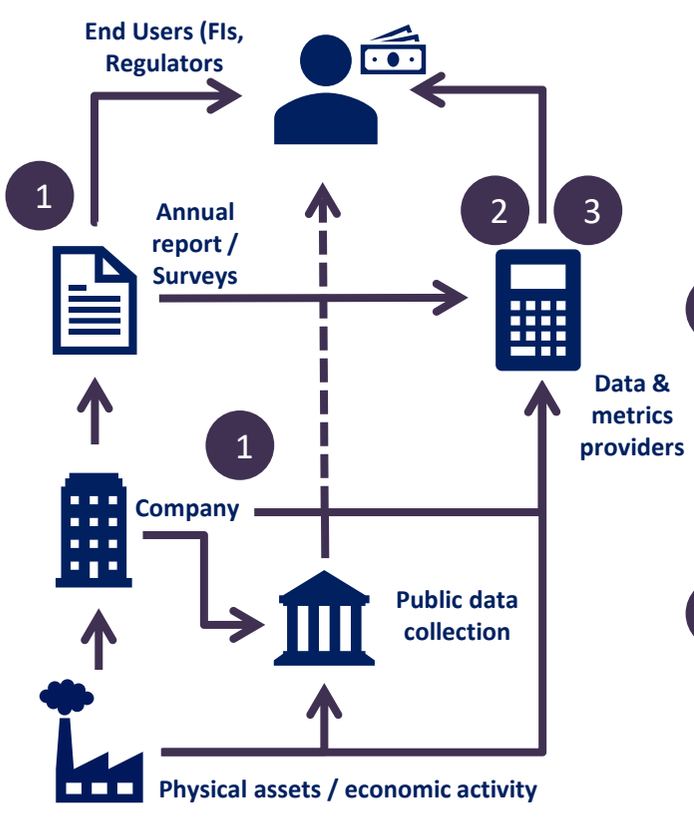
Accessing data from companies. Investors access company data primarily through annual reports or climate-specific data requests (see pg. 16), either directly or through data providers that aggregate such information. The scope of financial disclosures is usually regulated (e.g. SEC form 10-K in the US), and nonfinancial data is starting to be regulated (such as in the European Directive on Nonfinancial Reporting). As discussed by TCFD, a number of key climate-related indicators are currently not broadly reported by companies (TCFD 2016b), with companies often justifying this disclosure gap by arguing that it involves propriety information that could affect competitiveness.

Accessing public data. Investors can access public data either directly (see pg. 21) or through data providers who aggregate such information. This data may be relevant for assessing specific companies (e.g., fuel efficiency of cars by manufacturer) or for benchmarking companies relative to national indicators (e.g., annual electricity generation).

Accessing data from data providers. Data providers aggregate (and usually sell) data from physical assets, companies, reporting mechanisms, and public agencies (see Section 3.3). Data providers often also provide performance metrics, e.g. qualitative or quantitative scores, which in turn utilize corporate-level and asset-level data.

Financial vs. nonfinancial data. Both financial and nonfinancial data can be relevant for climate-related investment activities. Regulatory and market standards usually result in financial data that is reported in a standardized fashion (e.g. revenues, balance sheet). Nonfinancial data, in contrast, is largely nonstandardized and thus needs to be harmonized, as recently highlighted by TCFD (2016).

FIG 2.1: TRACING THE PATH OF DATA FOR INVESTORS
(SOURCE: PCI 2015)



1 **Primary data** is directly provided by companies through surveys or annual reports. Primary data may also be collected by public agencies or data providers at the physical asset or corporate level.

Sales, EBITDA, net profits, debt levels.

Proved reserves, CO_2 emissions (incomplete), reporting on climate change strategy / risk

2 **Secondary data** includes data and metrics collected, aggregated, harmonized, and estimated by data and metrics providers using annual reports, public data sources, and analysis of physical assets.

Geography of sales, tax, cost of capital, harmonization of business segmentation

Installed capacity, breakdown of capital expenditure, estimates of CO_2 emissions

3 **Performance metrics** (subjective or objective) developed by data and metrics providers, including scoring, benchmarking, and ratios.

P/E ratio, EV/EBITDA

ESG scores, risk metrics related to climate change

2.3 PHYSICAL ASSET-LEVEL DATA: A NEW FRONTIER?

There is emerging interest in using physical asset-level data for climate-related assessments due to their advantages in several of the key characteristics described above:

- **Geographic and technological detail**: Data are often geolocated—which is critical for assessing physical risk and country-level transition risks and policies—and also available with technological and economic detail in most sectors;
- **Completeness and consistency**—Due to their sources (see Section 3.2), such data are often universal or near-universal in coverage, eliminating non-disclosure bias and providing consistency across companies.
- **Forward-looking**: In some sectors, capital plans (i.e. planned assets) can help to show not only where a company is today but also its future capital planning, allowing forward-looking scenario analysis.

However, even a preliminary review in certain sectors shows that such data are no panacea in their current form. First and foremost are issued related to cost (both licensing costs and transaction costs related to search, acquisition, and integration with existing analysis). A further question relates to their applicability to ESG and climate analysis given that most asset-level data were not designed with this use case in mind (see section 3.3).

Study method. Assessing the advantages and disadvantages of such data lies at the heart of this study, which to our knowledge represents the first attempt to systematically review existing asset-level data sources across climate-relevant sectors. The study reviewed over 35 data sources, including both commercial (Annex 1) and open source databases. Table 2.2 shows the information that we attempted to gather for each database, covering the method by which the data is procured, its coverage, specific data fields available (e.g. location, age, emissions), and accessibility and pricing issues.

In general information was gathered first through first desk research, followed by information requests and product demos where necessary. Several disclaimers should be made regarding the coverage and method utilized:

- **Not universal**—The reviewed sources are not exhaustive, and inclusion in the study does not represent endorsement. Instead we strove for a representative sample to answer the study questions (Table 2.2).
- **Point in time**—The research was conducted over a series of months so no guarantee can be made on the timeliness of database characteristics. Many data providers are constantly improving their offering.
- **Confidentiality**—Due to the proprietary nature of some data sources, it was not always possible to obtain or print certain information that is confidential to the data provider, particularly regarding pricing information.

TABLE 2.2: STUDY QUESTIONS USED TO REVIEW DATA SOURCES (SOURCE: AUTHORS; 2II 2016b)

General Topic	Specific Question	Section
Method	• How is data obtained and updated? • Is data self-assured? • Who are the primary users/customers?	3.2 What types of asset-level data exist? 3.3 How is commercial asset-level data created and used?
Coverage and Asset Attributes	• How many assets are available? • What percentage of global assets are covered? • Activity factors (e.g. MWh & MW for power plants, reserves & production for fossil fuels) • Location: What level of geographical detail is available? • Age information (year of construction/refurbishment) • Fuel and Emissions information: Fuel type, CO_2 emissions	3.4 What information is available on assets?
Accessibility	• How do users access information (downloadable/machine readable vs. portal)? • Are prices variable across user groups? • Are “pay per view” queries available?	3.5 hHw are assets connected to owners? 3.6 How do users access commercial data?

3. REVIEW OF ASSET LEVEL DATABASES

3.1. COVERAGE AND STRUCTURE OF DATA REVIEW

Scope and structure. This section will describe first the scope and then the results of the database review. In general, due to the confidentiality concerns described above, results are described at high level in this summary section, with more detailed database-level results shown in an Annex. This section presents the high level results by research topic/question and conclusions and recommendations are provided in the following section.

Sector coverage. One of the defining features of asset-level and market intelligence data is its sector-specificity, and thus a decision had to be made on which sectors to include within the scope of this review. Generally we focused the review on sectors most important for the energy transition, defined in terms of their GHG emissions intensity, aggregate materiality to climate change, and their potential for significant transition risk (TCFD 2016b).

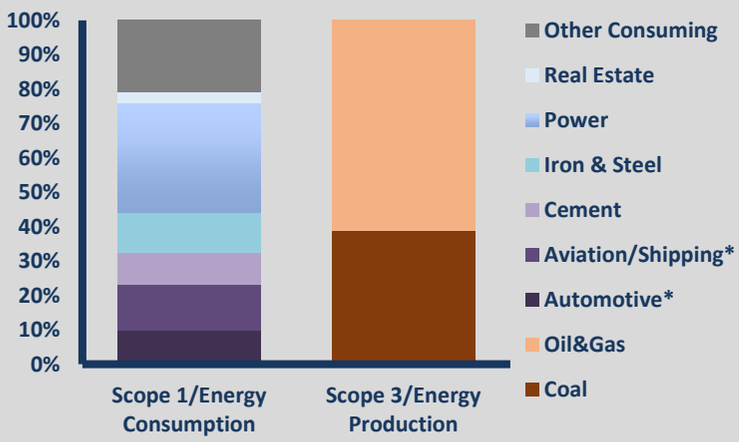
As shown in Figure 3.1, a focus on 9 key sectors (coal mining, oil & gas production, automotive, aviation, shipping, cement, iron & steel, power generation, and commercial real estate) covers over 80% of the global carbon budget (constituting over 65% of total GHG emissions, EPA 2016) from an energy consumption (Scope 1 GHG emissions) perspective, or nearly 100% of such emissions from an energy supply (Scope 3 downstream GHG emissions) perspective. Many sectors are also important sources of non-CO_2 emissions, particularly coal mining and oil & gas production (both of which produce substantial portions of global methane emissions). Of course, different sectors contribute to such emissions in different ways (see also WRI/UNEP FI 2015; GHGP 2014), either by:

- Supplying carbon-intensive fuels (coal mining, oil & gas production)
- Emitting CO_2 emissions directly due to combustion or industrial processes (cement, steel, power, real estate)
- Producing GHG-intensive equipment (aircraft manufacturing, shipbuilding, automotive)
- Enabling infrastructure (airports, shipping ports)
- Consuming energy carriers (e.g. electricity) that emitted CO_2 in their production (Real estate, iron & steel)

An important missing segment from a global emissions perspective is agriculture, forestry, and land use, constituting roughly 25% of global GHG emissions (EPA 2016), including a majority of non-CO_2 emissions and 10% of CO_2 emissions (from land use change). Such sectors are also exposed to many types of physical climate risk (water scarcity, extreme weather). A forthcoming report will discuss data needs in these sectors.

