YELLOW BRICK ROAD

FROM CLIMATE INVESTMENT ROADMAPS TO SCIENCE-BASED FINANCING ROADMAPS

EUROPEAN UNION

H2020 - Grant agreement No 649982

July 2017

2° Investing Initiative

ABOUT 2° INVESTING INITIATIVE

The 2° Investing Initiative [2°ii] is a multi-stakeholder think tank working to align the financial sector with the 2°C climate goal and long-term investment needs. Our research work seeks to align investment processes of financial institutions with climate goals; develop the metrics and tools to measure the climate friendliness of financial institutions; and mobilize regulatory and policy incentives to shift capital to energy transition financing. The association was founded in 2012 and has offices in Paris, London, Berlin, and New York City.

ABOUT SEI METRICS PROJECT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649982. This report was published in the context of the H2020 "Sustainable Energy investment Metrics" project. The project aims to develop a climate performance framework and associated investment products that measure the exposure of financial portfolios to the 2°C economy. The metrics, benchmarks, and tools will enable investors to align their portfolio with decarbonization roadmaps. The project runs from March 2015 to March 2018 and mobilizes over €2.5m in funding. Consortium members in the project include the 2° Investing Initiative, CIRED, WWF Germany, Kepler-Cheuvreux, Climate Bonds Initiative, Frankfurt School of Finance & Management, CDP, WWF European Policy Office and the University of Zurich.

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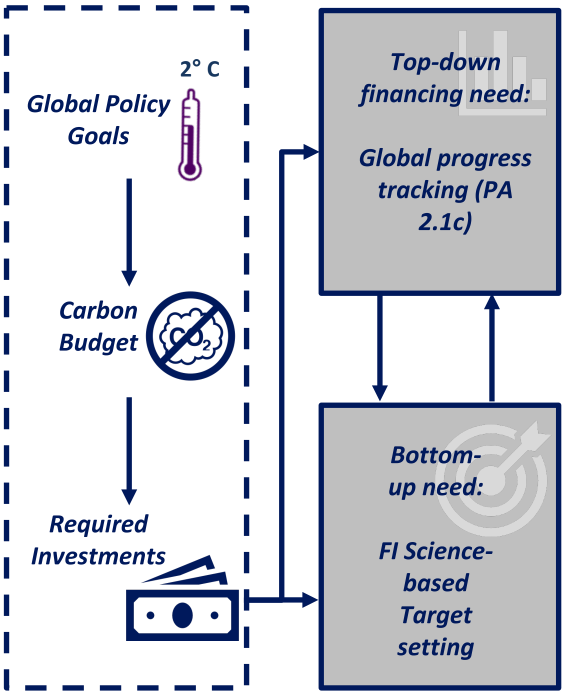
EXECUTIVE SUMMARY

Financing roadmaps: the need (Section 1). The importance of finance to support climate action is now widely recognized, enshrined in the Paris Agreement (Article 2.1(c)). Further, non-state actors of all kinds (cities, regions, companies, and financial institutions (FIs)) are endeavoring to set "science-based targets", a recognition that achieving global goals will require everyone to do their fair share of climate mitigation. However, until now no formal approach is available for financial institutions to understand, measure, and set targets for how much "green" finance is required for mitigation, or how "brown" finance might need to be limited. Thus, there are both urgent 'top-down' (global progress tracking for the Paris Agreement) and 'bottom-up' (FI target setting) needs for a science-based approach to tracking financial flows in line with global policy goals—"financing roadmaps" (Figure ES1). This report explores how such a system can be created.

FIGURE ES1: TOP-DOWN AND BOTTOM-UP NEEDS FOR FINANCING ROADMAPS

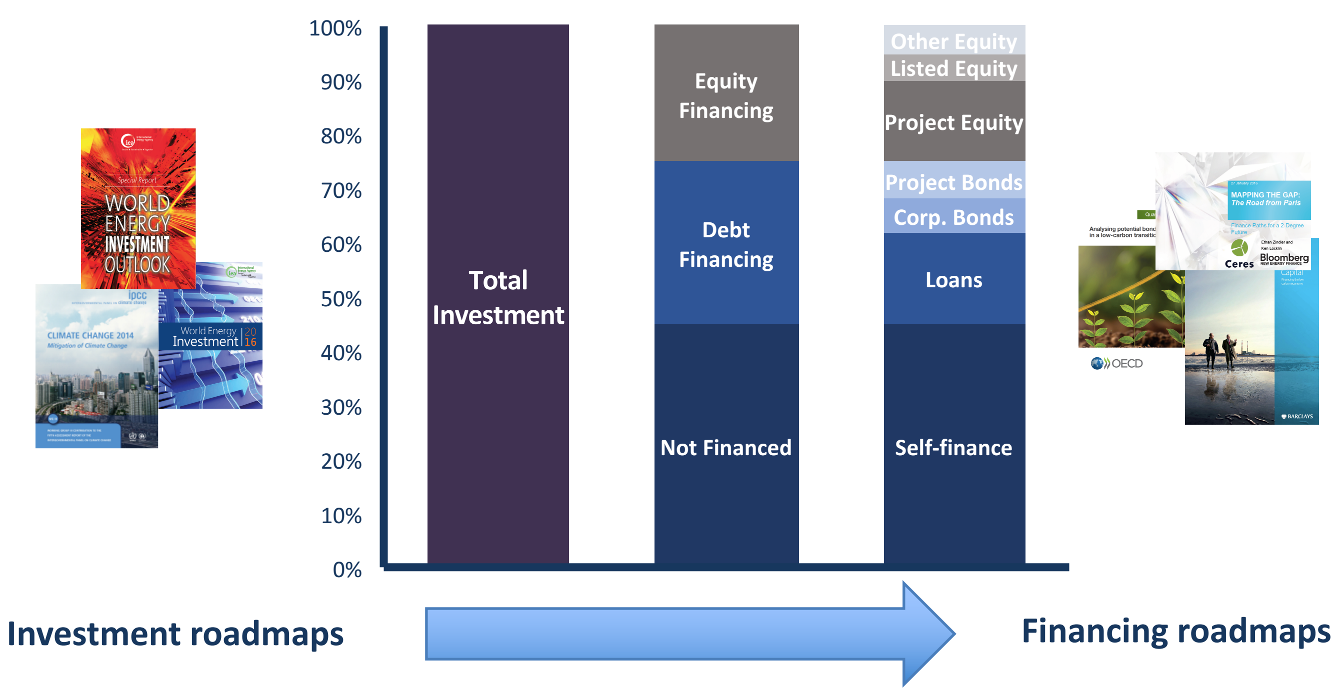


Estimating investment needs (Section 2). Science-based financing roadmaps start from an understanding of the required capital investments to support global goals, a function of the goal and its associated carbon budget. As described in Section 2, energy systems models track such investments based on the technology requirements of different climate scenarios (e.g. required growth in renewable power by region over time, required decline in oil & gas production by region over time). Various institutions and authors, including IPCC and IEA, have estimated such needs. However, a key limitation of investment roadmaps is that they do not distinguish different types of capital (e.g. debt vs. equity, and loans vs. bonds within debt).

Estimating financing needs (Section 3). To break down these investment flows into constituent financing flows requires data and assumptions on how different sectors and technologies are financed (e.g. debt/equity ratios) and how this may change with time. The difficulty in doing so is a function of several factors that vary considerably between sectors and technologies:

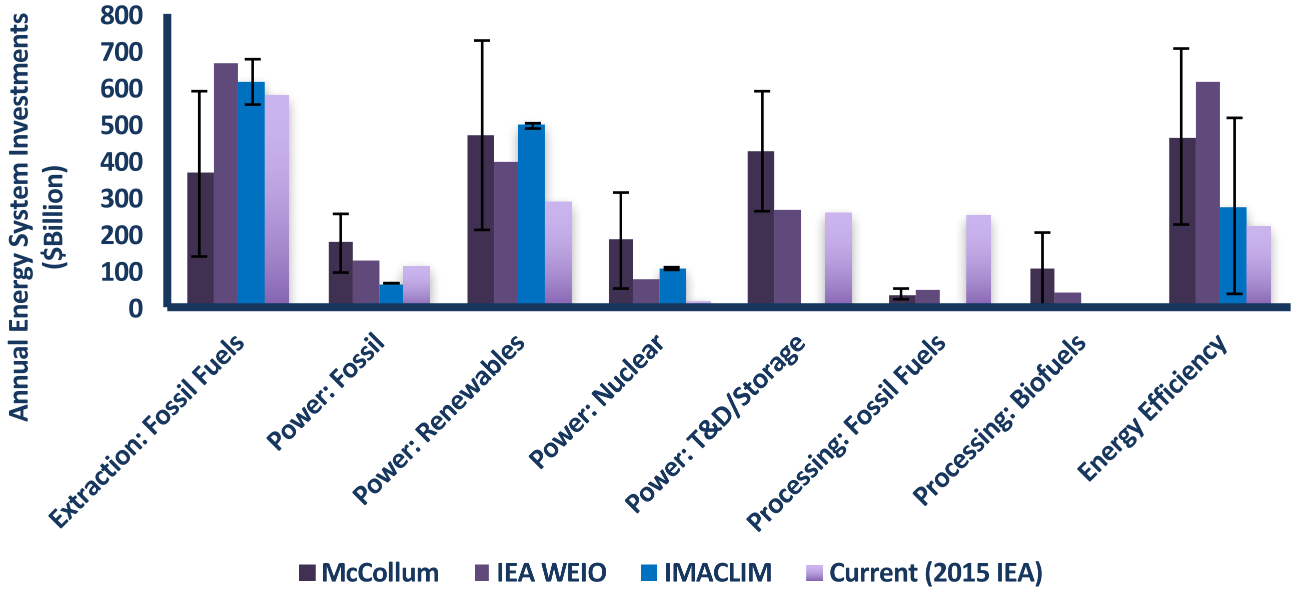
- How many types of **owners** play a material role?
- How many **financial actors** play a material role?
- How many **financial instruments** are commonly utilized?
- Is detailed **data** available on current financing?

FIGURE ES2: DEFINING 2° C FINANCING ROADMAPS 'TOP-DOWN' FROM INVESTMENT ROADMAPS (SOURCE: AUTHORS)



Example roadmaps (Section 4). Section 4 of this report illustrates different ways to estimate financing roadmaps for key energy technologies, starting with an understanding of investment needs and current investment levels (Figure ES3). Short of energy efficiency, where accounting is challenging (pg 15), current annual investment in energy systems ($1.6-1.8 trillion/yr) is consistent with the *total* investment needs under a 2C scenario across models (Fig 4.1), but low carbon investments (renewables, nuclear, efficiency) are near the low end of needs and some high carbon investments (fossil extraction and processing) are near the high end of estimated needs.

FIGURE ES3: ANNUAL GLOBAL ENERGY INVESTMENTS IN A 2C ENERGY TRANSITION (MCCOLLUM 2013; IEA 2014; SMASH 2017)



Building on required investment levels, high-level financing targets for the entire economy can be set by first breaking down investments into different types of financing based on current finance structures (pg 15). These high-level targets can then be applied to individual institutions in two ways:

- **Absolute financing targets** (e.g. Figure ES4 for project finance to the power sector), based on regional financing market shares
- **Relative (ratio-based) financing targets** (e.g. Figure ES5) at portfolio level showing relative levels of 'green' and 'brown' financing consistent with the 2C scenario.

Each method has important strengths and weaknesses in terms of practicality and uncertainty (see Section 5).

FIGURE ES4. ESTIMATED RENEWABLE POWER AND FOSSIL-FIRED POWER FINANCING TARGETS, EU 2020-2025

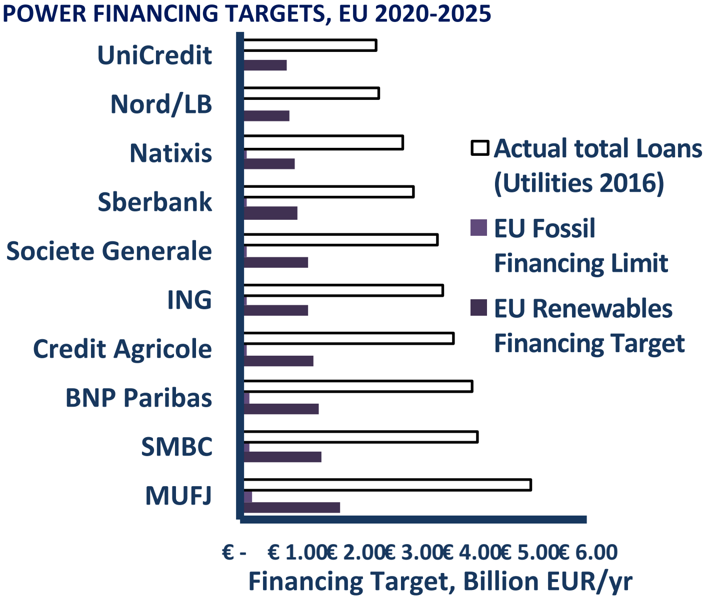
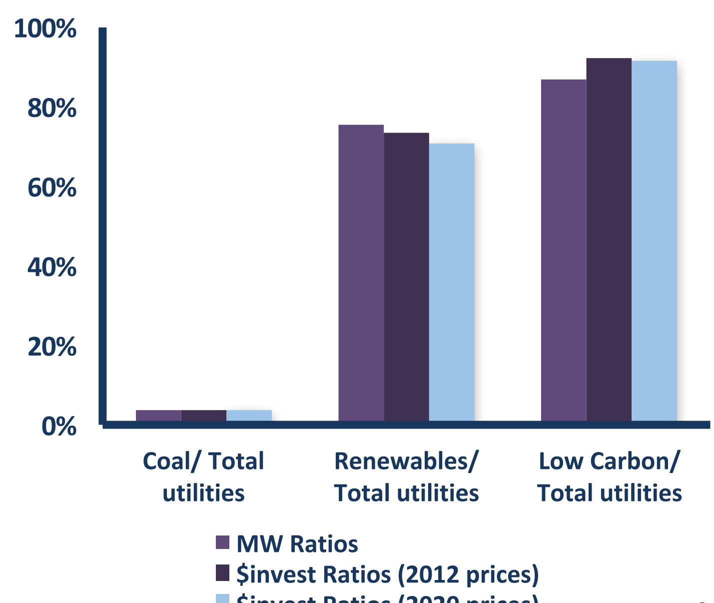


FIGURE ES5: SAMPLE 'SCIENCE-BASED' INVESTMENT AND TECHNOLOGY RATIOS IN PHYSICAL AND FINANCIAL TERMS, EU 2020-2025 (SOURCE: AUTHORS)



Key recommendations: financing roadmaps and science-based targets. Regardless of the use case (top-down tracking; institutional target setting) and approach taken (absolute targets; relative targets), several important steps are still needed to provide a comprehensive framework and data for meeting the use case's needs. This future work ranges from data gathering and research to potential regulatory and standardization responses. The following key enabling activities would begin to overcome the key identified challenges (pg 16) to developing credible and accepted roadmaps and targets for climate mitigation finance.

1

Modeling needs: Scenarios and investment tracking in line with stocks. A critical need for investment and financing roadmaps are transparent, consistent, annually updated forward-looking scenarios and backward-looking tracking of climate-relevant investments. Institutions including the IPCC and IEA already provide pieces of such a consistent system, but IEA recently switched to only annual updates of its backward-looking report (World Energy Investment Report) rather than forward-looking scenarios (World Energy Investment Outlook). Generally climate and energy scenarios will be most useful to the financial sector if both *stocks* of technologies (e.g. MW of renewables in EU in 2025) and *investment levels (*e.g. MW renewables additions and retirements per year) are consistently reported. Importantly, this should not be a significant lift in terms of modeling, as energy systems models must internally solve for additions/investments and retirements anyway—it is just a matter of outputting the results consistently.

2

Data needs: Further detail on existing financing structures. Data availability is a key challenge for finance roadmaps and targets, as the sparse existing data suggests highly uncertain financing structure (Section 3.3) and limited information on investments in some sectors. This may be partly solved by more institutions developing and disclosing voluntary targets, though a "chicken and egg" problem exists here, since standards may require such data. A public sector role could also be important here, with top-down tracking needs meeting bottom-up voluntary target setting through a holistic system such as the conceptual "transition capital monitor" (2ii 2017b). Financial regulators could also play a role in providing aggregated data from collection efforts such as the Anacredit project (ECB 2015).

3

Policy and Engagement needs: Broad agreement on the role of public and private FIs. In line with the broader discussion on climate finance, broader agreement on the various roles of different financial institutions (DFIs, commercial banks, institutional investors) in providing the needed levels of climate finance would be very helpful to target setting, since they affect the "fair share" of different players (Section 5.1). Such discussions should continue in appropriate venues (UNFCCC, G20, etc.).

4

Research needs: Benchmarks for RD&D. Given the critical need for innovation finance in addition to deployment finance, research is direly needed to develop credible roadmaps and targets on financing for research, development, and early demonstration of emerging technologies. Such research should bring together industry, government R&D funders, and energy systems modelers.

5

Standardization needs. Finally, some aspects of science-based targets and roadmaps for the financial sector can only be solved through standardization since no "right answer" exists. Institutions like the Science-Based Targets Initiative should establish rules and methodologies to govern such issues, like accounting across asset classes and setting institution level targets. Such work should follow the general principles already laid out by DFIs in Common Principles on Climate Finance Accounting (Joint Climate Finance Group 2015).

1. CONTEXT

The need for climate finance. The importance of finance for responding to climate change mitigation and adaptation issues has been recognized for several years, formalized in the 2009 Copenhagen Accord (UNFCCC 2009) with a pledge of $100 billion/yr by 2020 to support mitigation and adaptation activities. As tracked by the Climate Policy Initiative, current estimates of such “climate finance” amount to nearly $400 billion in 2015, including government and private sources (Figure 1.1). The Paris Agreement further recognized the critical role of financing to support mitigation and adaptation in Article 2.1(c), calling to “[make] finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.”

