

Linking MARKAL/TIMES with REMI Policy Insight

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Presentation Outline

- Short Description of REMI and Its Use
- REMI-Energy Concept and Organization
- R2M Linkage Approach
- M2R Linkage Approach
- Status and Plans

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REMI Key Model Features

- Includes all inter-industry linkages
 - Is based on Economic Theory
 - Includes New Economic Geography Theory
 - Is calibrated and estimated using data for the region(s) being modeled
 - Is dynamic and simulates the timing of economic impacts
- Is the leading Policy Analysis model in the U.S.



Short Description of REMI

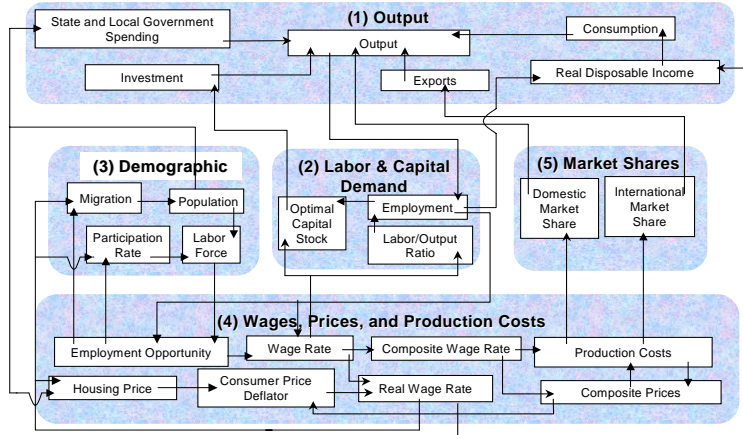
The REMI-PI model integrates aspects of several economic modeling tools:

<u>Module</u>	<u>Aspect</u>
I/O	Inter-industry processing sector (173X173 matrix) 13 consumer expenditures
CGE	Equilibrium 'tendencies' in factor and material input markets.
Econometric	Estimates derived from panel data
Economic Geography	Labor and product agglomeration. Lags in labor and plant mobility Instantaneous equilibrium of capital



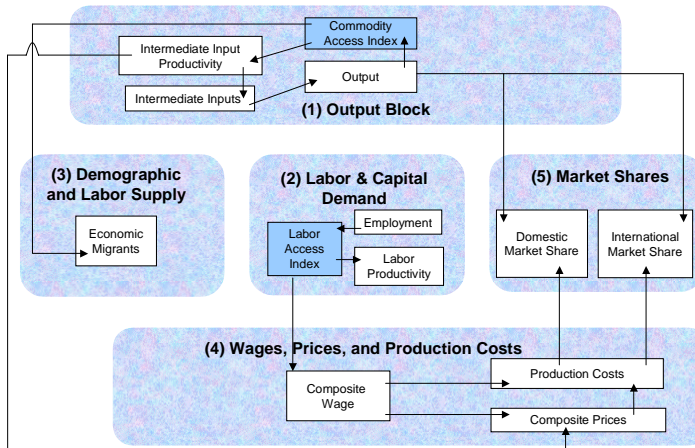
REMI Model Linkages

REMI Model Linkages (Excluding Economic Geography Linkages)



REMI Model Linkages (Cont.)

Economic Geography Linkages



REMI Applications - Energy

What would be the effect of electric utility restructuring and the associated price change of electricity on the Wyoming economy?

Policy Variables Used

- In-state rate changes by customer class
- Export of Electricity estimates

Key REMI Results

- Employment, personal income, and population impacts



REMI Applications -Transportation

What are the impacts of a high-speed rail link between San Diego & San Francisco?

Policy Variables Used

- Construction and operation spending
- Highway, conventional rail, and aviation savings
- Gasoline tax
- Housing cost change
- Consumer and government spending

Key REMI Results

- Effects of tax, spending, and cost changes
- Housing cost impacts drive the results
- Benefit/cost and net present value measures show feasibility



REMI Applications - Environment

What will be the effect of proposed air pollution control regulations on the Los Angeles area?