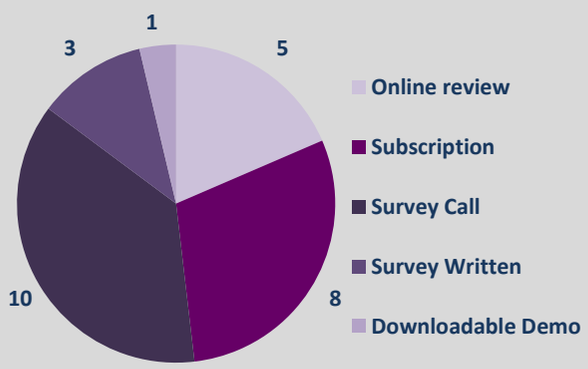
Database coverage. As discussed above, the data providers reviewed here do not constitute a full landscape, and inclusion does not constitute endorsement. We attempted to cover a variety of different types of providers (Section 3.2), at least two providers per sector. The sample was limited in some cases by interest in study participation, and in some cases information relied solely on desk research from provider websites (2 of 35 databases reviewed).

FIG 3.1: SECTOR CARBON BUDGETS UNDER A 2° C SCENARIO. (SOURCE: AUTHORS; based on SBTI 2015)



NB: * denotes a sector using GHG accounting from a use phase (automotive = light duty vehicle use; aviation = aircraft use) perspective rather than a Scope 1 perspective (e.g. Scope 1 emissions of automotive plants)

FIG 3.2: DATA REVIEW METHODS FOR COMMERCIAL DATABASES (# OF DATABASES) (SOURCE: AUTHORS)



3.2 WHAT TYPES OF ASSET-LEVEL DATA EXIST?

What is asset-level data? Although different terminology with different meanings can be found (asset-level data, industry data, market intelligence data), in this report we define "asset-level data" as any type of quantitative or qualitative information regarding physical assets (tangible assets of economic value), including their characteristics/attributes, their ownership, and their operation. From a climate/energy, and environmental risk standpoint, such assets can include (Caldecott & Kruitwagen 2016; 2dii & Oxford 2016; WRI/UNEP FI 2015):

- Energy producing assets (e.g. oilfields, coal mines)
- Stationary GHG emitting assets (e.g. power plants, cement plants, steel plants, buildings, etc.)
- Mobile GHG emitting assets (e.g. aircraft, ships, light and heavy duty vehicles, trains)
- Infrastructure assets (e.g. airports, shipping ports, highways)

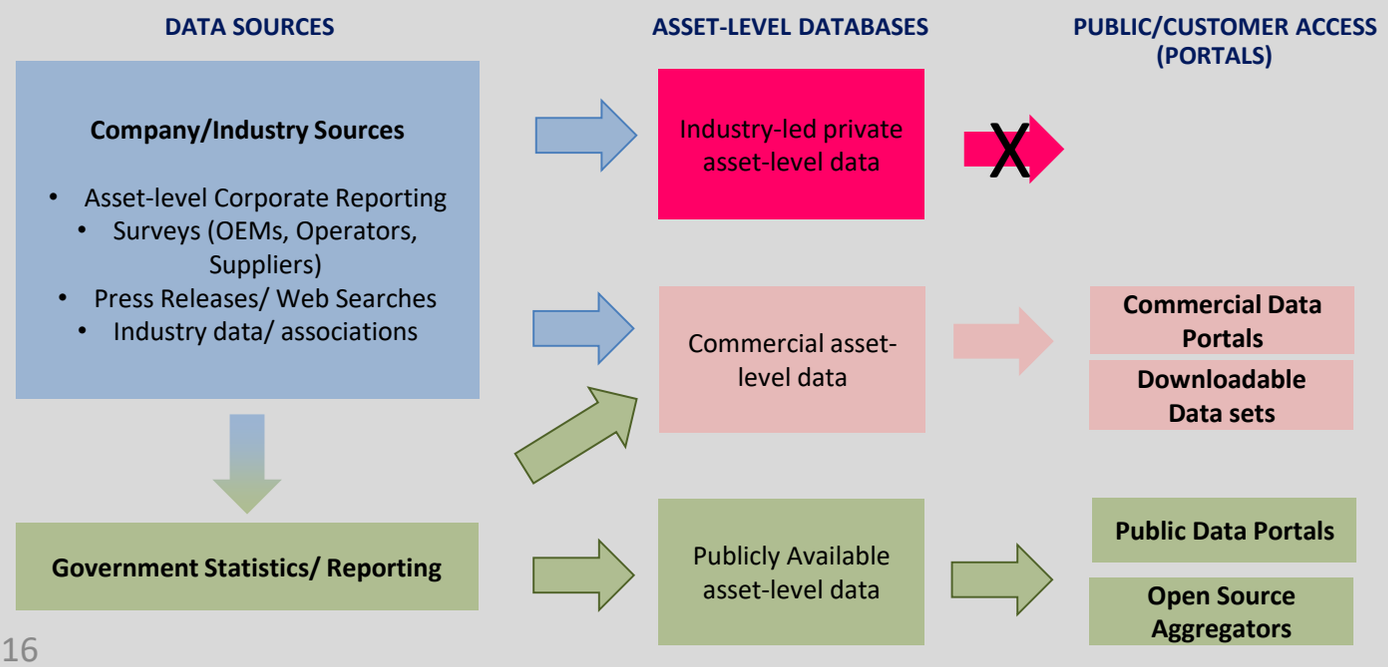
Where does asset-level data come from? Figure 3.3 (developed further throughout this section) shows a high level overview of the main types of underlying data sources, databases, and user access. As companies are the owners of a large majority of physical assets, they are the primary source of most asset-level data, which can be gathered by providers through a variety of means (see pg. 18). Governments also gather asset-level information from reporting companies for various regulatory and statistical reasons (see pg. 21). In both cases, data can be consolidated and provided to customers or the public in several ways:

- **Industry-led private asset-level data**—Some asset-level data is gathered through industry-led initiatives and not released publicly. In the climate context, two primary examples are WorldSteel's CO_2 emissions data collection and the Cement Sustainability Initiative's GNR (Getting the Numbers Right) database (See Table A.1). Such data are not a primary focus of this report, but represent a potential future source of information if such industry initiatives choose to release data.

- **Raw government data**—Data can be released to the public in raw form through public data portals. Examples include mandatory and voluntary GHG reporting programs and energy statistics surveys. Such data represent an important and currently underutilized source. **"Free" aggregators of public data,** including NGOs, researcher/university initiatives, and cross-governmental data portals consolidate raw data for different user groups, including government and private sources. Examples include Enipedia and CoalSwarm (See Table A.2).

- **Commercial databases—**The primary source of asset-level data, commercial providers combine government and company data to sell it to different customers. Some cross-sector data providers like CDP also collect asset-level information from companies (see next page). Given the significantly different characteristics of commercial asset-level data and publicly available ALD we split the discussion, with a focus on publicly available data on page 21.

FIG 3.3: SOURCES AND TYPES OF ASSET-LEVEL DATA (SOURCE: AUTHORS)



FOCUS: ASSET-LEVEL DISCLOSURE IN THE CDP CLIMATE CHANGE SURVEY

The CDP climate information request is currently the primary source of corporate climate data for most investors and ESG providers today (Portfolio Carbon Initiative 2015).

The survey covers a wide amount of quantitative and qualitative information through three modules on company management, risks & opportunities, and GHG emissions. Given the scope of this report we focus here on quantitative disclosure questions, which make up roughly half of the survey (Table 3.1), mostly in the Emissions module (Questions 7-14).

CDP's survey is largely known for collecting "consolidated" company level emissions in line with the global standard GHG Protocol (GHGP 2004). Such totals represent all GHG emissions directly or indirectly emitted by a company's operations, summed over all of its facilities/assets. Less known is that the survey also asks for reporting of emissions by geography, asset, business division, and activity levels (Questions 9 and 10). Fig 3.4 shows that response rates to these questions are relatively low, but a small number of GHG-intensive companies do report at the asset-level:

- 18 utilities disclosing 500 assets
- 28 chemicals companies disclosing over 500 assets
- 26 oil & gas companies disclosing over 500 assets
- 17 real estate companies disclosing over 250 assets

While such questions have low reporting today, they could become a more important vehicle for asset-level GHG emissions data in the future.

FIG 3.4: FRACTION OF CDP REPORTERS REPORTING GHG EMISSIONS AT ASSET OR ACTIVITY LEVELS (SOURCE: CDP 2016a)

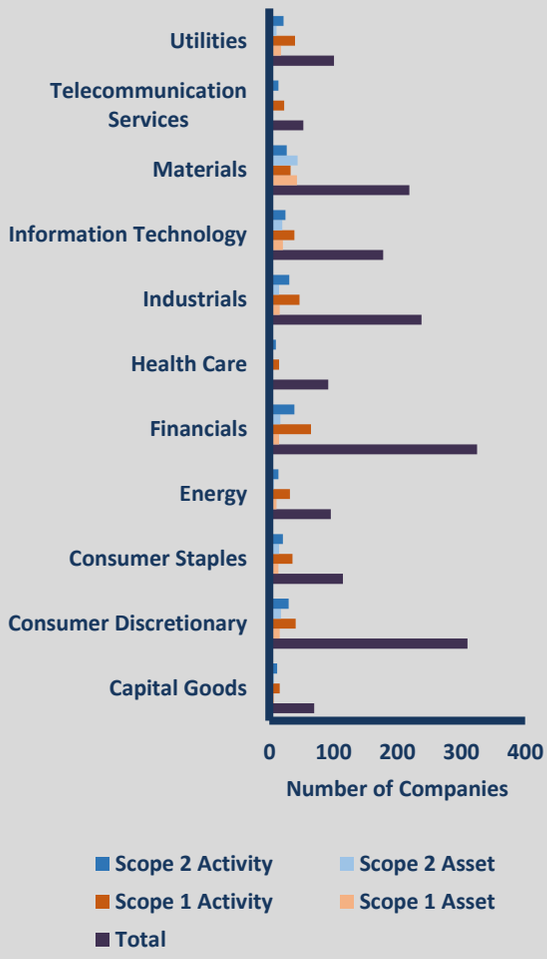


TABLE 3.1: CDP CLIMATE CHANGE INFORMATION REQUEST SUMMARY (SOURCE: CDP 2016c)

Module	Question		Response Form
Management Module	1	Governance	Narrative
	2	Strategy	Narrative
	3	Targets & Initiatives	Semi-Quantitative
	4	Communications	Narrative
Risks & Opportunities Module	5	Climate Risks	Narrative
	6	Climate Opportunities	Narrative
Emissions Module	7	Emissions Methodology	Narrative
	8	Emissions Data	Quantitative
	9	Scope 1 Emissions Breakdown	Quantitative
	10	Scope 2 Emissions Breakdown	Quantitative
	11	Energy	Quantitative
	12	Emissions Performance	Quantitative
	13	Emissions Trading	Semi-Quantitative
	14	Scope 3 Emissions	Quantitative

3.3 HOW IS COMMERCIAL ASSET-LEVEL DATA CREATED AND USED?

Asset-level data providers use a variety of sources. Traditional corporate reporting, including both financial and nonfinancial reporting avenues, represents the predominant source of most traditional ESG data and ratings. On the other hand, asset-level data providers rely on a wider variety of sources, with traditional annual reporting ranking relatively low on importance. Figure 3.4 shows the most commonly reported sources underlying data sources based on the our database review (both in total and in terms of number of sectors where at least one provider utilized the source). In order of prevalence, the most common reported sources are:

- **Press releases and automated web searches**. Particularly in order to capture announcements regarding new assets (see pg. 19), many commercial data providers use customized web crawlers and automated searches of primary and industry/trade press sources and company websites.

