INDUSTRIAL ENERGY ACCELERATOR BRAZIL

Industrial Energy Efficiency Policy Modelling

Policy simulation model user guide and recommendations

Background

The Brazilian Industrial sector is a significant energy consumer, accounting for 25-35% of the nation's total energy consumption. Such high consumption has a significant carbon impact and an associated cost to purchase the energy. Consumption is forecast to further increase substantially over the next 30 years; to ensure the industrial sector continues to grow without the burdens of increased energy costs and a burgeoning carbon footprint it is key that all sub-sectors embrace energy efficiency measures.

The Brazilian government has an important role to play in ensuring businesses have the necessary support needed to reduce their energy consumption, outgoing costs, and carbon footprint through the introduction of energy efficient policy measures.

The work completed aims to help in the development process for policy measures through the production of a policy modelling tool and associated report.

Therefore, an excel based tool has been produced that models three shortlisted energy efficiency policy measures, and their effects on energy consumption, associated energy costs, and jobs supported. The model can be adjusted through a variety of inputs in order to determine what the best policy outcomes could be, as well as make it more representative to the actual Brazilian industrial sector.

This project is conducted under the Industrial Energy Accelerator (IEA), which is a multi-stakeholder partnership co-convened by UNIDO and the Carbon Trust under the umbrella of the Sustainable Energy for All (SE4All) flagship accelerator platform.

Visit the IEA's homepage for more information: www.industrialenergyaccelerator.org

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Content

1 Introduction – Brazilian Industrial Sector

Industries are responsible for ~21% of Brazil's GDP (IBGE, 2018); ~35% of the country's total energy consumption (EPE, 2017); and 8% of its GHG emissions (SEEG, 2018). These shares are expected to remain relatively stable up until 2030, although there is significant potential for energy efficiency (EE) savings throughout industrial sub-sectors. Official government projections for energy demand between 2016-2026 are presented in the country's latest 10-year-energy plan (MME, 2017), where a projected baseline is compared against an efficient scenario in which ~17 Mtoe/year are saved across all economic sectors by 2026 - 5.6% less than the baseline in that year. Figure 1 - dissects Brazil's EE potential per economic sector and across fuel and electricity savings. It reveals that approximately 48% of such savings could come from industries, primarily in the form of fuel savings.

Brazil has a number of governmental plans and regulations that bear relevance to industrial EE, most are non-compulsory and lack targets. The table below summarises the existing plans at federal level, cross-sector federal programmes as well as policies specifically addressed to the industrial sector. An assessment of such drivers reveals that Brazilian industries lack regulatory incentives to become more efficient. Programmes with greatest impact are mostly focused on electricity savings and consumer goods; leave the vast majority of the industrial thermal EE opportunity untapped.

DRIVERS	KEY TARGETS / SUMMARY
FEDERAL PLANS	
NDC	Mitigate 37% of GHG emissions in relation to 2005 levels by 2025. Reduce electricity demand by 10% by 2030 against a baseline in line with National EE Plan
NATIONAL PLAN ON CLIMATE CHANGE (PNMC)	Mitigate 36% - 39% GHG emissions by 2020 - against a baseline.
NATIONAL ENERGY EFFICIENCY PLAN	Reduce electricity demand in 10% by 2030 against a baseline.
PLANO BRASIL MAIS PRODUTIVO (P+B PLAN)	No targets - technical assistance provided to 48 industrial SMEs to identify EE opportunities, aiming to scale up to 400 SMEs.
INOVA PLAN	No targets - seeks to accelerate innovation in specific sectors offering credit and grants through periodic public tenders.
CROSS-SECTOR FEDERAL PROGRAMMES	
ANEEL'S EE PROGRAMME (PEE)	No targets - EE obligation scheme mandating electricity distribution utilities to invest 0.5% of their net revenues in end-user EE adding to ~R$630million/year.
EQUIPMENT LABELLING PROGRAMME (PBE)	No targets - mandatory labels to communicate the relative efficiency of electric equipment to consumers

NATIONAL PROGRAMME FOR ELECTRICITY CONSERVATION (PROCEL)	No targets - awareness raising initiatives around EE in multiple sectors and a flagship labelling award for the most efficient equipment under each category of the PBE.
NATIONAL PROGRAM FOR THE RATIONAL USE OF OIL AND GAS PRODUCTS (CONPET)	No targets - mandatory labels to communicate the relative efficiency of fossil-fuel-powered equipment to consumers.
GOVT. SUSTAINABLE PURCHASE PROGRAMME	No targets - non-compulsory sustainable procurement guidance to federal and state institutions.
CROSS-SECTOR FEDERAL REGULATION	
ENERGY EFFICIENCY LAW	Determines minimum efficiency standards for a range of energy consuming product categories
INDUSTRIAL SECTOR PLANS AND REGULATIONS	
PETROBRAS' OPERATIONAL EE PROGRAMME	No targets - in-house measures to enhance the efficiency of the company's fossil extraction, refining, distribution, petrochemicals and biofuels - set as a regulation given the company's public status.

2 Methodology

In recognising the opportunity to accelerate industrial energy efficiency via implementing new policies, as well as the challenge of estimating the cost and benefits associated with such actions, the beneficiary requested a policy simulating model which would be able to carry out modelling scenarios.

This involved firstly, identifying which key policies should be modelled. Each of the polices were assessed against a criteria matrix (ease of modelling, data availability, relevance, proven results) to form a list of three priority policy measures to model for the Brazilian industrial sector.

Secondly, a model was programmed in Microsoft Excel, to show the three different simulations. The model was built across four months, and strength tested against existing Carbon Trust models and following internal QA standards. A draft model was presented to the Ministry team, which was subsequently refined following specific recommendations from the workshops.

Once the final model had been produced, a final capacity building workshop was help with key Ministry staff, which was provided with training, the final tool, and this report, which includes key policy recommendations.

2.1 Industrial Energy Efficiency Policy selection

For the results of the model to be both reasonable and relevant, energy efficiency policies have been based on existing national policies that have been implemented in other countries globally. Furthermore, the model has been set up so that policy inputs can be altered by the model user to ensure that policies can be optimised based on knowledge from those within Brazilian government and industrial sector.