The rise of non-state actors. At the same time, it has increasingly been recognized that government action alone may not be sufficient to meet these global goals. Instead, collective action will require both a conducive policy framework from nations and voluntary actions from subnational “non-state actors”, including financial institutions. The UN Framework Convention on Climate Change (UNFCCC) has tracked such voluntary actions in the lead-up to and since the Paris Agreement, with over 5000 individual and collective actions currently tracked (Figure 1.2).

Financial institutions as a critical driver. These broader trends have increased activity at financial institutions on climate change mitigation (and its related financial risk). Such actions span the range of financial institutions (institutional investors, commercial banks, insurance, etc.) and range from voluntary reporting initiatives (e.g. UN PRI Montreal Pledge), commitments to ‘green’ financing (e.g. individual bank commitments), coordination and standardization initiatives (e.g. DFI GHG Harmonization process, FSB Task Force on Climate-related Financial Disclosures), and more general commitments of support (e.g. Mainstreaming Climate Action in Financial Institutions).

FIGURE 1.1. FINANCIAL INSTRUMENTS BREAKDOWN OF TRACKED CLIMATE FINANCE, 2015 (CPI 2016)

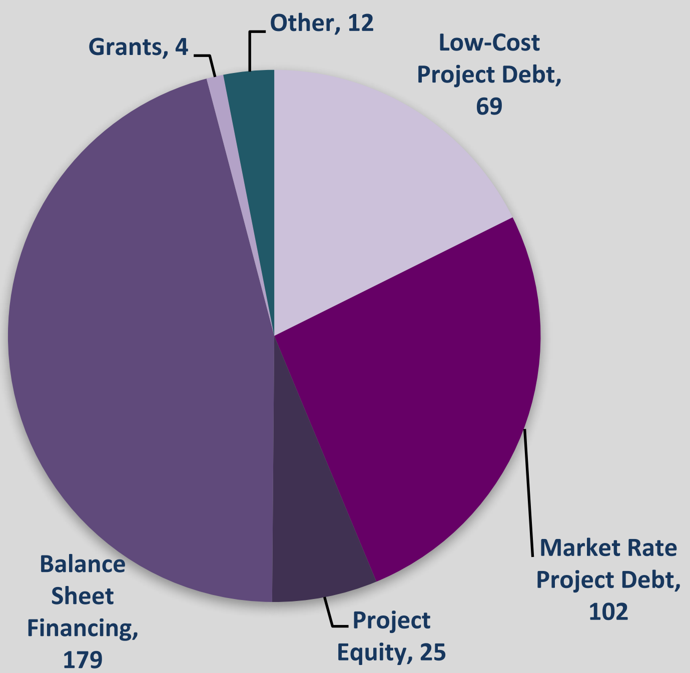
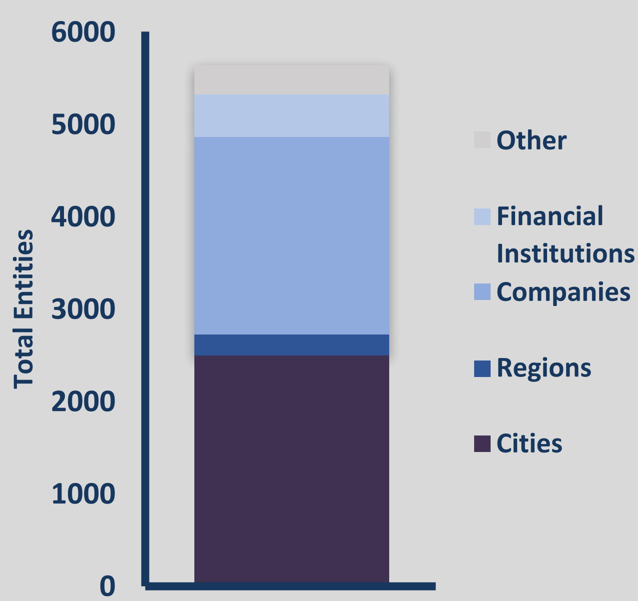


FIGURE 1.2 TOTAL CLIMATE COMMITMENTS TRACKED BY UNFCCC NAZCA (UNFCCC 2017)



Current practices in performance tracking and reporting. The Portfolio Carbon Initiative has recently tracked current practices in performance tracking and climate reporting among investors (PCI 2015) and banks (PCI 2017). Annex 1 and Figure 1.3 provide a summary of current metrics and reporting, which is largely focused on simple and unstandardized backward-looking performance indicators and strongly biased toward reporting on "green" financing activities over carbon-intensive "brown" financing activities.

The need for next generation and 'science-based' metrics and targets. Outside the financial sector, a strong effort has been made for companies and other non-state actors to adopt "science-based" performance tracking and targets, under the logic that each institution should do its 'fair share' of global climate mitigation and adaptation (SBTI 2017). Such metrics and targets provide critical context of "how much is enough" that is largely missing from current financial institution performance tracking. Science-based targets applied to financial flows could support two critical needs (Figure 1.4):

- **The "Top-down" need: Finance Roadmaps:** Based on the language of the Paris Agreement, there is a need to track whether financial flows are adequate to support mitigation and adaptation goals, and such tracking is necessary for all types of financial institutions, technologies/sectors, and regions.
- **The "Bottom-up" need for "Science-based targets" for FIs.** The global sum of climate-related financial flows is in effect a sum total of all financial institution's contributions. Thus, the 'top-down' total financial flows needed are a function of the 'science-based targets' for each institution and vice-versa. Because financial institutions own or finance many different types of financial products, such targets are also dependent on the type of financing or asset class.

Purpose and structure of this report. This report seeks to provide a first overview of how required investment levels to support global mitigation goals (adaptation is out of the scope of this work) can be used to create such top-down 'finance roadmaps' and bottom-up 'science-based targets' for financial institutions. Section 2 provides an overview of the core conceptual framework. Section 3 then discusses how such roadmaps and targets can be created in practice. Section 4 then provides example 'top-down' roadmaps for critical technologies and Section 5 discusses options for bottom-up target setting and future research needs.

FIGURE 1.3: EXISTING CLIMATE METRICS DISCLOSED BY BANKS (PCI 2017)

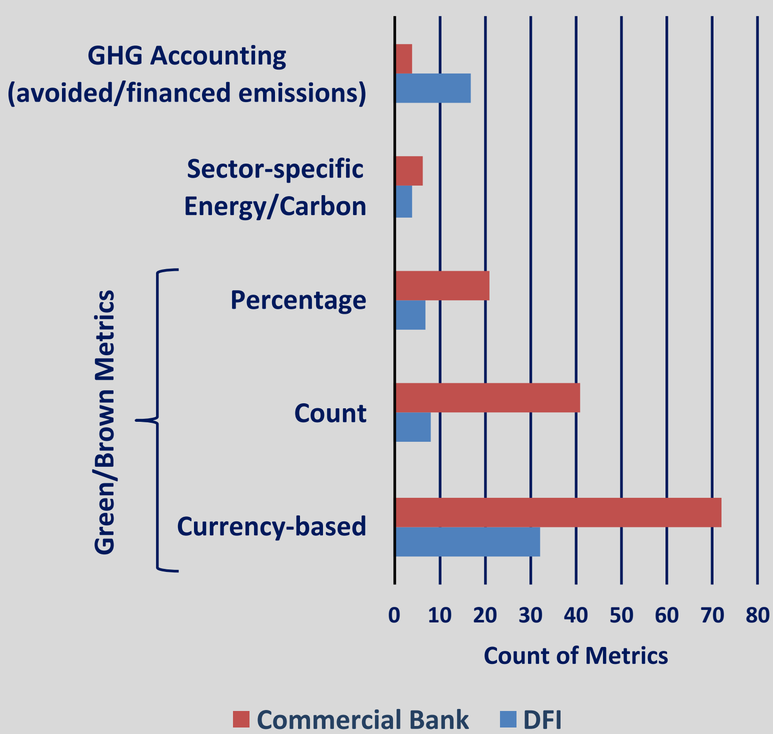
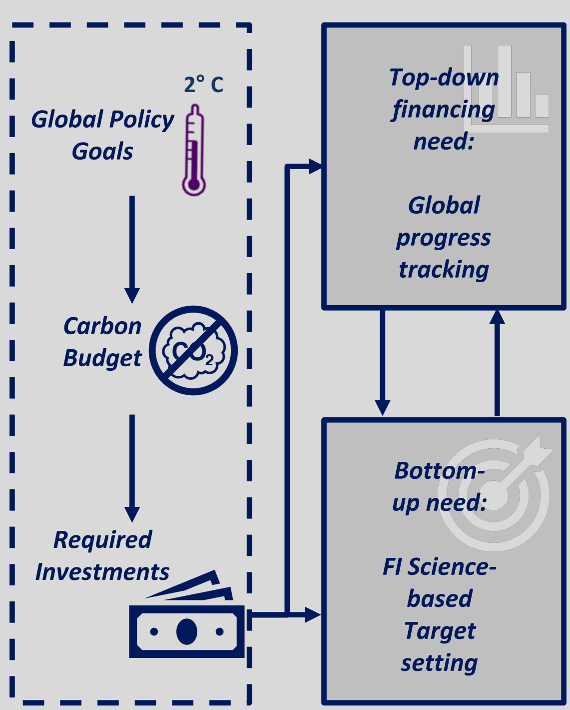


FIGURE 1.4: TOP-DOWN AND BOTTOM-UP NEEDS FOR TRACKING CLIMATE-RELATED FINANCIAL FLOWS (SOURCE: AUTHORS)



2. INVESTMENT NEEDS FOR THE TRANSITION

Overview. This section provides a high-level conceptual framework to connect global climate goals to needed financial flows. Figure 2.1 depicts the general framework, which builds from:

- the political articulation of climate goals (e.g. 2C);
- to 'carbon budgets' associated with these climate goals;
- to the development of economic and energy system roadmaps that illustrate pathways to achieving such goals;
- to the investment needs (i.e. capital expenditures in the economy) associated with these roadmaps; and finally
- to the financing needs by type of financial asset.

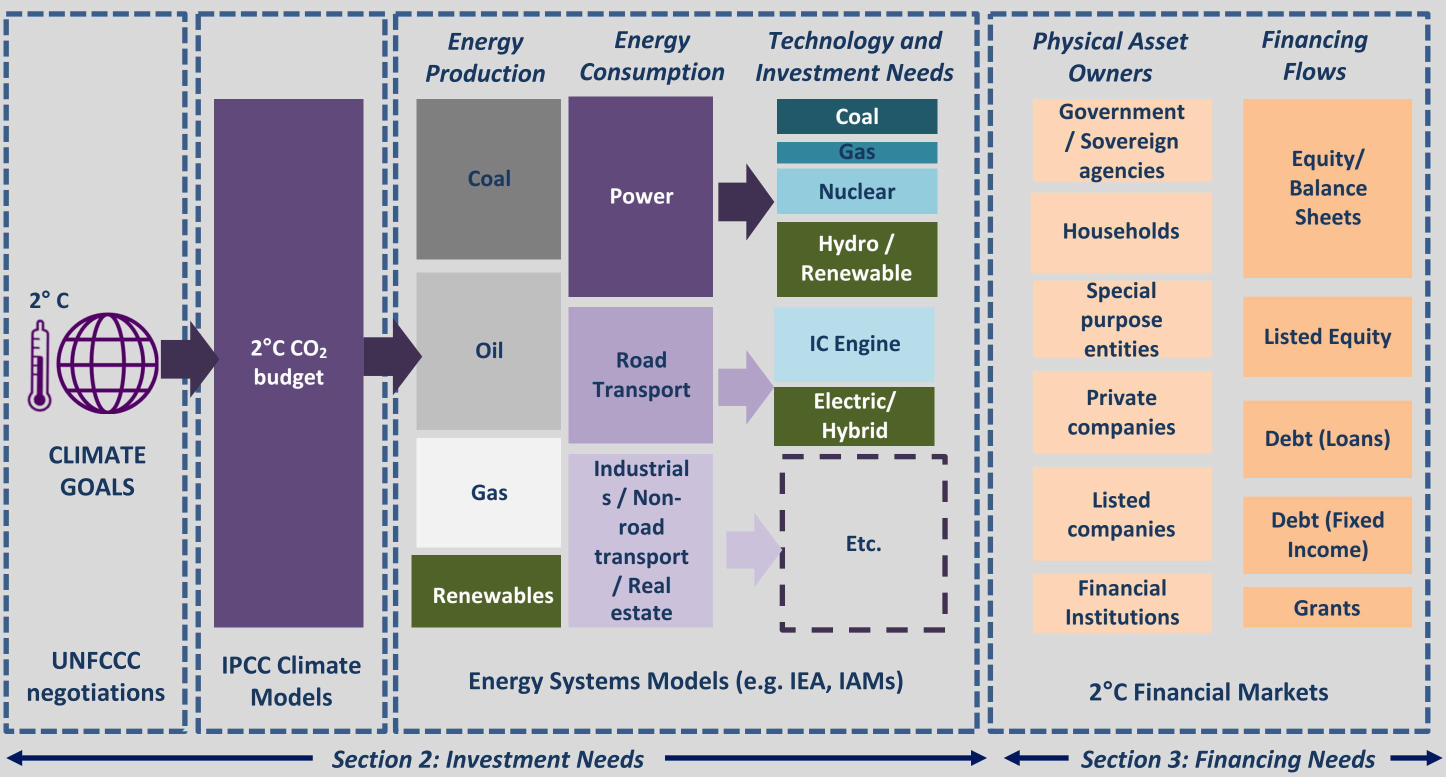
2.1. CLIMATE GOALS

Climate policy goals are in the first instance political. In 2010, the UNFCCC Conferences of the Parties (COP) established the goal to limit global warming to below 2° C. This 2° C target has been broadly accepted by non-governmental stakeholders and informs the subsequent climate change negotiations, notably the Paris Agreement, which calls for "holding the increase in the global average temperature to well below 2 ° C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 ° C above pre-industrial levels."

2.2. FROM CLIMATE GOALS TO CARBON BUDGETS

Climate change is driven by global anthropogenic GHG-emissions, and scientific research has linked the 2° C climate goals to probabilities that, given certain levels of GHG-emissions, average global temperature increases can indeed be limited to 2° C. These 'carbon budgets' are then used as the basis of subsequent developments of economic and technology roadmaps (next page). For instance, the IEA 2° C scenario (2DS) in the Energy Technology Perspectives reports represents a world with a 1000 Gt CO2 budget from 2015 to 2100, with an associated 50% probability of limiting warming to below 2° C in the 21st Century (IEA 2017).

FIG. 2.1: DEFINING 2°C COMPATIBLE FINANCING FLOWS (SOURCE: 2° II 2015)



2.3. FROM CARBON BUDGETS TO TECHNOLOGY ROADMAPS

Available technology roadmaps. Implementing GHG-emissions targets in practice requires an understanding of the associated energy, industrial, and technology mix that enable GHG reductions to the levels required by a certain carbon budget. The FSB Task Force on Climate-related Financial Disclosures (TCFD) recently reviewed such energy system scenarios, highlighting work by the IEA (2016; 2017), the International Renewable Energy Association (IRENA 2016), and Greenpeace (2015) as well as the Deep Decarbonization Pathways Project. The IPCC and Integrated Assessment Modelling Consortium also hosts a large number of energy system scenarios (over 1100) compiled during the writing of the last IPCC report (IPCC/IAMC 2015). Such roadmaps differ in several important ways in terms of their sector coverage, time horizon, level of detail, and geography (2ii 2017a).

Results of technology roadmaps. While a detailed review of technology roadmaps is outside the scope of this report, arguably the most prominent global roadmaps are from the IEA, which extensively cover the energy sector and crucially, are updated on an annual basis (IEA 2016; 2017). Results from IEA modelling are released at relatively detailed sector and geographical scales, allowing detailed overviews of the needed growth or decline in different technologies in select sectors over time (e.g. Figure 2.2 for renewable power).

2.4. FROM TECHNOLOGY ROADMAPS TO INVESTMENT ROADMAPS

State-of-the-art. In addition to technology roadmaps, many energy system models also estimate capital investment levels needed in different sectors to reach the required levels of technology output. The most publicly prominent of such 'investment roadmaps' are produced by organizations such as the IEA (2014; 2016) and Bloomberg New Energy Finance (BNEF 2017), though again the scientific literature and academic community have produced several important estimates as well (IPCC 2014; McCollum et al. 2013). The results of such models are discussed in Section 4, but as a preview, Figure 2.3 shows aggregate capital investment required in the 450 Scenario (roughly 2C compliant) vs. IEA's central New Policies Scenario, averaging ~$1.8 trillion/yr.

Shortcomings and next steps. Beyond limitations and uncertainty in such models generally, a key limitation of investment roadmaps is that they do not distinguish different types of capital (e.g. debt vs. equity, and loans vs. bonds within debt). This is the focus of "financing roadmaps," the focus of this report and discussed more fully in Section 3.