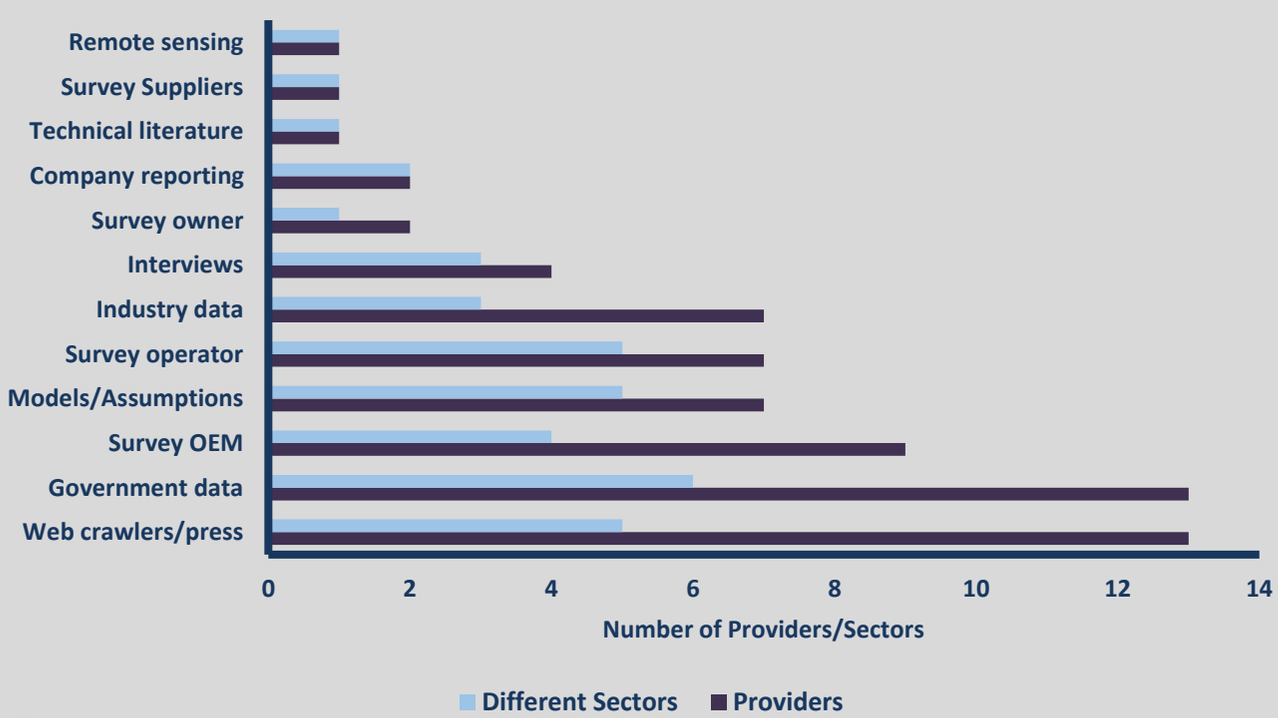
- **Government databases**. A wide variety of governmental statistical and regulatory sources are utilized by data providers, including energy statistics, occupational safety and health information (e.g. mine safety permits), usage patterns (e.g. flight routes), environmental permits, and many other sources.

- **Direct surveys and communication.** Asset-level database providers also make use of direct interactions with companies. Such surveys and interactions take many forms, including one-on-one engagements with companies, written surveys, direct data feeds, and investor relations activities (e.g. shareholder meetings).

- **Modelling**. Where data are not fully disclosed through other sources, some providers perform modelling (regression analysis, asset valuation) to either interpolate non-response or estimate certain asset attributes that companies deem confidential. This is particularly true for sensitive parameters like asset production cost (e.g. oil & gas, coal mining) and valuation (e.g. aircraft).

Patterns by sector. Although based on a limited sample, our review suggests that the broad characteristics of a sector dictate to some extent the primary data source utilized. For instance, heavily regulated sectors (aviation, power) tend to make heavy use of government data whereas in less regulated sectors, data providers rely more heavily on surveys and direct engagement with OEMs, operators, and suppliers. Further, the structure and concentration of the sector can dictate the extent to which direct surveys and interactions target primarily OEMs (in oligopolistic sectors like aircraft and automotive manufacturing) or asset operators and owners (more distributed/localized sectors like power and cement).

FIG 3.4: MOST COMMONLY REPORTED DATA SOURCES (SOURCE: DATABASE REVIEW)



Users of asset-level data are predominantly industry-specific. Current users tend to fall into one of two categories:

- **Industrial companies and suppliers**—depending on the sector, users from within the industry often include asset owners and operators themselves (e.g. power companies, cement companies), who use the information for competitive benchmarking, and suppliers and consultants to such companies, who use the information to target business opportunities.

- **Industry-specific investors/lenders,** including private equity firms, specialized investors, and equity and credit analysts at large FIs. Based on discussions, financial institution use of asset-level data tends to be limited to large FIs with significant staff and budget for sector specialization (i.e. commercial banks) plus sector-focused investors (thematic private equity, REITs, etc.). Diversified institutional investors are generally not a target market, with a few exceptions (notably in real estate data and for ESG-themed data providers, see pg. 23).

Providers reported somewhat less use by governments (e.g. regulators) and researchers (e.g. universities), but some providers see this as a potential growth market, in particular providers with some level of ESG focus.

What about traditional ESG providers? An informal survey was conducted of several leading ESG ratings and data providers on their use of asset-level data. Some providers report that they are increasingly using such data, particularly in certain sectors (power, automotive), yet are also subject to the same barriers as diversified investors:

- **Acquisition cost.** This includes particularly license fees but also search costs for finding the correct providers.

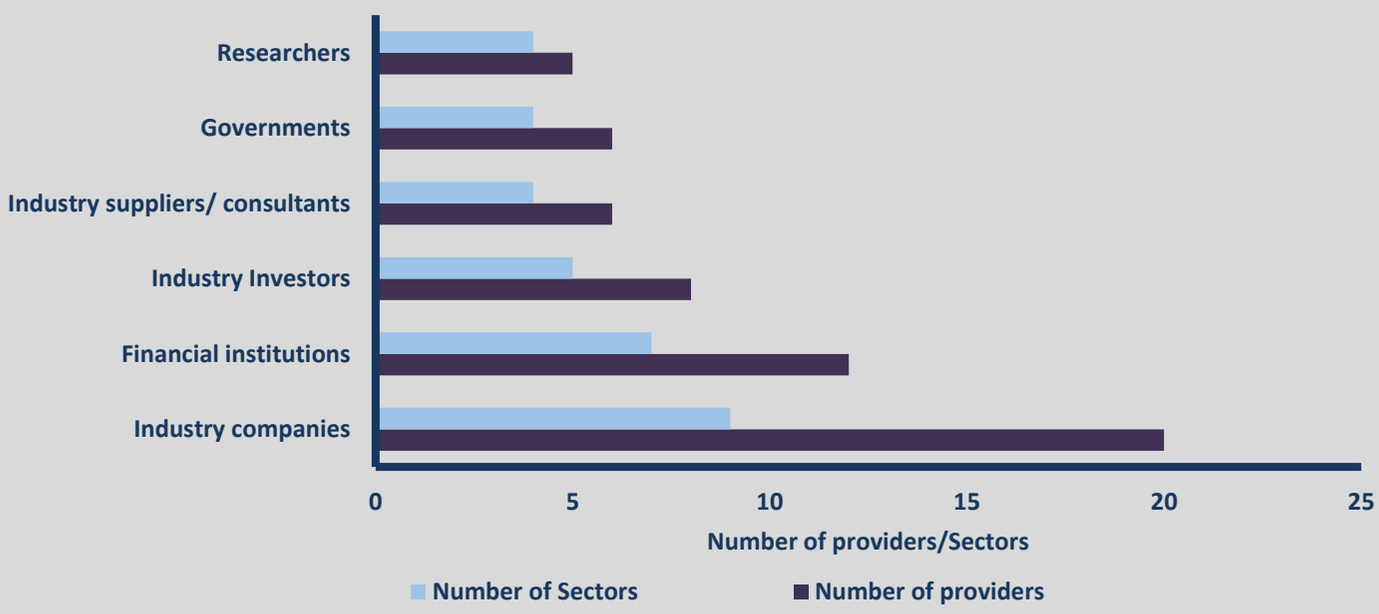
- **Licensing issues.** ESG providers prefer either be the primary source of data or to use open source data to avoid possible contract disputes/termination.

- **Company/Security Identifier matching** (see section 3.5)

- **Lack of emissions and ESG information**. As discussed on the following page, most asset-level databases contain little if any information on emissions or other ESG attributes, making them of limited use without either modeling or matching to other datasets (such as public GHG emissions databases, see pg. 21).

- **Lack of demand.** Most providers reported a lack of demand for the resolution and detail that asset-level data provides, and particularly that other barriers could be overcome with sufficient demand. On the other hand, some ESG data providers increasingly see the cost-benefit tilting toward asset-level information as GHG emissions data become more available and tools to match assets to companies become more prevalent (Section 3.5).

FIG 3.5: MOST COMMONLY REPORTED DATA USERS/CUSTOMERS (SOURCE: DATABASE REVIEW)



3.4 WHAT INFORMATION IS AVAILABLE ON ASSETS?

Types of asset attributes. Given the sector-specific nature of asset-level data, it is difficult to easily summarize the available 'asset attributes' (i.e. different data fields associated with each asset) across databases. Moreover, certain attributes can be present for a limited subset of assets but not broadly available for all assets, further complicating the situation. Broadly speaking, however, several different types of attributes are relevant to climate and environmental risk and performance assessments (2dii 2016c; Caldecott and Kruitwagen 2016). Summarized in Table 3.2 on the following page, relevant attributes include the following:

ASSET CAPACITY AND ACTIVITY LEVELS

Assets can be characterized by their size (i.e. capacity) and activity (i.e. production or usage) levels. It is common in energy and emissions accounting to consider the emissions of an asset as the product of its activity level (e.g. power generation per year, cement production per year, km flown per year) and its emissions factor (e.g. kg CO_2/MWh, kg CO_2/km, kg CO_2/ton) (IPCC 2006). Activity is in turn a function of the size/capacity of an asset and its utilization, sometimes called a capacity factor (i.e. fraction of time it is used). As shown in Table 3.2, while asset capacity levels are generally available across all sectors, in many sectors activity/production levels are more limited (steel, cement, aviation, shipping, power). This important limitation can be overcome by estimating activity/production levels using national or company average capacity factors (see e.g. Davis and Socolow 2014), albeit with uncertainty.