As part of the diagnostic task a list of 23 national industrial energy efficiency policies have been identified (this list can be found within appendix A) and researched. For each one, the following items were determined:

- Target - eg. Businesses with more than *x* employees, or with turnover greater than *£xx,xxx*
- Funding – private or public sector, tax mechanism, utilities, etc.
- Operation – how it works and for how long, is additional employment required, is there a target fuel type.
- Results – typical energy and or cost savings.

Each of the polices were assessed against a criteria matrix (ease of modelling, data availability, relevance, proven results) to form a list of three priority policy measures to model for the Brazilian industrial sector. The priority policy measures have been detailed below:

The metrics uncovered from the above investigation in to three detailed policy measures were analysed to see if a) they could be directly applied to the Brazilian industrial sector or b) need to undergo manipulation to make them applicable to the Brazilian industrial sector. Such metrics may include typical energy savings per measure, funding amounts and currency, target business sizes and types. Ultimately, all data was manipulated such that calculations could be carried out to find energy savings, jobs supported and cost savings. Where assumptions were made about the value of certain metrics for policy measures, an option has been provided in the model dashboard such that the user can override with their own more informed input.

2.1.1 Policy 1: Compulsory Energy Audits

This policy mandates that businesses with a level of employment greater than a set threshold must have energy audit(s) completed at recurring intervals. Businesses that fail to complete an energy audit may risk a fine.

The policy modelling was based on the concepts outlined below:

COUNTRY	Japan
POLICY NAME	Energy audits programme (1997)
POLICY TYPE	Command and control – Minimum EE requirements Incentive (SMEs) – Subsidy
TARGET AUDIENCE	Companies and factories consuming > 3,000 kL coe/year SMEs with annual energy consumption > 100 kL coe
COST TO PUBLIC BUDGET	ECCJ: USD 12.5 million NEDO: USD 21 million
PRIVATE SECTOR CONTRIBUTION	N/A
HOW IS IT FUNDED	The Energy Conservation Centre of Japan (ECCJ) provides free-of-charge audits, subsidized by the METI and the Agency on Natural Resources and Energy, to SMEs whose annual energy consumption > 100kL coe. Factories not matching those requirements bear the energy audit costs.
DESCRIPTION OF HOW IT WORKS	The energy audits programme, launched in 1997 under the Energy Conservation Law, provides free-of-charge energy audits to SMEs through the ECCJ, whereas it requires large enterprises to appoint Certified Energy Manager technically supported by NEDO when performing energy audits. Applicant SMEs submit EE proposals to the ECCJ which, upon examination and a preliminary interview, will proceed to an on-site visit to inspect the documentation and audit the site with a technical team. After the on-site audit, a report on needed EE interventions including advice for management, quantification of economic efficiency and detailed operational improvement is submitted to the company which voluntary decide whether to execute EE measures or not. On the other hand, non-SMEs are used to file for NEDO audits when lacking in-house energy management expertise thus using the audit results as base for the Certified Energy Manager work performance. In both clusters, most of the recommendations resulted in operational improvements that require no investment or limited financing with short payback periods (usually less than three years).
DESCRIPTION OF RESULTS	The ECCJ conducts about 300 to 1,000 audits annually in SMEs. 2.409 audits helped to achieve 2.38 TWh of energy savings, and 0.38 $MtCO_2$ emissions reduction, between 2004 – '07. Additional 2.518 audits with no detailed results were performed between 2010 – '14.

	NEDO performed about 40 to 100 audits per year between 1999 – 2007 in large enterprises. 501 audits achieved 6.95 TWh of energy savings and 1.12 $MtCO_2$ emissions reduced in the period.

2.1.2 Policy 2: Industrial Support Networks

This policy sets a framework by which businesses within a level of employment within a set range may voluntarily sign up to an 'energy saving network'. The network offers access to a dedicated energy saving expert who can suggest energy efficiency measures that can be implemented. Collaboration and regular meetings between the businesses within each network can allow for knowledge and results sharing.

The policy modelling was based on the concepts outlined below:

COUNTRY	Germany
POLICY NAME	Energy Efficiency Network Initiative (EENI)
POLICY TYPE	TA support
TARGET AUDIENCE	Businesses with energy costs between EUR 100,000 and EUR 20 million per year
COST TO PUBLIC BUDGET	N/A
PRIVATE SECTOR CONTRIBUTION	Costs vary between EUR 3,300 - 5,000 per company per year for SMEs and low energy-intensive companies, and between EUR 3,900 - 6,400 per company per year for large energy consumers, respectively.
HOW IS IT FUNDED	Companies pay the costs of joining the network with contributions varying according to the companies' energy costs, size of the network and project duration.
DESCRIPTION OF HOW IT WORKS	The initiative develops on voluntary basis and foresees the creation of two types of network, Mari:e and LEEN-Standard, for small and large businesses, respectively, which mainly differ in the amount of networking and monitoring sessions allocated, companies' contribution and network duration. Companies gather in groups of 8-15 to receive subsidized consultancy from EE experts previously selected by the scheme. EENI consultants take groups through a three-phase process which signs companies up through contracts; identifies EE potential and sets targets per company and per group; implements interventions and measures results. Throughout the process, consultants moderate regular discussions to enable greater sharing of experiences. A steering committee consisting of representatives of the federal ministries and representatives of relevant associations comes together once a year to oversee the scheme and propose improvements to the process.
DESCRIPTION OF RESULTS	EENI contributed to establish 176 networks to date, 21 of which presented complete results: 253 participating companies implemented a total of 1051 measures until June 2018

	248.9 GWh of final energy, 357.9 GWh of primary energy saved and 105.8 $ktCO_2$ per year saved Each network saved on average 11.9 GWh of final energy, 17.0 GWh of primary energy and 5.37 $ktCO_2$ per year.

2.1.3 Policy 3: Green House Gas emission tax

This policy introduces a climate change levy (CCL) to all energy bills for businesses, the size of the levy depends on the fuel being consumed. Businesses may introduce a climate change agreement (CCA), thereby volunteering to a binding agreement to reduce energy consumption by a set value by 2050. Businesses with a CCA in place then benefit from a reduced rate on their CCL, benefitting from lower energy costs.