FIGURE 2.2: REQUIRED GROWTH IN RENEWABLE ELECTRICITY CAPACITY 2015-2040 (SOURCE: IEA WEO 2016)

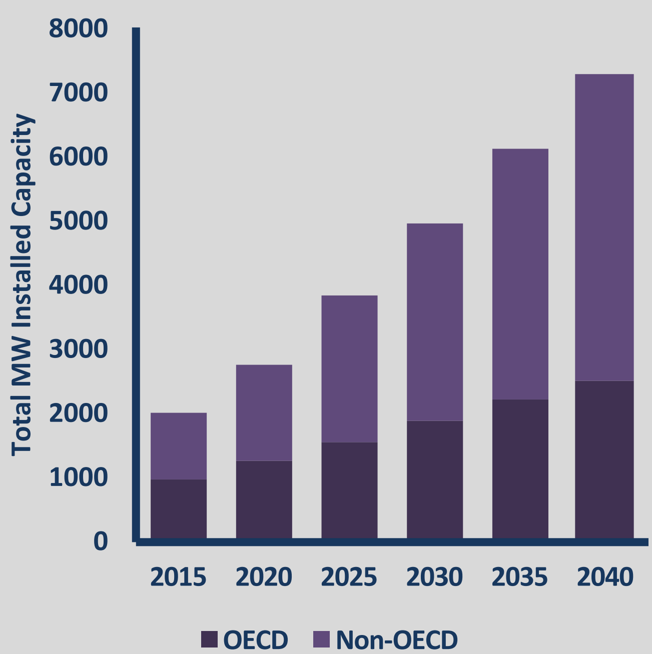
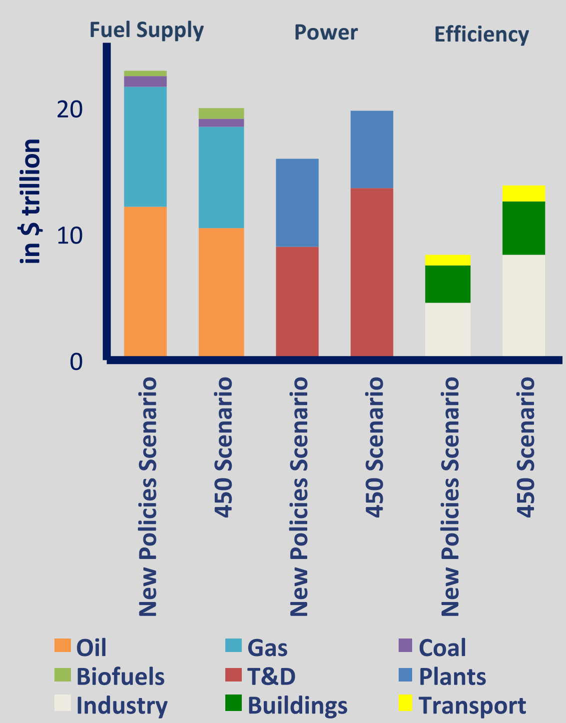


FIGURE 2.3: INVESTMENT NEEDS 2011-2035 UNDER VARIOUS IEA SCENARIOS (SOURCE: IEA 2014)



FOCUS – INNOVATION & R&D AND 2° C CLIMATE GOALS

R&D warrants a specific focus in the context of climate change. According to the IEA, the global carbon budget will be almost exhausted in 20 years and entirely exhausted in 2050. Thus, R&D on breakthrough technologies is needed now. Although the associated financing is a fraction of the amounts required for infrastructure ($100 billion in R&D annually versus $1 trillion), the shortfall relative to current levels is significant (Fig. 2.5). Taking the cement sector, the IEA projects 63% of emissions associated with cement production to be captured through carbon storage by 2050 (high-demand scenario). That still leaves roughly 1/3 that need to be reduced through other means, even in an optimistic CCS scenario. R&D will be a key bridge in this regard, in particular expenditures on R&D for low-carbon alternatives to cement (e.g. copying the chemical processes producing eggshell or coral reef at industrial scale). The IEA scenario does not address this.

A key challenge in terms of funding technology development is engaging private capital from institutional investors. Institutional investors may indirectly be involved in funding R&D through a range of channels (Fig. 2.4).

FIG 2.5: R&D ANNUAL INVESTMENT VERSUS INVESTMENT NEEDS (SOURCE IEA ETP 2012)

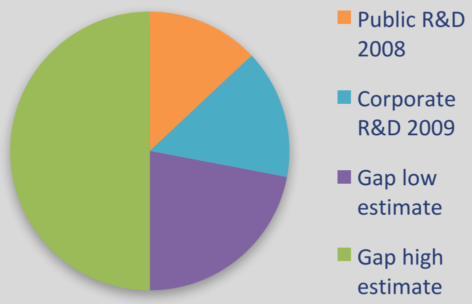
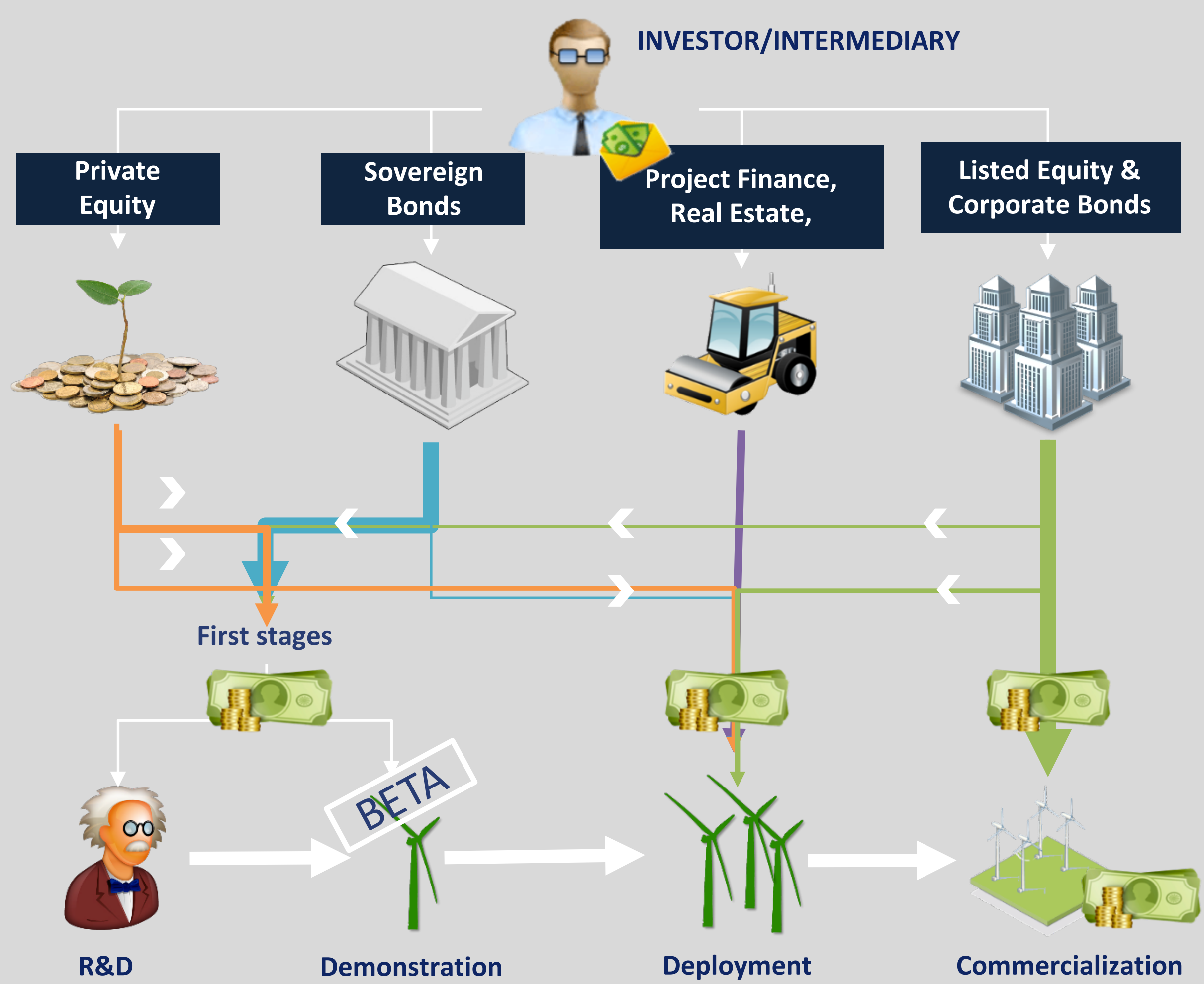


FIGURE 2.4: FUNDING OPTIONS FOR DIFFERENT STAGES OF TECHNOLOGY DEVELOPMENT



3. FINANCING NEEDS FOR THE TRANSITION

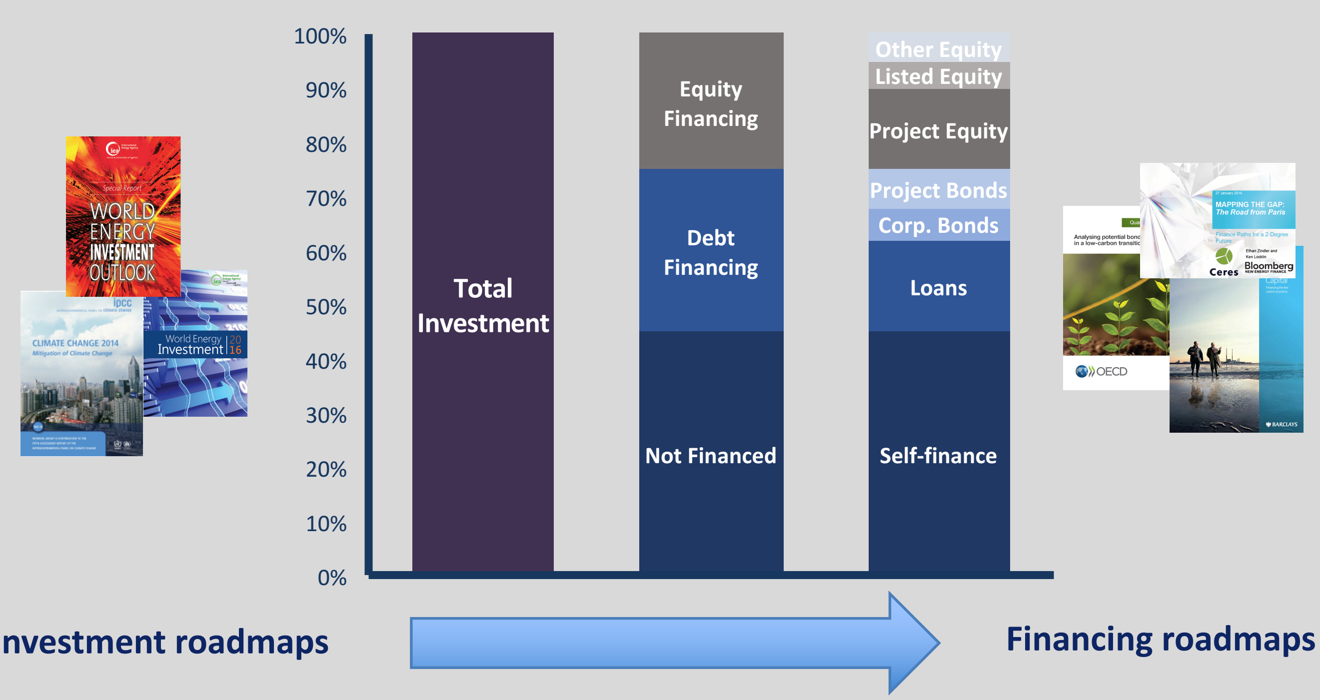
3.1 2° C FINANCING ROADMAPS: A DEFINITION

Derived from *investment roadmaps*, which shows the needed total *capital investment* to meet the needs of climate goals, *financing roadmaps* can be defined as a breakdown of the total amount of *financing* (defined here as different types of debt and equity) of different types to meet the needs of the energy transition (Figure 3.1). Because financial institutions track their financial exposure (e.g. $ lent, $ invested) rather than the capital investment associated with such positions, financing roadmaps should provide a more usable performance tracking system for financial institutions.

Ideally, such financing roadmaps would have several characteristics:

- **Future looking/"Science-based".** Clearly to be useful for target setting (a forward-looking activity), financing roadmaps must themselves be based on forward-looking scenarios anchored in global policy goals. Thus the starting point for FRs is the "science-based" investment needed in different sectors to meet climate goal**s.**
- **Green and brown**. Financing roadmaps should cover both required levels of "green" capital investment as well as limits to "brown"/carbon-intensive financing to avoid the current problem of one-sided reporting on 'green' financing alone (PCI 2017; Fair Finance 2015).
- **Asset class specificity.** Financial institutions own assets and provide services across a wide array of financial assets, and distinguishing between such assets and business lines provides crucial nuance, especially for diversified institutions operating in several market areas (e.g. universal banks).
- **For the target setting use case, financial institution specificity.** Different financial institutions also play different roles depending on mandate; for example development financial institutions (DFIs) provide similar services to banks in many ways but may have different roles in climate mitigation due to being mandate-driven rather than profit-driven. This is also partly a function of asset class, as certain FIs hold more of certain asset classes based on their structure, asset-liability management, etc.

FIGURE 3.1: DEFINING 2°C FINANCING ROADMAPS 'TOP-DOWN' FROM INVESTMENT ROADMAPS (SOURCE: AUTHORS)



3.2. IDENTIFYING THE RELEVANT ACTORS AND ASSET TYPES

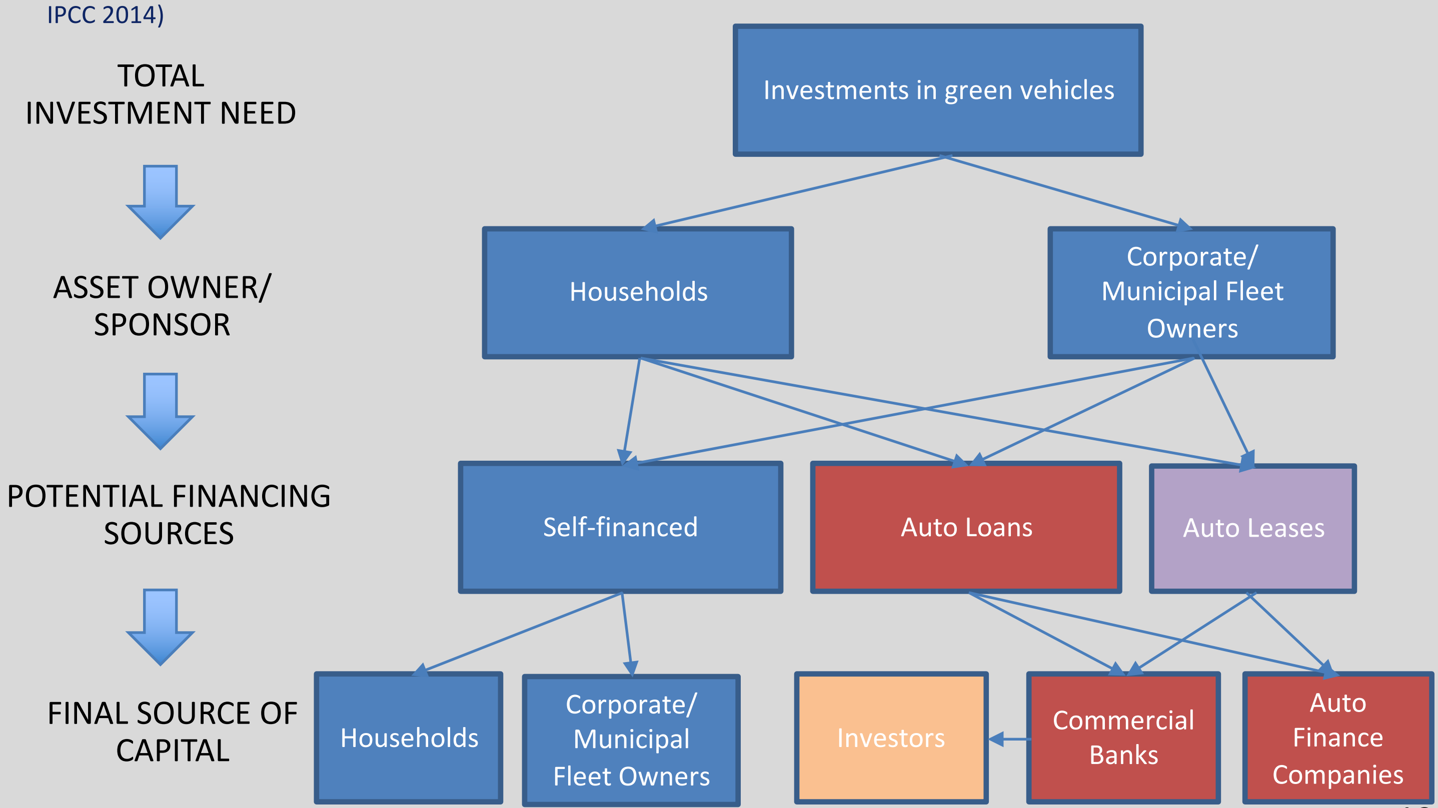
Financing Model Data and Assumptions. Defining a financing roadmap is largely a function of defining the source of capital for the needed investments. Such a breakdown can be drawn from a variety of sources, including climate finance accounting exercises, along with past accounting of current finance structures and actors and assumptions or modelling about how financing structures will/will not change in the future. Following IPCC (2014), defining the final source of capital to support climate-related investment starts with the investment and identifying a series of potential actors and assets (Figure 2.2 illustrates this using a simple example of automotive finance).

- **Who owns the asset?**: Who directly procures and owns (i.e. holds equity in) the capital investment? Such actors may include:
  - Companies, both established entities and project-specific companies (e.g. special purpose entities)
  - Non-corporate owners (municipal governments, households, universities, etc.)
  - Project aggregators, such as yieldcos, master limited partnerships, etc.

- **Potential Financing Sources**: What are the potential sources of capital, including both equity and debt?
  - "Self-financed" (i.e. not financed) from the balance sheet of the asset owner/sponsor
  - Sale of equity to others (e.g. listed equity issuance, project equity)
  - Bond Issuance (project-specific or general purpose)
  - Loan (project-specific or general purpose)
  - Equipment lease
  - Grant (e.g. government)

- **Final Source of Capital**: Who could be the financial intermediary or final source of capital? Importantly, this could be a financial institution that holds the financing on their balance sheet or sells it to other institutions as a new financial product (e.g. auto loans securitized into automotive asset-backed securities).
  - Banks or other intermediaries (e.g. auto finance companies)
  - Investors (institutional investors, funds held by retail investors)

FIGURE 3.2: ACTORS AND FINANCING TYPES: EXAMPLE AUTOMOTIVE FINANCE (SOURCE: 2° II, based on IEA 2014, 2016; IPCC 2014)



How difficult is it to create detailed financing roadmaps? The difficulty in creating a finance roadmap or science-based financing target largely hinges on the level of complexity across these three actors and assets, as well as the general availability of data on current investment and financing in the sector.

- How many types of **owners** (households, companies, SPEs) play a material role?
- How many **financial actors** (intermediaries, final source of funds) play a material role?
- How many **financial instruments** are commonly utilized?
- Is detailed **data** available on current financing, particularly at individual asset level (2ii 2017b)?