ASSET LOCATION

One of the key advantages of asset-level data is its geographical specificity. The majority of reviewed databases provide geolocation information (e.g. latitude/longitude) for stationary assets or the flag registration country for mobile assets, allowing not only exposure assessment to energy/climate policies (transition risk/alignment assessment) but precise overlays with physical risk vulnerability assessment.

ASSET AGE

The majority of sectors and databases also provide information on the age (e.g. initial year of operation) of covered assets, allowing users to estimate remaining lifetime or production. This variable is not always easy to define, however, as certain assets may have initially been constructed in one year but completely overhauled in a later year. Others (particularly power and cement plants) may have multiple different units (generators, kilns) of different ages. Because of this issue, some databases (e.g. power and steel sectors) track this parameter at unit/production line level rather than plant level.

ASSET ECONOMICS

For certain use cases, particularly financial analysis, understanding the economics (e.g. production cost, remaining reserves) of assets is of critical importance. Generally such information is (unsurprisingly) treated as confidential by producing companies due to competitiveness issues. To reply to this demand, in some sectors data providers estimates production costs or asset valuation using proprietary models to assist financial analysts and investors. However, such estimation is generally limited to upstream mining and oil & gas operations (though asset valuations are also available from aircraft data providers).

FUTURE (AND HISTORICAL) ASSETS

Another consideration is whether data providers include future (planned/under construction) assets and historical (i.e. retired) assets or only cover currently operational assets. Generally most of the providers reviewed here track future assets using company announcements and permits, allowing users to assess both companies' current exposure and capital planning. The only limiting factor in many cases is the availability of all asset attributes, which may not be included in company announcements or permits. For instance, certain providers in the shipping only cover existing assets because order books do not contain detailed engine information needed to estimate energy efficiency.

ASSET EMISSIONS/ESG INFORMATION

Given the climate focus of this review, we sought out information on which data providers track and provide relevant ESG information at asset-level (particularly GHG/CO_2 emissions but other indicators were also noted). As shown in Table 3.2 (following page), the majority of sectors have very little of such information in traditional commercial asset databases (oil & gas, coal mining, aviation, iron & steel, cement). However, new providers with at least some ESG focus in their product offering have recently emerged in several sectors (see pg. 23).

TABLE 3.2: TYPICAL ATTRIBUTE COVERAGE OF COMMERCIAL ASSET-LEVEL DATABASES (SOURCE: AUTHORS)

Sector	Capacity	Activity	Location	Age	Production Cost/ Valuation	Planned Assets	CO_2/GHG Emissions
Automotive	Plant capacity (vehicles/yr)	Production (vehicles/yr) Sales (vehicles/yr)*	Country of sales (car) Geolocation (production plant)	Yes	No	Production forecast	Most databases have limited fuel economy information
Aviation	Aircraft ownership (seats/tons)	Routes flown (cycles)**	Flag Country	Yes	Yes	Order books	No reviewed databases
Cement	Plant capacity (ton/yr)	No reviewed databases	Mapped Location	No	No	Announced and Under Construction Plants	ESG focused databases
Coal	Reserves (tons)	Production (ton/yr)*	Geolocation	Yes	Yes	Planned/ Permitted mines	No reviewed databases
Iron & Steel	Plant capacity (ton/yr)	No reviewed databases	City/State/ Country	Yes	No	Planned and Under Construction Plants	ESG focused databases
Oil & Gas	Reserves (BBL)*	Oil/gas produced (BBL/yr)	Geolocation	Yes	Yes	Planned/ Permitted fields	No reviewed databases
Power	Plant capacity (MW)	Plant generation (MWh)*	Geolocation	Yes*	PPAs*	Announced and Under Construction Plants	Most databases limited coverage of CO_2 emissions and SO_2/NO_X equipment
Real Estate	Floor area (m2)	Occupancy*	Geolocation	Yes	No	Under Construction buildings	ESG focused databases
Shipping	Dead weight (ton) TEU capacity	Routes traveled*	Flag Country Routes*	Yes	No	Order books***	ESG focused databases

NB: Data represent values derived from interviews, desk research, and existing subscriptions at a single point in time between August and December 2016. All values are subject to change. Any errors are those of the authors. Blanks represent unknown or confidential values. Table represents typical values but individual data providers' offerings vary (see Annex 2).

*represents attributes that are limited in coverage to less than ~90% of assets in database.
**Routes flown are not typically given at asset-level (i.e. individual aircraft) but are connected to detailed aircraft model types (e.g. Boeing 777)
***Order books are available from ship registry databases but emissions performance data are not currently estimable for ships on order.

FOCUS: GOVERNMENT SOURCES FOR EMISSIONS FACTORS

As discussed above, most commercial asset-level databases do not have an ESG focus and thus need to be coupled with other sources of ESG information, most commonly verified/disclosed emissions or emissions factor data.

Several types of such information exist, including information gathered by voluntary corporate disclosure (see page 16 for asset-level CDP data) and mandatory disclosure programs. In order to support climate policy and GHG inventory development, many countries and subnational governments have mandated either asset or company-level energy performance or GHG emissions data (WRI 2015; BuildingRating 2016). We focus here on programs disclosing asset-level GHG data, 4 of the 11 programs recently reviewed by WRI (2015). Other country programs are either still being implemented (Mexico), have company-level disclosure but not asset-level (e.g. France, UK), or collect asset-level information but only disclose publicly at company level (Japan). Some countries also use company-level data to develop emissions tools, such as the French Transport CO_2 calculator (Aviation Civile 2017).

Over 5 GT CO_2 direct emissions are now disclosed publicly at asset-level across these four programs (US, EU, Australia, and Canada), representing over 11% of global GHG emissions (WRI 2016). Given their mandatory nature, the quality of such information is generally quite high for covered sectors. However, the level of supporting information is quite varied, with location and sector classification information available only in Canada and the USA and parent company only available in USA. Generally activity data are lacking. Further, all programs have a reporting threshold to limit administrative burden to reporting companies, meaning smaller assets (typically <25,000 tons CO_2/year) are not required to report. More crucially, no program provides codes allowing automated matching to company or financial security in other data systems (e.g. LEIs, tickers, FIGIs/ISINs, see section 3.4).

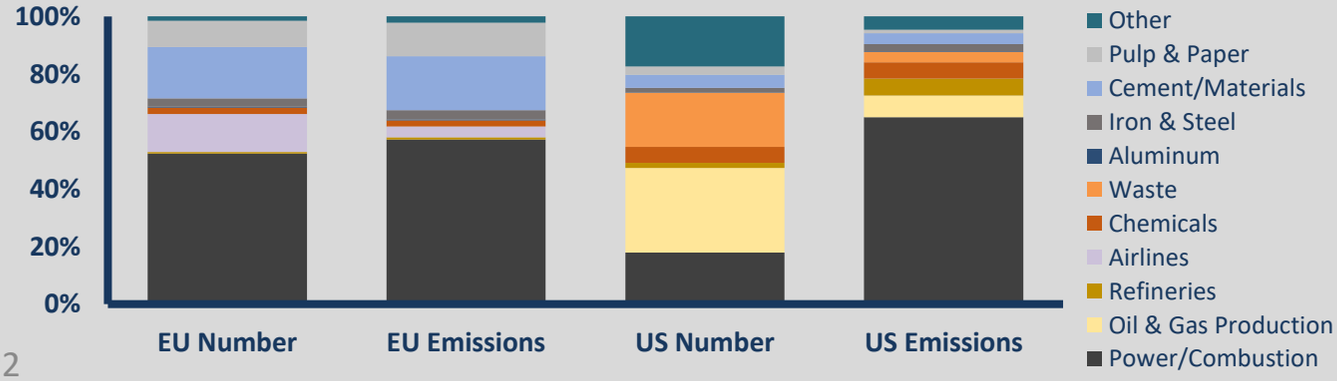
In addition to national level GHG reporting programs, a growing number of cities and subnational governments have created mandatory commercial building energy disclosure programs recently. According to Buildingrating.org, over 66,000 buildings across 16 countries and jurisdictions (Atlanta, Boston, Boulder, California, Cambridge, Chicago, China, Washington DC, Estonia, Kansas City, Minneapolis, Montgomery County, New York City, Philadelphia, Rockville, Seattle) to the public via a public website. Such programs have even more variability in terms of disclosure requirements, data provision formats, size thresholds, etc.

TABLE 3.3: CHARACTERISTICS OF MANDATORY GHG REPORTING PROGRAMS (SOURCE: SEE ANNEX 2)

Country	Number of Assets	Total GHG Emissions (Mt CO_2e)	Fraction of total GHG emissions*	Company	Location	Sectors	Sector code
Australia	356	178	27%	Operator	State	Power	NA
Canada	574	264	37%	Operator	Lat/Long (96%)	See Annex 2	NAICS
EU	9941	1671	38%	Operator	Country	See Annex 2	IPCC Category
USA	8229	3033	49%	Parent	Lat/Long (99%)	See Annex 2	IPCC Category and NAICS

NB: Estimated as total currently disclosed GHG emissions in latest year divided by country's reported total GHG emissions, excluding land use/land use change/forestry from (WRI 2016)

FIG 3.6: SECTORAL DISTRIBUTION OF ASSETS IN EU AND US GHG REPORTING PROGRAMS (SOURCE: AUTHORS)



FOCUS: SUMMARY OF STRENGTHS AND CHALLENGES OF ASSET-LEVEL DATA ACROSS TRANSITION SECTORS

AUTOMOTIVE. Generally current and forecasted production data are available at detailed make/model level by region and in some regions by plant. Sales data and current fleets (i.e. registrations) are available for some regions, requiring fleet/survival curve models to assess current fleets globally. Limited fuel economy data are available but are generally limited to EU/USA and may be inconsistent due to different testing cycles used in these regions (ICCT 2014).

AVIATION. Asset-level airport and aircraft (existing and order book) data are widely available including details on seats/cargo space, engine type, and age/use cycles. Fuel consumption is generally not known, requiring modeling to assess energy use/emissions. Aircraft classes, but not individual aircraft, can be matched to specific airport to airport routes. Aircraft valuation models are available for financial analysis.