The policy modelling was based on the concepts outlined below:

COUNTRY	United Kingdom
POLICY NAME	Climate Change Agreement (CCA)
POLICY TYPE	Tax relief
TARGET AUDIENCE	Industrial, commercial, agricultural and public services sectors
COST TO PUBLIC BUDGET	No detailed information is available about the CCA impact on Climate Change Levy (CCL) tax.
PRIVATE SECTOR CONTRIBUTION	N/A
HOW IS IT FUNDED	UK Government allows carbon tax reductions. Private businesses finance EE investments
DESCRIPTION OF HOW IT WORKS	In 2001, the UK Revenues and Customs department (HMRC)introduced the CCL, an energy tax that applies to energy-intensive industrial and agricultural enterprises in the UK, chargeable on both electricity and gas supplies. The CCA is a voluntary-based incentive scheme to reduce the CCL, provided that certain agreed EE measures are fulfilled, according to each business' feature. Businesses entering a CCA with the environment agency can achieve a reduction of CCL rate up to 90% on electricity and up to 65% on gas, LPG, coal and other fossil fuels. Eligible processes and fuels are calculated ex-ante and applications for CCA only includes a certain amount of the companies' energy consumption, the amount of which varies depending on the fuels type. The CCA scheme provides specific financial penalties and termination provisions. The provision of incorrect information, failure to meet information submission deadlines as well as missing targets are considered as CCA's infringements and fines are applied. The amount of which vary between a fixed and a variable amount, calculated upon the total tCO2 the target unit missed to deliver, according to its energy efficiency plan.
DESCRIPTION OF RESULTS	5.6 $MtCO_2$ emissions and 28.453 GWh energy saved between 2013-2014 7.8 $MtCO_2$ emissions and 39.541 GWh energy saved between 2015-2016

2.2 Model Development

2.2.1 Baseline

In order to model the effects of any industrial energy efficiency policy measures, a baseline of current energy consumption needs to be developed. The granularity and reliability of the data used to construct the baseline is key to ensuring a strong foundation to model policies and projections through to 2050.

Three key data sources were used to first identify energy consumption (GWh) for the following sectors: Cement, Iron & steel, Mining & Pelletisation, Non-ferrous & other metals, Chemicals, Food & beverage, Textiles, Paper & pulp, Ceramics, and Other. The data sources were 'Balanço Energetico Nacional 2017', 'PDE 2026 graph 85 – 91', and 'PNE2050'. These provided the sectoral energy consumption from 2007 to 2016 (the baseline year), as well as providing an interesting background to sectoral consumption and growth, the historical data helped to direct the projection of consumption to 2050. The 'National Energy Balance 2017 (EPE 2017)' provided the possibility to further break down the baseline in to specific fuel consumption per industrial sector; fuels considered were: Natural gas, Steam coal, Firewood, Diesel oil, Fuel oil, Coal coke, Electricity, Charcoal, Others, LPG, Kerosene, Coke gas, Other petroleum secondaries, Petroleum coke, Sugar cane bagasse, Black liquor, Other waste.

Costs of energy and carbon emissions are deemed as other important metrics to be analysed within any policy modelling, therefore cost factors and emission factors were used to transform energy consumed in to cost of energy and carbon dioxide emissions respectively. As cost factors for Brazil were unattainable, UK cost factors (£/kWh) produced by BEIS (department for business, energy and industrial strategy) were used for specific fuels; this data source has the additional benefit of providing projections of costs too. Exchange rates to convert GBP to USD were provided by MacroTrends (offering historical and future exchange rates), inflation rates provided by OECD for Brazil have been applied also. This allows for inflation adjusted cost factors in US dollars to be calculated from 2007 to 2035. Emission factors ($kgCO_2e/kWh$) were similarly provided by BEIS, this is seen as not being disadvantageous in anyway as emission factors are typically fuel specific and not affected by other externalities; the exception being for electricity which is entirely dependent on the electricity generation mix. As such the emission factor used for electricity consumption was taken from the 'IGES v10.3' database.

Key data sources are listed in the table below:

Primary inputs	Secondary inputs
Energy Consumption: • 2009-2018: Balanço Energético Nacional 2019 • 2019-2029: PDE 2029 graph 2.1	**Policies:** • ENEA 2017 (Italian energy dept.) • Major Economics Forum • UK govt. CCA • BMU (German energy dept.)
Emission Factors: • BEIS GHG reporting conversion factors • IGES List of Emission Factors v10.3	
Business & Employment:	

• IBGE SIDRA Table 1851 • IBGE SIDRA Annual Industrial Statistics	
Economics: • OECD – Inflation • MacroTrends - EXR	

2.2.2 Assumptions and Limitations

Ultimately, there are limitations to the reliability and accuracy of the modelling methodology, as is the case with any form of modelling. It should be noted that models are only as accurate as the values input in to them and as robust as the assumptions behind them. Model outputs should only ever be used to guide and inform decision making and not as pre-deterministic results.

The outputs from the model are not to be taken as the exact consequences of such policies but are merely there to help inform and guide policy makers of the overarching effects of such policies. The option to tailor the policies within the model is intended to help the user to converge on reality, or understand the effects of different scenarios.

Wide ranging policies can be modelled to investigate specific areas of interest, in this situation energy usage and efficiency. However, the model cannot take in to account all external factors that may affect on or be affected by the policy. Therefore, if any modelled policies are implemented they should always undergo a rigorous risk assessment to ensure any unintended consequences of a policy are mitigated or minimised.

3 Model user guide

3.1 Worksheet hierarchy

Three types of worksheet (or 'tabs') make up the model.

a) Input sheets, identified by an **i.** at the start of the worksheet name

- Input sheets contain the underlying data used by the model.
- The data is either taken from an external source (sources can be found at the top of each sheet) or derived using the available data.
- Changes made by the user to the dashboard do not affect the input sheets.
- Input sheets should largely be ignored by the user, unless they are looking to interrogate the underlying data in the model.

