Materials and Methods

Materials

Vensim software will be used for the energy modelling of the airport. The data required include: Power supplied to the airport (Grid and Diesel generating sets), diesel consumption year by year from 2010 to 2020 for the airport, emission accompanying diesel used, power supplied, price of diesel, number of airplanes that used a chosen gate, fuel consumption for turnaround (Auxiliary power and ground power), accompanying emissions, number of passengers processed etc., all for the same period.

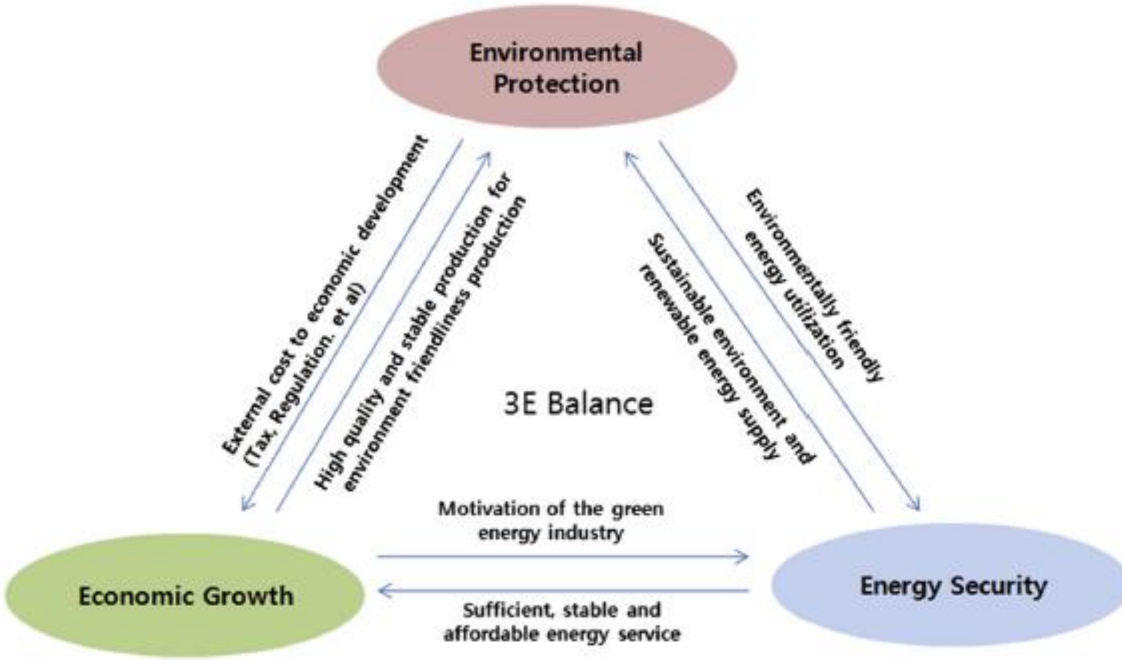
Methods

System definition

This analysis considers power generation from the from and the standby diesel generators at the airport, use of ground power units for aircrafts turnaround and the auxiliary power units on the aircrafts for turnaround.

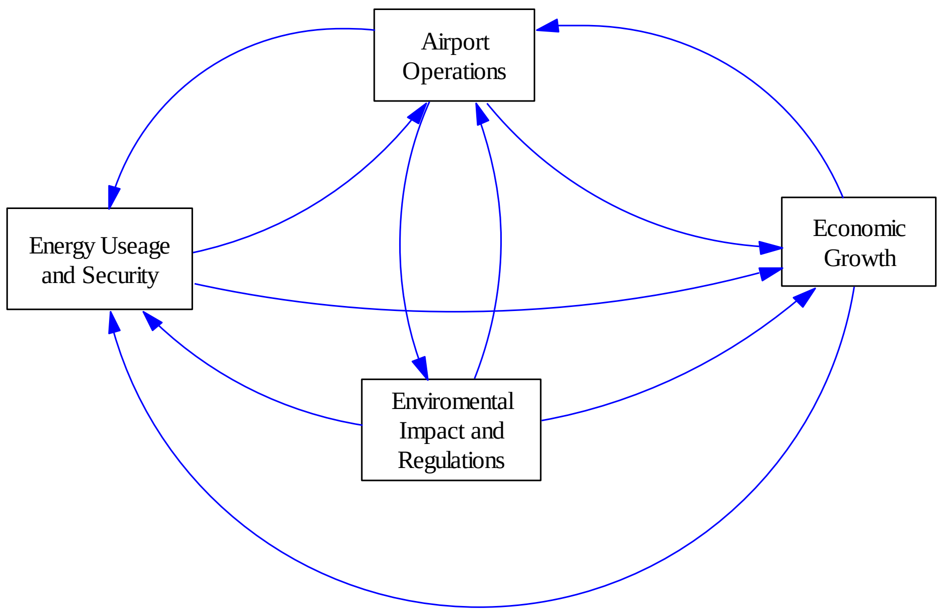
In system dynamics models, data are mainly required to define reference modes, estimate parameters, determine other parts of system structure and determine the model's initial values. However, data may be collected later to fill gaps in constructed models and in fact an SD transport model can act as a means for assessing the appropriate data needed for future enhancement of the model.