Table 3.1 shows the major types of investments (IEA 2014) and prominent asset owners, financial actors, financial instruments, and example databases on investment. More detailed ownership and financing trees are available in Annex 2. Generally Table 3.1 suggests three similar groups of investments, each with its own challenges:

- **Upstream fossil fuel investment**: well-developed corporate finance models with a variety of instruments
- **Power generation and T&D:** Wider variety of actors with project and corporate finance structures and widely available data
- **Energy efficiency investment**: Large variety of actors, limited financing models, and limited data

TABLE 3.1 ACTORS, FINANCING, AND DATA FOR DIFFERENT INVESTMENT NEEDS (AUTHORS, BASED ON IEA 2014; 2016; IPCC 2014; 2ii 2017b)

INVESTMENT CATEGORY	CUMULATIVE 2DS INVESTMENT ($T, IEA 2014)	OWNERS OF UNDERLYING ASSETS	FINANCIAL ACTORS	MOST IMPORTANT FINANCIAL INSTRUMENTS	EXAMPLE DATABASES
O&G Upstream	$14.1	O&G E&P Companies SPEs (project companies)	Companies (bal sheet), Commercial Banks, Investment Banks, DFIs, Investors	Project finance, Corporate loan (inc. RBL), Corporate Bonds, Listed Equity	Infrastructure Journal (project), Thomson Reuters/ Bloomberg (syndicated debt, bonds)
O&G Transport/ Refining	$4.4	Integrated/refining Companies SPEs (MLPs, Infra Funds)	Companies (bal sheet), Commercial Banks, Investment Banks, DFIs, Investors	Project finance, Corporate Bonds, Listed Equity	
Coal Mining & Transport	$0.7	Mining Companies SPEs (project companies)	Companies (bal sheet), Commercial Banks, Investment Banks, DFIs, Investors	Corporate loan, Corporate Bonds, Listed Equity	
Power Generation	$13.4	Utilities, Equipment Mfgs, SPEs (Yieldcos), Investors, Municipalities, Other (small distributed; households, universities, etc.)	Companies (bal sheet), Commercial Banks, Investment Banks, DFIs, Investors	Project finance, Corporate loan, Project bonds, Leasing, Corporate bonds, Listed Equity	Platts/Globaldata (public deals), BNEF (green only), EnerData
Power T&D	$5.9	Utilities, SPEs (MLPs, Infra Funds)	Companies (bal sheet), Commercial Banks, Investment Banks, DFIs, Investors	Project finance, Project bonds, Corporate bonds, Listed Equity	
Biofuels	$0.9	O&G companies, pure play companies	Companies (bal sheet), Commercial Banks, Investment Banks, DFIs, Investors	Corporate loans, Corporate bonds, Listed Equity	Several public databases
Industry EE	$1.4	Companies	Companies (bal sheet), ESCOs, Gov agencies	Leasing, Corporate bonds, Listed Equity,	Limited data availability except in local/regional markets
Transport EE	$8.1	Households, companies	Retail banks, Auto finance cos, Investment Banks (ABS), Investors	Vehicle Loans, Leasing, ABS	
Buildings EE	$4.0	Households, Companies, REITs, Investors	Retail banks, Commercial banks, Investment banks, ESCOs, Gov agencies	Mortgages, Commercial Mortgages, MBS, CMBS	

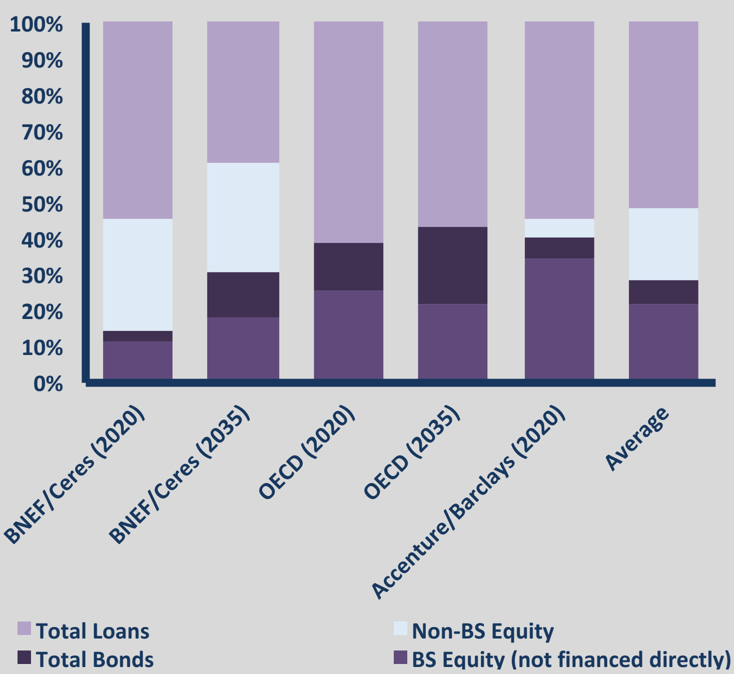
3.3. SUMMARY OF EXISTING FINANCING ROADMAPS

Compared to investment roadmaps, there has been limited effort to date to create financing roadmaps, likely due to the complexity of doing so. Outside work on investment by IEA (2014, 2016) the authors are familiar with three studies specifically attempting to identify financing sources for the transition, each with different regional and sectoral focuses but all focused exclusively on green finance requirements rather than brown finance limits.

- **Accenture/Barclays Carbon Capital (2011)**. This report was the first serious effort toward a finance roadmap, focused on financing in Europe in the 2011-2020 timeframe in "green" portions the power, buildings, and transport sectors. Carbon Capital was unique in its attempt to identify both *deployment* financing and *development* financing (i.e. financing for research, development, and demonstration). Its financing structure was taken from expert judgment.
- **BNEF/Ceres (2015)**: Building on BNEF's work on power sector finance, this study focused on global deployment of green and low-carbon power sources on a global scale from 2015-2040. Its financing structure was taken from expert judgment and interviews, including a projection of how financing models will change over time.
- **OECD (2016).** This study built on IEA's investment roadmap (2014) and focused on the role of fixed income asset classes in financing the transition in 4 regions (US/EU/China/Japan) and 3 technologies/sectors (power, auto loans, buildings) from 2015-2035. Its financing structure builds on expert judgment and existing financing models in the four regions, plus assumptions on how these models will change to 2035. OECD (2016) was also the first study to consider the role of green bonds from the finance sector itself.

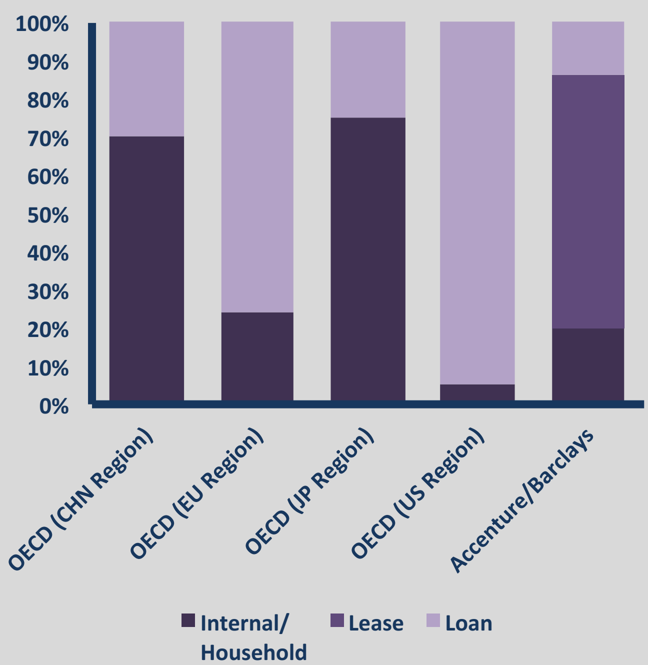
What do existing roadmaps believe about source of funds? Comparing the financing structure assumptions existing financing roadmaps is difficult due to lack of common definitions, regions, sectors, etc. Sectors where multiple estimates exist across studies are power and automotive, as seen in Figures 3.3 and 3.4. Generally structures in the power sector, the most studied, compare reasonably but automotive financing varies considerably by region and under different assumptions of leasing vs. purchase. Finally, BNEF/Ceres and OECD both attempt to describe how source of funds will change with time, generally expecting securitization to increase with time as green bonds in particular gain market prominence.

FIGURE 3.3 FINANCING STRUCTURE FOR POWER INVESTMENT IN DIFFERENT STUDIES. (SOURCE: BNEF/CERES 2016; OECD 2016; ACCENTURE/BARCLAYS 2011)



Nb: For BNEF/Ceres, institutional investor ownership, project equity, yieldcos/REITs/MLPs are mapped to 'Non-BS Equity'.

FIGURE 3.4 FINANCING STRUCTURE FOR AUTOMOTIVE INVESTMENTS IN DIFFERENT STUDIES (SOURCE: OECD 2016; ACCENTURE/BARCLAYS 2011)



3.4. CHALLENGES IN FINANCING ROADMAPS

Creating financing roadmaps requires complexity in many dimensions, complicating their creation. Some challenges are particular to the creation of financing roadmaps, while others also apply to investment roadmaps.

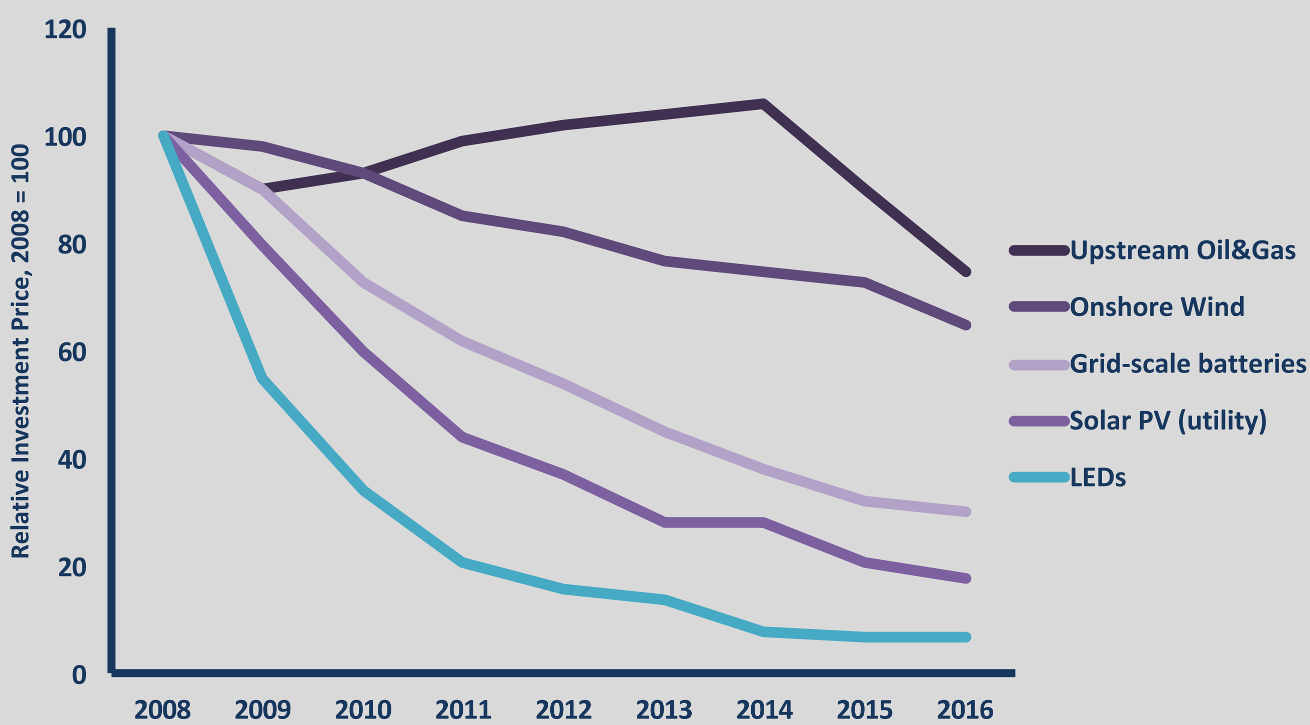
Challenges in estimating investment levels and targets.

- **Accounting challenges**. Accounting for investment is not always obvious, particularly regarding energy efficiency, where no standard definition of investment exists. General practice in the energy modelling literature has been to account for only incremental investment in more energy-efficient equipment (IEA 2014; McCollum 2013; IPCC 2014), but OECD (2016) argues that total investment levels are more appropriate for financing new build construction and new green vehicles. Further difficulties exist in accounting for annualized vs. upfront investment, and models can vary in their accounting strategy (SMASH 2017).
- **The problem of prices.** Investment levels themselves are a function of technology prices, but more importantly prices change the underlying amount of physical asset per unit of investment. Figure 3.5 shows prices for different energy technologies relative to 2008. To illustrate the problem, a financing roadmap using monetary terms set in 2008 would deliver 5 times less MW of solar than one set in 2015. Importantly, the same is true in oil & gas production, where falling investment costs (15%-25%/yr since 2014) can drive substantially different physical production levels.

Challenges in estimating financing roadmaps and targets:

- **Large scope of actors with different mandates** In some technologies/sectors, several different types of financial actors and owners/sponsors (households, project companies) exist, some with mandates to deliver green investment (e.g. development banks, green banks). In some sectors governments are also key funders (Table 3.1; Annex 2). This complicates accounting generally and also complicates assignment of 'fair shares' across actors (see Section 5).
- **Group level vs. portfolio level targets.** At group level many FIs are very complex and it is unclear how to balance between their different roles (lending, underwriting, advisory, etc.), particularly where multiple parties are involved in financing (e.g. underwriting a bond vs. purchasing the bond).

FIGURE 3.5: DECLINING INVESTMENT COSTS FOR DIFFERENT ENERGY TECHNOLOGIES, RELATIVE TO 2008 (IEA 2016)



4. EXAMPLE FINANCING ROADMAPS

This section will provide example financing roadmap calculations for three key sectors and technologies to illustrate the concept, starting from required investments and estimating required financing flows.

4.1 STARTING POINT: WHAT DO WE KNOW ABOUT INVESTMENT FLOWS?

The IPCC 5th Assessment (WG3, Ch 16) provides the broadest recent overview of required investment under a 2C scenario, heavily drawing on a review by McCollum et al. (2013). In addition to this work and the work of IEA (2014), additional modeling work was performed as part of the SEI Metrics project (SMASH 2017), which provided additional detail on investments under alternative future oil prices and macroeconomic contexts.

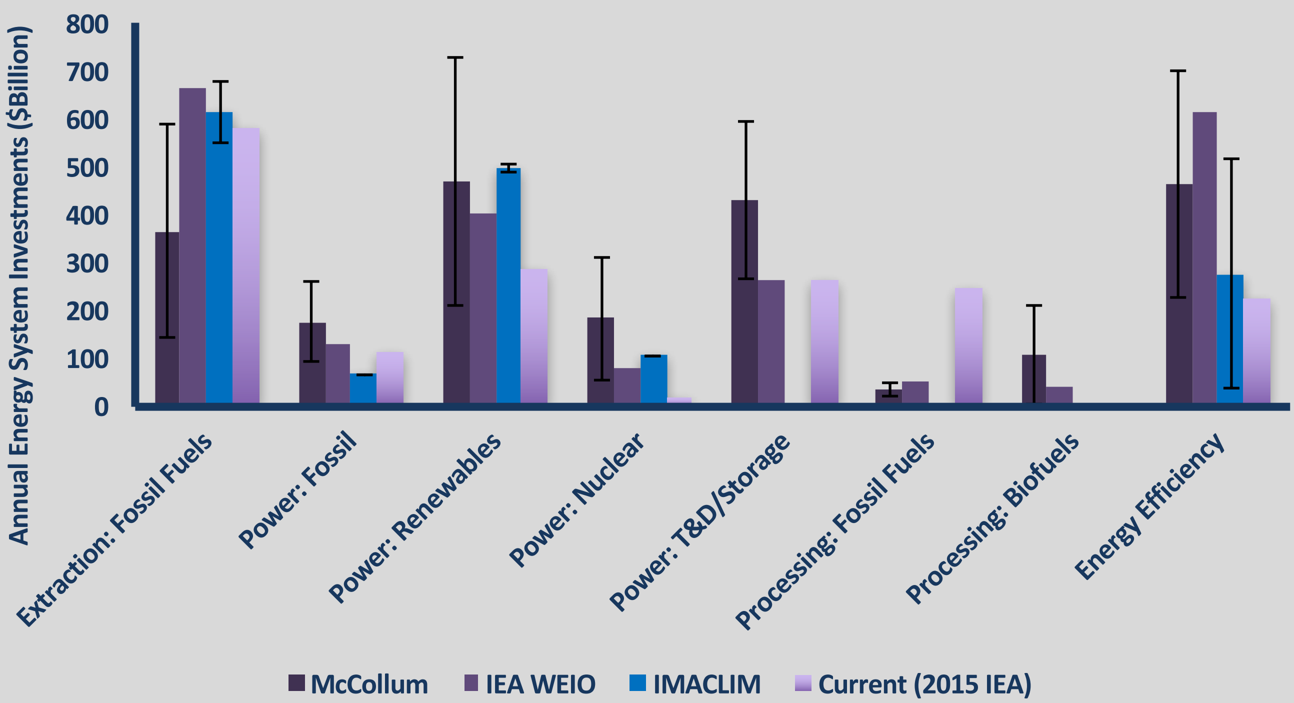
High level results from investment roadmaps

Recently investments in the global energy system according to IEA (2016) have averaged $1.6-1.8 trillion annually in energy supply, plus $220 billion in energy efficiency. Short of energy efficiency, where accounting is challenging (see pg 15), this annual investment in energy supply is largely consistent with the *total* investment needs under a 2C seen across models (Fig 4.1). More important of course is the breakdown of current and required investments by technology. On the whole, current investment levels are in line with projected needs under a 2C scenario, though on the low side for renewables and energy efficiency, on the high side for fossil fuel extraction and processing, and extremely low for nuclear power (Figure 4.1).

Importantly, according to IEA, even in a 450 scenario, the total amount of investment in upstream fuel supply oil & gas is still significant—higher than both energy efficiency and power system investment—showing that investments in fossil fuels need not systematically be misaligned with climate goals, as long as they are balanced by 'green' investment. This insight is critical for the creation of FI investment and financing targets (Section 5), as it allows the comparison of fossil fuel investment/financing to 'green' investment/financing.