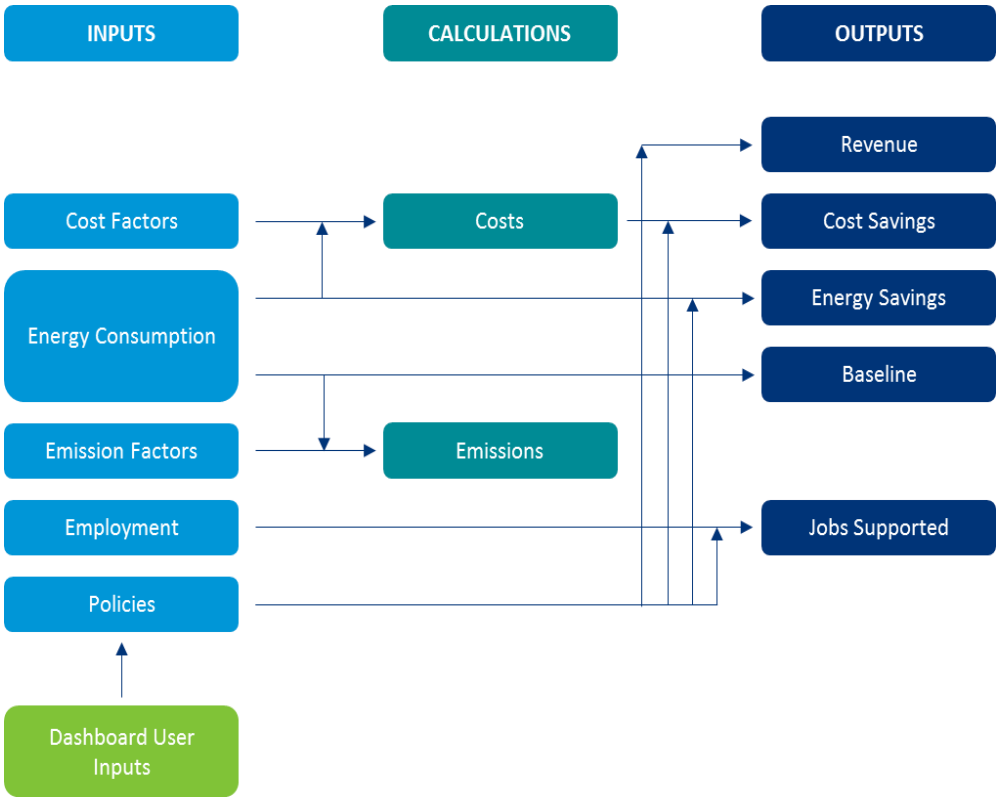
b) Calculation sheets, identified by a **c.** at the start of the worksheet name

- Calculation sheets process data contained in the relevant input sheets.
- The worksheets (c.Energy, c.Energy Costs, c. Emissions, c.Employment) manipulate input sheet data into a compatible format.
    - User changes to the dashboard do not affect these sheets
- The policy calculation sheets (c.Policy1, c.Policy2, c.Policy3) use the manipulated data and user inputs to derive the key outputs
    - User changes to the dashboard do affect these sheets

c) Output sheets, identified by a **o.** at the start of the worksheet name

- Output sheets extract the user's desired information from the calculation sheets & present the core outputs (cost savings, jobs supported, revenue generated, emission savings) in a concise form that can be graphically displayed to the User.

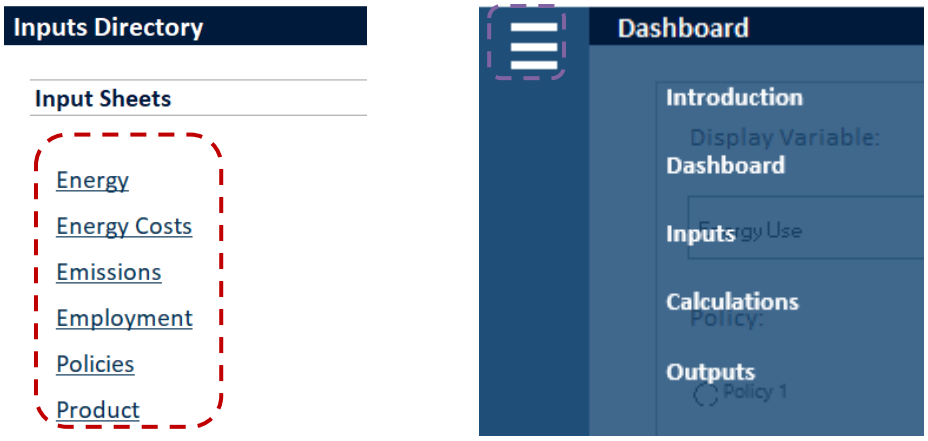
The worksheets interact with each other to form the model outputs (*see below a model flow diagram*):



Above: Model flow diagram showing the interaction between worksheets.

3.2 Model navigation

On each title worksheet (e.g. Inputs, Calculations, Outputs), a directory contains hyperlinks to sheets that make up that section of the model (*see dashed red box below*). Three vertical lines in the top-left corner allows the User to navigate between title worksheets as necessary (*see yellow dashed box below*).



Above: navigation panes are contained throughout the model

3.3 Dashboard

3.3.1 User inputs

The model is designed for the User to primarily interact with the 'Dashboard' worksheet, which extracts and displays key information from the Output sheets. On the dashboard, the User can manipulate inputs to the policy simulation. This can be done through:

a) Overriding policy inputs.

- Each policy has a set of key inputs that dictate its theoretical performance across the core outputs. The inputs are specific to each policy.
- Default options for each input have integrated into the model and are shown in the 'Default' section of the dashboard (Column M). The user can choose to override these values by inputting a value into the 'Override' section (Column N). Default values have been defined by the typical results and inputs from the international policies they are based on.
- When an override value is inputted, the model automatically updates the policy simulation using the User-inputted value(s) in place of the default value(s).

Policy Inputs:

		Default	Override
Start Year		2021	2025
Initial main rate electricity	*USD/kWh*	$ 0.011	
Initial main rate gas	*USD/kWh*	$ 0.004	
Initial main rate other	*USD/kWh*	$ 0.005	$ 0.010
Increase with inflation?	*Boolean*	Yes	
Reduced rate as % of main electricity	*%*	10%	
Reduced rate as % of main gas	*%*	35%	
Reduced rate as % of main other	*%*	35%	
CCA Charge p.a.	*USD*	$ 240.00	$ 300.00
CCA Registration Fee	*USD*	$ 3,000.00	
CCA Target Reduction by 2050	*% of 2018*	50%	
% of businesses with CCA	*%*	50%	

Above: example of the User overriding policy input default values. The model uses the values highlighted in blue.

b) Target sectors and businesses.