CEMENT. Most data is private, with only limited technology details (dry vs. wet kiln, clinker and/or cement capacity) and location known. Production levels are generally not available. Fuel type is known for some plants, allowing emissions estimates. Given the expense of plant-level data procurement, data are not generally available in machine-readable formats.

COAL MINING. Mine-level production and reserves data are available for almost all developed country mines, with gaps in developing nations (China in particular). Mines are geolocated and often matched to purchasers (power plants, steel plants, etc.) with contractual data. No emissions data are widely available.

IRON & STEEL. Substantial technical detail (capacity, equipment detail) is available by process (iron and steelmaking, finishing, sintering, etc.) for existing plants and to some degree planned plants. Plants are mapped to city/country but not geolocated. No emissions data are available except in privately held data from WorldSteel.

OIL & GAS. Field, lease, and well-level data are available for a nearly universal sample of existing and planned oil & gas fields worldwide. Current production, reserves, and production forecasts are available along with mostly estimated financial data (e.g. production costs). Emissions estimates are available from third party sources (Carnegie 2016; EPA 2016) but are not generally linked to commercial databases.

POWER GENERATION. Plant and generator detail by fuel and technology are available for existing and planned assets. Capacity is universally available but production is not always available or is estimated. Some providers offer CO_2 emissions estimates (e.g. EnerData) but most have only limited information on air pollution (e.g. SO_2) control technology. Limited data are available on power purchase agreements.

REAL ESTATE. Asset-level detail is available for buildings held and planned by real estate funds but is not universally available for all buildings. Energy use and emissions data are available for limited subsets from mandatory and voluntary reporting programs (below and pg. 21).

SHIPPING. Asset details (size/weight, engine type) are available for nearly all commercial ships globally, and geolocated route data from AIS (automatic identification system) are available for most in use ships. Emissions estimates are becoming available, based either on AIS tracking data or ship attributes, though planned ships (order books) are more difficult to estimate.

FOCUS: EMERGENCE OF ESG-FOCUSED ASSET-LEVEL DATA

The past several years have seen the emergence of several initiatives and data providers with some degree of specific ESG, energy, or climate focus. Examples include RightShip and BetterFleet in shipping, the Cement Sustainability Initiative, GRESB and Geophy in real estate). In addition, in other sectors where the energy transition is already underway, data providers are increasingly providing ESG relevant attributes such as fuel economy information (automotive) and CO_2/SO_2/NO_x emission or control technology information (power). Data providers who see research and government communities as key client bases are generally more likely to have such information.

3.5 HOW ARE ASSETS CONNECTED TO OWNERS?

Types of companies associated with physical assets. In order for physical asset-level data to be useful for financial analysis, it is necessary for databases to link individual assets to associated companies (and potentially to financial securities associated with those companies). Associated companies can be one of the following (Fig 3.7):

- **Asset operator/operating company**: In many sectors, when affiliated with a global ultimate owner, the operating company legally responsible for the asset may be a local affiliate or subsidiary company in the country or region.

- **Asset owner(s)**: The direct owner of the asset, which can be the operating company or can be another company. For some larger assets (oilfields, large power plants) assets can be owned in part by several different companies.

- **Ultimate parent owner**: From a risk standpoint, the ultimate parent company associated with the asset is often the most relevant, as this company is ultimately exposed and is also more likely to be an issuer of financial securities.

Consolidation and Security Matching. Due to the complicated ownership chain often associated with assets, financial and nonfinancial accounting standards have set up different standardized 'consolidation' approaches for assets and subsidiary companies. Current GHG accounting standards (ISO 2006; 2013; GHGP 2004) allow for three types of approaches (financial control, operational control, and equity share), and companies use different approaches in their reporting (see Fig 3.8 as an example of the uncertainty caused by consolidation).

This variability causes severe challenges in comparing consolidated company-level disclosures. Asset-level data can help to solve the problem by allowing consistent consolidation across all issuers; however this is only possible if each step in Fig 3.7 can be completed (match assets to owners (potentially through operators), owners to parents, and parents and financial security Identifiers (necessary for portfolio management and financial analysis). Our review shows that while the majority (18 of 26 databases) have some asset-level matching to ultimate parents, issues persist:

- Only 25% of commercial providers (7 of 26 in 3 sectors, oil & gas, mining, and power) link to financial security IDs
- In many cases ownership information is not complete (e.g. is only available 'when disclosed')
- Very few providers (mainly power and oil & gas) have information on asset-level equity stakes for multiple owners

Creating such connections is complex and time consuming and is further complicated by the use of proprietary standards for company and security IDs. Open source standards such as the legal entity ID (LEI) and financial instrument global ID (FIGI) are beginning to fix this problem but adoption is limited by the high market prevalence of proprietary IDs.

FIG 3.7: CONSOLIDATION NEEDED TO CONNECT ASSETS TO FINANCIAL SECURITIES. SOURCE: AUTHORS

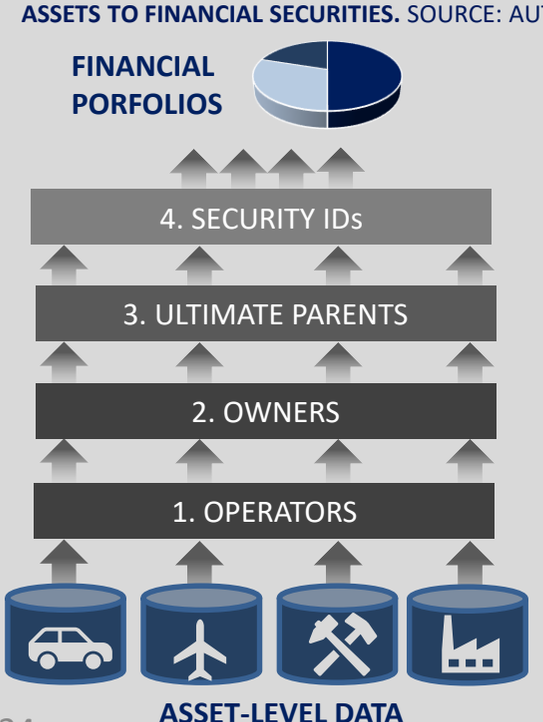
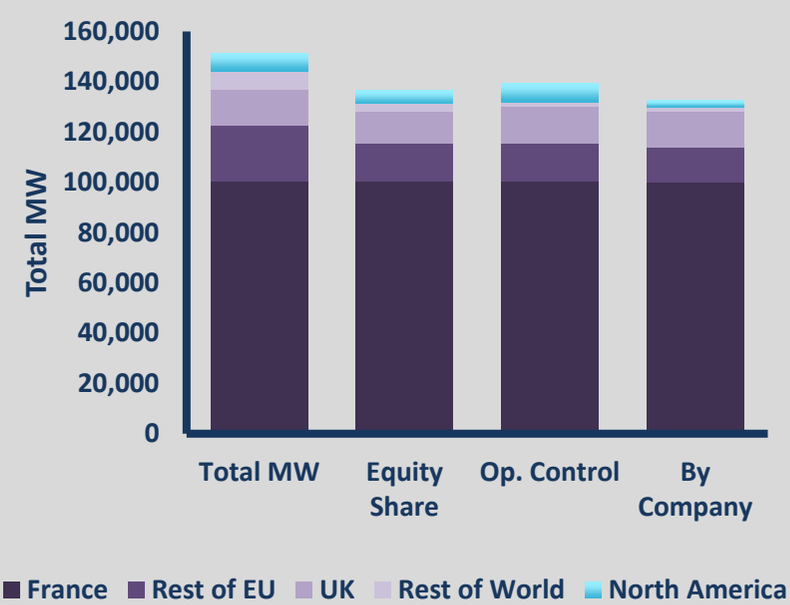


FIG 3.8: EXAMPLE CONSOLIDATION UNCERTAINTY—EDF SOURCE: EDF ANNUAL REPORT 2016



3.6 HOW DO USERS ACCESS COMMERCIAL ASSET LEVEL DATA?

Data needs for different users. Different users and use cases of asset-level data have different data needs, as shown in Table 3.5. In general, relatively few users/use cases require 100% global coverage of assets. For instance, competitive benchmarking and identification of business opportunities may be limited to a single market of interest (North America, EMEA), whereas financial institutions will generally only require either the assets of their current clients/investees (sell side equity, credit analysis) or assets associated with a certain market (e.g. listed equities for buy side analysis). Thus, ideally different users would be able to directly purchase or access specific subsets of the (usually) global universe of assets, including:

- **Countries** (e.g. all cement plants in Gemany)
- **Markets** (e.g. all aircraft owned by publicly listed airlines in developed markets)
- **Global parents** (e.g. all power plants owned/operated by Enel S.P.A.)

Existing business models. Obviously, open source databases (e.g. government data) can be utilized and subset to any of these use cases where they exist. Commercial data providers, on the other hand, choose their business model and whether they will offer only subscription-based access (generally priced to include the entire universe of assets) or also sell subsets of the data, generally for a discounted price.

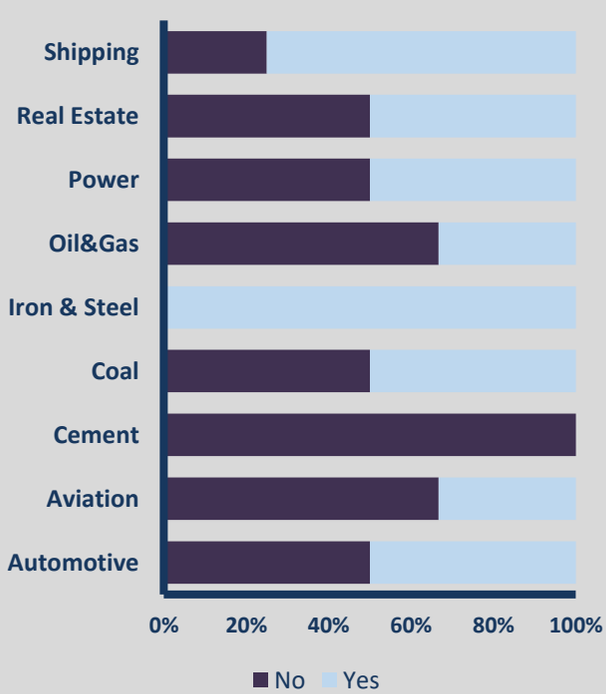
Figure 3.9 shows the proportion of data providers offering either custom or single asset-level data extracts. Interestingly, even with the relatively small sample reviewed here, most sectors have data providers that both do and do not offer them, implying that no major barriers exist to providers offering such services outside the obvious business model choice (volume vs. price). Several providers reported the challenge of transaction costs related to such an offering, given the associated lower revenues per client and the high per-client management costs (licensing agreement negotiation, client questions, etc.). However, other providers openly market data down to the individual asset and still others reported selling custom extracts alongside consulting services, which naturally increase the attractiveness of such an offer. Regardless of the offering, the vast majority of interviewed providers reported that subscriptions/licenses represent the bulk of revenues, with relatively few exceptions.

