Soft-linking TIMES-FACETS and REMI models: Policy analysis for achieving ambitious GHG and RE energy goals in the Vermont State (USA)

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ETSAP Workshop: TIMES and CGE Models – Moving towards best practice
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1. Project overview

Project mandated by the Public Service Department (PSD)

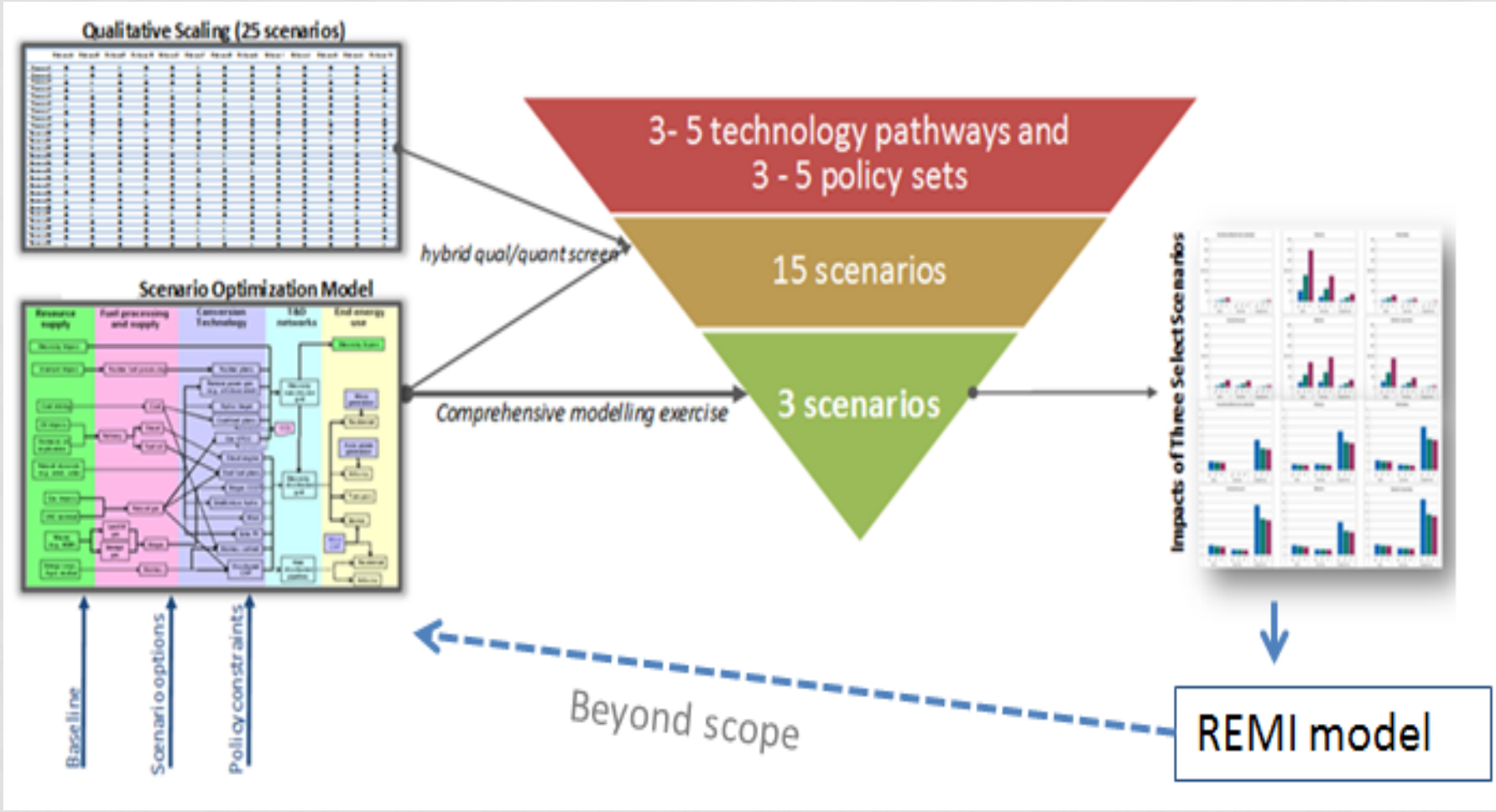
VERMONT

- VT has very ambitious targets
  - 75% GHG reduction by 2050
  - 90% renewables by 2050
- Objective:
  - Identify best technology pathways and policies sets
- Total Energy Study:
  - Is part of a larger process involving VT legislators, stakeholders and general public
  - Will inform the next ***Comprehensive Energy Plan***