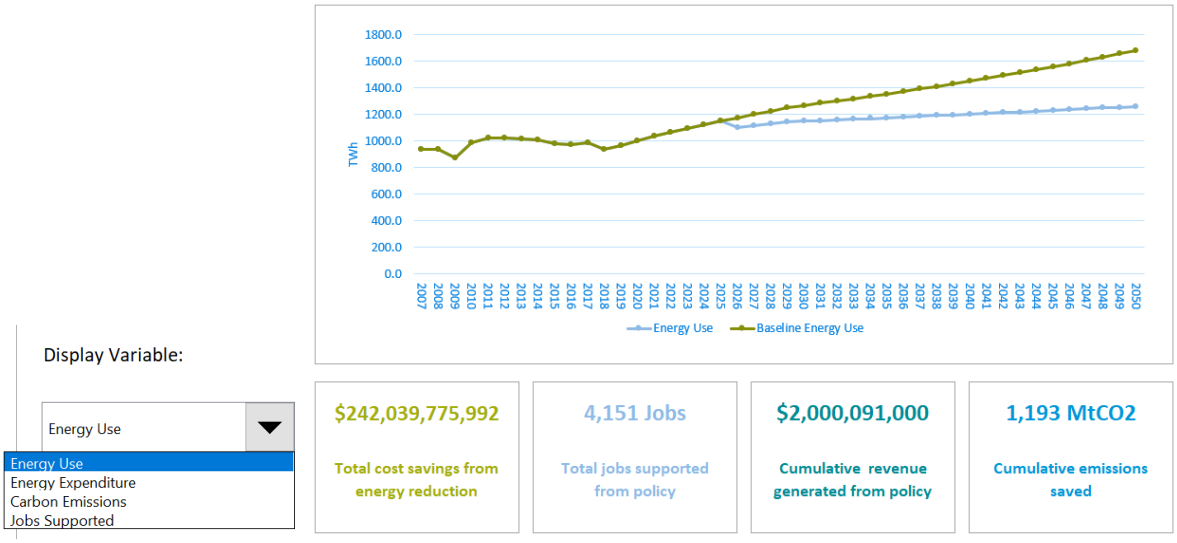
- The impact of tailoring policies to specific business sizes and sectors can be simulated from the dashboard's 'Target Sectors and Businesses' section.
- Ticked boxes signal that the model is including their involvement in the policy simulation. The User can manually adjust this as desired, across both business size and sectors.
- Any changes made by the User will not automatically update the simulation, which can be done by selecting the 'Refresh Data' button (*see dashed red box below).*
- The user is advised to refresh the data each time the model is used, to ensure that the data is fully representative of the dashboard display.

Above: The User can tailor policy simulations to specific business sizes and/or sectors. In the example above, all business sizes & sectors are included in the simulation

3.3.2 User outputs

The dashboard displays key outputs of the policy simulation to the User; a graphical display & the headline figures for the four core outputs is displayed. The graph shows a time-series out to 2050 of the policy simulation, relative to the baseline (i.e. no policy implementation) scenario.

The User can adjust the y-axis variable of the graph to display each of the core outputs using the 'Display Variable' drop-down list.



Above: The dashboard output display

3.4 Policy 1 - instructions for simulation

This policy mandates that businesses with a level of employment greater than a set threshold must have energy audit(s) completed at recurring intervals. Businesses that fail to complete an energy audit may risk a fine.

Policy Inputs:

		Default	Override
Start Year	*yrs*	2020	
Audit Recurrence	*yrs*	3	
Energy Saving Potential	*%*	5%	
Fine for non-compliance	*USD*	$10,000	
Audits per week per auditor	*#*	1	
% Market pen. By 2050	*%*	75%	
% Non-compliant enrolled businesses	*%*	2%	

Target Sectors and Businesses:

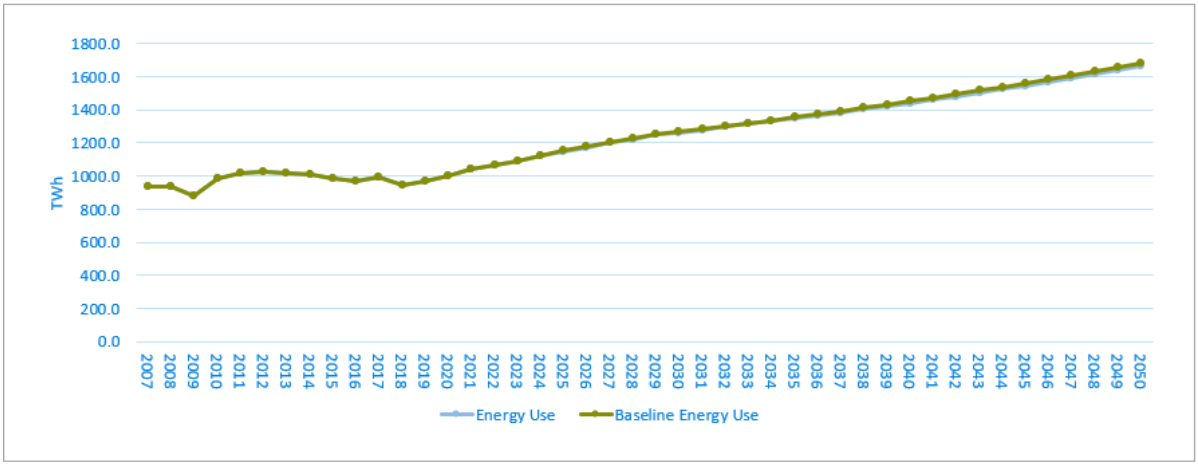
Business size:

- ☑ Micro (1-4 employees)
- ☑ Very Small (5-29) employees)
- ☑ Small (30-49 employees)
- ☑ Medium (50-249 employees)
- ☑ Large (250+ employees)

Industry sectors:

- ☑ Cement
- ☑ Iron & Steel
- ☑ Mining & Pelletisation
- ☑ Non Ferrous & Other Metals
- ☑ Chemicals
- ☑ Food & Beverage
- ☑ Textiles
- ☑ Paper & Pulp
- ☑ Ceramics
- ☑ Other