Data format issues. Another important accessibility issue is related to data format issues. While the majority of providers (both commercial and open source) provide machine readable data (e.g. Excel, CSV) formats, a limited number of providers do protect their IP by either limiting the size of downloads (e.g. 1000 assets per month) or providing information in non-machine readable format (e.g. PDF).

TABLE 3.5: USERS OF ASSET LEVEL DATA AND ASSETS NEEDED
SOURCE: AUTHORS

User Type	Use Case	Assets needed
Industry	Competitive Benchmarking	Assets owned by Competitors
Industry Supplier/ Service Provider	Business opportunities	Covered market
Financial Institutions	Buy side equity	Assets of listed companies
	Sell side equity/ engagement	Assets of investees
	Credit Analysis	Assets of Clients
Academic/NGO Researchers	Industry Research	Varies
Government	Industry Regulation	All assets in Region/ Country
	GHG Inventory Development	All assets in Region/ Country

FIG 3.9: FRACTION OF COMMERCIAL DATA PROVIDERS OFFERING CUSTOM EXTRACTS SOURCE: DATABASE REVIEW



4. SUMMARY: BARRIERS AND SOLUTIONS

4.1 SUMMARY OF CURRENT STRENGTHS AND BARRIERS

Key strengths and limitations. The previous sections have identified key strengths but also key weaknesses of asset-level data for key climate-related assessments (climate policy support and climate-related risk assessment). These strengths and limitations, summarized below in Table 4.1 below, are largely complementary with traditional ESG information from corporate disclosure channels:

- **PROs**: Asset-level data can add rich detail on certain company business operations and achieve broad, near universal, coverage where nondisclosure is an issue (as it is in many climate-related sectors, see pg. 9). It also offers forward-looking detail on planned capital expenditures in nearly all sectors (Table 3.2), allowing investors and other stakeholders insight into strategy and planning while tracking business and market-relevant parameters that can be directly connected to and are material for financial analysis.

- **CONs**: On the other hand, most asset-level data is not free, and the cost of using it is further complicated by usability concerns such as the need for consolidation and company/security matching to portfolios. Further, while databases offer key information on assets (production capacity, age, etc.), some critical information is missing (e.g. activity levels) and many existing offerings have not coupled assets to traditional ESG indicators (e.g. GHG emissions, GRI indicators), even where such indicators are already available.

The "Deep dive". In the broadest terms, asset-level data can currently be seen as a "deep dive" alternative to traditional ESG metrics and techniques—rich detail and insights but at significant costs in both monetary (license fees) and temporal (processing/analysis time) terms. To date, most ESG providers consulted for this study reported that this tradeoff is not worth the cost of asset-level data—they see a limited demand for the additional detail asset-level detail offers and thus the cost-benefit analysis limits their use of such data in analysis and ratings. Fortunately, this cost-benefit ratio is not fixed. As discussed in the remainder of this section, improvements in the data ecosystem can help derive the value asset-level data promises while limiting the cost.

TABLE 4.1: KEY STRENGTHS AND LIMITATIONS OF ASSET LEVEL DATA FOR CLIMATE-RELATED ASSESSMENTS. SOURCE: AUTHORS

Attribute	Asset Level Data	Corporate Disclosure Data
Completeness / Coverage	Near universal in most sectors	Significant non-disclosure currently
		Potential to change disclosure standards
Cost	Expensive licenses, one per sector/segment	Free (reports) or relatively low cost (one cross-sector database)
Accessibility / Usability	Consistent consolidation possible	Formatted for cross-company comparisons/screening
	Consolidation and security matching not always completed	Inconsistent consolidation rules
Available Attributes	High levels of technological and risk-relevant detail (e.g. asset age)	Company verified qualitative context
		Possible greenwashing High level/consolidated metrics
Data Quality	Business/market relevant metrics and information	Company-verified (and/or third party verified) data
	Company validation limited in many cases Limited ESG attribute information in existing offerings	Quality may be limited for non-material metrics
Time horizon	Existing assets and forward-looking capital planning	Forward-looking information generally qualitative only (could change with further forward-looking disclosure, CDP/ADEME 2017)

4.2. SUMMARY: THE FIVE CHALLENGES OF CONNECTING ASSET LEVEL DATA TO CLIMATE ANALYSIS

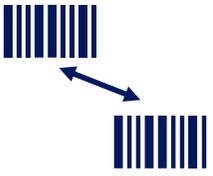
In this report we have explored the availability and strengths and weaknesses of asset-level data for climate analysis. Five core challenges emerge:

Cost. Most investors and ESG data providers (see pg. 18) report that the cost of asset-level databases are a major barrier to use. While any single industry database's costs may be manageable, the need to assess ESG- and climate-related issues across ***all*** (or at least all material) sectors makes purchasing high-resolution data for each sector cost-prohibitive. Search costs and training time compound these issues. This naturally leads to the desire for a single cross-industry solution (e.g. ESG scores, portfolio carbon footprint) that can achieve broader coverage of a diversified portfolio, even if the level of detail is not as high.

Asset Emissions/ESG Information: In general, asset-level databases were not designed for ESG and climate-related analysis and past/existing clients do not demand such information from commercial data providers. Thus, despite their increasing availability, asset-level emissions and ESG information are not broadly linked to commercial databases. The growth of asset-level data providers with some ESG focus (pg. 22) shows that at least some market players believe that adding such information could create a competitive advantage, but this is not yet widespread in the market intelligence data provider world.

Context: To be relevant for most analysis needs, asset-level data is not sufficient—it must be coupled to forward-looking transition/climate scenarios as well as company-level context on strategy, R&D, market positioning, and so on. Much of this data is in narrative form and disclosed by companies via traditional corporate disclosure channels (e.g. annual reports) or produced by investment and ESG research groups. Most asset-level data providers do provide analyst opinions and market research along with data, but this analysis may not always meet the needs of ESG-focused investors, regulators, etc.

Consolidation: In most cases, financial institutions invest in companies, not assets (exceptions are clear in private equity, project finance, etc.). Thus, these users require consistent ways to match individual physical assets to operating companies and the ultimate parent companies who own them at group level. Complicating the situation is the variability of consolidation rules applied in both financial and non-financial accounting practices (see pg. 3.8). While some asset-level data providers offer pre-consolidated (i.e. aggregated to ultimate parent) or information to perform consolidation (e.g. operating company-parent matching), this is not universal and requires further time and effort.



ID matching. Due to proprietary data standards for financial securities and lack of demand from industry users, many asset-level databases do not provide identifiers allowing users to match assets to financial securities. This in turn prevents financial institutions from directly assessing asset-level exposures with financial portfolios.

4.3 THE TRANSITION CAPITAL MONITOR: A LONG TERM VISION FOR CLIMATE AND FINANCIAL DATA

In the medium to long term, achieving the goals of the Paris Climate Agreement and monitoring climate-related risks will require a more permanent and systemic system tracking progress in both physical and financial terms. This envisioned system, a "transition capital monitor" would start from asset-level data to systemically track climate policy and energy transition progress by combining and linking together:

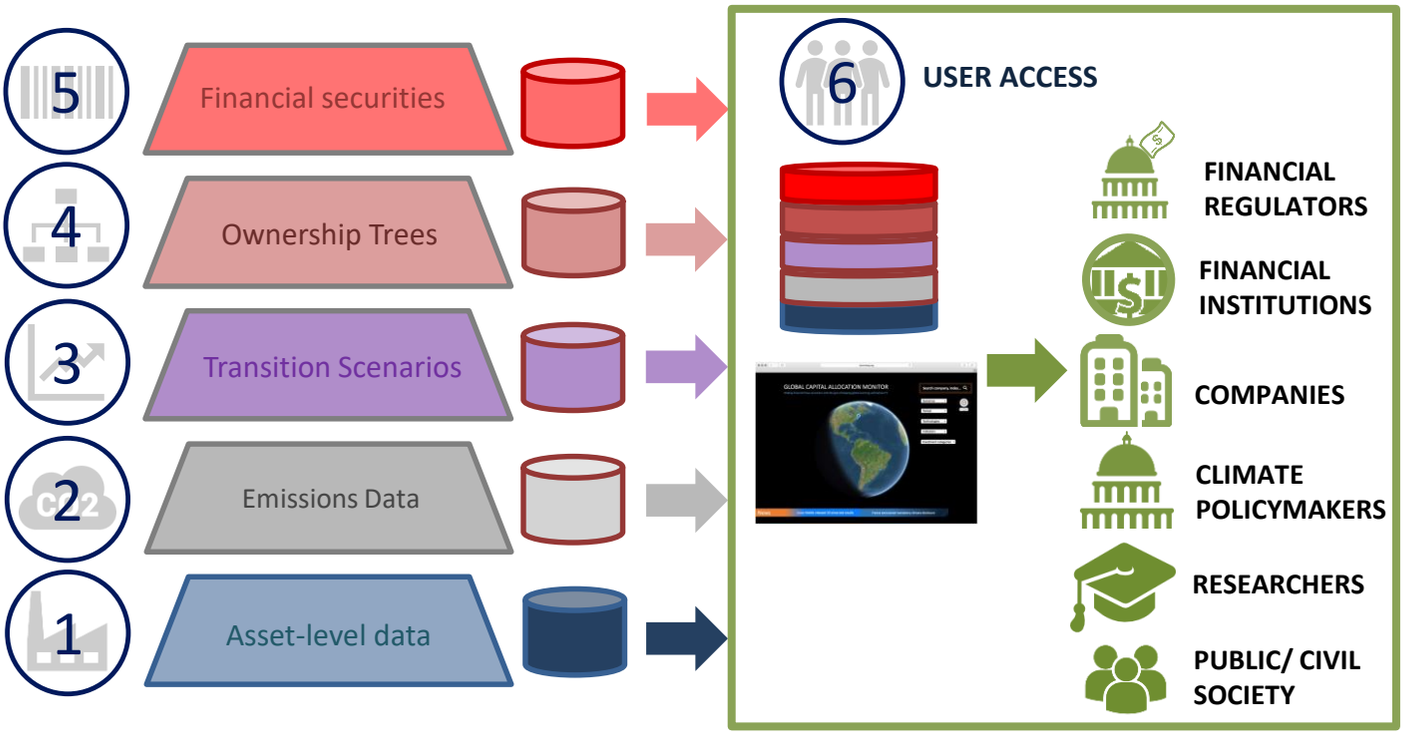


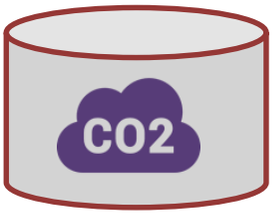
FIGURE ES-3: PROPOSED "TRANSITION CAPITAL MONITOR" (SOURCE: AUTHORS)

ASSET LEVEL DATA

The core basis of climate progress tracking, and GHG inventory creation, is the physical asset. Harnessing data on existing and planned assets with both activity (e.g. production) and ownership data would allow systematic tracking of climate policy goals by industry, country/region, and company/non-state actor. This in turn would allow any entity (country, company, city, financial institution) to assess their current state and future trajectory in the energy transition as well as physical climate risk exposure via geolocated asset maps.