Project awarded to Dunsky Energy Consulting

dunsky ENERGY CONSULTING

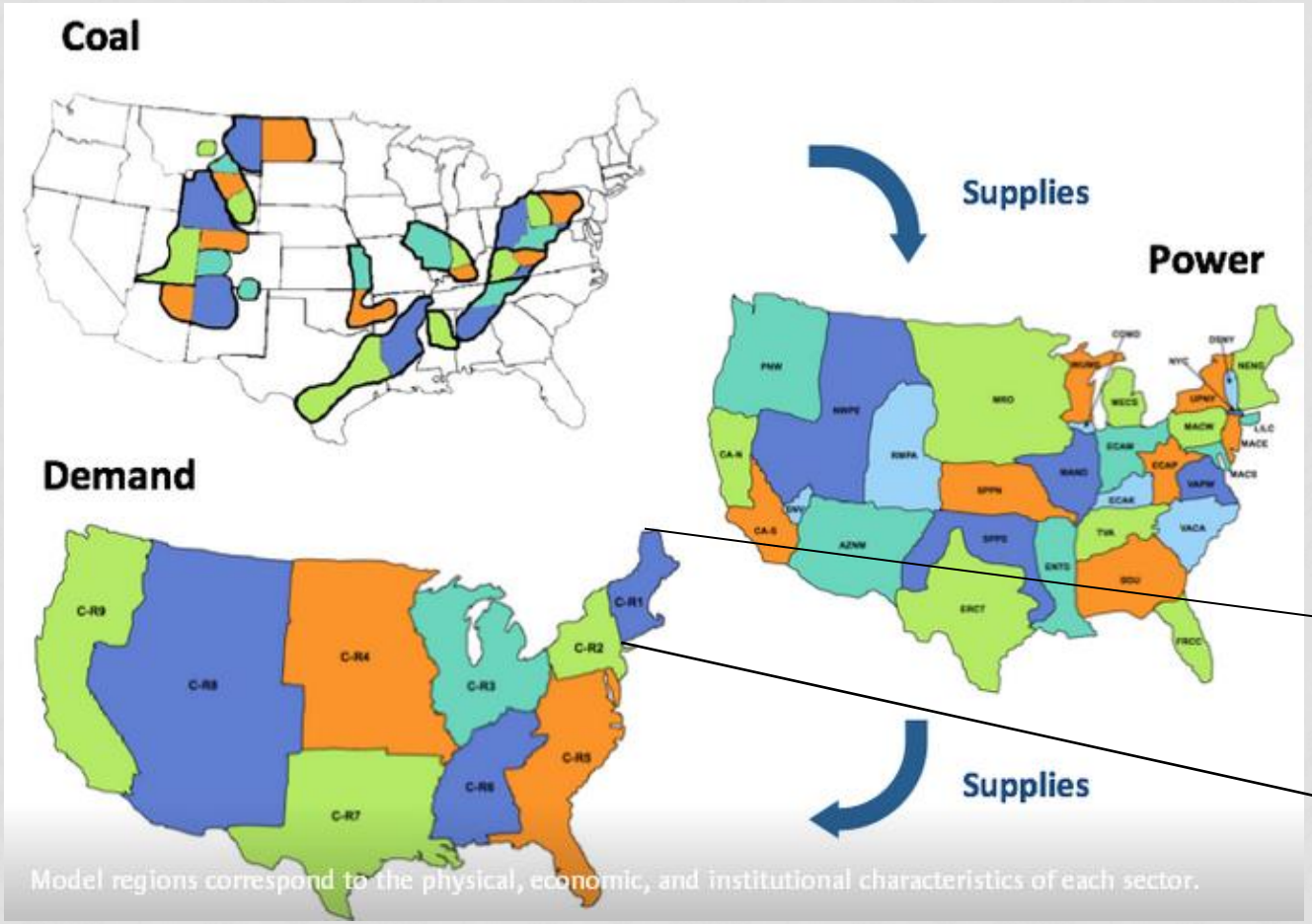
Project overview



2. Main modeling approach

THE FACETS MODEL:

