MSCI Climate VaR methodology part 3: Technology opportunities

MSCI ESG Research

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Contents

1 Technology opportunities methodology

1.1 Objectives of the methodological approach

The transition to a low-carbon economy may present untapped growth potential for investors. Looking into the future, the question is: which companies may emerge as future innovators and take advantage of these growth opportunities via the successful development or growth of key low-carbon technologies?

MSCI ESG Research's low-carbon technology model is based on estimated current low-carbon revenues as well as company-specific patent data. Recently-published patent databases allow an evidence-based view into the strategic research and development investments of companies, which may complement the policy risk analysis on GHG reduction requirements.

MSCI ESG Research's model currently covers 96 million unique patents that have been granted from over 70 patent authorities worldwide. Using patent filings as a proxy for low-carbon innovative capacity, as well as companies' current estimated low-carbon revenues, MSCI ESG Research's model aims to provide an indicator of which companies may be the beneficiaries if 3ºC, 2ºC or 1.5ºC aligned climate policies are implemented on a global level.

MSCI ESG Research takes a multifaceted approach to estimating the potential future value of each patent. Using estimated current low-carbon revenues as a starting point, patent valuation techniques are then used to estimate the level of "future green revenue" that each company could attain from the development and sale of low carbon technologies.

MSCI ESG Research's low-carbon revenue forecast for each company can be used to assess an investment's exposure to certain technologies under a 3ºC, 2ºC, or 1.5ºC transition scenario. Our 3°C scenario model bases its technology pathways (how the technology mix changes in each scenario) on countries' Nationally Determined Contribution (NDC) targets, while UNEP GAP statistics inform 1.5 and 2°C scenario pathways. MSCI ESG Research also references pathways defined by different global Integrated Assessment Models (IAMs): AIM-CGE, IMAGE and GCAM.[1]

[1] For more information on NDC targets, UNEP GAP statistics, and Integrated Assessment Models, please see **Climate VaR methodology part 2: Policy risk.**

2 Modelling steps and key assumptions

Exhibit 1 - Technology opportunities modelling steps

	Modelling Steps	Key Assumptions
1	Gather a global database of patents from 70 national patent offices. Analyze the database to determine which patents were granted and which were filed unsuccessfully. Match patents to companies using big data approaches and machine learning.	MSCI ESG Research can accurately match patents to companies.
2	Separate out the patents referring to low carbon technologies, as defined by the European Patent Office (EPO), the International Centre for Trade and Sustainable Development (ICTSD) and the United Nations Framework Convention on Climate Change (UNFCCC), within the databases.	The sector classification system is comprehensive (there are more than 400 groups of low carbon technologies) and patents are accurately classified by the patent assessor. Low carbon patents are a proxy of innovation, and the technologies defined in patents will act as a source of low-carbon revenue in the future. In a low carbon economy, companies that do not have granted patents for low carbon technologies are at a competitive disadvantage to those that do.
3	Assess each patent for quality and future potential and assign a score.	The four statistical measures that MSCI ESG Research chose to qualitatively assess each patent establish a picture of the relative level of quality of patents.
4	Classify the share of each company's current revenue considered "green".	Current low-carbon revenues of a company will continue to grow, giving the company an advantageous share in low carbon sectors.
5	Forecast the low-carbon revenue potential for each company for the next 15 years. MSCI ESG Research's low-carbon revenue forecast is based on a company's aggregated patent scores relative to sector peers and current low-carbon revenues in each sector.	Sector-level revenue forecasts are based on the assumption that one company's cost to comply with climate policy is another company's low-carbon revenue, as a result of selling products to help the regulated company to reduce emissions. At a company level, we assume that the number and quality of patents are proxies of a company's R&D investment and therefore a good indicator of future market innovation potential. Access to future low-carbon revenue can be obtained either through having a large

		low carbon patent portfolio, or a large share of current low-carbon revenue. Patents have a greater bearing on future low-carbon revenue over a 15-year horizon vs. current low-carbon revenue.
6	Per year profits are calculated as the sum of modelled annual low-carbon revenues multiplied by the average profit margin per sector.	Sector-level profit margins apply across companies and across green and non-green products and services.
7	Total present value of future profits is calculated. For a detailed explanation of how this works please consult the financial modelling chapter.	The effect of low-carbon revenues on the share price of a company can be estimated using classic financial discounting methods.
8	Company-level Technology Opportunities Climate Value-at-Risk is the present value of future profits in relation to the enterprise market value.	