Using these investment levels, example financing roadmaps are derived in this section for key technologies, including power, green vehicles, and R&D.

FIGURE 4.1: ANNUAL GLOBAL ENERGY INVESTMENTS IN A 2C ENERGY TRANSITION (MCCOLLUM 2013; IEA 2014; SMASH 2017)



NB: This figure consolidates unlike categories across studies and thus estimates are not always available for all studies (e..g Power T&D, Biofuels, Processing Fossil Fuels

4.2. EXAMPLE FINANCE ROADMAP: POWER GENERATION IN THREE REGIONS (EU/US/CHN)

Scope.

This example focuses on power generation technologies, the most studied energy transition sector. We further select for geographies where multiple studies are available on investment levels, focusing on the EU, US, and China. These three regions are expected to represent over half of global power investment under a 2C scenario based on IEA estimates (IEA 2014).

Investment levels.

Due to price uncertainty, particularly in renewables, the analysis focuses in the near term 2020-2025 investment timeframe. After annualizing total investment flows , sources show a relatively similar conclusion, that 2C compliant investment flows in power generation are focused on renewables including hydropower ($150-225 billion/yr in the three regions) and potentially other zero carbon technologies, notably nuclear ($20-100 billion/yr), though with a high degree of variability between transition pathways and models. This is particularly due to the treatment of nuclear power, which varies between being critical transition technology to being essentially irrelevant. Nevertheless, the required annual flows are largely consistent, in both 'green' and 'brown' terms, with current investment levels (Fig 4.2, as tracked by IEA (2016)).

Geography.

Important differences exist across the three geographies shown here, with US and China showing relatively similar fractions of annual investment levels in renewables and other zero carbon technologies. These differences are expressed in Fig. 4.3 as 'green/brown' ratios of renewable or zero carbon investment levels to fossil fuel-fired power (without CCS) investment levels. As described in Section 5, such ratios can be utilized to set targets on investment levels in financial portfolios. In the US and China regions, across studies a 2C transition requires approximately $2-4 of zero carbon or renewable investment for every $1 spent on new fossil fuel-fired power generation. In the EU these ratios are substantially higher (8-10) due to several factors, including fossil fuel resource endowments, regulations, etc.

FIGURE 4.2: TOTAL INVESTMENT FLOWS FOR POWER GENERATION, EU/US/CHN. (SOURCES: BNEF/CERES 2016, SMASH 2017, MCCOLLUM 2014, OECD 2016)

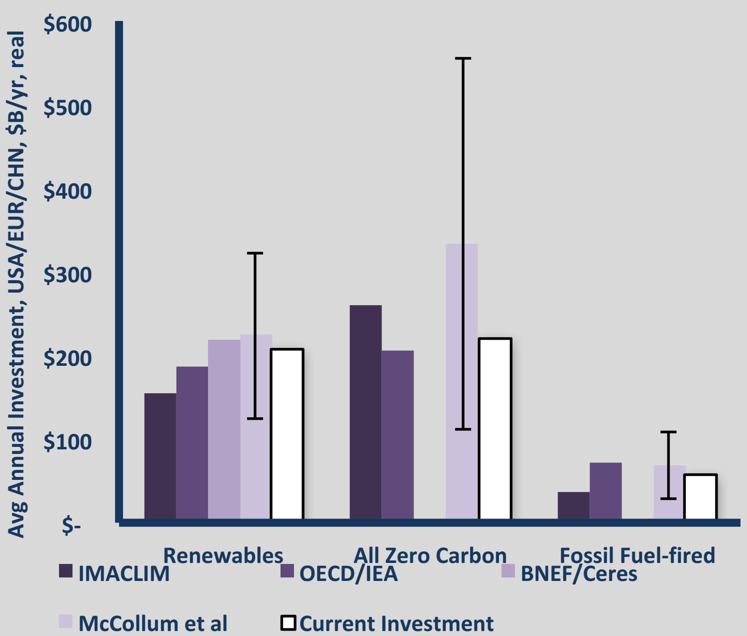
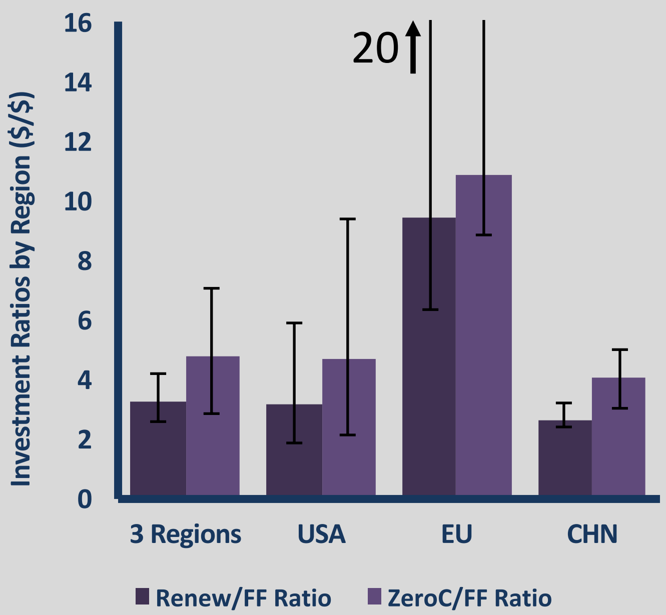


FIGURE 4.3. GREEN/BROWN INVESTMENT RATIOS ACROSS REGIONS, RENEWABLES/FOSSIL AND ALL ZERO C/FOSSIL (SOURCE: AUTHORS)



Nb: For BNEF/Ceres, global totals are scaled to the investment levels of the three regions using IEA averages (IEA 2014)

Financing levels.

The next step is then to convert these total investment levels to financial flows. Using the average financial structure shown in Figure 3.3 above, the total financial market size can be estimated as shown in Figure 4.4. In total the financial opportunity in a 2C transition is estimated as around $260 billion/yr, split between:

- various types of equity stakes (~$60 billion/yr; project equity, direct institutional investor ownership, and indirect ownership through vehicles such as master limited partnerships and yieldcos);
- Bond issuance ($20 billion/yr); and
- Various types of loans (project finance loans, asset finance, short term bridge loans)

Naturally these types of financial flows can be matched more or less to different types of financial institutions, with banks providing the majority of loans, investment banks issuing bonds to investors, and different actors taking equity stakes depending on their risk tolerance. Further they can be broken down by region, with zero carbon power attributing roughly $70-80 billion/yr in US and EU and $90 billion/yr in China and fossil-fired power representing ~$20 billion/yr in US and China and $5 billion/yr in EU.

Assigning financing targets.

The final step in creating a financial roadmap is then the assignment of specific targets to individual financial sector players. Given the range of assumed financial structures (see 3.3) and the expected change in such structures over time as green securitization grows in prominence, such a top-down assignment is very challenging. A first estimate can be made by first deducting a likely share that could be provided by mandate/mission driven organizations (green banks, DFIs, etc., see 3.4) and then using private sector league tables to distribute top-down targets to different players.

Figure 4.4 shows such a calculation, subtracting a global average ~10% of green financing expected to be provided by IFIs (IEA 2016; OECD 2016), and using EMEA region Initial Mandated Lead Arranger league tables from PFI (2017) for market shares. Renewables (debt) financing targets and fossil-fired power (debt) financing limits are calculated using the EMEA market share for the top 10 lead arrangers of project debt. Notably, European renewables financing targets for all FIs represent approximately 1/3 of total EMEA deal volume, a substantial but not infeasible goal.

FIGURE 4.4. ESTIMATED ANNUAL FINANCIAL FLOWS TO NEW POWER GENERATION, US/EU/CHN (SOURCE: AUTHORS)

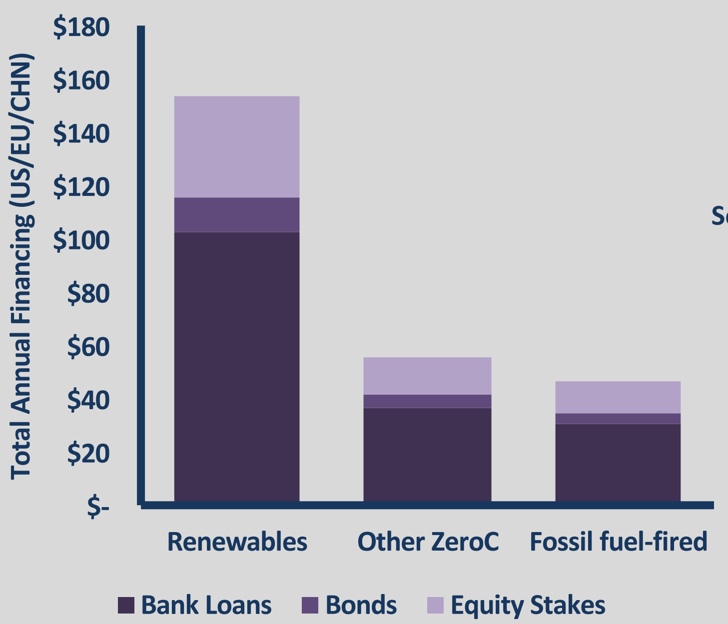
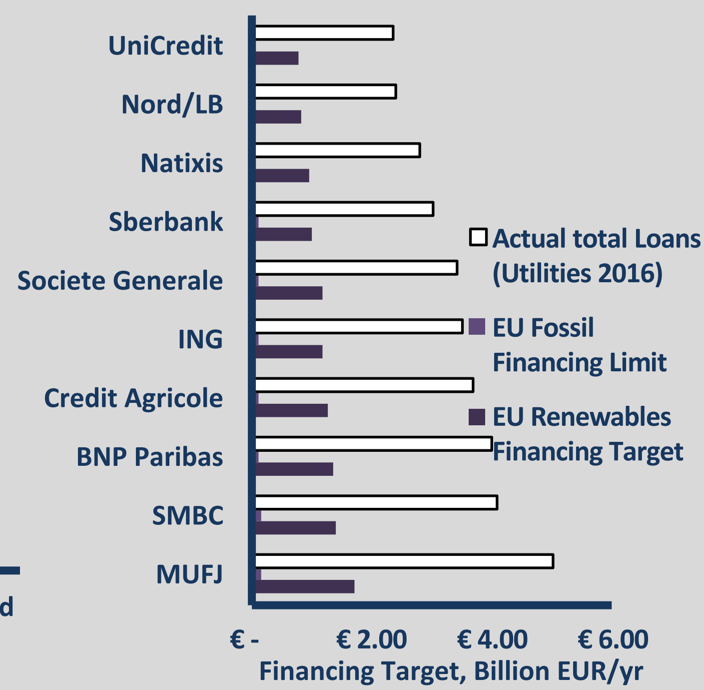


FIGURE 4.5. ESTIMATED RENEWABLE POWER AND FOSSIL-FIRED POWER FINANCING TARGETS (SOURCE: AUTHORS)



Nb: Two Fis are removed for only having projects in Russia, China Development Bank and Gazprombank

4.3. EXAMPLE: AUTOMOTIVE FINANCING IN THE US

Scope.

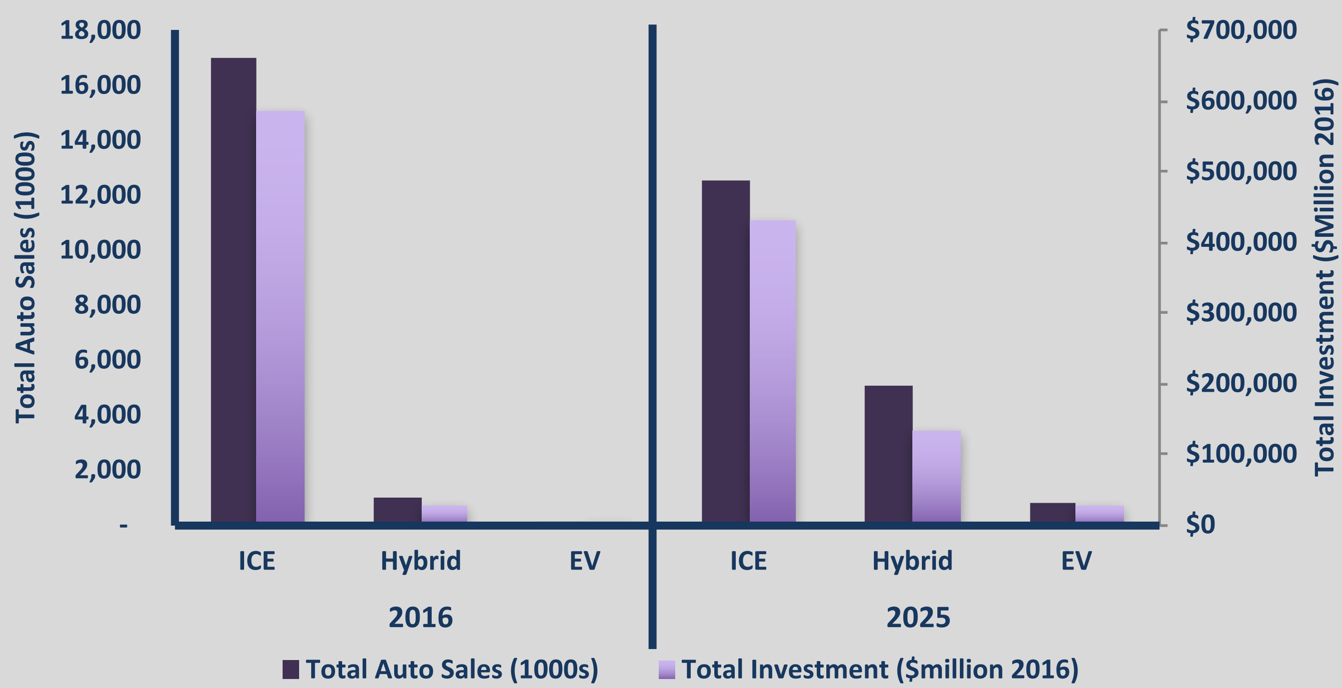
The focus of this case study is new car loans in the US market, world's second largest auto market where data is the most available. The production and sale of more efficient and alternative propulsion vehicles are a critical trend for the energy transition (IEA 2016; 2017; 2ii 2015). On the whole, automotive financing consists of both loans and leases for new and used vehicles (KPMG 2012; EXPERIAN 2016; OECD 2016). The case study focuses exclusively on the new car financing market, as used car financing does not materially change the fleet of vehicles on the road but rather shifts ownership of existing vehicles. Further, while the lease model is growing in popularity in the U.S. due to escalating upfront costs, purchase with loan remains the most prevalent purchase and finance model for personal vehicles, responsible for around 54% of new US automotive purchases (compared to 31% lease and 15% cash purchase; EXPERIAN 2016).

Investment levels.

Investment levels for new automobiles are much less available from existing investment roadmaps due to the focus on existing roadmaps on the marginal investment associated with energy efficiency (MCCOLLUM 2013; IEA 2014). OECD (2016) claims to use full price of car but the derived values appear infeasible, representing an average loan amount of only $3000-$4000/vehicle ($42 billion investment/yr 2015-2020 for an automotive market of 17 million vehicles) in the US. Instead, average transaction levels by drivetrain type are taken from (KBB 2017) and (EXPERIAN 2017), averaging $34,000/vehicle in the US, and coupled to 2C scenarios in terms of total automotive sales (IEA 2016; 2017; see Figure 2.6).

As with power sector case study, we focus on near term (2020-2025) financing levels and targets due to the difficulty of projecting investment levels, prices, and financing structures beyond this time. Automotive analysts differ in their expectation on transaction price growth but recent growth is generally seen as unsustainable so we take the average transaction price as stable for the next 10 years to be conservative (approx. $34,000/vehicle in 2016; KBB 2017). Even over this short time period, though, the 2C scenario requires a relatively large shift in the fraction of automotive sales and investment levels away from internal combustion engines (ICE) toward hybrid and electric drive vehicles (Figure 4.1).

FIGURE 4.6: ESTIMATED TOTAL US NEW CAR SALES (LEFT) AND INVESTMENT (RIGHT) FOR NEW AUTOMOBILES IN US MARKET, 2016 and 2025. SOURCES: AUTHORS, IEA 2017, EXPERIAN 2017.



Financing levels.

Estimating total financing levels from investment levels is relatively trivial in the case of automotive financing due to the relative simplicity of automotive financing vs. power sector financing. Largely personal vehicles are either not financed (i.e. paid for upfront in cash, 15% of sales), leased (a record 31% of the market in 2016), or purchased with a loan (54% in 2016). Within the portion purchased with a loan, average loan-to-value (ratio of loan amount to value of automobile) is around 90% for household purchases (95% of total market; Automotive Fleet 2017). For simplicity and illustration, here we assume these financing ratios will be stable for the near term (through 2025). These assumptions yield a total financing level of approximately $270 billion/yr in 2016, matching the total new car loan origination value (CFPB 2017; EXPERIAN 2017)

Assigning financing targets.

Unlike with power sector financing, mandate-driven organizations do not represent a material share of the financing market in automotive finance, which is instead largely made up of banks and bank-like entities (e.g. credit unions) as well as 'captive' financing companies, wholly owned subsidiaries of automakers that provide financing to purchasers of that company's (and only that company's) vehicles (see Figure 4.8, top 10 auto loan financers in US). Assigning financing targets for green vehicles to such captive financers, as would be required under the assumption that all financial institutions should do their 'fair share' toward the 2C goal (2ii 2015; 2017), is not necessarily fair to these companies, since they are extremely unlikely to meet their financing target if the underlying automotive producer is not producing enough green vehicles.

Despite this inflexibility, financing targets using a 'fair share' logic are consistent with the broader discussion on Science-Based Targets (SBTI 2017) and are thus adopted here. Figure 4.8 shows derived financing targets for the top 10 automotive loan companies in the US market. It is clear that substantial growth is required to meet hybrid and electric vehicle financing goals, with hybrid vehicle financing needs growing by over 400% and electric vehicle financing needs growing by over 800% from 2016 to 2025 target levels. For instance, based on current market shares, Ford Motor Credit's 2016 target grows from approximately $140 million of EV loan origination in 2016 to $1.3 billion EV loan origination in 2025 to support its 'fair share' in the 2C transition under current price levels.