FRAMEWORK FOR ANALYSIS OF CLIMATE-ENERGY-TECHNOLOGY SYSTEMS



Developed by Amit Kanudia and Evelyn Wright

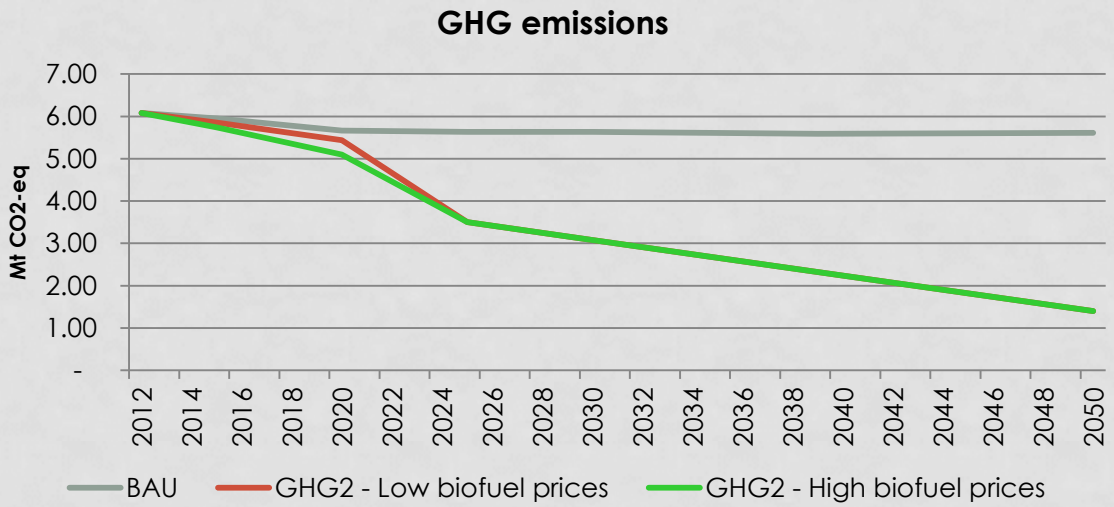
http://facets-model.com/

GHG SCENARIOS

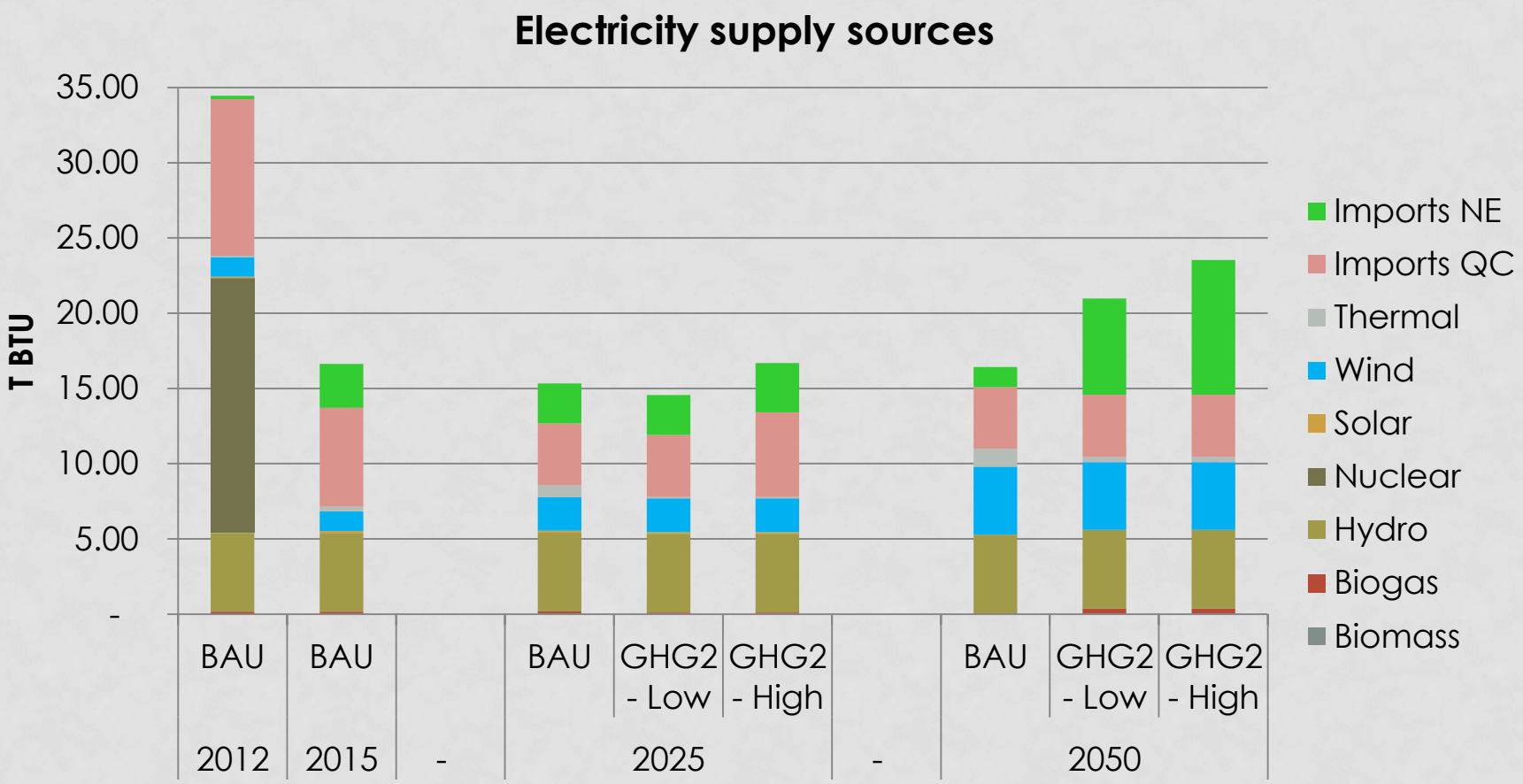
Scenarios	Target 2028	Target 2050
GHG2 – Low biofuel prices	- 50%	- 75%
GHG2 – High biofuel prices	- 50%	- 75%

Adjustment in demand for energy services
Fuel/Technology switch
Utilization of zero-carbon resources

- Clean electricity imports from Quebec and New England
- In-State wood biomass
- Wind potential
- Solar PV rooftop



ELECTRICITY SOURCES



3. Evaluation of technology pathways and policy sets

Examples of technologies and policies

Technology pathways	Policy sets
- **Energy Efficiency and Load Management**: Storage technologies, batteries, Intelligent Home - **Fuel Choice** : Electrification for End Use and Supply (esp. wind and solar), Biofuels/pellets (including biogas/farm methane), Fuel-Cell, CHP (District Heat and Stand-alone), Natural gas - **Sector Fuel and Technology**: Buildings, Transportation, Industrial Processes. - **Behavior change**	**Economy-wide and cross-sector policies** - Pricing carbon: tax, cap& trade, revenue recycling - Energy efficiency: codes and standards, low income assistances, etc. - Incentives & programs **Sector policies and choices** - Power: utility motivations, EE delivery, frontiers of policy opportunity - Transportation: technologies (electrification) and policies - Buildings and appliances - Industry & manufacturing