Refresh Data



$18,524,474,536	30,233 Jobs	$112,429,375	43 MtCO2
Total cost savings from energy reduction	Total jobs supported from policy	Cumulative revenue generated from policy	Cumulative emissions saved

Policy inputs:	Further explanation:	Modelling Approach / Affected variables:
Start Year	First year the policy takes affect	Defines the number of years for which the policy is active to 2050. The earlier the start year for the policy, the greater the cumulative energy savings, cost savings, jobs, etc.
Audit recurrence	The number of years before a business requires a repeat energy audit	The audit recurrence defines the time period over which a business will carry out energy saving measures of a fixed energy saving potential (see below). The lower the recurrence, the more often energy audits are carried out, and therefore the more often a business unlocks the energy saving potential. More frequent audits result in more audits over the lifetime of the policy, therefore the more auditors that are needed and the higher the level of jobs supported.
Energy saving potential	The energy saving potential each time an audit is conducted	This is the percentage saving realised by a business once an audit has been completed, it doesn't affect the number of audits simply the energy saving. This unsurprisingly has a linear relationship with the total energy and carbon saved through the policy.
Fine	Fine for non-compliance and failing to receive an energy audit	It is assumed that not all businesses that are enrolled within the scheme will actually undertake an audit, this is called non-compliance. The percentage of non-compliant businesses can be set (see below). There is a monetary fine for businesses that are non-

		compliant. Increasing the fine results in an increase in policy revenue only.
Audits per week per auditor	The number of audits an individual auditor can complete per week.	This variable is intended to reflect the level of training and skill of the work force: the number of audits an auditor can carry out in a week. Increasing this means fewer auditors are required and the level of total jobs supported decreases. The overall number of audits undertaken remains constant however, so energy and carbon savings remain constant.
% market pen. By 2050	The percentage of businesses that are enrolled in the scheme by 2050	Market penetration is the percentage of businesses within the selected scope (ie. Business size and industry) that will be enrolled within the scheme by 2050. The rate at which this takes effect is linear, ie. 0% of business will be enrolled in the start year and increase constantly to X% BY 2050. This input is key in determining the level of energy savings, jobs supported and revenue. Intuitively, the greater the market penetration the greater the effectiveness of the policy.
% non-compliant enrolled businesses	The percentage of enrolled businesses that are non-compliant with the scheme and do not receive energy audits.	This input determines the % of businesses in the scheme that are non-compliant, ie. Don't complete an energy audit. Increasing the level of non-compliance will result in fewer businesses undertaking audits, therefore fewer energy and carbon savings, fewer auditor jobs, but greater revenue from the policy as more fines are handed out.

3.5 Policy 2 - instructions for simulation

This policy sets a framework by which businesses within a level of employment within a set range may voluntarily sign up to an 'energy saving network'. The network offers access to a dedicated energy saving expert who can suggest energy efficiency measures that can be implemented. Collaboration and regular meetings between the businesses within each network can allow for knowledge and results sharing.

Policy Inputs:

		Default	Override
Start Year		2021	
Network sign up fee	*USD*	$ 3,000.00	
Businesses per network	#	12	
Total measures per business during scheme	#	2	
Average saving per measure	*GWh*	0.237	
Run time	*yrs*	3	
Market Penetration by 2050	*%*	5%	
Jobs supported by network	#	0.2	

Target Sectors and Businesses:

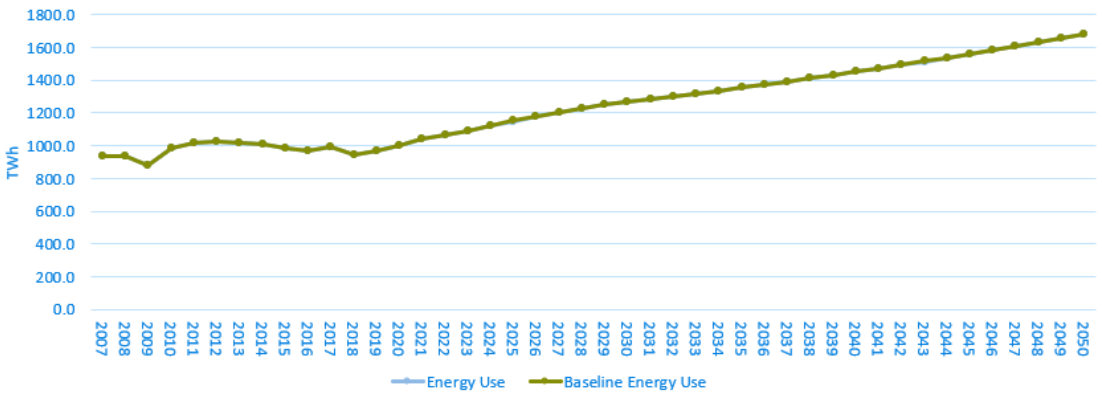
Business size:

- ☑ Micro (1-4 employees)
- ☑ Very Small (5-29) employees)
- ☑ Small (30-49 employees)
- ☑ Medium (50-249 employees)
- ☑ Large (250+ employees)

Industry sectors:

- ☑ Cement
- ☑ Iron & Steel
- ☑ Mining & Pelletisation
- ☑ Non Ferrous & Other Metals
- ☑ Chemicals
- ☑ Food & Beverage
- ☑ Textiles
- ☑ Paper & Pulp
- ☑ Ceramics
- ☑ Other

Refresh Data



$2,470,125,063	17,665 Jobs	$305,165,417	6 MtCO2
Total cost savings from energy reduction	Total jobs supported from policy	Cumulative revenue generated from policy	Cumulative emissions saved