GHG EMISSIONS DATA

While not the only relevant indicator for some analyses (particularly financial risk) , a key component of climate progress tracking and transition risk assessment is the gross GHG emissions and emissions intensity (e.g. CO_2/MWh, CO_2/ton) of assets. Such an accounting system allows local/regional/national exposure assessments to energy transition-related policies and market dynamics. As discussed above, such data can be sourced from voluntary (pg. 16) or mandatory (pg. 21) reporting programs or estimated at asset-level and verified at company level (2dII 2017).



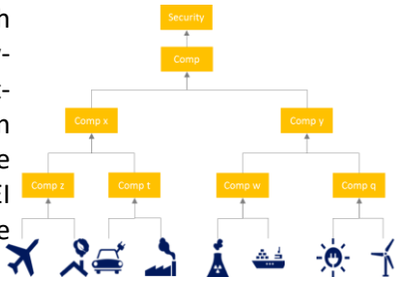
3 TRANSITION AND CLIMATE SCENARIOS

Understanding transition risk and assessing climate policy progress require forward-looking scenarios capturing alternative futures for climate change and energy systems (2ii 2016c, TCFD 2016a). As highlighted recently by TCFD, many (near) open-source transition and physical climate scenarios exist, but have limitations, including: a) hampered by similar access and usability issues as transition data and b) not currently directly linkable to financial analysis due to downscaling (e.g. region vs. country, country vs. company) and parameterization issues (see 2ii 2016a for more detail). Further, such scenarios can lack key data needs for corporate planning, such as the identification of innovation/R&D needs. Public access to reference and alternative energy/climate scenarios in usable and consistent formats thus represent a key area for research and engagement.

...

4 OWNERSHIP TREES

Connecting emissions and economic activity “on the ground” with financial markets requires consistent and transparent subsidiary-parent relationship matching, a key current limitation in both asset-level data and corporate reporting (due to inconsistent consolidation approaches). While incorporation information is private in some jurisdictions, projects like OpenCorporates (2017) and the Global LEI Foundation (GLEIF 2017) show the potential for an open source transparent system on corporate structure.



5 FINANCIAL SECURITIES

Linking companies to financial security information allows the final level of usability in financial analysis—connection to financial portfolios and institutions. As shown above, such connections are already common if not universal in commercial asset-level databases, though are limited in open governmental data and are not always complete. This is partly due to the lack of demand from users, but most data providers expect this link is possible without much effort if a market opportunity was identified.

6 USER ACCESS

Probably the most difficult issue in achieving this vision is assuring cost-effective (possibly free) and user/use-case specific access to such data, linked in a useful manner. In most cases, asset-level data is gathered using proprietary and often time-intensive methods and in certain cases (e.g. some financial security identifiers) data itself is proprietary. This said, achieving the visions set out in both the Paris Agreement (Art 2.1c) and the TCFD voluntary disclosure paradigm (i.e. consistent disclosure of climate-related scenario analysis) likely requires such a system. It is unlikely to occur overnight, but initial steps by both data providers and data users can start movement toward the goal, and the need creates both new potential business opportunities for data providers and new potential research opportunities for the public, academia, and research organizations.

4.4. HOW DO WE GET THERE? NEAR TERM RECOMMENDATIONS

Achieving the vision described in the previous section is a multi-year, multi-step process, but initial steps by different actors will help achieve more cost-effective use of asset-level data in climate and ESG applications.

RECOMMENDATIONS FOR ASSET-LEVEL DATA PROVIDERS

1. MAKE ASSET-LEVEL DATA MORE USABLE FOR FINANCIAL ANALYSIS. As discussed in previous sections, for many data providers adding a range of asset attributes (e.g. open source financial and company identifiers (e.g. LEI, FIGI), ultimate parent company, geolocation, age) elements, where possible, will greatly enhance the usability for financial and climate/ESG assessments.

2. CONSIDER CUSTOM ASSET EXTRACTS. While transaction costs and fixed costs will limit this in some cases, developing sub-global product offerings may open new markets for users outside the sector of focus (who may not need global coverage). Partnering with ESG data providers, researchers, and environmental authorities may provide new opportunities for collaboration.

3. INTEGRATE GHG EMISSIONS AND OTHER ESG INFORMATION WHERE RELEVANT. While the market may be limited currently, climate policy, the energy transition, and climate change itself are likely to make such asset attributes a competitive product differentiator.

RECOMMENDATIONS FOR ESG DATA PROVIDERS AND RESEARCHERS

1. CONSIDER ASSET-LEVEL DATA FOR KEY MATERIAL SECTORS. The strengths of asset-level data, particularly coverage for poorly disclosing entities and ESG outlier assessment and forward-looking capital plans, strongly suggests a use case for forward-looking analysis and ratings.

2. DEVELOP RESEARCH COLLABORATIONS TO CLOSE EXISTING GAPS. The combined financial sector and ESG expertise of ESG providers represent a unique skill set for the use cases described above, and new collaborations may emerge in the near future with academia, environmental regulators and agencies, and NGOs. A particular focus could be open source matching from government emissions and asset data to issuers and voluntary disclosure data (e.g. CDP).

RECOMMENDATIONS FOR GOVERNMENTS AND DISCLOSURE ORGANIZATIONS

1. ENCOURAGE ASSET- AND CORPORATE LEVEL DISCLOSURE WITH CONSISTENT CONSOLIDATION. As both voluntary and mandatory disclosure programs advance, ensuring their consistency will become increasingly important. Encouraging both asset- and corporate-level disclosure will maximize the key strengths of both models.

2. REQUIRE ACTIVITY DATA DISCLOSURE. Where not limited by CBI concerns, requiring or encouraging the disclosure of asset-level activity information (alongside emissions) greatly enhances the meaningfulness and usability for many use cases. Tools like US EPA's eGrid (EPA 2015) that combine both emissions and activity data are more useful than emissions data alone.

RECOMMENDATIONS FOR INVESTORS

1. EXPLORE THE USE OF ASSET-LEVEL DATA IN ENGAGEMENT. Engagement activities represent a key potential first use case for asset-level data, particularly for forward-looking engagement on energy transition plans and scenario analysis (TCFD 2016a; Ceres 2016).

2. WORK WITH EQUITY AND CREDIT ANALYSTS TO ACCESS ASSET-LEVEL DATA. Some ESG or sustainable investment officers may have indirect access to market intelligence data through analysts. This represents an important collaboration point with sector analysts.

ANNEX 1: REVIEWED DATABASES

TABLE A.1: REVIEWED COMMERICAL ASSET-LEVEL DATABASES

Sector	Type	Database	Website
Oil&Gas	Commercial ALD	GlobalData	Link
	Commercial ALD	WoodMackenzie Upstream Data Tool	Link
	Commercial ALD	Rystad Energy Ucube	Link
Coal Mining	Commercial ALD	SNL Energy Metals & Mining	Link
	Commercial ALD	WoodMackenzie	Link
Automotive	Commercial ALD	WardsAuto/AutoForecastSolutions	Link
	Commercial ALD	IHS Automotive	Link
	Commercial ALD	Marklines	Link
Power Generation/ Utilities	Commercial ALD	GlobalData	Link
	Commercial ALD	Platts WEPP	Link
	Commercial ALD	EnerData Power Plant Tracker	Link
	Commercial ALD	Bloomberg New Energy Finance (BNEF)	Link
Aviation	Commercial ALD	CAPA Fleets	Link
	Commercial ALD	FlightGlobal Ascend Fleets	Link
	Commercial ALD	CAPA airport investors database	Link
Shipping	Commercial ALD	Rightship GHG Rating	Link
	Commercial ALD	IHS Seaweb	Link
	Open Source/ Commercial ALD	shippingefficiency.org BetterFleet	Link
	Commercial ALD	Clarksons	Link
Iron & Steel	Commercial ALD	PlantFacts	Link
	Industry-led Private	WorldSteel	Link
Cement	Commercial ALD	Global Cement Directory	Link
	Commercial ALD	Global Cement Review	Link
	Industry-led Private	WBCSD GNR	Link
Real Estate	Commercial ALD	GRESB	Link
	Commercial ALD	Geophy	Link

TABLE A.2: REVIEWED GOVERNMENT, PRIVATE AND OPEN SOURCE ASSET-LEVEL DATABASES

	Type	Database	Website
Cross-sector	Government	EU ETS	Link
	Government	EPA GHGRP	Link
	Government	Australia's National Greenhouse and Energy Reporting Scheme	Link
	Government	Canada's GHG Emissions Reporting Program	Link
	Government	Japan's Mandatory GHG Accounting and Reporting System	Link
Power Generation/ Utilities	Open Source	CoalSWARM	Link
	Open Source	Enipedia/CARMA	Link
	Government	EPA eGrid 2012	Link
Aviation	Open Source	OpenFlights	Link

ANNEX 2: DETAILED DATA AVAILABILITY TABLES

FIG A2.1: COVERAGE OF COMMERCIAL ASSET-LEVEL DATABASES (SOURCE: AUTHORS)