Examples of criteria (quantitative/qualitative)

Technology pathways	Policy sets

- GHG reduction
- RE potential
- Cost minimization
- In-State capital
- Risk minimization
	- Risk factors
	  - Responsiveness
	  - Independence
	- Impact:
	  - Scope of emissions covered
	  - Leverage
	- Pacing

Applicability of each policy to each technology pathways
Alternative combinations of the technology pathways (4 different futures)
Relevance of policy sets for these 4 futures

4. Next steps

Next steps

Meeting with Climate Cabinet

Selection 3 final combination scenarios

Quantitative assessment of 3 scenarios using FACETS

Provide FACETS outputs in a format compatible with REMI

Achieving sustainability in energy systems requires long term planning and investments at regional, national and international levels.

Policies also affect regional development.

The REMI model

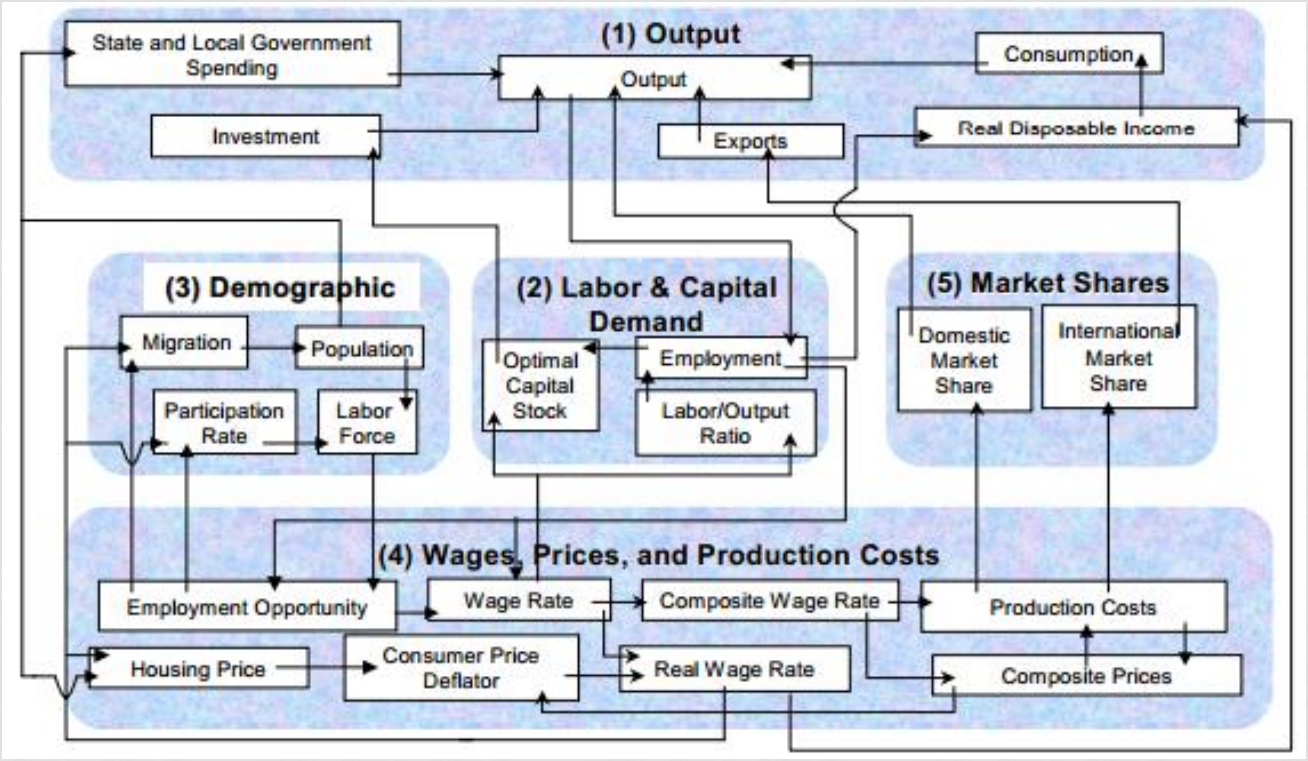
- REMI was founded in 1980 with the aims of developing regional forecasting and policy analysis models to improve the quality of public policy decisions.
- The REMI model:
  - Comprehensive representation of the regional economy
  - Standard tool for economic policy analysis modeling
  - Multiregional US model (50 states + DC)
- Applications of REMI models internationally

