Snapshot of - BLUES

Archive of BLUES, version: 1.0

Contents

Reference card - BLUES

The reference card is a clearly defined description of model features. The numerous options have been organized into a limited amount of default and model specific (non default) options. In addition some features are described by a short clarifying text.

Legend:

☐ not implemented

☑ **implemented**

☑ **implemented (not default option)**

About

Name and version	BLUES 1.0
Model link	https://www.nature.com/articles/s41558-018-0213-y
Institution	COPPE/UFRJ (Cenergia), Brazil, http://www.cenergialab.coppe.ufrj.br/.
Documentation	BLUES documentation consists of a referencecard and detailed model documentation
Process state	published

Model scope and methods

Model documentation: Model scope and methods - BLUES

Model type	☑ **Integrated assessment model** ☐ Energy system model	☐ CGE ☐ CBA-integrated assessment model
Geographical scope	☐ Global	☑ **Regional**
Solution concept	☐ Partial equilibrium (price elastic demand) ☐ Partial equilibrium (fixed demand)	☑ **General equilibrium (closed economy)**

Note: BLUES is partial equilibrium energy-land system model, with integration with the TEA model (CGE model).

Solution horizon	☐ Recursive dynamic (myopic)	☑ **Intertemporal optimization (foresight)**
Solution method	☐ Simulation	☑ **Optimization**

Temporal dimension	Base year:2010, time steps:5 year, horizon: 2050
Spatial dimension	Number of regions:5

Time discounting type	☑ **Discount rate exogenous**	☐ Discount rate endogenous

Policies	☑ **Emission tax**	☑ **Capacity targets**
	☑ **Emission pricing**	☑ **Emission standards**
	☐ Cap and trade	☑ **Energy efficiency standards**
	☑ **Fuel taxes**	☐ Agricultural producer subsidies
	☑ **Fuel subsidies**	☐ Agricultural consumer subsidies
	☑ **Feed-in-tariff**	☑ **Land protection**
	☑ **Portfolio standard**	☑ **Pricing carbon stocks**

Socio-economic drivers

Model documentation: Socio-economic drivers - BLUES

Population	☑ **Yes (exogenous)**	☐ Yes (endogenous)
Population age structure	☑ **Yes (exogenous)**	☐ Yes (endogenous)
Education level	☑ **Yes (exogenous)**	☐ Yes (endogenous)
Urbanization rate	☑ **Yes (exogenous)**	☐ Yes (endogenous)
GDP	☑ **Yes (exogenous)**	☐ Yes (endogenous)
Income distribution	☑ **Yes (exogenous)**	☐ Yes (endogenous)
Employment rate	☐ Yes (exogenous)	☐ Yes (endogenous)
Labor productivity	☐ Yes (exogenous)	☐ Yes (endogenous)
	☐ Yes (exogenous)	☐ Yes (endogenous)

Total factor productivity		
Autonomous energy efficiency improvements	☐ Yes (exogenous)	☑ **Yes (endogenous)**

Macro-economy

Model documentation: Macro-economy - BLUES

Economic sector

Industry	☑ **Yes (physical)** ☐ Yes (economic)	☐ Yes (physical & economic)
Energy	☑ **Yes (physical)** ☐ Yes (economic)	☐ Yes (physical & economic)
Transportation	☑ **Yes (physical)** ☐ Yes (economic)	☐ Yes (physical & economic)
Residential and commercial	☑ **Yes (physical)** ☐ Yes (economic)	☐ Yes (physical & economic)
Agriculture	☑ **Yes (physical)** ☐ Yes (economic)	☐ Yes (physical & economic)
Forestry	☐ Yes (physical) ☐ Yes (economic)	☐ Yes (physical & economic)

Macro-economy

Trade	☑ **Coal** ☑ **Oil** ☑ **Gas** ☐ Uranium ☑ **Electricity**	☑ **Bioenergy crops** ☑ **Food crops** ☐ Capital ☐ Emissions permits ☐ Non-energy goods
Cost measures	☐ GDP loss ☐ Welfare loss ☐ Consumption loss	☐ Area under MAC ☑ **Energy system cost mark-up**

Categorization by group	☐ Income ☐ Urban - rural ☐ Technology adoption ☐ Age	☐ Gender ☐ Education level ☐ Household size
Institutional and political factors	☐ Early retirement of capital allowed ☐ Interest rates differentiated by country/region ☐ Regional risk factors included ☑ **Technology costs**	**differentiated by country/region** ☑ **Technological change differentiated by country/region** ☑ **Behavioural change differentiated by country/region** ☐ Constraints on cross country financial transfers