2.1 Patent database coverage

The number of patent families within the patent database and mapped to the MSCI ESG Research universe can be found in the table below.

Exhibit 2 - Summary of patent database coverage as of April 2020

	Full patent database	MSCI universe
Patents	96M	25M
Patent families	50M	11.4M
Granted patent families	13.6M	4.7M
Low carbon patent families	1.4M	0.5M
Granted low carbon patent families	0.6M	0.26M

MSCI ESG Research, IPLytics, as of April 2020.

These patents are owned by patent issuers, which we map to companies, summarized in the table below.

Exhibit 3 - Summary of patent database coverage mapped to companies as of April 2020

Full patent database	209.3k
Publicly listed	16.1k
Non-publicly listed	193.2k
Companies matched to MSCI ESG Research issuers	12.3k
Distinct MSCI ESG Research issuers matched (excluding subsidiaries)	10.7k

MSCI ESG Research, IPLytics, as of April 2020.

2.2 Patent valuation & scoring assessment methodology

Four statistical measures underpin MSCI ESG Research's patent valuation and scoring assessment. These are well-established in academic literature and by practitioners.[2] The Swiss Federal Institute of Intellectual Property has collaborated extensively with MSCI ESG Research to support the development of this methodology. The four statistical measures are shown below:

Exhibit 4 - Summary of patent scoring methodology

a. Forward citations

When patents are cited by other patents this is known as a forward citation. Therefore, the number of forward citations a patent receives is often used as a measure of a patent's significance. New patents rarely earn many forward citations because it takes time for a patent to be recognized and cited by newer patent documents. In other words, forward citations build up over time and a strict citation analysis will favour older patents. The notion is that if a patent is cited often by other

[2] See for example Abrams, D., and J. Popadak. 2013. "Patent Value and Citations: Creative Destruction or Strategic Disruption?" doi:10.3386/w19647; Hall, B., A. Jaffe, and M. Trajtenberg. 2005. "Market Value and Patent Citations." *The RAND Journal of Economics* 36 (1):16-38; Albert, M., D. Avery, F. Narin, and P. McAllister. 1991. "Direct Validation of Citation Counts as Indicators of Industrially Important Patents." *Research Policy* 20 (3):251-9.

patents, then other entities are more likely to be building on the patented technology, and the highly cited patents are more likely to be fundamental or important. It is important to note that this analysis makes no judgment on an individual patent but rather refers to the value of a patent in a group of other patents.

b. Backward citations

On the other hand, backward citations are the opposite of forward citations. Here the issuer of a patent refers to many established, older patent technologies. A higher number of backward citations therefore decreases overall patent score.

c. Market coverage

Statistics around market coverage pertain to the size of the market that the patent was granted protection in, and this is scaled by GDP. Therefore, the higher the GDP of total market filing, the higher the patent score.

d. The Cooperative Patent Classification (CPC) system[3]

The Cooperative Patent Classification (CPC) system was introduced in 2013 and is based on the International Patent Classification (IPC) system. It is divided into 9 sections: A-H (i.e. *Human necessities, Performing operations and transport, Chemistry, Textiles, Construction, Mechanical Engineering, Physics, Electricity*) and Y, which are further sub-divided into classes, sub-classes, group and sub-groups. The Y codes classify new emerging technologies, such as low-carbon technologies. The patent assessor determines to which patent group an individual patent relates. The higher the number of patent groups tagged, the higher the value. Overall, there are approximately 250,000 classification entries in the database (see www.epo.org for more information).

In order to map the CPC system to MSCI ESG Research's emission sector system[4] we utilise a mapping matrix which allows us to translate the specific CPC patent categorisation and tag to an emission sector with a given low-carbon revenue estimate. The figure below illustrates an example of carbon capture and storage and how a patent in this area could be valued when it comes to different MSCI ESG Research emission sectors.