- Developed by Regional Input Model, Inc. http://www.remi.com

The REMI model

- The REMI model integrates four major modeling approaches:
  1. **Input-Output**: captured inter-industry relationships.
  2. **General Equilibrium**: supply and demand are balanced in the long run, as prices, production, consumption, imports, exports, and other changes occur to stabilize the economic system.
  3. **Econometric**: underlying equations and responses are estimated using advanced statistical techniques, to quantify the structural relationships and define the speed of economic responses.
  4. **Economic Geography**: represent the spatial dimension of the economy (transportation costs and accessibility); economic geography equations representing agglomeration economies.

The REMI model

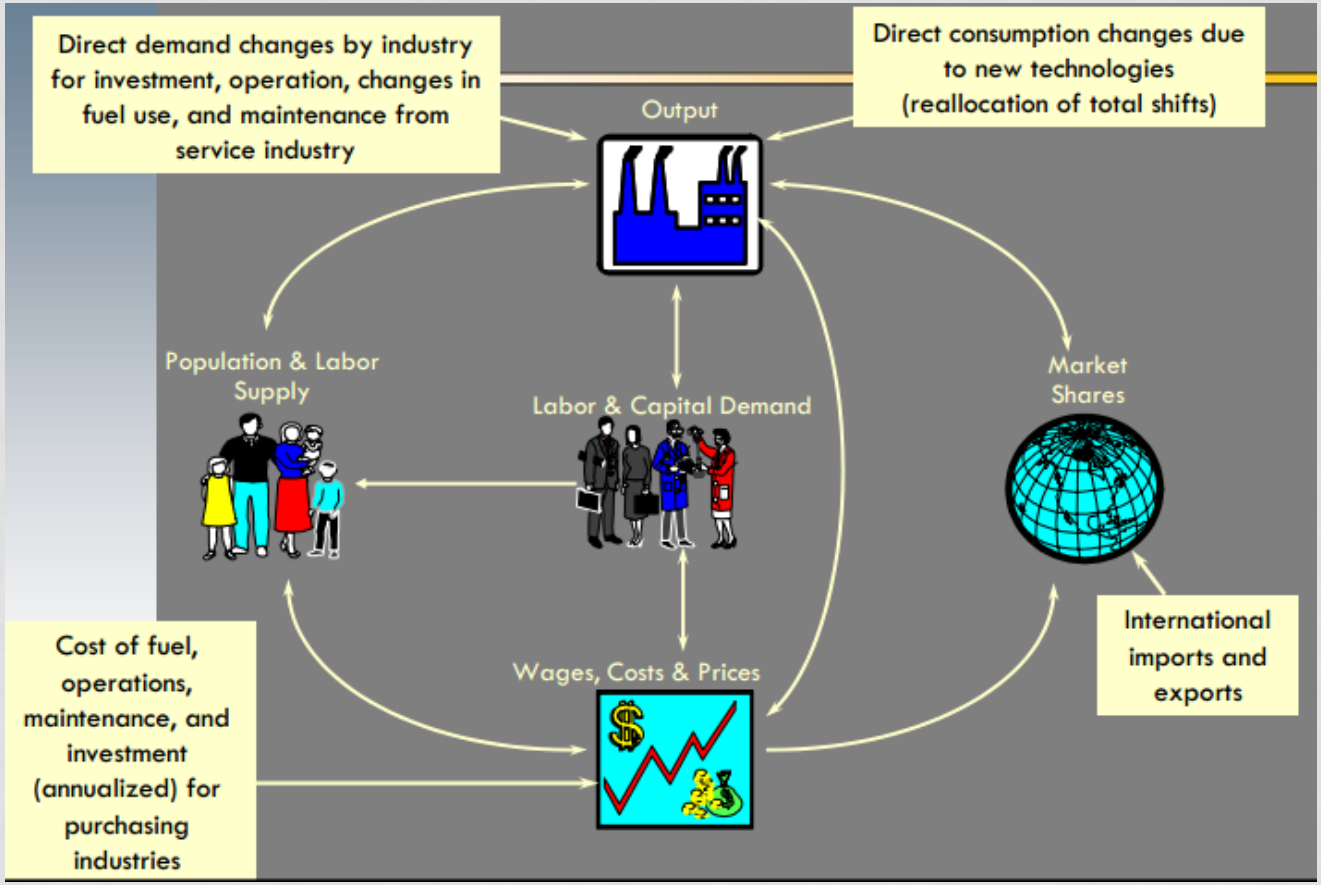


Outputs

- Changes in **gross state (regional) product**
- Changes in **employment**, labor income
- Changes in total **economic** production
- **Industry-specific** and aggregate impacts specific and aggregate impacts state/region

Source: Richard Loulou, HALOA, Pat Delaquil, CEC, George Treyz, REMI Gary A. Goldstein, IRG (2005). Linking MARKAL/TIMES with REMI Policy Insight. Presentation. IEA-ETSAP, Oxford, UK, November 2005

Soft-link with REMI



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Links

1. REMI provides economic parameters for TIMES baseline scenarios (beyond scope)