Resource use

Coal	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**
Conventional Oil	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**
Unconventional Oil	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**
Conventional Gas	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**
Unconventional Gas	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**
Uranium	☐ Yes (fixed) ☑ **Yes (supply curve)**	☐ Yes (process model)
Bioenergy	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**
Water	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**
Raw Materials	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**
Land	☐ Yes (fixed) ☐ Yes (supply curve)	☑ **Yes (process model)**

Technological change

Energy conversion technologies	☐ No technological change ☐ Exogenous technological change	☑ **Endogenous technological change**
Energy End-use	☐ No technological change ☐ Exogenous technological change	☑ **Endogenous technological change**
Material Use	☐ No technological change ☐ Exogenous technological change	☑ **Endogenous technological change**
Agriculture (tc)	☐ No technological change ☐ Exogenous technological change	☑ **Endogenous technological change**

Energy

Model documentation: Energy - BLUES

Energy technology substitution

Energy technology choice	☐ No discrete technology choices ☐ Logit choice model ☐ Production function	☑ **Linear choice (lowest cost)** ☐ Lowest cost with adjustment penalties
Energy technology substitutability	☐ Mostly high substitutability ☐ Mostly low substitutability	☑ **Mixed high and low substitutability**
Energy technology deployment	☐ Expansion and decline constraints	☑ **System integration constraints**

Energy

Electricity technologies	☑ **Coal w/o CCS** ☑ **Coal w/ CCS**	☑ **Gas w/o CCS** ☑ **Gas w/ CCS**

- ☑ Oil w/o CCS
- ☑ Oil w/ CCS
- ☑ Bioenergy w/o CCS
- ☑ Bioenergy w/ CCS
- ☑ Geothermal power
- ☑ Nuclear power
- ☑ Solar power
- ☑ Solar power-central PV
- ☑ Solar power-distributed PV
- ☑ Solar power-CSP
- ☑ Wind power
- ☑ Wind power-onshore
- ☑ Wind power-offshore
- ☑ Hydroelectric power
- ☑ Ocean power
- ☑ Hydrokinetic

Hydrogen production

- ☐ Coal to hydrogen w/o CCS
- ☐ Coal to hydrogen w/ CCS
- ☑ Natural gas to hydrogen w/o CCS
- ☑ Natural gas to hydrogen w/ CCS
- ☑ Oil to hydrogen w/o CCS
- ☑ Oil to hydrogen w/ CCS
- ☑ Biomass to hydrogen w/o CCS
- ☑ Biomass to hydrogen w/ CCS
- ☐ Nuclear thermochemical hydrogen
- ☐ Solar thermochemical hydrogen
- ☑ Electrolysis

Refined liquids

- ☐ Coal to liquids w/o CCS
- ☐ Coal to liquids w/ CCS
- ☑ Gas to liquids w/o CCS
- ☑ Gas to liquids w/ CCS
- ☑ Bioliquids w/o CCS
- ☑ Bioliquids w/ CCS
- ☑ Oil refining

Refined gases

- ☐ Coal to gas w/o CCS
- ☐ Coal to gas w/ CCS
- ☑ Oil to gas w/o CCS
- ☑ Oil to gas w/ CCS
- ☑ Biomass to gas w/o CCS
- ☑ Biomass to gas w/ CCS

Heat generation

- ☑ Coal heat
- ☑ Natural gas heat
- ☑ Oil heat
- ☑ Biomass heat
- ☐ Geothermal heat
- ☐ Solarthermal heat
- ☑ CHP (coupled heat and power)

Grid Infra Structure

Electricity

- ☑ Yes (aggregate)
- ☐ Yes (spatially explicit)

Gas

- ☑ Yes (aggregate)
- ☐ Yes (spatially explicit)

Heat

- ☐ Yes (aggregate)
- ☐ Yes (spatially explicit)

CO2

- ☑ Yes (aggregate)
- ☐ Yes (spatially explicit)

Hydrogen	☑ **Yes (aggregate)**	☐ Yes (spatially explicit)

Energy end-use technologies

Passenger transportation	☑ **Passenger trains** ☑ **Buses** ☑ **Light Duty Vehicles (LDVs)** ☑ **Electric LDVs** ☑ **Hydrogen LDVs**	☑ **Hybrid LDVs** ☑ **Gasoline LDVs** ☑ **Diesel LDVs** ☑ **Passenger aircrafts**
Freight transportation	☑ **Freight trains** ☑ **Heavy duty vehicles**	☑ **Freight aircrafts** ☑ **Freight ships**
Industry	☑ **Steel production** ☑ **Aluminium production** ☑ **Cement production** ☑ **Petrochemical production**	☑ **Paper production** ☑ **Plastics production** ☑ **Pulp production**
Residential and commercial	☑ **Space heating** ☑ **Space cooling** ☑ **Cooking**	☑ **Refrigeration** ☑ **Washing** ☑ **Lighting**