Policy Variables Used

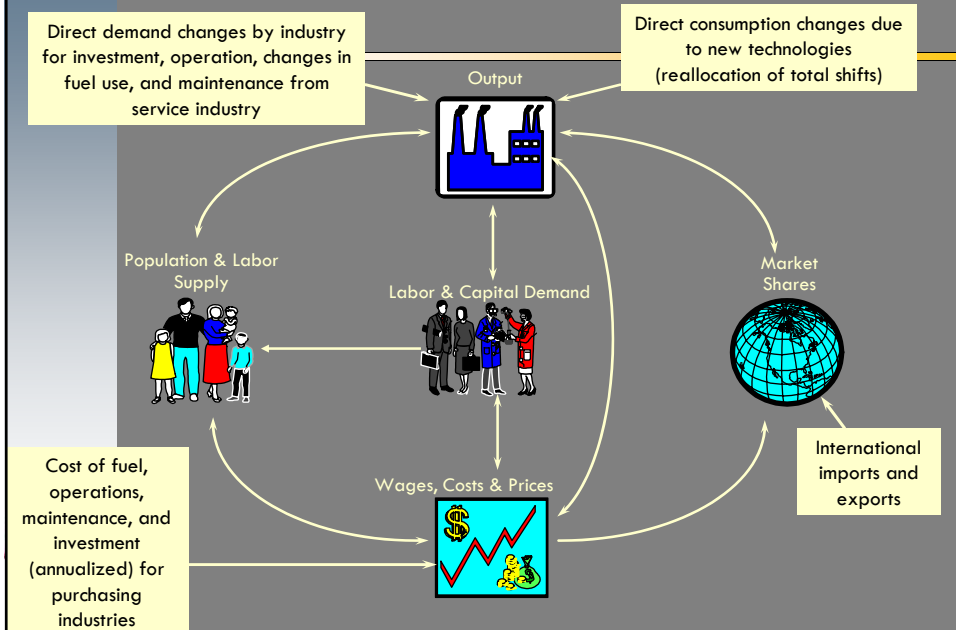
- Cost of equipment
- Spending
- Non-pecuniary benefits of better health

Key REMI Results

- Economic effects of costs, spending, and amenities
- Employment increase and real income per capita decrease



MARKAL/TIMES Links to REMI Model Inputs



REMI-Energy Concept

- *2-way linkage between REMI-Insight and MARKAL/TIMES*
- *REMI provides economic parameters for MARKAL/TIMES reference scenario*
- *MARKAL/TIMES simulates specific energy/environmental policies*
- *REMI calculates detailed economic impacts of MARKAL/TIMES results*



REMI-Energy Main Issues

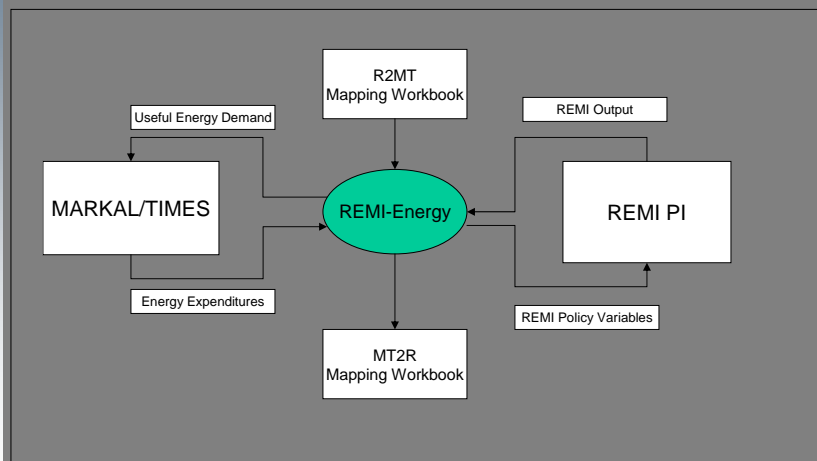
- *Can REMI economic output be mapped to MARKAL demands?*
- *What parts of MARKAL output should be sent to REMI?*
 - ❑ *Convey all or most of MARKAL results*
- *Avoid or reduce double-counting by REMI (e.g. if MARKAL calculates investments in energy techs, REMI should not further modify these investments)*
- *How to convey MARKAL results to REMI? (Policy variables, I/O coefficients, etc.).*