2. REMI calculates detailed regional economic impacts of TIMES results on policy analysis

Soft-link with REMI: Issues

- Mapping the TIMES model cost results such as annual investments and fuel payments to REMI inputs
  - Investment costs are allocated by supplier groups, as they provide the goods and services being ordered with the investment,
  - But the annualized investment cost gets allocated to producer groups – that are now generating more products based on their investment.
- A common barrier relates to the different definitions of geographical regions.
  - FACETS: census region level + Vermont State out
  - REMI: state level, county level

End-use demand in FACETS

- End use demand sectors (35) follow the AEO aggregation level:

COM	RSD	IND*	TRN
Heating	Heating	Steam	Air
Cooling	Cooling	Process Heat	Bus
Water Heating	Water Heating	Machine Drive	Medium Duty Trucks
Ventilation	Refrigeration	Electrochemical	Heavy Trucks Short Haul
Cooking	Freezing	Facility Demand	Heavy Trucks Long Haul
Lighting	Lighting	Feedstock	Ships
Refrigeration	Other	Other heat	Rail Freight
Office Equipment			Rail Passenger
Miscellaneous			Light Duty Vehicles
			Commercial Trucks
			Off-road Vehicles

- For each end-use demand, a large number of technologies are in competition to meet that demand. For instance:
  - There are 7 categories of Light Duty Vehicles (Compacts cars, SUV, ...)
  - There are 15-25 technologies in each category with different input fuel and efficiency standard.