Policy inputs:	Further explanation:	Modelling Approach / Affected variables:
Start Year	First year the policy takes affect	Defines the number of years for which the policy is active to 2050. The earlier the start year for the policy, the greater the cumulative energy savings, cost savings, jobs, etc.
Network sign-up fee	The fee charged to businesses joining (and renewing their membership to) the scheme	This fee is charged to all businesses within the selected scope (business size and industry) who sign up to an energy saving network. This fee is charged for renewal to the scheme too (renewal is automatic at the end of the network activity period). The size of the fee simply increases the amount of revenue generated from the policy. A larger fee does not discourage businesses from enrolling, aspects of business psychology are hard to capture in a model and need to be based on survey data which is not available.
Business per network	The number of businesses within a single 'energy saving network'	The number of businesses assigned to a network simply alters the number of jobs supported. If there are more businesses per network then there must be fewer networks (and vice versa). If there are fewer networks then less energy consultants are required to support the network and therefore fewer jobs supported. This is a linear relationship. The number of businesses in a network does not affect the energy saving potential from being involved in the network.
Measures per business	The number of measures put forward per business during the run time of the network	This input defines how many energy saving measures are installed per business during the 'run time' (see below) of the network. This means the more measures per business the greater the energy and carbon saving. This is a linearly proportional relationship, if the number of measures double then so does the amount of total energy and carbon savings. Jobs and revenue do not change. The jobs supported refer to the energy consultants of the network. In reality there would likely be more jobs supported indirectly through more measures being installed.
Average saving per measure	Average energy saving from each measure put forward by a business within a network	This input goes hand in hand with the number of measures. This is the average energy saving a business is likely to unlock through the installation of a measure. It is based on the average saving realised from businesses in other countries that have implemented similar schemes/policies. Therefore, the average saving per measure may likely be very different in reality in Brazil, due to different subsector composition and business sizes. If the energy saving per measure is increased then the total energy and carbon saving from the policy increases too. There is no change to revenue or jobs supported.

Run time	The run time of each network	This is a key input and effects all of the outputs. The run time is the duration of the energy saving network, before it is renewed. Importantly, the number of measures (see above) that are installed are done so over the 'run time' duration. For example, if the number of measures installed is set to 2, then every business will install 2 energy saving measures over the run time. This means the shorter the run time, the more energy saving measures that are installed over the lifetime of the policy. Thus, a shorter run time results in greater total energy and carbon savings from the policy. Furthermore, a shorter run time means that the networks are renewed more often meaning network sign up fees are paid more often; therefore, revenue generated increases. As mentioned previously, businesses are not dissuaded from enrolling in the scheme if they have to pay a network fee more often. Decreasing the run time also results in more jobs being supported. The reason for this is more nuanced, and the relationship is non-linear.
Market penetration by 2050	The percentage of businesses that are enrolled in the scheme by 2050	Market penetration is the percentage of businesses within the selected scope (ie. Business size and industry) that will be enrolled within the scheme by 2050. The rate at which this takes effect is linear, ie. 0% of business will be enrolled in the start year and increase constantly to X% BY 2050. This input is key in determining the level of energy savings, jobs supported and revenue. Intuitively, the greater the market penetration the greater the effectiveness of the policy.
Jobs supported by network	Number of jobs required to manage each 'energy saving network'	This input affects the level of jobs supported only, and again is meant to represent the skill level and experience of the jobs required. It is assumed that an energy consultant can support more than one network by default, however, if an energy consultant can only support one network then more jobs will be required/supported. If the number of jobs supported is increased, this does not affect the energy or carbon savings – despite the network getting more dedicated consultant time.

3.6 Policy 3 - instructions for simulation

This policy introduces a climate change levy (CCL) to all energy bills for businesses, the size of the levy depends on the fuel being consumed. Businesses may introduce a climate change agreement (CCA), thereby volunteering to a binding agreement to reduce energy consumption by a set value by 2050. Businesses with a CCA in place then benefit from a reduced rate on their CCL, benefitting from lower energy costs.

Policy Inputs:

		Default	Override
Start Year		2021	
Initial main rate electricity	*USD/kWh*	$ 0.011	
Initial main rate gas	*USD/kWh*	$ 0.004	
Initial main rate other	*USD/kWh*	$ 0.005	
Increase with inflation?	*Boolean*	Yes	
Reduced rate as % of main electricity	*%*	10%	
Reduced rate as % of main gas	*%*	35%	
Reduced rate as % of main other	*%*	35%	
CCA Charge p.a.	*USD*	$ 240.00	
CCA Registration Fee	*USD*	$ 3,000.00	
CCA Target Reduction by 2050	*% of 2018*	50%	
% of businesses with CCA	*%*	50%	

Target Sectors and Businesses:

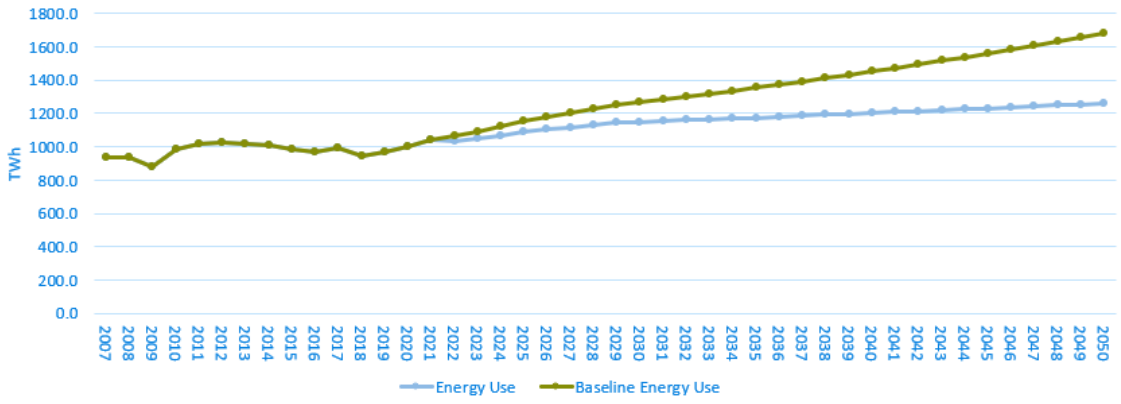
Business size:

- ☑ Micro (1-4 employees)
- ☑ Very Small (5-29) employees)
- ☑ Small (30-49 employees)
- ☑ Medium (50-249 employees)
- ☑ Large (250+ employees)

Industry sectors:

- ☑ Cement
- ☑ Iron & Steel
- ☑ Mining & Pelletisation
- ☑ Non Ferrous & Other Metals
- ☑ Chemicals
- ☑ Food & Beverage
- ☑ Textiles
- ☑ Paper & Pulp
- ☑ Ceramics
- ☑ Other

Refresh Data



$307,390,921,626	Jobs	$1,886,346,360	1,227 MtCO2
Total cost savings from energy reduction	Total jobs supported from policy	Cumulative revenue generated from policy	Cumulative emissions saved

Policy inputs:	Further explanation:	Modelling Approach / Affected variables:
Start Year	First year the policy takes affect	Defines the number of years for which the policy is active to 2050. The earlier the start year for the policy, the greater the cumulative energy savings, cost savings, jobs, etc.