[3] https://www.epo.org/searching-for-patents/helpful-resources/first-time-here/classification/cpc.html

[4] The emission sector classification is a specific classification of activities designed by MSCI ESG Research in order to analyze companies' greenhouse gas emissions as well as global climate policies. For more information, see **Climate VaR methodology part 2: Policy risk.**

Exhibit 5 – Mapping carbon capture and storage patents to emission sectors

	CO2 capture or storage	Capture or disposal of greenhouse gases [GHG] other than CO2
CPC Code	Y02C10/00	Y02C20/00
Commercial buildings and services	0	0
Residential buildings	0	0
Aluminum	0.0476	0.1111
Cement	0.0476	0.1111
Chemicals	0.0476	0.1111
Glass	0.0476	0.1111
Iron and steel	0.0476	0.1111
Heavy manufacturing	0.0476	0.1111

2.3 Energy mix assumptions

Global energy policies implemented in parallel with changing customer demands for renewable energy sources may have a pronounced effect in the utility sector.[5] Clean energy sources may form a greater part of the global energy mix under a low-carbon scenario in contrast to energy sources with high emissions such as coal, which may begin to be phased out (see below). This is relevant for the technology opportunity analysis calculations because developing patents for an industry that will be phased out will reduce the future revenue assigned to such patents when compared to patents in an energy industry that is expected to remain the same or grow in size.

The table and graph below show the global energy mix in 2017 as compared to the energy mix in 2030 under various 2°C scenarios. Under these scenarios, the prevalence of coal as an energy source halves as compared to gas, which remains the same. Therefore, we assume that patents relating to coal energy generation would see a fall in value of 50% compared with patents relating to gas energy generation which would retain the same value over this time period.

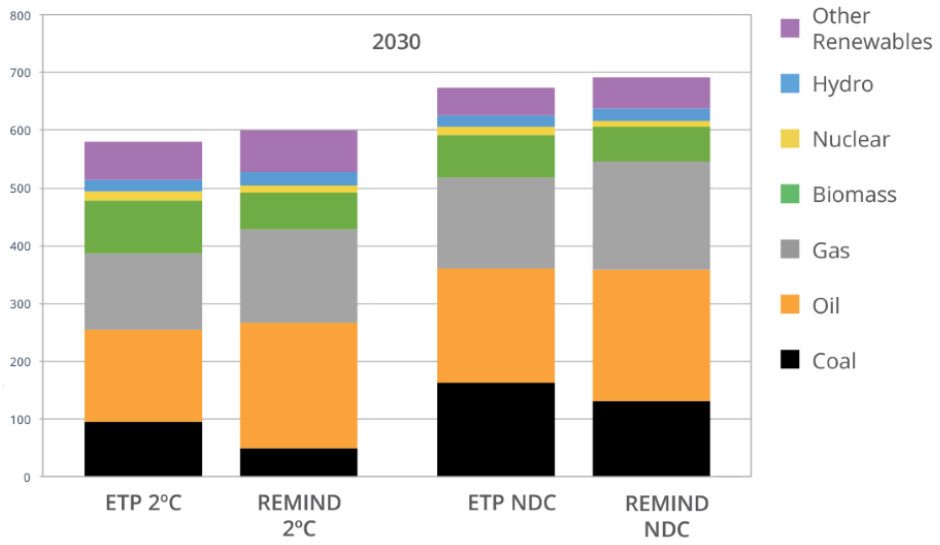
[5] Watanabe, K. and V. Karadzhova. 2019. "Utilities Industry Report." MSCI ESG Research.

Exhibit 6 - Global Energy Mix Scenarios – 2017 (IEA) & 2030

Utilities Sector	Current energy mix (IEA, 2017)	2°C energy mix (2030)
Biomass	8.0%	12.0%
Coal	25.0%	12.0%
Gas	23.0%	23.0%
Nuclear	3.0%	5.0%
Oil	30.0%	18.0%
Geothermal	0.5%	3.0%
Hydro	3.2%	13.0%
Solar	3.5%	5.0%
Wind	3.8%	9.0%

Source: International Energy Agency (IEA). Energy Technology Perspectives (ETP) 2017, scenario aligned with 2-degree warming.

Exhibit 7 - Global 2030 Energy Mix Scenarios – IEA ETP vs. PIK REMIND



Source: International Energy Agency (IEA). Energy Technology Perspectives (ETP) 2017; Potsdam Institute for Climate Impact Research (PIK) REMIND model.