Supplying group		Purchasing group	
Policy variable	ID	Policy variable	ID
Consumer Spending (amount)	REMI Residential	Consumption Reallocation	REMI Residential REMI Vehicles
Exogenous Final Demand (amount)	REMI Comm Appliances REMI Comm Appliances Efficiency REMI Comm Elec Appliances REMI Comm Elec Appliances Efficiency REMI Comm Lighting REMI Comm Lighting Efficiency REMI Comm Heat/AC/Vent/Ref REMI Comm Heat/AC/Vent/Ref Efficiency REMI Chemical Processing REMI NG Distribution REMI Nuclear Fuel Cycle REMI Oil Refining REMI Bio-Energy REMI Waste Mgnt REMI Basic Chemicals REMI Primary Metals REMI Pulp & Paper REMI Food Manufacturing REMI Non-Metals REMI Other Industry REMI Transportation Equip Manuf	Production Cost (amount)	REMI Comm Appliances REMI Comm Appliances Efficiency REMI Comm Elec Appliances REMI Comm Elec Appliances Efficiency REMI Comm Lighting REMI Comm Lighting Efficiency REMI Comm Heat/AC/Vent/Ref REMI Comm Heat/AC/Vent/Ref Efficiency REMI Aerospace REMI Transit REMI Truck REMI Electric Power REMI Electric Power Emission Control REMI Chemical Processing REMI NG Distribution REMI Nuclear Fuel Cycle REMI Oil Refining REMI Bio-Energy REMI Waste Mgnt REMI Rail Transport REMI Water Transport REMI Basic Chemicals REMI Primary Metals REMI Pulp & Paper REMI Food Manufacturing REMI Non-Metals REMI Other Industry REMI Transportation Equip Manuf
Producer's Durable Equipment Investment (amount)	REMI Vehicles REMI Aerospace REMI Transit REMI Truck REMI Electric Power Emission Control REMI Rail Transport		

Technology	Fuel	Policy Variable	Invest	O&M	Policy Variable
FACETS, through VEDA-BE tables	REMI Fuel	REMI Supplying Group			REMI Purchasing Group
All gasoline and diesel vehicles • Mini compact cars, Compact cars • Mini vans, Full size cars • Small SUV, Large SUV • Pick-up trucks	Oil	Consumption	New Autos	Auto repair	Consumption reallocation
CNG cars	Gas				
All electric cars	Elc				
All hydrogen	RE				
All plug-in cars	Oil+ELC				
All biofuels (flex) cars	Oil+RE				
Commuter rail diesel	Oil	Producers' Durable Equipment (PDE)	Other transportation equipment (OTE)	Scenic and sightseeing transportation; support activities (S&STSA)	Cost of Production Rail transportation
Electric space cooling technologies	Elc	Consumption	Household appliances	Other household operation	Consumption reallocation
Nuclear power plants	Nuc	Producers' Durable Equipment (PDE)	Other equipements	C&IERM	Cost of production Electric power generation, transmission, and distribution (EPGT&D)

Results to REMI

FACETS	REMI	FACETS
INVEST.COST	Investment Cost* (2010 US million dollars) - Value goes to **Supplying Investment** Group	GHG case (2012-2050) - BAU case (2012-2050)
AC.INVEST	Annualized Investment Cost* (2010 US million dollars) - Value goes to **Purchasing Investment** Group	
AC.O&M	Change in Annual O&M Cost* (2010 US million dollars) - Value goes to **Supplying O&M** Group and **Purchasing** Group	
AC.FuelExp	Change in Annual Expenditures on Fuel* (2010 US million dollars) - Value goes to **Purchasing** Group	
AC.RESOURCE	Annual Revenue for Resources* (2010 US million dollars) - Value goes to **Supplying Fuel** Group	
L.RESOURCE	Quantity of each Resources* (Petajoules) - Value goes to **Supplying Fuel** Group	

Questions?

- What is the reliability of using such a one-way soft-link approach?
- How to make a more efficient use of TIMES model cost results as a way to provide feedback to the economic drivers?
- How to account for the feedback of the economy on the energy system?

For more information

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- Kathleen Vaillancourt, ESMIA Consultants, kathleen@esmia.ca

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On the methodology (www.decisionwaregroup.com):

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Thank you

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