Initial main rate electricity	Initial rate of electricity in the start year	This value is the main rate climate change levy (CCL) that is added to the utility rate for electricity for all businesses without a climate change agreement (CCA). The default value is set to match the same proportionality between the UK's CCL and average electricity utility rate. Increasing this value will not affect the amount of energy or carbon saved, or indeed revenue. It will simply result in higher bills for businesses, ie. Energy expenditure will increase.
Initial main rate gas	Initial rate of gas in the start year	Same as above, but for natural gas.
Initial main rate other	Initial rate of other fuels in the start year	Same as above but for all other fuels, this may include coal, petroleum products, etc.
Increase with inflation?	The User can toggle whether or not fuel prices should increase with the forecasted inflation rate	This option will affect the CCL and increase it in line with inflation (based on current estimates for Brazil's inflation).
Reduced rate as % of main electricity		The reduced rate is the CCL that is added to businesses' utility rates who have agreed to a CCA. The magnitude of the reduced rate is determined as a percentage of the main rate. In reality the level of the reduced rate is the main incentive for businesses to agree to a CCA. However, to demonstrate the uptake of CCAs in the model the '% of businesses with CCA' (see below) needs to be adjusted. Again, the reason why the change in reduced rate CCL doesn't automatically alter the uptake is the difficulty in capturing business psychology within a model. The lower the percentage, ie. the smaller the CCL reduced rate, the lower the cost of energy for businesses with a CCA. Therefore, the lower the total expenditure on energy from the policy. (Note: this isn't a reduction in energy, but a reduction in the cost of energy). Revenue, carbon savings and jobs supported are not affected by any change in the reduced rate CCL. The default values are based on the differenced between reduced rate and main rate CCLs in the UK.
Reduced rate as % of main gas		Same as above, but for natural gas.
Reduced rate as % of main other		Same as above but for all other fuels, this may include coal, petroleum products, etc.

CCA charge p.a.	Annual charge to businesses for being involved in a CCA	The annual charge for agreeing to a CCA may seem like a punitive measure for agreeing to be more energy efficient. However, the annual charge should be small enough to not outweigh the savings from the reduced rate CCL. The annual charge increases revenue from the policy and is intended to pay for the running of and implementation of the scheme. Increasing the annual charge only affects the revenue in the model, however in reality, would likely affect the number of businesses who agree to a CCA.
CCA registration fee	One-off charge to businesses becoming involved in the CCA scheme	Similar to above this input results in revenue from the policy. The greater the registration fee the greater the increase in revenue. There are no other affects of this in the model (to energy/carbon savings). However, in reality a higher registration fee would result in lower uptake in CCAs, especially for smaller businesses.
CCA target reduction by 2050	The reduction in energy consumption from businesses under a CCA	This input is the agreed reduction in energy consumption that must be achieved by 2050 by businesses that agree to a CCA. Therefore, increasing the CCA target would result in in increased energy and carbon savings.
% of businesses with CCA	Number of businesses that are enrolled in the scheme from the start year to 2050.	The number of businesses that agree to a CCA in reality would be dependent on the magnitude of the reduced rate CCL, annual fees and registration fee. However, the impact on uptake of CCAs on the aforementioned factors is incredibly complex and would require surveys of businesses to gauge impact. Therefore, the model simply lets the user adjust the number of businesses that agree to a CCA. Increasing this will increase the energy savings, carbon savings and revenue generated.

4 Conclusions and recommendations

From this work it is clear that there is potential to reduce the energy consumed within the Brazilian industrial sector significantly; and in the process reduce the utility bills that Brazilian businesses pay, support highly skilled jobs, generate revenue for local businesses and government, and help to mitigate carbon emissions.

From the three modelled policies it has been determined that even if one of the policies were implemented it could be possible to support almost 600 new highly skilled jobs, within an increasingly important and growing low carbon sector. Furthermore, by implementing another of the modelled policies there could be potential to reduce annual energy bills across the industrial sector by over $3,000,000,000 USD.

The implementation of these policies would encourage and advise businesses to invest and install energy efficient or low carbon measures. This provides a unique opportunity for Brazil to build on its current high-end manufacturing sector, and grow its portfolio of manufacturing of energy efficient technologies. This could include energy efficient industrial equipment (boilers, driers, heaters and cooling systems) or low carbon transport (electric vehicles and aviation).

It is recommended that the tool produced as an output of this project is used and adjusted to help advise any policy development and implementation.

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Appendix A – Policies

POLICY TYPE	COUNTRY	NAME
COMMAND AND CONTROL – MINIMUM EE REQUIREMENTS	Germany	Non-SMEs Audit
	Italy	Non-SMEs Audit
	Japan	Energy Conservation Law
	Japan	Energy audits – Non SMEs
	Japan	Tokyo Cap&Trade programme
	China	Top 1,000 Programme
	China	Top 10,000 Programme
	China	Promotion of ESCOs under the 12th 5-year plan
FINANCING SUBSIDIES	Germany	Step up!
	Germany	KfW EE Programme
	Japan	Energy audits programme – SME
	China	Financial rewards for industrial EE technical retrofit
	China	Town and Village enterprises programme
	US	Energy Trust of Oregon – Production Efficiency Programme
RISK GUARANTEE MECHANISM	China	China Utility-base EE Programme (CHUEE)
TA SUPPORT	Germany	SME Initiative
	Germany	EE Network Initiative
	Japan	Industrial Voluntary Agreement
	US	West Virginia Industries of the Future (WV-IOF)
	US	Energy Smart Industrial programme
MARKET-BASED INSTRUMENT	Italy	White Certificates
FISCAL INCENTIVE	UK	Climate Change Agreement
	UK	Enhanced Capital Allowance


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