FIGURE 4.7: MARKET SHARES FOR DIFFERENT FIs, US NEW CAR AUTOMOTIVE LOANS. ORANGE DENOTES CAPTIVE AUTO FINANCERS. SOURCE: EXPERIAN 2017.

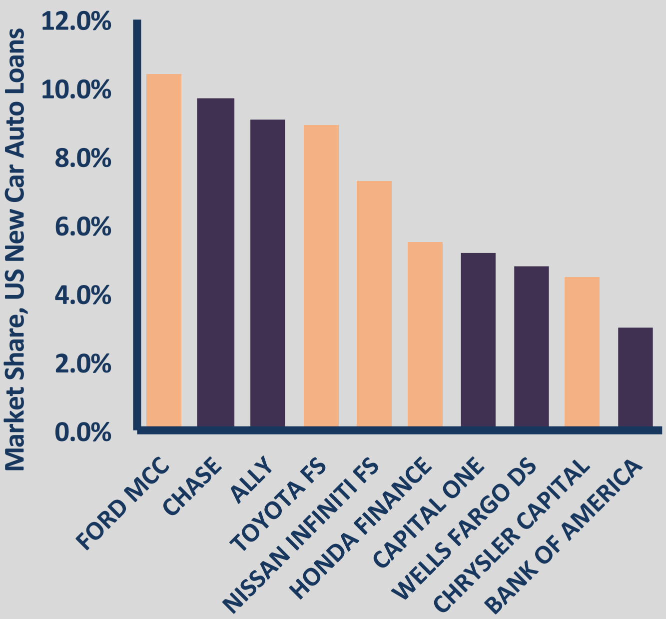
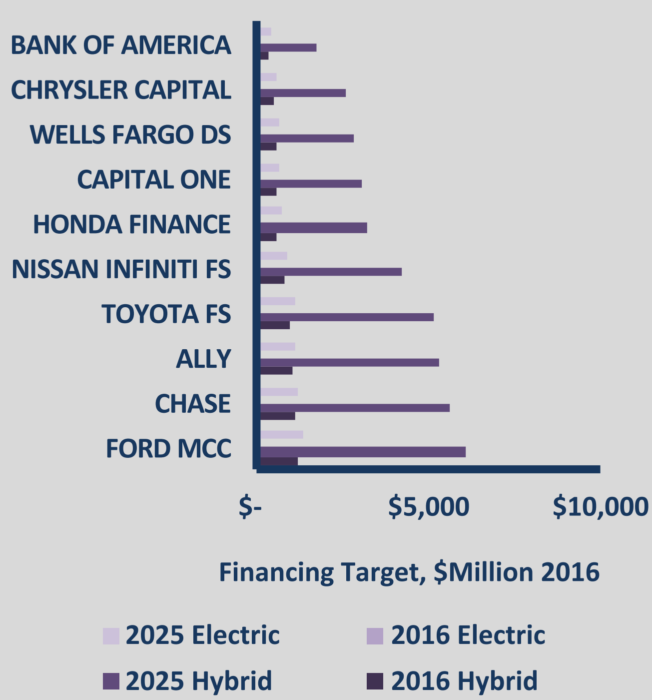


FIGURE 4.8: ESTIMATED HYBRID AND ELECTRIC VEHICLE FINANCING TARGETS UNDER A 2C SCENARIO AND 'FAIR SHARE' ASSUMPTION (SOURCE: AUTHORS)



4.3. FINANCING FOR INNOVATION

Scope. Innovation is a critical piece of the investment puzzle around the transition to a low-carbon economy. For a number of sectors, zero-carbon technologies are still missing as viable alternatives, leaving efficiency as the only decarbonization pathway. Incremental technologies however will not deliver the full decarbonisation needed under a 2°C scenario. For example in the transport sector, while the IEA suggests that efficiency carries the bulk of the decarbonisation burden, this still only equates to about 50% of decarbonisation, with at least another 30-50% related to fuel switching associated with disruptive technologies (e.g. electric vehicles, fuel cells, etc.), and the "other" related to avoiding and transport mode switching.

Research and development contributes through three pathways in realizing a realistic and affordable transition to 1.5-2°C:

- **Costs.** RD&D reduces deployment costs. While such costs are also driven by "learning by doing", RD&D plays an important role. Thus, the costs per kWh of electric vehicle battery packs have dropped by two-thirds in 8 years, despite relatively limited deployment (FIG. 4.9).

- **Efficiency / Productivity.** RD&D improves technical efficiency / productivity, a part of deployment costs. For example, several technologies are in development to greatly increase the current 11-15% technical efficiency of solar cells.

- **New technologies.** Naturally, RD&D can also involve the inventing of entirely new technologies or products for which no current low- or zero-carbon solution exists. Examples here include the development of new 'flying wind drones' and alternative cement that does not rely on clinker.

Investments in innovation require much lower overall levels of financing – billions rather than trillions. According to a study from Accenture (2011), development capital related financing needs was only about 1/5th that of procurement capital (e.g. asset finance, etc.) for the 2010-2020 period in financing European cleantech (FIG 4.8). At the same time, investment needs are poorly defined, making both the development of investment as well as financing targets difficult to analyze. Moreover, the gap – in relative terms – between current financing and financing needs associated with a 2° C transition may be even higher for innovation. While investment targets are lacking to build financing roadmaps, the next page illustrates the options using the power sector as a case study.

FIG. 4.8: SOURCES OF CLEANTECH FINANCING IN EUROPE 2010-2020 (SOURCE: ACCENTURE 2011)

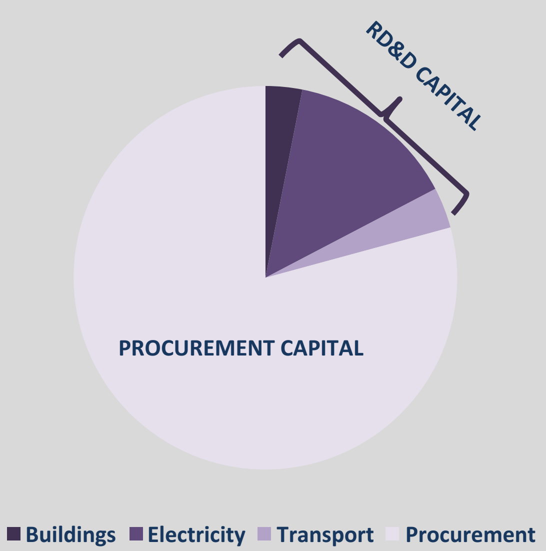
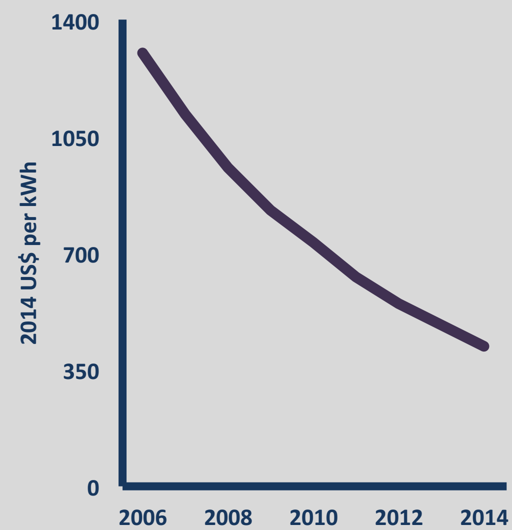


FIG. 4.9: COSTS OF ELECTRIC VEHICLE BATTERY PACKS (SOURCE: NYKVIST ET AL. 2015)



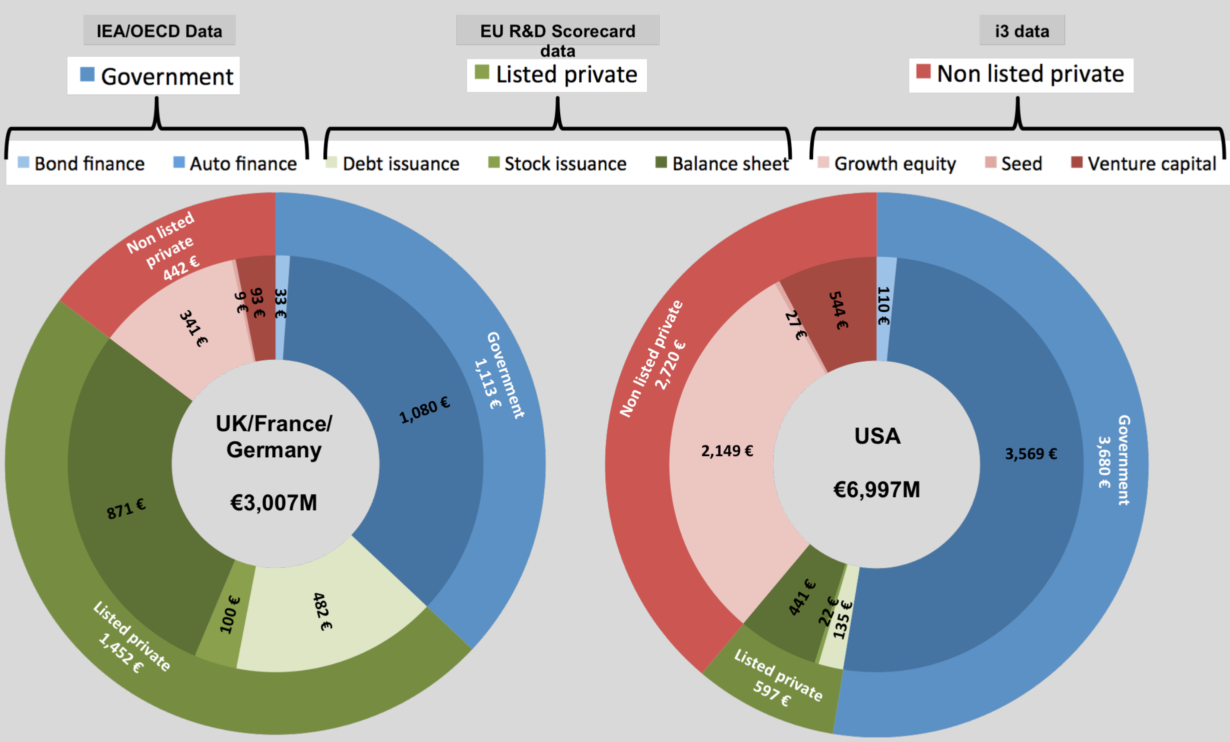
Case study: Innovation in the power sector. The power sector is the largest emitter of CO_2 within the energy sector and will require emissions reductions in the magnitude of 320 $GtCO_2$ to 2050 under the IEA's 2DS. This will involve the financing of low carbon innovations today that could be commercialized in the future. The figures below (FIG.10) seek to provide an illustrative breakdown of the sources of financing for low carbon innovation related to the power sector in the United States and Europe (limited to France, Germany, and UK at this stage). The point of these charts is to provide an overview of the financing vehicles available to investors looking to expose themselves to low carbon innovations in the power sector. In order to gain gross figures of investment from these sectors data was used from the OECD, IEA, i3 and 2014 EU RD&D Scorecard. Ratios of financing low carbon power technologies were then applied to gain an insight into the financing vehicles used by these main actors. A full list of ratios used and explanations can be found in the Appendix. Crucially, the figures presented here are designed to be illustrative based on existing databases for electricity sector related technologies. They should thus not be seen as absolute conclusions. Further research is needed, in particular on the activities of listed companies to provide a more conclusive picture.

Public financing. Governments utilize tax payer funds to finance external third parties through government grants and other financing mechanisms. It is important to note that bond finance makes up only 3% of RD&D financing mainly due to the inherent risks in developing new innovations and also the long time horizons of technology development that may be longer than the term to maturity of the bond.

Listed corporate finance. To estimate the figures from energy utilities and energy suppliers (oil and gas, coal, alternative energy) the authors used only the listed energy related companies found in the 2013 EU Innovation Scorecard from the USA, UK, France and Germany. The charts show that the listed corporate sector plays a much larger role in RD&D in Europe than in the United States, both in relative as well as absolute terms. One important point is that while in large-cap companies equity issuance may be a minor source of financing, this may be more prominent for mid-caps or small-caps which were not found in the innovation scorecard list.

Non-listed private. The figures for non-listed private have been determined from the i3 database which records a majority of investments made in clean tech companies by source and financing stage or vehicle. As the focus of this report is pre-operations growth of the innovation cycle, only venture capital (series A & B), seed and growth equity were used to determine these figures. Non-listed private finance plays a large role in the United States, thanks at least in part to vibrant venture capital and private equity markets found in Silicon Valley. Small- and medium-sized enterprises that may deliver innovation, like German Mittelstand companies, are not captured in this data, given their lack of interaction with venture capital / private equity or capital markets financing. These areas may thus deliver a significant part of the innovation without necessarily being linked to financial markets.

FIG. 4.10 LOW CARBON FINANCING IN THE POWER SECTOR – All FIGURES IN €MILLIONS (SOURCE: 2°ii)



5. IMPLICATIONS AND KEY QUESTIONS

5.1 SUMMARY OF FINDINGS: CREATING FINANCE ROADMAPS AND FINANCE-BASED SBTs

Key takeaways. The increased importance of non-state actors to delivering the Paris Agreement in general, the importance of ensuring adequate financial flows more specifically, and a lack of adequate metrics and methods demand a new context-based measurement framework for both global climate finance progress tracking and institutional target setting. Thus, the creation of a 'financing roadmap' and institution-level financing targets are critical research needs. This work shows such target setting is possible but is also hindered by key challenges including:

1. **Uncertain technology pathways and investment levels.** While certain technologies (and thus investments) will certainly be needed, i.e. a vast expansion of renewable power and energy efficiency, other technologies/ investments will depend on future technological innovation and societal choices (e.g. nuclear power, hydropower, CCS, hydrogen fuel cell vehicles).

2. **Variability of actors and financial roles/institutions.** The energy transition requires investment across all sectors of the economy, which in turn will require different types of financial activity, from retail lending to corporate finance and investment banking. This complicates target setting at institutional level, which can include institutions ranging from local banks to global financial institutions with dozens of different businesses. Further, this wide variety of actors means a risk of overprescribing a roadmap that will likely change with financial innovation.

3. **Fair Share issues**. The "fair share" assumption taken to date in Science-based target setting (i.e. all companies in a sector have similar responsibilities for emissions reduction) may not hold up among financing institutions. Profit-driven institutions are unlikely to have similar levels of green financing compared to mandate-driven ones, and in some areas of specialized finance it may be nearly impossible for invidual institutions to hit their targets based on the underlying client base (e.g. captive automotive finance orgs). A related issue comes in financing structures where multiple institutions play different roles, and thus double counting will occur, such as in securitization (underwriting securities vs. purchasing them).

4. **Price/investment level issues**. As shown above, investment costs are changing rapidly for many critical technologies, requiring roadmaps that are either anchored in constant price levels (which will vary across technologies) or that change annually as prices decline in order to deliver the same amount of climate mitigation.

5. **Projecting financing structure.** As there is no 'science-based' way to split an investment flow into required financing, converting investment roadmaps to financing roadmaps relies on assumptions and projections of financing structures, which many analysts expect will change with time due to increasing market acceptance of green bonds and green asset-backed securities.

6. **Financing innovation**. Finally, a significant need exists to support finance for both the deployment of existing technologies and the development and demonstration of new technologies lacking current market acceptance. Financial models to support innovation are likely to be very different from those supporting existing technology deployment.

No "right" answer to 'top-down' roadmaps. For all these reasons, a top down approach to setting financing roadmaps is unlikely to lead to a single "right" or even broadly accepted answer. Similar to climate policy overall, climate finance represents a global collective action problem and the allocation of global financing needs to different institutions has legal, moral, and practical dimensions. These challenges do not mean that the exercise is not useful; as shown above, high-level insights on market sizing and indicative targets are possible in several sectors. However, particularly for institutional target setting, a flexible bottom-up system may be more appropriate, and is discussed in the remainder of this section.

5.2. RATIO-BASED TARGETS: A SIMPLIFIED APPROACH?

The potential for relative/ratio-based targets.

As shown above, allocating individual institutional financing targets from financing roadmaps is possible using a market share allocation with a 'fair share' assumption that all institutions should be required to contribute to the goal. An alternative target setting approach is to avoid the fair share question explicitly by using **ratios** rather than **absolute values,** taking advantage of the fact that financial institutions work in portfolios of assets and transactions**.** Such ratios could be built in technology, investment, or finance terms, and can be based on transition pathways to provide 'science-based' benchmarking. Examples in Table 5.1, taken from bank reporting, showing that banks already think in these terms—the key is to provide 'science-based' benchmarks in the same units.

Physical or financial units?

Given the price uncertainties discussed above, the Ideal unit for forward-looking target setting is the physical unit (e.g. MW, number of cars), which connects the provided financing directly to impact on the ground. As Figure 5.1 shows, differences can emerge between such a physical unit and investment or financing cost, since investment costs change. In this case, the performance ratio of renewables investment to total investment in the power sector goes down by 76% to 71% through assumed dropping prices in renewables. However, this change is not so rapid as the overall change in prices, since both the numerator and the denominator of the KPI are changed, another key advantage to using ratios.

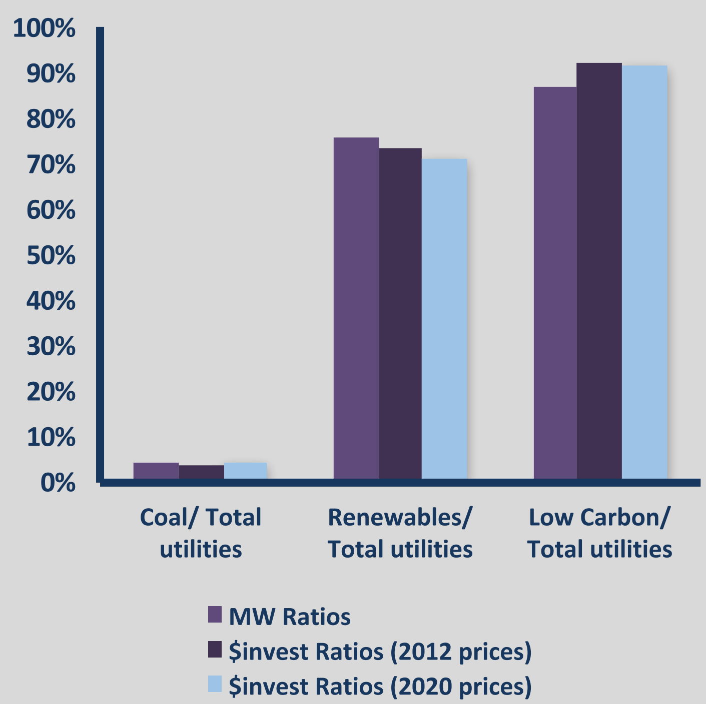
The problem of the brown-only sector.