➤ *Devise semi-automatic interfaces between the two models*

➤ *Are iterations needed?*

REMI-Energy OVERVIEW



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Components of the Linkage

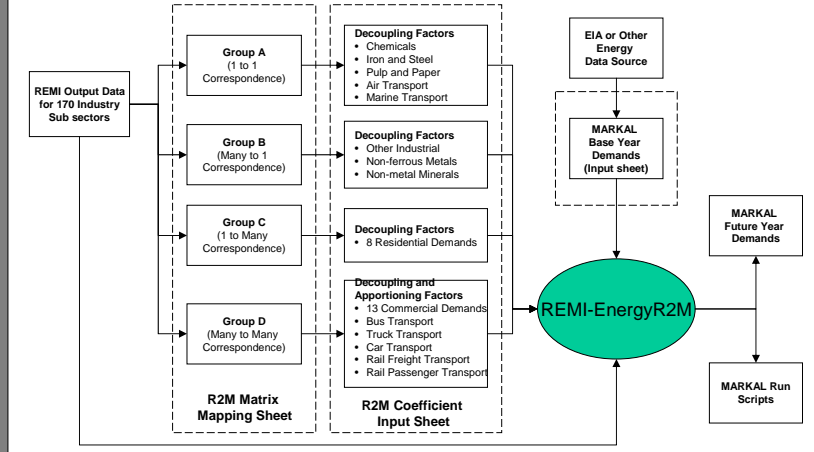
- REMI-Energy “control center”
 - ❑ Oversees exchange and transformation of the outputs/inputs
- REMI-2-MT Workbook
 - ❑ R2MT Output to Sector (DM) mapping table
 - ❑ R2MT Output to Sector (DM) (de)coupling factors
- MT-2-REMI Workbook
 - ❑ MT2R technology group/mapping table
 - ❑ MT Results (from VEDA-BE)
 - Lumpsum and annualized investment
 - Operating and maintenance costs
 - Fuel expenditure
 - ❑ Relies on VEDA-BE “rules” and tables

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REMI-PI Outputs to MARKAL Demands

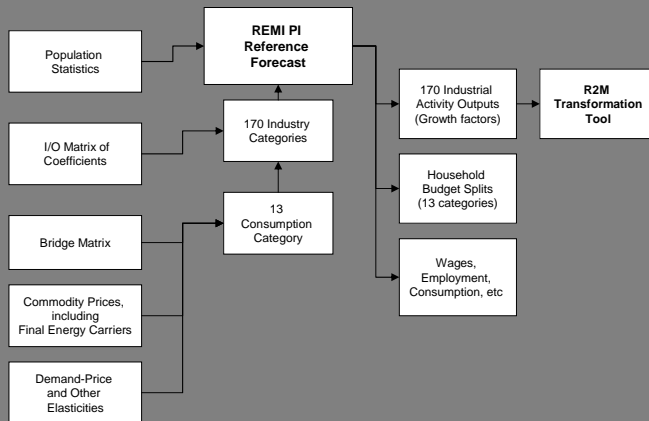
REMI-EnergyR2M – REMI Outputs to MARKAL End-use Service Demands



R2M Workbook



REMI-PI Outputs to be Transferred to MARKAL *{for REMI to do}*



REMI-2-MARKAL/TIMES Workbook – Mapping Table

This screenshot shows an Excel spreadsheet titled 'REMI-Energy_R2M_v1'. The main table is a mapping matrix with columns for 'REMI Industry Subsectors' (rows 5-24) and 'MARKAL Demand Subsectors' (columns 7-13). The REMI subsectors are categorized by 4-digit NAICS codes and 2-digit categories. The MARKAL subsectors include Endogenous MARKAL, Other Industrial, Chemicals, Iron and Steel, Pulp and Paper, Non-ferrous metals, Non-Metals, Residential Cooling, Residential Freezers, and Residential Heating. The matrix cells contain numerical values representing the mapping between these two systems. The spreadsheet also includes a legend and notes explaining the color coding and data sources.