Sector	Database	Total Number of Assets	(units)	% of global total coverage	Planned Assets
Oil & Gas	GlobalData Upstream Analytics	24,000	fields & licenses	near global	Yes
	WoodMackenzie Upstream Data Tool	30,000	fields & licenses	near global	Yes
	Rystad Energy Ucube (upstream)	65,000+	fields & licenses	global	Yes
Coal	SNL Energy	1,105	coal mines (US)	near universal for US/Canada	
	WoodMackenzie	292	coal mines	near global	Yes
	GlobalData Mining IC	~5,000	coal mines	near global	Yes
Automotive	WardsAuto/Auto Forecast Solutions	~100M	light duty vehicles	near global	Yes (vehicle)
	Marklines	~100M	light duty vehicles	near global	Yes (vehicle)
Power	GlobalData	143,000	generating units	near global	Yes
	Platts WEPP	210,000	generating units	near global minus China	Yes
	EnerData Power Plant Tracker		80% of global assets	near global minus China	Yes
	BNEF			near global	Yes
	Enipedia/CARMA	75,000	plants	near global	No
Aviation	CAPA Fleets	57,000	commercial aircraft	near global	Yes
	FlightGlobal Ascend Fleets	240,000	includes >100,000 commercial aviation, 50,000 biz aviation, and 80,000 helicopters	near global	Yes
Shipping	Rightship GHG Rating	200,000	ships (over 100 tons)	near global	No
	IHS Seaweb	180,000	ships (over 100 tons)	near global	Yes
	shippingefficiency.org BetterFleet	70,000	existing ships (over 100 tons)	near global	No
	Clarksons	135,000	ships (over 100 tons)	near global	Yes
Iron & Steel	PlantFacts	12,800	plants, with works representing multiple (~2-10) plants	near global minus China	Yes
Cement	Global Cement Directory	2,200	integrated cement plants	near global	Yes
	International Cement Review	2,300	integrated and grinding	near global minus China	Yes
	WBCSD GNR	934	integrated cement plants	21% of global production	No
Real Estate	GRESB	22,000	buildings (asset-level)	56% of reported holdings (from 74% in Europe to 39% in Asia)	No
	Geophy	102,000,000	buildings	High share of focus portfolios (large insurance/pensions)	
Airports	OpenFlights	7,000	airports	30% of airports, near 100% of traffic	Yes
	CAPA airport investors database	5,025	airports	30% of commercial airports	Yes

NB: Data represent values derived from interviews, desk research, and existing subscriptions at a single point in time between August and December 2016. All values are subject to change. Any errors are those of the authors. Blanks represent unknown or confidential values.

FIG A2.2: OWNER/OPERATOR VARIABLES OF COMMERCIAL ASSET-LEVEL DATABASES (SOURCE: AUTHORS)

Sector	Database	Owner Available?	Operator Available?	Ultimate Parent Available?	Financial Identifiers Available?
Oil & Gas	GlobalData	Yes	Yes	Yes	Financial
	WoodMackenzie Upstream Data Tool	Yes	Yes	Yes	Financial
	Rystad Energy Ucube (upstream)	Yes	Yes	Yes	No
Coal	SNL Energy	Yes	Yes	Yes	Financial
	WoodMackenzie	Yes	Yes	Yes	Financial
	GlobalData Mining IC	Yes	Yes	Yes	Financial
Automotive	WardsAuto/Auto Forecast Solutions	Yes	Yes	Yes	No
	Marklines	Yes	NA	Yes	No
Power	GlobalData	Yes	Yes	Yes	Financial
	Platts WEPP	Yes	Yes	Yes	No
	EnerData Power Plant Tracker	Yes	Yes	Yes	No
	BNEF	Yes	Yes	Yes	Financial
	Enipedia/CARMA	Yes	No	No	No
Aviation	CAPA Fleets	Yes	Yes	Yes	Industry (IATA)
	FlightGlobal Ascend Fleets	Yes	Yes	No	Industry (IATA)
Shipping	Rightship GHG Rating	Yes	Yes	No	Industry (IMO)
	IHS Seaweb	Yes	Yes	Yes	Industry (IMO)
	shippingefficiency.org BetterFleet	Yes	Yes	No	No
	Clarksons	Yes	Yes	Yes	Industry (IMO)
Iron & Steel	PlantFacts	Mix of both		No	No
Cement	Global Cement Directory	No	Yes	Yes by country	No
	International Cement Review	Yes	Yes	Yes	No
	WBCSD GNR	No	No	No	No
Real Estate	GRESB	Yes	No	Yes	Financial
	Geophy	yes		Yes	Financial
Airports	OpenFlights	No	No	No	No
	CAPA airport investors database	Yes	Yes	No	Industry (ICAO/IATA)

NB: Data represent values derived from interviews, desk research, and existing subscriptions at a single point in time between August and December 2016. All values are subject to change. Any errors are those of the authors. Blanks represent unknown or confidential values.

FIG A2.3: ASSET ATTRIBUTES OF COMMERCIAL ASSET-LEVEL DATABASES (SOURCE: AUTHORS)

Sector	Database	Status	Capacity completeness for included assets	Activity completeness for included assets	By Fuel Type?
Oil & Gas	GlobalData	Yes	Yes	Where disclosed/ Modeled	Yes
	WoodMackenzie Upstream Data Tool	Yes	Yes	Where disclosed/ Modeled	Yes
	Rystad Energy Ucube (upstream)	Yes	Yes	Where disclosed/ Modeled	Yes
Coal	SNL Energy Metals & Mining	Yes	Yes	Yes	No
	WoodMackenzie	Yes	Yes	Where disclosed/ Modeled	Yes
	GlobalData Mining IC	Yes	Partial (reserves)	Where disclosed/ Modeled	Yes
Automotive	WardsAuto	Yes	US (facility-level)	Yes	Yes
	Marklines	Yes	Partial (facility-level)	Yes	Yes
Power	GlobalData	Yes	Yes	Where disclosed	Yes
	Platts WEPP	Yes	Yes	No	Yes
	EnerData	Yes	Yes	Where disclosed	Yes
	BNEF	Yes	Yes	Where disclosed	Yes
	Enipedia/CARMA	No	No	<80%	No
Aviation	CAPA Fleets	Yes	Yes	Yes	No
	FlightGlobal Ascend Fleets	Yes	Yes	Yes	No
Shipping	Rightship GHG Rating	Yes	Yes	No	No
	IHS Seaweb	Yes	Yes	Where available	Yes (partial)
	shippingefficiency.org BetterFleet	Yes	Yes	Where available	Yes
	Clarksons	Yes	Yes	Where available	Yes
Iron & Steel	PlantFacts	Yes	Yes	No	Yes
Cement	Global Cement Directory	Yes	Yes	No	No
	International Cement Review	Yes	No	No	Yes (partial)
	WBCSD GNR	Yes	Yes	Yes	Yes
Real Estate	GRESB	Yes	Yes		Yes
	Geophy	Yes	Yes	Yes (modeled)	Yes (modeled)
Airports	OpenFlights	No	No	Where available	No
	CAPA airport investors database	Yes	Yes	Yes	No

NB: Data represent values derived from interviews, desk research, and existing subscriptions at a single point in time between August and December 2016. All values are subject to change. Any errors are those of the authors. Blanks represent unknown or confidential values.

FIG A2.3 (cont.): ASSET ATTRIBUTES OF COMMERCIAL ASSET-LEVEL DATABASES (SOURCE: AUTHORS)

Sector	Database	Location type	Initial operation age available?	Refurbishment information available?	GHG Emissions info available?	Production Cost Available?
Oil & Gas	GlobalData	Geolocation	Yes	Capex by year	No	Estimated
	WoodMackenzie Upstream Data Tool	Geolocation	Yes	Capex by year	No	Estimated
	Rystad Energy Ucube (upstream)	Geolocation	Yes	Capex by year	No	Estimated
Coal	SNL Energy Metals & Mining	Geolocation	Yes	No	No	Estimated
	WoodMackenzie	Geolocation	Yes	Capex by year	No	Estimated
	GlobalData Mining IC	Gelocation	Yes	No	No	Estimated
Automotive	WardsAuto	Country (production/sales /registrations) City/state (production facilities)	Yes		Yes (USA)	No
	Marklines	Geolocation	Yes	Yes	Limited CO_2	No
Power	GlobalData	Geolocation	Yes	Capex	Limited CO_2/SO_2/NO_x/ CCS	Limited power purchase information; LCOE modeling
	Platts WEPP	Geolocation	Yes	No	No	No
	EnerData	Geolocation	Yes	Capex	Yes	No
	BNEF		Yes		Limited	Where disclosed plus extensive LCOE modeling
	Enipedia/CARMA	Geolocation	No	No	Yes (modeled)	No
Aviation	CAPA Fleets	Flag Country	Yes	No	No	Estimated
	FlightGlobal Ascend Fleets	Flag Country	Yes	No	No	Estimated
Shipping	Rightship GHG Rating	Flag Country	Yes	No	Yes	No
	IHS Seaweb	Flag and Geolocation (Route)	Yes	No	No	No
	shippingefficiency. org BetterFleet	Geolocation	No	No	Yes (modeled)	No
	Clarksons	Flag Country	Yes	Yes	No	No
Iron & Steel	PlantFacts	City/Country	Yes	Yes	No	No
Cement	Global Cement Directory	Map	No	No	No	No
	International Cement Review	Map	No	No	No	No
	WBCSD GNR	Country	No	No	Yes	No
Real Estate	GRESB		No	No	Yes	No
	Geophy	Geolocation	Yes (partial)	No	Yes	No
Airports	OpenFlights	Geolocation	No	No	No	No
	CAPA airport investors database	Geolocation	Yes	No	No	No

NB: Data represent values derived from interviews, desk research, and existing subscriptions at a single point in time between August and December 2016. All values are subject to change. Any errors are those of the authors. Blanks represent unknown or confidential values.

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NB: This list represents only report references, not reviewed databases. For links to reviewed databases please see Annex 1.

GLOSSARY

CBI—Confidential business information

CSR—Corporate Social Responsibility, traditional sustainability reporting by companies

ESG—Environmental, social, and governance; term used to describe non-financial corporate performance indicators in these dimensions.

ETS—Emissions trading scheme; an environmental policy mechanism whereby emitting assets are allocated or auctioned permits to emit, which can then be traded on a market.

FIGI—Financial Instrument Global Identifier, the only open source data standard/identifier for financial instruments

FSB—Financial Stability Board

GHG—Greenhouse gas, including CO_2, CH_4, N_2O, fluorinated gases, and others

ISIN—International Securities Identification Number, based on ISO 6166, an internationally used security identification number based on ISO issuing country and a nationally determined identifier.

LEI—Legal Entity Identifier, a global centralized system of corporate identifiers advanced by the G20 and FSB to standardize company identification and overseen by the Global LEI Foundation.

Physical Asset—a tangible asset of economic value.

R&D—Research and development

REIT—Real Estate Investment Trust

SEC—Securities and Exchange Commission, a financial regulatory body in the USA.

TCFD—Task force on Climate-related Financial Disclosures, a body set up by the Financial Stability Board to study and make recommendations regarding disclosure on climate-related risks in financial markets

Ticker—Commonly used to represent “ticker symbol”, a symbol for identifying equity securities and assigned by stock exchanges.

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