The 3E framework adapted for this study is shown below:

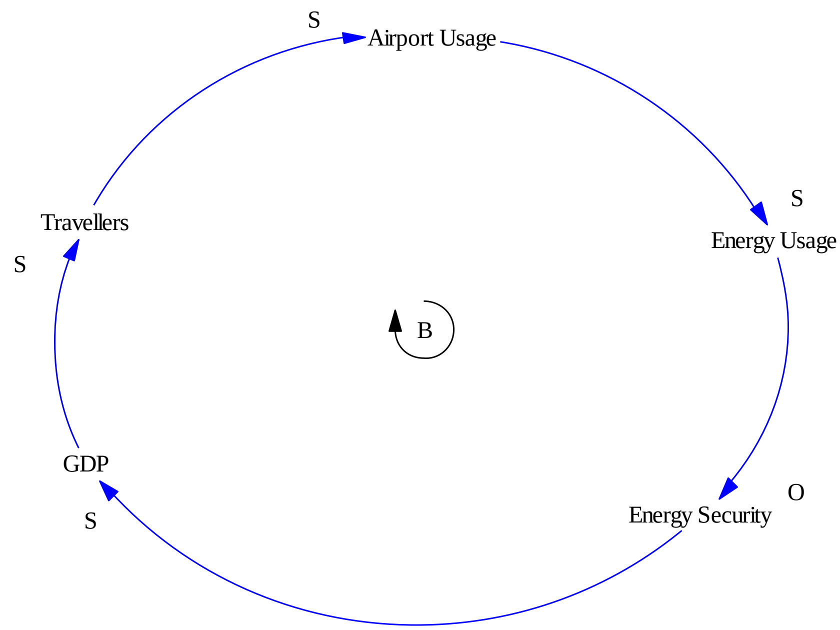


Jeon and Shin (2014)

- Overarching model of airport operations is added to the - 3E framework, giving rise to - Four Sectors of SD Model



- Dynamic Hypothesis?



Mapping system structure

System dynamics includes a variety of tools to help you communicate the boundary of your model and represent its causal structure. These include model boundary diagrams, subsystem diagrams, causal loop diagram, and stock and flow maps.

Model boundary chart

A model boundary chart summarizes the scope of the model by listing which key variables are included endogenously, which are exogenous, and which excluded from the model.

The table below shows a model boundary diagram for a model designed to study the feedbacks between the energy system, the economy and the environment. There are two main techniques for sustainable energy use. The first is reduction of energy demand and the second is to use or increase use of renewable energy technology. Thus sustainability is about minimising the adverse effects of energy use to the environment and society while maximising its benefits to society and economy.

The purpose of the model is to explore the impact of use of ground power for turnaround, auxiliary power units and the standby diesel generating sets for the airport on economic growth and emissions and how these considerations might constrain the development of new energy sources. The time horizon of the model is 2010-2050 to capture the full transition from fossil fuels to renewable or other energy sources.

Endogenous	**Exogenous**	**Excluded**
GDP	Emission	All ground equipment in the airside except ground power
Fuel price	Population	Terrorism, Pandemic, war etc.
Generator turn over		
Airlines		
Supply from the national grid		
Revenue passenger kilometres		
Airfare		
Flight frequency		
Diesel consumption		
Subsidy		
Employment		
Dwell time for turnaround		

Generator manufacturers		
Energy demand		
Energy supply		
Installed capacity		
Accidents		
Security		
Delay		
Carbon tax		
Fuel storage		
Federal aviation authority of Nigeria (FAAN)		

Subsystem diagram

A subsystem diagram shows the overall architecture of a model. Subsystem diagrams convey information on the boundary and level of aggregation in the model by showing the number and type of different organizations or agents represented. They also communicate some information about the endogenous and exogenous variables.

My reference mode is the graph showing the diesel consumption over the last ten years. The data for which is yet to be collected. From the data of the energy supplied to the terminals of the airport, it showed that diesel consumption will continue to increase as the consumption for airport increases until energy supplied from the grid improves and energy is generated from renewable sources and other cleaner sources.

Causal loop diagrams

Causal loop diagrams (CLDs) are flexible and useful tools for diagramming the feedback structure of systems in any domain. Causal diagrams are simply maps showing the causal links among variables with arrows from a cause to an effect.

Stock and flow maps

Causal loop diagrams emphasize the feedback structure of a system. Stock and flow diagrams emphasize their underlying physical structure. Stocks and flows track accumulations of material, money, and information as they move through a system. Stocks characterize the state of the system and generate the information upon which decisions are based. The decisions then alter the rates of flow, altering the stocks and closing the feedback loops in the system.

Policy structure diagrams

Policy structure diagrams focus attention on the information cues the modeller assumes decision makers use to govern the rates of flow in the system. This show the causal structure and time delays involved in particular decision rather than the feedback structure of the overall system.

Formulating a simulation model

In the majority of cases, you must conduct these experiments in a virtual world. To do so, you must move from the conceptual realm of diagrams to a fully specified formal model, complete with equations, parameters, and initial conditions.

Formalization is where the real test of your understanding occurs. Computer accepts no hand waving arguments.

Testing

Testing begins as soon as you write the equation. Part of testing, of course, is comparing the simulated behaviour of the model to the actual behaviour of the system. But testing involves far more than the replication of historical behaviour. Every variable must correspond to a meaningful concept in the real world. Every equation must be checked for dimensional consistency (so you aren't adding apples and oranges). The sensitivity of model behaviour and policy recommendations must be assessed in light of the uncertainty in assumptions, both parametric and structure.

Models must be tested under extreme conditions, conditions that may never have been observed in the real world. Extreme conditions tests, along with other tests of model behaviour, are critical tools to discover the flaws in your model and set the stage for improved understanding.

Policy design and evaluation

Once confidence has been developed in the structure and behaviour of the model, you can use it to design and evaluate policies for improvement.

Jeon, C., & Shin, J. J. E. (2014). Long-term renewable energy technology valuation using system dynamics and Monte Carlo simulation: Photovoltaic technology case. *66*, 447-457.