Land-use

Model documentation: Land-use - BLUES

Land cover	☑ **Cropland** ☐ Cropland irrigated ☐ Cropland food crops ☐ Cropland feed crops ☑ **Cropland energy crops** ☑ **Forest** ☑ **Managed forest** ☑ **Natural forest**	☑ **Pasture** ☐ Shrubland ☐ Built-up area ☑ **Pasture HighCapacity** ☑ **Pasture LowCapacity** ☑ **IntegratedSystems** ☑ **DoubleCrop** ☑ **ILPF**
Agriculture and forestry demands	☑ **Agriculture food** ☑ **Agriculture food crops** ☑ **Agriculture food livestock** ☑ **Agriculture feed** ☑ **Agriculture feed crops** ☑ **Agriculture feed livestock** ☑ **Agriculture non-food**	☑ **Agriculture non-food crops** ☑ **Agriculture non-food livestock** ☑ **Agriculture bioenergy** ☑ **Agriculture residues** ☐ Forest industrial roundwood ☑ **Forest fuelwood**

☑ **Forest residues**

Agricultural commodities

☑ **Wheat**
☑ **Rice**
☑ **Other coarse grains**
☑ **Oilseeds**
☑ **Sugar crops**
☑ **Ruminant meat**
☑ **Non-ruminant meat and eggs**
☑ **Dairy products**

Emission, climate and impacts

Model documentation: Emissions - BLUES, Climate - BLUES, Non-climate sustainability dimension - BLUES

Greenhouse gases

☑ **CO2 fossil fuels**
☑ **CO2 cement**
☑ **CO2 land use**
☑ **CH4 energy**
☑ **CH4 land use**
☑ **CH4 other**
☑ **N2O energy**
☑ **N2O land use**
☑ **N2O other**
☐ CFCs
☐ HFCs
☐ SF6
☐ PFCs

Pollutants

☐ CO energy
☐ CO land use
☐ CO other
☑ **NOx energy**
☑ **NOx land use**
☑ **NOx other**
☐ VOC energy
☐ VOC land use
☐ VOC other
☑ **SO2 energy**
☑ **SO2 land use**
☑ **SO2 other**
☐ BC energy
☐ BC land use
☐ BC other
☐ OC energy
☐ OC land use
☐ OC other
☐ NH3 energy
☐ NH3 land use
☐ NH3 other
☑ **PM energy**
☑ **PM land use**
☑ **PM other**

Climate indicators

☐ Concentration: CO2
☐ Concentration: CH4
☐ Concentration: N2O
☐ Concentration: Kyoto gases
☐ Radiative forcing: CO2
☐ Radiative forcing: CH4
☐ Radiative forcing: N2O
☐ Radiative forcing: F-gases
☐ Radiative forcing: Kyoto gases
☐ Radiative forcing: aerosols
☐ Radiative forcing: land albedo
☐ Radiative forcing: AN3A
☐ Radiative forcing: total
☐ Temperature change
☐ Sea level rise
☐ Ocean acidification

Carbon dioxide removal	☑ **Bioenergy with CCS**	☑ **Soil carbon enhancement**
	☑ **Reforestation**	☑ **Direct air capture**
	☑ **Afforestation**	☐ Enhanced weathering
Climate change impacts	☐ Agriculture	☐ Economic output
	☐ Energy supply	☐ Built capital
	☐ Energy demand	☐ Inequality
Co-Linkages	☑ **Energy security: Fossil fuel imports & exports (region)**	**emissions**
	☑ **Energy access: Household energy consumption**	☐ Air pollution & health: Health impacts of air Pollution
	☑ **Air pollution & health: Source-based aerosol**	☑ **Food access**
		☑ **Water availability**
		☐ Biodiversity

Model Documentation - BLUES

Introduction

The Brazilian Land Use and Energy System (BLUES) model is a perfect-foresight, least-cost optimization model for Brazil. It chooses the energy system configuration with the least total system cost over the entire time horizon of the study, in this case 2010 to 2050. The model minimizes costs of the entire energy system, including electricity generation, agriculture, industry, transport and the buildings sectors. BLUES finds optimized mixes for the energy system as a whole, rather than evaluating sectorial optimal solutions. It includes CO2, CH4 and N2O emissions associated with land use, agriculture and livestock, fugitive emissions, fuel combustion, industrial processes and waste treatment.

BLUES has six native regions. One main overarching region into which five sub-regions are nested following the geopolitical division of the country. The energy system is represented in detail across sectors, with over 1500 technologies available in and customized for each of its six native regions. The representation of the land-use system includes forests, savannas, low- and high-capacity pastures, integrated systems, cropland, double cropping, planted forests, and protected areas. Cropland is made up of Land useis also regionalized and customized for each subregion, with yields and costs varying from region to region. Demand is exogenous but endogenous energy efficiency measures permit demand responses through technological options.

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References