One issue with this approach is that intra-sector ratios will only be easily applied work when both a green and brown technology exist within sector, such as for project finance power generation and automotive loans, where a clear 'green' (renewables/hybrid/EV) and a clear 'brown' technology exist. For sectors where no 'green' alternative exists (e.g. fossil fuel sector financing), there is the possibility of cross-sector ratios (e.g. fossil fuels $/ renewable $). Such cross-sector ratios taken in investment terms from Figure 4.1, for instance, suggest that a ratio of total fossil fuel extraction investment to renewable power investment should not exceed ~0.8-1.6 depending on model. Despite several caveats (the financing structure might be totally different for fossil fuel extraction and renewable power, $1 investment might not mean same thing), such ratios can be used to benchmark financing as well. Existing analysis on syndicated lending and underwriting shows current ratios are instead ~5:1 in lending and ~9:1 underwriting based on existing publicly available data (Fair Finance 2015).

TABLE 5.1: SAMPLE TECHNOLOGY AND FINANCING RATIOS DERIVED FROM TECHNOLOGY AND INVESTMENT ROADMAPS AND FI REPORTING (IEA 2016; PCI 2017)

SECTOR/ INSTRUMENT	TECHNOLOGY RATIOS	FINANCING RATIOS
Power / Project Finance	Renewables/ Total (MW/MW) Coal/ Total (MW/MW)	Renewables/ Total ($/$) Coal/Total ($/$)
Vehicles/ Car Loan/lease	Hybrids financed/ Total (n/n)	Hybrids financed/ Total ($/$)
Oil & Gas/ Corporate Credit	NA	Oil & gas lending / Renewables lending ($/$)

FIGURE 5.1: SAMPLE 'SCIENCE-BASED' INVESTMENT AND TECHNOLOGY RATIOS IN PHYSICAL AND FINANCIAL TERMS, EU 2020-2025 (SOURCE: AUTHORS)



5.3 OPTIONS FOR TARGET SETTING

Different metrics for different use cases. The analysis done for this report suggests that no universal answer is available, and different metrics have different strengths and weaknesses for different use cases:

Top-down tracking of financial flows (e.g. Paris Agreement 2.1(c)).
In general top-down tracking will require the use of absolute levels/targets, given political objectives (e.g. tracking of the Copenhagen commitment) and the nature of the exercise (ensuring adequate flows to support a certain level of mitigation). The key, which separates investment and financing roadmaps from backward-looking climate finance tracking exercises (e.g. CPI 2017) is the use of forward-looking scenarios that track investment *needs* as a benchmark for current levels (see Figure 4.1 comparing investment levels to 2C requirements). The only drawback of using absolute investment or financing levels is in the attribution to individual actors, where 'fair share' issues and financing structure uncertainty become very complicated. This requires either a more advanced tracking system (see next page) or an acceptance that top down totals, as are available from IEA Investment Reports, may be sufficient rather than detailed roadmaps that track different types of financing in further detail.

"Science-based" Institutional Target setting:
In the case of institutional target setting, the situation is less clear, as strong pros and cons exist for each different type of metric:

- **Practicality**: As evidenced by current reporting (Figure 1.3), it is likely easiest for most financial institutions to track financing levels rather than investment levels or even more difficult, their underlying physical investment level. This argues for targets and metrics in financing terms.
- **Accuracy**: On the other hand, because of price, market share, and financing structure uncertainties, metrics and targets in financing terms are likely to be the least accurate and may require constant updating, which is not ideal for institutional target setting. Physical unit ratios avoid many of these pitfalls but likely require much more effort to track performance.

Further, additional effort is needed to standardize targets and metrics for financing with multiple financial or economic actors (Project finance, Syndicated debt, underwriting) to deal with potential double counting of the same investment. Here there is no "right" answer and standardization is required to ensure consistent tracking.

TABLE 5.2: PROS AND CONS FOR THE USE OF DIFFERENT METRICS FOR DIFFERENT USE CASES (SOURCE: AUTHORS)

	TECHNOLOGY RATIOS	TECHNOLOGY TARGETS/LEVELS	INVESTMENT OR FINANCING RATIOS	INVESTMENT OR FINANCING TARGETS/LEVELS
TOP-DOWN CLIMATE FINANCE TRACKING	CON: Ratios can't effectively track global progress	CON: doesn't track "financial flows" directly	CON: Ratios can't effectively track global progress	PRO: Direct tracking of "financial flows" in line with targets CON: Requires actor and asset class detail
"SCIENCE-BASED" INSTITUTIONAL TARGET SETTING	PRO: Direct translation of needs, limited price effects, useful across asset classes CON: May be impractical to track; accounting unclear (c.f. below)	PRO: Direct translation of needs, limited price effects CON: requires market share assessment	PRO: Likely most practical for FIs CON: more difficult to link to scenarios	PRO: Aligns most closely with current private FI practices CON: requires market share assessment

5.4 FUTURE WORK AND RECOMMENDATIONS: FINANCING ROADMAPS AND SCIENCE-BASED TARGETS

Regardless of the approach chosen for each core use case (top-down tracking; institutional target setting), several important steps are still needed to provide the framework and data for meeting use case needs. This future work ranges from data gathering and research to potential regulatory and standardization responses. The following key enabling activities would begin to overcome the many challenges to developing credible and accepted roadmaps and targets for climate mitigation finance.

1. **Modeling needs: Scenarios and investment tracking in line with stocks.** A critical need for investment and financing roadmaps are transparent, consistent, annually updated forward-looking scenarios and backward-looking tracking of climate-relevant investments. Institutions including the IPCC and IEA already provide pieces of such a consistent system, but IEA recently switched to only annual updates of its backward-looking report (World Energy Investment Report) rather than forward-looking scenarios (World Energy Investment Outlook). Generally climate and energy scenarios will be most useful to the financial sector if both *stocks* of technologies (e.g. MW of renewables in EU in 2025) and *investment levels (*e.g. MW renewables additions and retirements per year) are consistently reported. Importantly, this should not be a significant lift in terms of modeling, as energy systems models must internally solve for additions/investments and retirements anyway—it is just a matter of outputting the results consistently.

2. **Data needs: Further detail on existing financing structures.** Data availability is a key challenge for finance roadmaps and targets, as the sparse existing data suggests highly uncertain financing structure (Section 3.3) and limited information on investments in some sectors. This may be partly solved by more institutions developing and disclosing voluntary targets, though a "chicken and egg" problem exists here, since standards may require such data. A public sector role could also be important here, with top-down tracking needs meeting bottom-up voluntary target setting through a holistic system such as the conceptual "transition capital monitor" (2ii 2017b). Financial regulators could also play a role in providing aggregated data from collection efforts such as the Anacredit project (ECB 2015).

3. **Policy and Engagement needs: Broad agreement on the role of public and private FIs**. In line with the broader discussion on climate finance, broader agreement on the various roles of different financial institutions (DFIs, commercial banks, institutional investors) in providing the needed levels of climate finance would be very helpful to target setting, since they affect the "fair share" of different players (Section 5.1). Such discussions should continue in appropriate venues (UNFCCC, G20, etc.).

4. **Research needs: Benchmarks for RD&D**. Given the critical need for innovation finance in addition to deployment finance, research is direly needed to develop credible roadmaps and targets on financing for research, development, and early demonstration of emerging technologies. Such research should bring together industry, government R&D funders, and energy systems modelers.

5. **Standardization needs**. Finally, some aspects of science-based targets and roadmaps for the financial sector can only be solved through standardization since no "right answer" exists. Institutions like the Science-Based Targets Initiative should establish rules and methodologies to govern such issues, like accounting across asset classes and setting institution level targets. Such work should follow the general principles already laid out by DFIs in Common Principles on Climate Finance Accounting (Joint Climate Finance Group 2015).

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ANNEX 1—CURRENT PRACTICE IN FI CLIMATE METRICS

The Portfolio Carbon Initiative have reviewed metrics and targets currently in use by institutional investors (PCI 2015) and banks (PCI 2017), generally finding four types of metrics in use (Table A1 shows quantitative metrics, PCI 2017):

- **GHG Accounting approaches**, including project level accounting (project finance, project bonds) and cross-sectional 'financed emissions' methods;
- **Sector-specific metrics** in physical units, which can be directly benchmarked to scenarios or the economy;
- **ESG Scoring,** a semi-quantitative analyst driven approach;
- **Green/brown shares**, accounting for portfolio shares of 'green' or 'brown' activities in monetary terms.

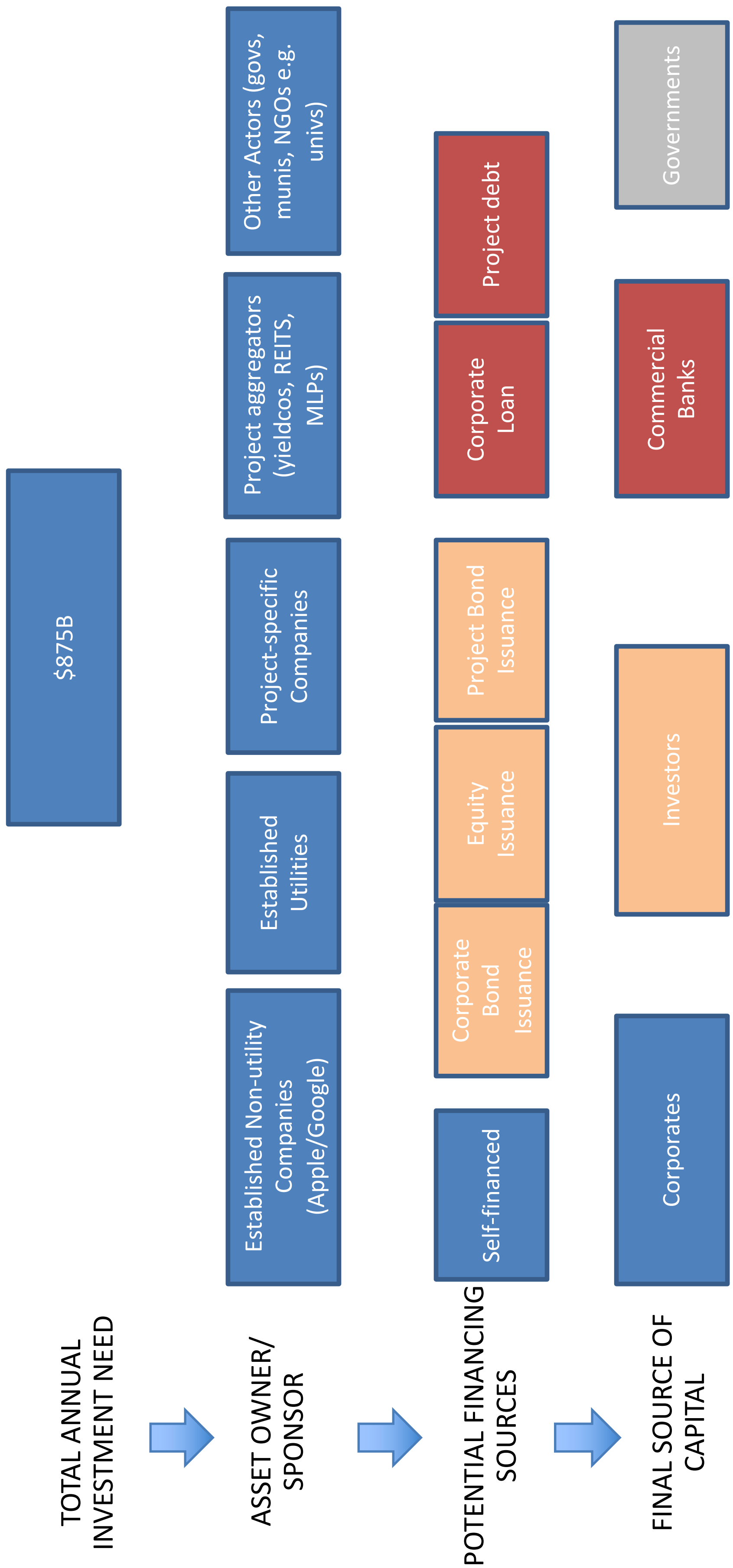
As shown in Table 5.2, all quantitative metrics currently in wide usage (sector-specific metrics not currently in wide use) suffer from weaknesses, notably the inability to benchmark to economic and scenario-based indicators.

TABLE 5.2: PROS AND CONS FOR THE USE OF DIFFERENT METRICS FOR DIFFERENT USE CASES (SOURCE: AUTHORS)

	DESCRIPTION & EXAMPLES	APPLICATION	PROS	CONS
GHG ACCOUNTING APPROACHES	Cross-sector portfolio-level assessment of investees' exposure to greenhouse gas (GHG) emissions such as financed emissions (a bank's scope 3 emissions)	• Connecting the dots between portfolios and GHG emissions in the real economy • Project finance screens (e.g. lifetime GHG emissions > 50 Mton) • Public communication & reporting, particularly for assets with known use of proceeds	• Broad information on carbon emissions of sectors and portfolios • Directly measures 'contribution' to each transaction (if 'proportional', i.e. for financed emissions) • Metric works across sectors and asset classes, thus enabling portfolio-level reporting	• Emissions data availability • Inability to track "green" activities directly (except through avoided emissions accounting) • Lack of accounting standard and agreement on some measurement issues • Data availability and confidentiality issues outside listed companies and projects • Difficult to apply to off-balance sheet services
SECTOR-SPECIFIC ENERGY/CARBON METRICS	Sector-specific physical unit metrics expressed in absolute units (e.g. kWh generated) or intensity units (kWh/ft2).	• Measuring sector-level climate performance • Comparing portfolio performance to economy-wide averages	• Sector- and asset-specific indicators can provide nuance and context • Benchmarks possible for transition (e.g. 2°C scenarios)	• Only applicable for a number of key sectors • No obvious way to aggregate data across sectors or assets/ transactions
GREEN / BROWN SHARES	Taxonomies distinguishing between activities and technologies that are climate solutions ("green") and climate problems ("brown")	• Tracking both 'green' and 'brown' financing in the context of portfolios • Tracking and reporting for any transaction or asset type, including services	• Ability to track both green and brown • Easy to track • Applicable to off-balance sheet services and on-balance sheet assets	• Controversial technologies and taxonomies (e.g. natural gas, nuclear, CCS, biofuels) • Lack of standard taxonomy