3 Examples

3.1 Detailed calculation example: Toyota Motor Corporation

To further present the technology opportunities model detailed above, we will use the example of Toyota Motor Corporation ("Toyota") to demonstrate the calculation process along with the required inputs.

3.1.1 STEPS 1, 2 & 3: Analyze global patent database

We start by analyzing a global database of patents. As of February 2020, we identified over 59,000 granted patents for Toyota, of which 16,902 were classified by patent assessors as low-carbon solutions. We then mapped these low-carbon technologies to emission sectors.

Exhibit 8 – Summary of patent data for Toyota, as of Feb 2020

	Toyota
Granted	59,363
Not granted	63,534
Low carbon patents – granted	19,225
Low carbon patents – not granted	16,902
Low carbon technologies – sectors	
Automobiles	52%
Energy supply	13%
E-Vehicles	12%
Chemicals	7%
GHG reduction	5%
Other	11%

Each patent receives a score based on forward citations, backward citations, market coverage, and Cooperative Patent Classifications System (CPC) / International Patent Classification (IPC) coverage.

3.1.2 STEP 4: Estimate current low-carbon revenue

The MSCI ESG Research team includes a team of content specialists dedicated to producing green revenue estimates. These analysts are specialists responsible for identifying involvement and estimating the relevant percentage of revenue for the most recently completed fiscal year.

This review involves an examination of company regulatory filings, annual reports, company websites, and third-party sources. Analysts assess the company's product pipeline and only consider revenues coming from products that match the Sustainable Impact categories outlined below. For more details on revenue estimates, see the **MSCI Sustainable Impact Metrics methodology**.

Exhibit 9 – MSCI ESG Research green revenue estimate for Toyota, FY2018

Category	Sub-category	Revenue Percentage
Alternative energy	Solar equipment & services	0.11%
Energy efficiency	Demand-side management	0.11%
	Zero-emission vehicles	0.03%
	Hybrid vehicles	16.93%
	Clean transport infrastructure	0.11%
	Insulation	0.11%
	Energy storage / batteries (excluding alternative energy)	0.11%
Green building	Not applicable	0.00%
Sustainable water	Not applicable	0.00%
Pollution prevention & control	Not applicable	0.00%
Sustainable agriculture	Not applicable	0.00%
Total green revenue percentage		**17.51%**

3.1.3 STEP 5: Forecast future low-carbon revenue

The first step to forecasting future low-carbon revenue for a company is to estimate the overall future low-carbon revenue for each sector. We base this on the assumption that the costs to reduce emissions are equal to the potential opportunities related to selling technologies and products that can help reduce emissions. Sector-level revenue forecasts for each year are equal to the associated policy costs for a given scenario (see **Climate VaR methodology part 2 – Policy risk** for more details).

The exhibit below shows the estimated low carbon revenues (in USD millions) for the Heavy Manufacturing sector for the first three (of 15) years based on the 2°C AIM CGE, SSP2 scenario.[6]

[6] Sector-level revenue estimates vary based on the scenario used, but the subsequent calculations remain the same. The following company example uses the 2°C AIM CGE, SSP2 scenario. For more information on scenarios, see **Climate VaR methodology part 2 – Policy risk**.

Exhibit 10 – Total low-carbon revenue forecast for Heavy Manufacturing industry (USD millions)

	Total sector-level low-carbon revenues
2019	23.77
2020	55.96
2021	351.73

Total sector-level low-carbon revenues are assumed to equal total sector-level policy costs for each year of a given scenario.

The next step is to calculate a specific company's (in this example, Toyota) share of the total low-carbon revenue. For year one, this is calculated based on our company-specific estimate of low-carbon revenues mapped to each sector (step 4) relative to the sum of sector-wide low-carbon revenues across the MSCI ESG Research universe of companies.

Exhibit 11 – Estimated current low-carbon revenue market share for Toyota by sector

Sector	Current low-carbon revenue market share (estimated)
Heavy Manufacturing	16.83%
Commercial	1.31%
Road Transport	0.00%
Other sectors	0.00%

To forecast the company's share of low-carbon revenues in subsequent years (i.e. years 2-15), we also consider its portfolio of low-carbon patents. We interpret patents as a proxy of the company's low-carbon innovation capacity.

