OSeMOSYS-CR-v2

This repository is the online documentation for the OSeMOSYS-CR model version used in the research article "*Prioritizing policy options to transform energy systems: aligning decarbonization and production sophistication in Costa Rica*." Additionally, with Python-based programs for model and scenario creation, we provide a toolset to accelerate the model production stage of the analysis and reach the insight generation stage quickly. Finally, we elaborate on the data sources and assumptions used to parametrize the model version for the research paper mentioned above.

# Overview

We expand the first version of the OSeMOSYS-CR model [1] with three objectives. First, we add a representation of the energy transformation technological chain in the industrial sector, i.e., the collection of firms that consume energy to manufacture goods. Previously, only the energy supply and transport sectors were included. Second, we reformulate the model to link it to gross domestic product (GDP) growth as the driver of end-use energy or transport demands. Third, we present a toolset to flexibly create the model and multiple scenarios under the OSeMOSYS paradigm.

OSeMOSYS is a bottom-up Energy System Optimization Model (ESOM) platform that supports long-term energy planning [2], [3]. OSeMOSYS-CR [1] is the ESOM used to inform the cost-benefit analysis [4] of Costa Rica's National Decarbonization Plan [5]. This model version, OSeMOSYS-CR-v2, has supporting Python-based software programs that facilitate the creation, parameterization, and analysis of multiple scenarios. Figure 1 shows the interaction of the supporting software programs.

Graphical user interface

Description automatically generated

**Figure 1.** Diagramof supportingsoftware tools of OSeMOSYS-CR-v2.

The first component of the toolset is *A. Building of bottom-up techno-economic model structure and input parameterization*. It comprises Microsoft Excel files containing inputs for A1\_Mode\_Structure.py and A2\_Compiler.py, which create all the necessary model sets, connections, and adequate parameterization for a Business-as-Usual scenario, i.e., a scenario without energy transformations. The second component is *B. Scenario configuration*, which contains Microsoft Excel files that indicate parameter changes performed by B1\_Base\_Scenarios.py to reflect transformation scenarios, execute OSeMOSYS, and obtain results. Finally, B2\_Results\_Creator\_f0.py converts all input and output data into two comma-separated files (inputs and outputs) for convenient data visualization.

We explain OSeMOSYS-CR-v2 in four sections for a step-by-step setup and scenario creation guide:

1. The *model structure* section shows the technological options we model.
2. The *parameterization* section elaborates on the assumptions and data inputs, including exogenous demand equations.
3. The scenario modeling section shows the tool component to create the multiple scenarios in "Prioritizing policy options to transform energy systems: aligning decarbonization and production sophistication in Costa Rica."
4. The *OSEMOSYS-CR-v2 execution guide* summarizes the modeling process in simple steps.

# Model structure

The model structure is a group of interconnected technologies through energy carriers that satisfy demands. Figure 2 illustrates the technological setup.

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**Figure 2.** Energy supply chain modeled in OSeMOSYS-CR for this analysis.

## Creating the model structure

Here we show how to create the model structure with Python scrips.

## Interconnecting technologies

Here we show how to populate the Excel files to interconnect the model.

# Parameterization

## Exogenous demands

Add distance Equation here

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| --- | --- |
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| (a) | (b) |
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|  | 1 |

**Table X.** Model input references for demand modeling.

|  |  |  |
| --- | --- | --- |
| **Model component** | | **Source** |
| Occupancy rates | We use a national transport survey from 2013 [11] | |
| Driven distance by vehicle type | Costa Rica's technical revision entity [12] | |
| Energy intensity by demand sector | Costa Rica's energy balances [13] | |
| Gross Domestic Product to drive demands and normalize expense and revenue results | We use official and publicly available GDP time series[20] and assume that all costs are in USD using the reported yearly average exchange rate [21]. | |

## Fleet composition assumptions

Explain how to parameterize the BAU

## Primary technologies

Explain technologies, parameters, and assumptions

**Table X.** Model input references for primary technologies.

|  |  |  |
| --- | --- | --- |
| **Model component** | | **Source** |
| LPG infrastructure characterization | U.S. Department of Energy [8] | |
| Biofuel blend for biodiesel and ethanol | RECOPE's (the national fuel state-owned monopoly) biofuel strategy [15] | |
| International fuel prices: present and projection | National statistics from RECOPE's website [16] for years up to 2020, and the trajectory of oil prices suggested by the IEA in the 2019 World Energy Outlook [17], which we take at 1.9% growth annually. | |
| Capacity factor of bioenergy power generation in 2050 | We model a transition from a bagasse-based option with energy balance to IRENA's characterization [18]. | |
| Capacity factor and costs of geothermal, hydro run-of-river, and dam | Personal communication with the Instituto Costarricense de Electricidad (ICE) | |
| Future capacity factors aligned with the National Generation Expansion Plan | ICE's 2019 Generation Expansion Plan [19] | |

## Secondary, transport, and other technologies

Explain technologies, parameters, and assumptions

**Table X.** Model input references for secondary, transport, and other technologies.

|  |  |  |
| --- | --- | --- |
| **Model component** | | **Source** |
| Hydrogen charging infrastructure | The International Council on Clean Transportation [6] | |
| Hydrogen electrolyzer characterization | IRENA'S "Hydrogen from renewable power: outlook for the energy transition" [7] | |
| Freight rail costs and energy consumption | Report for the Netherlands on costs per ton-kilometer [9] and rail electricity consumption from Spain [10]; there is no detailed information for Costa Rica. | |
| Fleet characterization and vehicle costs | Costa Rica's Ministry of Finance (personal communication; dataset unavailable). | |
| Passenger rail and urban interventions | Financial analysis of Costa Rica's passenger rail project [14] | |

# Scenario creation

## Distance and occupancy rate change

Explain the sheets

## Mode shift

Explain the sheets

## Demand-side technology adoption

Explain the sheets

## Power supply

Explain the sheets

## Demand elasticity

Explain the sheets

# OSeMOSYS-CR-v2 execution in steps

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