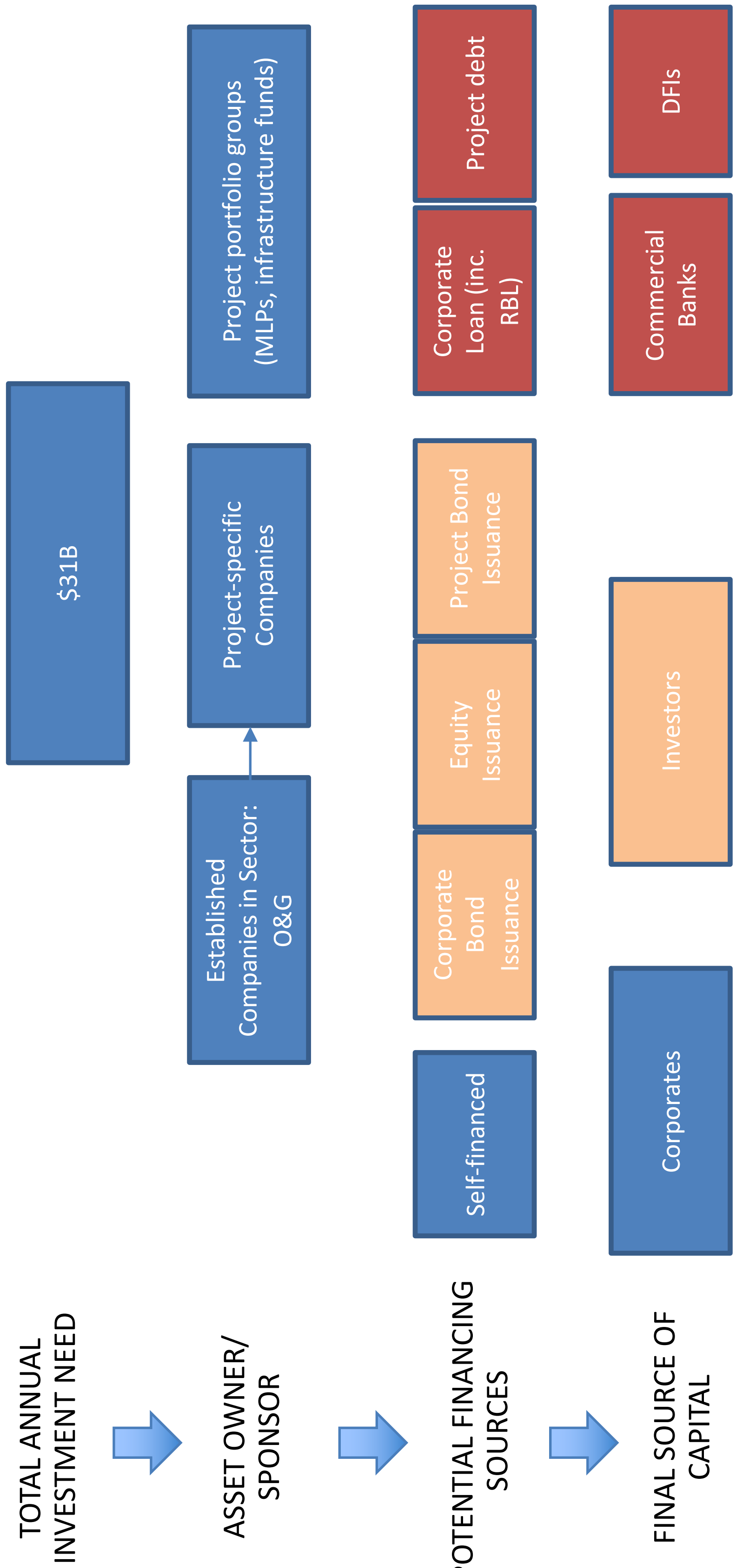
ANNEX 2—INVESTMENT FLOW DIAGRAMS

8.1. INVESTING AND FINANCING FOR POWER GENERATION



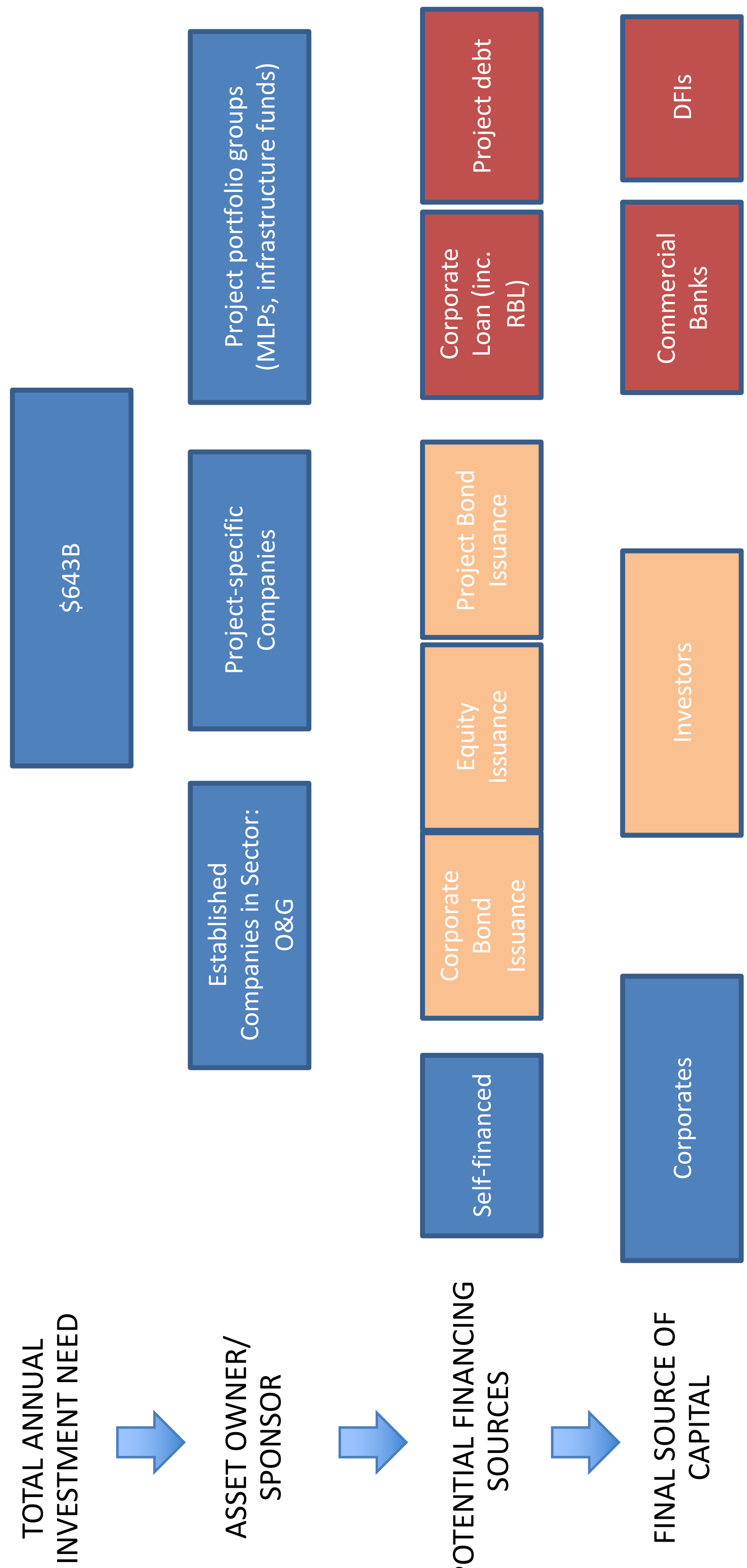
ANNEX 2—INVESTMENT FLOW DIAGRAMS

8.2. INVESTING AND FINANCING FOR COAL MINING



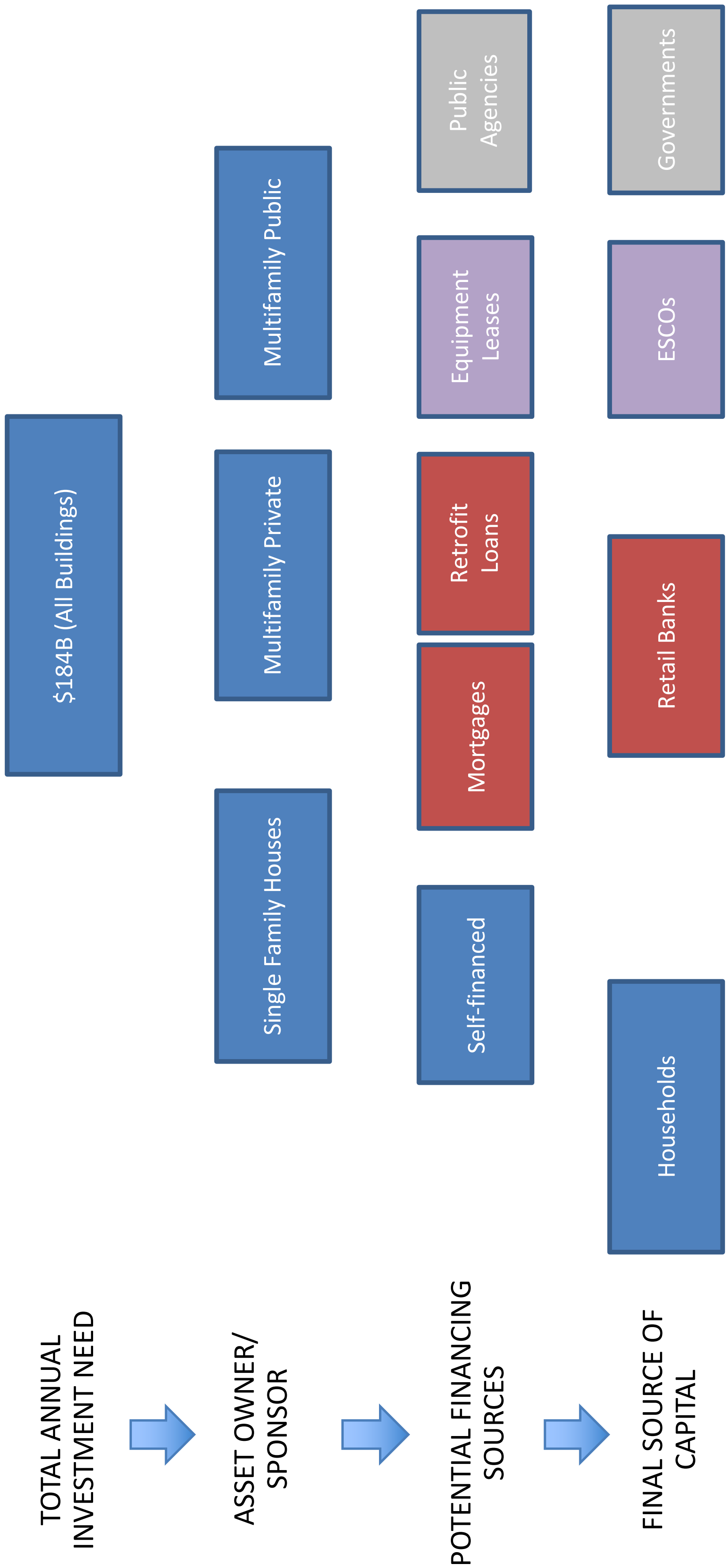
ANNEX 2—INVESTMENT FLOW DIAGRAMS

8.3. INVESTING AND FINANCING FOR OIL & GAS (UPSTREAM) DEVELOPMENT



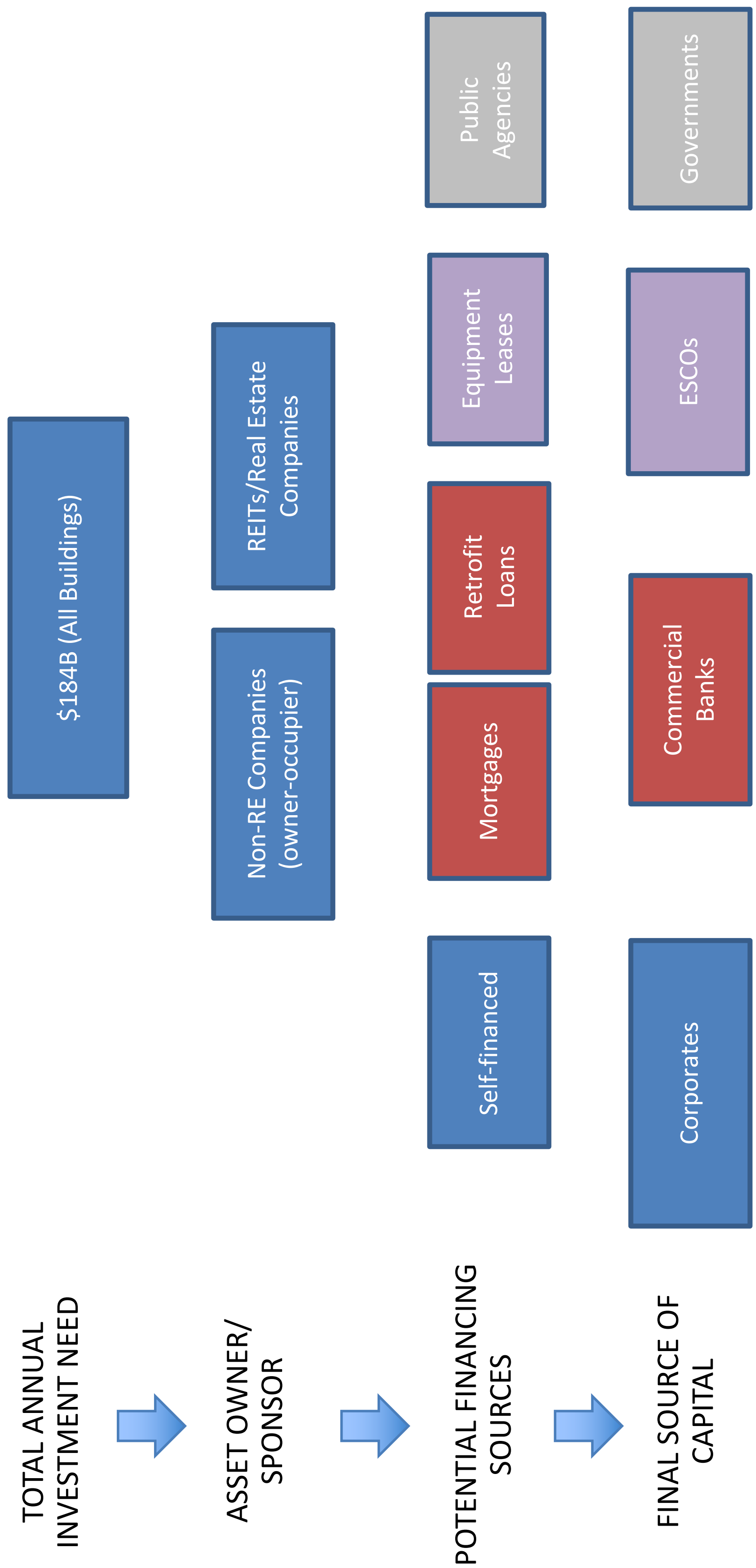
ANNEX 2—INVESTMENT FLOW DIAGRAMS

8.4. INVESTING AND FINANCING FOR RESIDENTIAL ENERGY EFFICIENCY



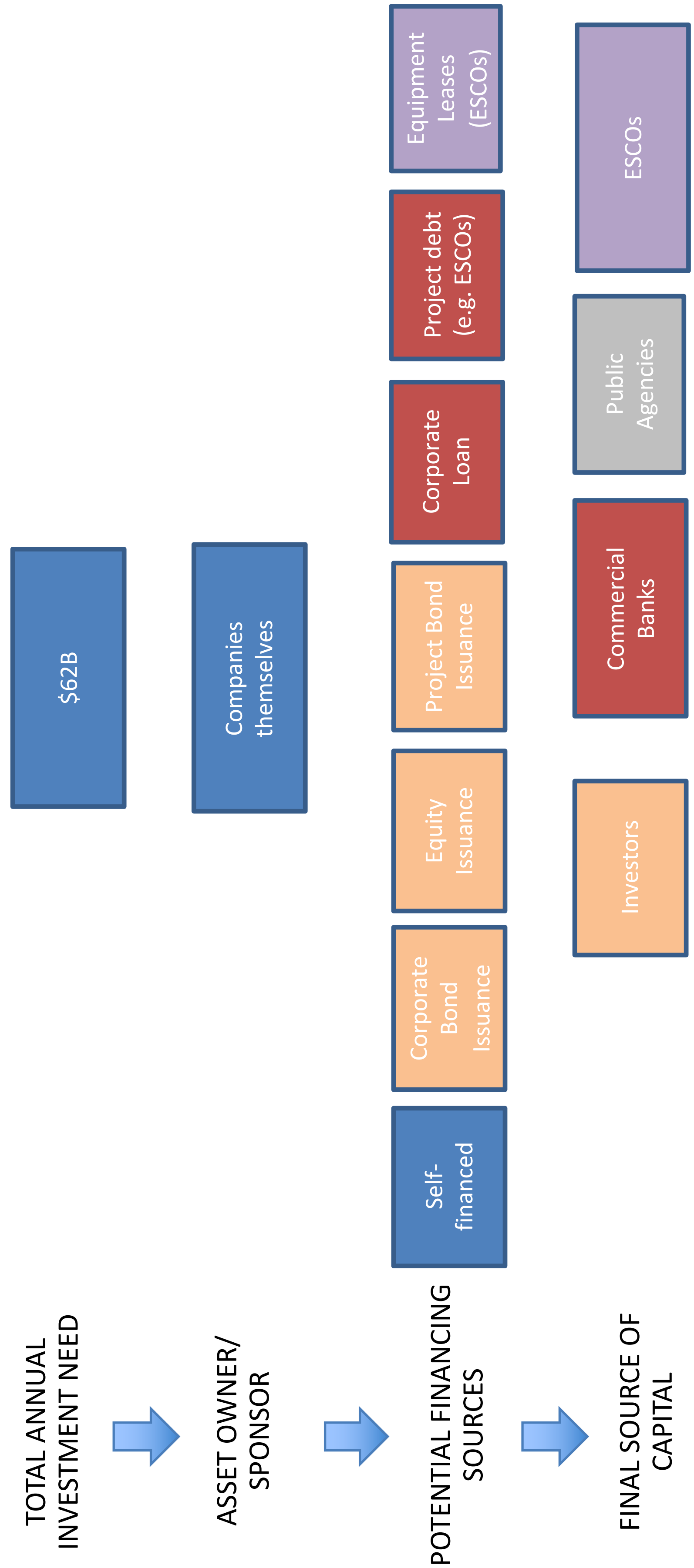
ANNEX 2—INVESTMENT FLOW DIAGRAMS

8.5. INVESTING AND FINANCING FOR COMMERICAL BUILDINGS ENERGY EFFICIENCY



ANNEX 2—INVESTMENT FLOW DIAGRAMS

8.6. INVESTING AND FINANCING FOR INDUSTRIAL ENERGY EFFICIENCY



ANNEX 3 — R&D FINANCING

The following ratios and explanations were used to determine the figures found on page 10 and 11.

In order to develop the figures of listed companies firstly the authors identified companies for inclusion from the EU innovation scorecard 2014 which ranks the top 2500 listed companies in terms of amount spent on RD&D in the year 2013. Only companies within the the utilities and energy supply sectors (i.e. Coal mining, oil and gas and alternative energy) from USA, UK, France and Germany were used as this is the focus of the 2°ii world.

Listed utility low carbon weights:

The ratio for low carbon weight for the utility sector in each country was determined by using the ratio of government low carbon RD&D investment in the energy sector compared to RD&D investment in conventional fuels. While the number of companies may appear low, after analyzing the annual reports of the top 20 energy utilities based on weight in the MSCI World Index, it was found that low carbon RD&D spending is either very low or non-existent across the industry.

Country	Number of companies	Total RD&D spend 2013 (€millions)	Low carbon weight
France	5	1404.70	0.36
Germany	3	382.90	0.91
United Kingdom	2	204.30	0.76
USA	2	136.30	0.81

Listed energy low carbon weights:

Companies were again determined form the EU 2014 RD&D Scorecard. The low carbon weight within the listed utility space was determined using an estimate that 10% of total RD&D spending in the coal mining and oil & gas sectors was used for low carbon RD&D purposes. For alternative energy this was given a low carbon weight of 100%.

Region	Sector	Number of companies	Total RD&D spend 2013 (€millions)	Low carbon weight
France/Germany/UK	Alternative Energy	3	183.30	1.00
	Coal mining	2	121.10	0.10
	Oil and Gas	4	2472.80	0.10
USA	Alternative Energy	1	97.40	1.00
	Coal mining	1	35.50	0.10
	Oil and Gas	4	1521.90	0.10

ANNEX 3 — R&D FINANCING

Listed energy company financing ratios:

The financing ratios have been determined using ratios from Bloomberg New Energy Finance that are on average used by listed corporations to finance research and development activities.

Financing	Alternative energy	Mining	Oil and Gas	Power/utilities
Debt issuance	0.37	0.49	0.14	0.37
Stock Issuance	0.08	0.15	0.01	0.08
Self finance	0.55	0.36	0.85	0.55

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