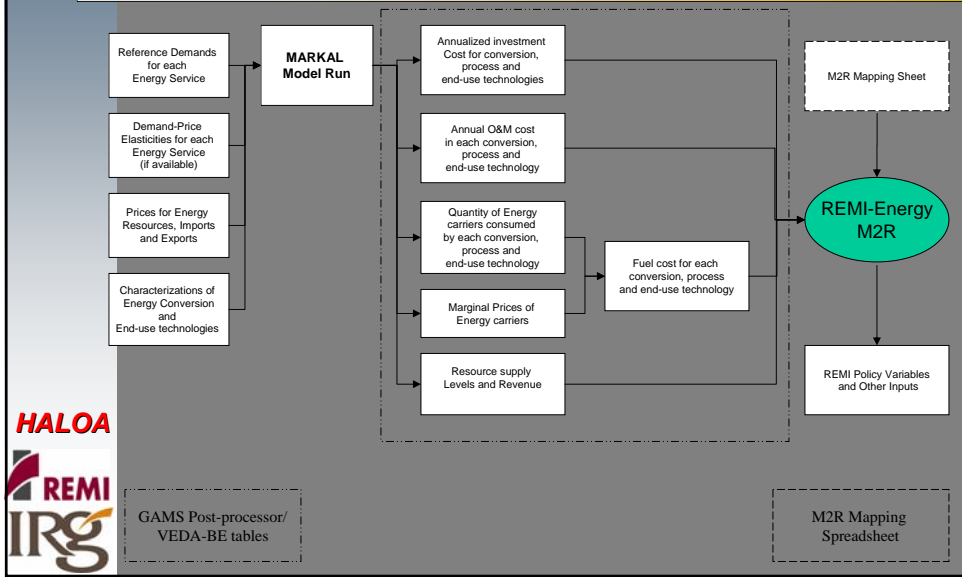


REMI-2-MARKAL/TIMES Workbook – Decoupling Matrix

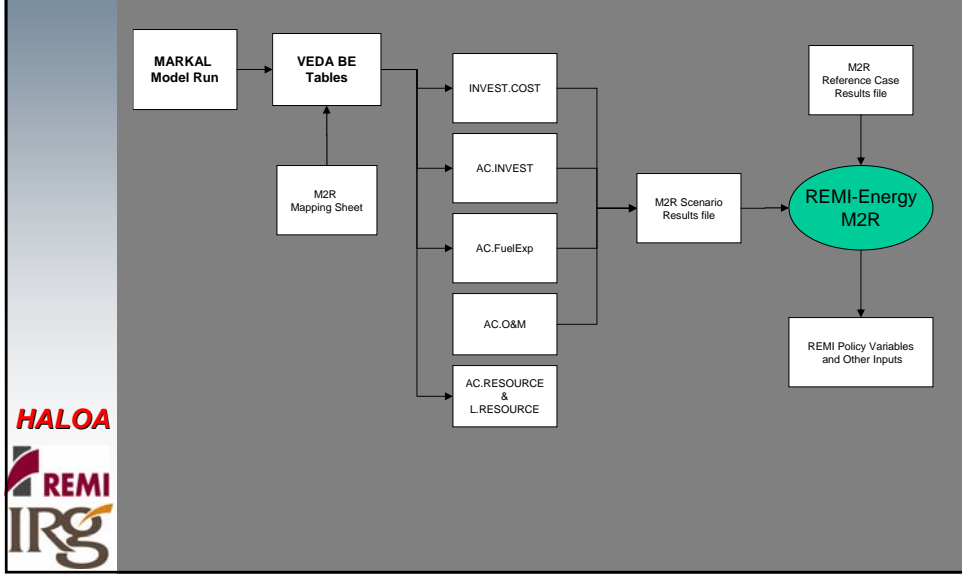
This screenshot shows an Excel spreadsheet titled 'REMI-Energy_R2M_v1' displaying 'R2M Coefficient Data'. The table is organized into four groups (A, B, C, D) based on the number of REMI subsectors mapping to a single MARKAL subsector. Group A (rows 10-11) shows one-to-one mappings for 'Basic chemical and inorganic chemical manufacturing', 'Iron and steel mills and ferroalloy manufacturing', 'Pulp, paper, and allied products', 'Air transportation', and 'Water transportation'. Group B (rows 12-13) shows many-to-one mappings for 'Other Industrial' and 'Non-ferrous metals'. Group C (rows 14-21) shows one-to-many mappings for various residential demand subsectors like 'Residential Cooling', 'Residential Freezers', 'Residential Heating', 'Residential Lighting', 'Residential Microwave Electric', 'Residential Microwave Gas', 'Residential Refrigeration', and 'Residential Water Heating'. Group D (rows 22-23) shows many-to-many mappings for 'Commercial' subsectors. The matrix columns represent 'Periods' from 2005 to 2045, with data points for 2005, 2010, 2015, 2020, 2025, 2030, 2035, 2040, and 2045.