To calculate the low-carbon patent share for a company, we use the following formula with *c* the company, *t* the year and *s* the sector:

$$Low\ Carbon\ Patent\ Share_{c,t,s} = \frac{Low\ Carbon\ Patent\ Score_{c,t,s}}{Low\ Carbon\ Patent\ Score_{t,s}}$$

This share may change over time as new patents are granted or as existing patents expire. We assume a 20-year holding period for patents.

Exhibit 12 – Low-carbon patent shares for Toyota, 2019-21

Sector	Toyota low-carbon patent share		
	2019	2020	2021
Heavy Manufacturing	0.52%	0.52%	0.52%
Commercial	0.15%	0.15%	0.15%
Road Transport	12.43%	12.50%	12.62%

The overall share of future low-carbon revenues attributable to a company is based on a weighted average of these two inputs: its estimated current market share and its modelled patent share. We assume that the relative importance of patents increases over time, so the weighting factors are adjusted accordingly. The weighting factor applied to the company's current market share starts at one and decreases linearly to zero in year 15, while the weighting factor applied to the company's patent share increases linearly from zero to one over this period.[7]

We calculate the company's future low-carbon revenue market share by using the following formula with *c* the company, *t* the year and *s* the sector:

$$Low\ Carbon\ Revenue\ Share_{c,t,s} = Current\ Revenue\ Share_{c,s} * Weighting\ factor_{t,s} + Patent\ Share_{c,t,s} * \left(1 - Weighting\ factor_{t,s}\right)$$

Exhibit 13 –Low-carbon market share forecast for Toyota (Heavy Manufacturing sector)

	Current low-carbon market share	Low-carbon patent share	Current revenue weighting factor	Patent share weighting factor	Estimated low-carbon revenue share
2019	16.83%	0.52%	1.00	0.00	16.83%
2020	16.83%	0.52%	0.93	0.07	15.69%
2021	16.83%	0.52%	0.86	0.14	14.54%

[7] This assumption is adjusted for the renewable energy sector, where we assume that companies with current low-carbon revenues will continue to retain market share over time. In the renewable sector, the weight attributed to a company's existing market share decreases from 1.0 to 0.7 over 15 years, while the weight attributed to its patent share increases from 0 to 0.3 during this period.

Using these market share figures, we can now calculate the future low-carbon revenue that can be attributed to Toyota under a given scenario by using the following formula with *c* the company, *t* the year and *s* the sector:

$$Low\ Carbon\ Revenue_{c,t,s} = Low\ Carbon\ Revenue\ Share_{c,s,t} * Low\ Carbon\ Revenue_{s,t}$$

This is calculated for each year for 15 years and in each sector in which the company operates. Exhibit 14 below presents the forecasted low-carbon revenues (in USD millions) for Toyota across its main sectors of operations based on the formula above.

Exhibit 14 – Forecasted low-carbon revenue in 2019-2021, USD millions

Sector	2019	2020	2021
Heavy Manufacturing	4.00	8.77	51.00
Commercial	1.77	3.89	22.85
Road Transport	0.00	27.23	345.68
Other Sectors	0.00	20.21	249.73
Total low-carbon revenue	**5.77**	**60.11**	**669.26**

3.1.4 STEP 6: Calculate green profits

Forecasted low-carbon revenues are converted into low-carbon profits by multiplying the revenues by a sector average profit margin (Exhibit 15).

Exhibit 15 – Forecasted low-carbon profits in 2019-2021, USD millions

	2019	2020	2021
Total low-carbon revenue	5.77	60.11	669.26
Total low-carbon profits	0.36	3.73	41.58

3.1.5 STEPS 7 & 8: Calculate present value and Climate VaR

Once the full time series of future green profits is calculated, we apply a discount model to get the present value (PV) of future profits (for more information, see **Climate VaR methodology part 6 – Financial modelling**).

We then divide this present value by the company's enterprise market value (sum of market capitalization and the market value of debt) which gives us the Technology Opportunities Climate VaR.

For the Toyota, the calculation is as follows:

$$Technology\ Opportunities\ Climate\ VaR = \frac{PV\ of\ Future\ Profits}{Market\ Value} = \frac{174.13\ bUSD}{415.91\ bUSD} = +41.87\%$$

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