MARKAL/TIMES Results to REMI-PI



MARKAL/TIMES Results to REMI_PI - Details



MARKAL/TIMES-2-REMI Workbook – Technology Grouping Table

US-EPA MARKAL Codes	MARKAL	REMI fuel type	REMI Supplying Group	REMI Purchas
Members	Descriptions and REMI Applicable to	Set definitions	Policy Variable Type Investment - Name	Q-Use - Name Policy Variable Type
6 AC24-27	space cooling, non-cent-air-heat pump AC	OUT(Dty) = "E"	Electric Consumption Household appliances	Other household operation Consumption Reallocation
6 AC24-32	space cooling, geothermal heat pump #1 - 1995	Renewables	Consumption Household appliances	Other household operation Consumption Reallocation
7 AC24-26	space cooling, air heat pump - 1995	Gas	Consumption Household appliances	Other household operation Consumption Reallocation
8 SP14-27	fridge	Electric	Consumption Household appliances	Other household operation Consumption Reallocation
8 SP15-02	space heating, electric	Electric	Consumption Household appliances	Other household operation Consumption Reallocation
10 SH23-12	space heating, electric heat pump, existing	Electric	Consumption Household appliances	Other household operation Consumption Reallocation
11 SH13-26	space heating, gas furnace + radiator	Gas	Consumption Household appliances	Other household operation Consumption Reallocation
12 SH23-32	space heating, biomass furnace	Oil	Consumption Household appliances	Other household operation Consumption Reallocation
13 SH14-43	space heating, LPG furnace	Oil	Consumption Household appliances	Other household operation Consumption Reallocation
14 SH44-83	space heating, Chilled Water Furnace + radiator	Oil	Consumption Household appliances	Other household operation Consumption Reallocation
15 SH14-44	space heating, wood heater	Renewables	Consumption Household appliances	Other household operation Consumption Reallocation
16 SH15-06	space heating, geothermal heat pump	Renewables	Consumption Household appliances	Other household operation Consumption Reallocation
17 SH15-12	space heating, Gas heat pump	Gas	Consumption Household appliances	Other household operation Consumption Reallocation
18 SH17-02	incandescent + fluorescent lighting	Electric	Consumption Household appliances	Other household operation Consumption Reallocation
19 SH15-11	miscellaneous household appliances, electric	Electric	Consumption Household appliances	Other household operation Consumption Reallocation
20 SH20-01	miscellaneous household appliances, gas	Gas	Consumption Household appliances	Other household operation Consumption Reallocation
21 SH15-16	refrigerator	Electric	Consumption Household appliances	Other household operation Consumption Reallocation
22 SH15-09	water heater, gas	Gas	Consumption Household appliances	Other household operation Consumption Reallocation
23 SH15-25	water heater, electric, existing	Electric	Consumption Household appliances	Other household operation Consumption Reallocation
24 SH15-22	water heater, electric, existing	Consumption	Household appliances	Other household operation Consumption Reallocation
25 SH24-31	water heater, LPG #1 - 1995	Oil	Consumption Household appliances	Other household operation Consumption Reallocation
26 SH15-35	water heater, solar #1 - 1995	Renewables	Consumption Household appliances	Other household operation Consumption Reallocation
27		Renewables	Consumption Household appliances	Other household operation Consumption Reallocation
28 TLCD19B5-35	Car, Hybrid (EV), Compact	OUT(Dty) = "E"	Electric Consumption New auto	Automobile repair Consumption Reallocation
29 TLCD19L5-35	Car, Advanced Diesel	Oil	Consumption New auto	Automobile repair Consumption Reallocation
30 TLCD19M5-35	Car, Gasoline, Advanced SPG, Compact	Oil	Consumption New auto	Automobile repair Consumption Reallocation
31 TLCD19O5-35	Car, CNG, medium, Compact	Gas	Consumption New auto	Automobile repair Consumption Reallocation
32 TLCD19D5-35	Car, CNG Bi-fuel, Compact	Oil + Gas	Consumption New auto	Automobile repair Consumption Reallocation
33 TLCD19H5-35	Car, Gasoline, Conventional, Compact	Oil	Consumption New auto	Automobile repair Consumption Reallocation
34 TLCD19S5-35	Car, Electric, Compact	Electric	Consumption New auto	Automobile repair Consumption Reallocation
35 TLCD19A5-35	Car, Flex Ethanol, Compact	Renewables	Consumption New auto	Automobile repair Consumption Reallocation
36 TLCD19G5-35	Car, Fuel cell-hydrogen, Compact	Renewables	Consumption New auto	Automobile repair Consumption Reallocation
37 TLCD19I5-35	Car, Fuel Cell Methanol, Compact	Gas	Consumption New auto	Automobile repair Consumption Reallocation
38 TLCD19R5-35	Car, LPG Bi-fuel, Compact	Oil	Consumption New auto	Automobile repair Consumption Reallocation
39 TLCD19Q5-35	Car, Gasoline, Moderate SPG, Compact	Oil	Consumption New auto	Automobile repair Consumption Reallocation
40 TLCD19C5-35	Car, New Vehicle, Compact	Oil + Gas	Consumption New auto	Automobile repair Consumption Reallocation
41 TL1E	Existing Cars + vans + SUV + light trucks	Oil	Consumption New auto	Automobile repair Consumption Reallocation
42 TLCD19J5-35	Car, Hybrid (EV) Full size	Oil	Consumption New auto	Automobile repair Consumption Reallocation
43 TLCD19K5-35	Car, Advanced Diesel, Full size	Oil	Consumption New auto	Automobile repair Consumption Reallocation
44 TLCD19N5-35	Car, Gasoline, Advanced SPG for full size	Oil	Consumption New auto	Automobile repair Consumption Reallocation



MARKAL/TIMES-2-REMI Workbook – Scenario Results

REMI Aggregate ID	1995	2000	2005	2010	2015	2020	2025	2030	2035
1 REMI Aggregate ID									
2 REMI Residential									
3 REMI Vehicles									
4 REMI Comm Appliances									
5 REMI Comm Des Appliances									
6 REMI Comm Lighting									
7 REMI Comm Heating/C									
8 REMI Coal Mining									
9 REMI Metal Mining									
10 REMI Oil and Gas Extraction									
11 REMI Exports - Feltex + Coal									
12 REMI Imports - Electric									
13 REMI Imports - Oil and Gas									
14 REMI Imports - Feltex and Coal Products									
15 REMI Airtransport									
16 REMI Transit									
17 REMI Trucks									
18 REMI Electric Power									
19 REMI Electric Power Emission Control									
20 REMI Chemical									
21 REMI NO Oxidation									
22 REMI Chemical Processing									
23 REMI Nuclear Fuel Cycle									
24 REMI Oil Refining									
25 REMI Bio-energy									
26 REMI Vehicle Mfg									
27 REMI Rail Transport									
28 REMI Water Transport									
29 REMI Basic Chemicals									
30 REMI Iron & Steel									
31 REMI Pulp & Paper									
32 REMI Non-ferrous Metals									
33 REMI Non-ferrous									
34 REMI Other Industry									



Current Status and Plans

- {TO BE ADDED by REMI 1st}



Final remarks

- Conceptual framework established, but full implementation pending a “client”
- Linkage to be re-assessed after experimenting current scheme
 - Harmonizing Reference Scenario assumptions
 - MARKAL outputs to send to REMI-PI
 - Need for iterations, convergence criterion

