Reinventing Fire Integration Model Methodology

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The Reinventing Fire (RF) integration model integrates outputs from the RF sector models (transportation, buildings, industry, and electricity) to determine the overall financial and climate implications of transitioning the U.S. economy off coal and oil to efficiency and renewables by 2050. The model also tracks and integrates sectoral results to ensure cross-sectoral consistency.

Figure 1 shows how information from the RF sector models is integrated: energy use by type, incremental capital investment, and saved energy purchases flow into the integration model from the transportation, buildings, and industry end-use sector models. (Incremental investment and operational savings are relative to EIA's *Annual Energy Outlook* 2010 (AEO) Reference Case baseline scenario.) Overall end-use demands for liquid fuels (oil, biofuels, hydrogen) are calculated and passed from the integration model to the refining model, which returns the energy use, incremental investment, and operational savings associated with meeting the given demands. Similarly, overall end-use demand for retail electricity (including net demand from fuel refining) is then calculated and passed to the electricity model, which also returns the energy use, incremental investment, and operational savings associated with meeting demand.

Inputs from the sectoral models are combined with exogenous inputs (carbon dioxide-equivalent emissions factors and discount rate) to determine 1) primary energy use, 2) carbon dioxide-equivalent emissions, and 3) net present value for the entire U.S. economy during 2010–2050.

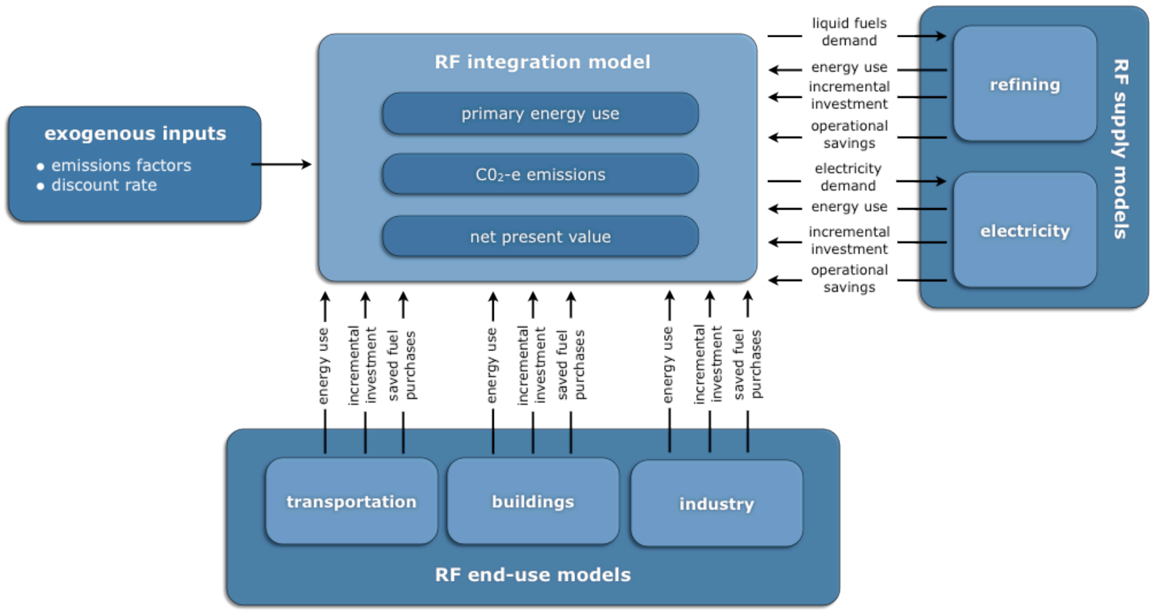

Fig. 1. The RF integration model integrates outputs from the RF sector models.

1. Energy use and carbon dioxide-equivalent emissions accounting

Annual primary energy use (BTU) is calculated by fuel type as the simple sum of the fuel's direct use across all RF sectors. Annual carbon dioxide-equivalent emissions (in metric tons) are given by the total sum of the product of each fuel's primary use by its associated emissions factor (metric tons $C0_2$-e/BTU).

Four energy use/emissions scenarios are included in the RF analysis. The first, "business-as-usual," assumes no additional adoption of end-use efficiency beyond that projected in AEO, and adopts the *Maintain* scenario for the electricity sector (see *Reinventing Fire*, Chapter 5). To validate the model, we compared this scenario's primary energy output to AEO's projected primary energy use (less feedstocks); the two matched to within 3% for each year of the simulation.

The other three scenarios assume the adoption of additional cost-effective efficient technologies (beyond those adopted in AEO) across the end-use sectors, as described in *Reinventing Fire*, Chapters 2–4, and adopts the *Transform* scenario for the electricity sector (Chapter 5). But they differ in their integrative design assumptions: The "standard RF" scenario (which we use to quantify net present value) conservatively assumes no additional efficiency gains from integrative design in buildings and industry; the "low integrative design" and "high integrative design" scenarios respectively assume the low and high ends of our integrative design savings ranges for buildings and industry. We do not quantify net present value for the low and high integrative design scenarios due to lack of reliable integrative design cost data.

2. Net Present Value

Net present value is calculated for the standard RF scenario; it's the difference between the present values of the overall operational savings and incremental capital investments over the 40-year forecast horizon (2010–2050). In keeping with our uniform convention, the discounting to present value uses a societal real discount rate of 3%/y.

Annual overall incremental investment is the simple sum of each sector's annual incremental investment. Annual operational savings, however, cannot be simply summed across sectors, as that would double-count electrical efficiency savings across the end-use and electricity sectors. (Efficiency savings would be counted in both the saved retail electricity price for the end-use sector and the fuel-and-operations-and-maintenance (O&M) savings for the electricity sector.) To avoid double-counting, annual fuel and O&M savings in the electricity sector are separated into those that result from end-use efficiency and those that result from switching to a generation portfolio with higher capital costs but lower operating costs; only the latter savings are counted in the overall operational savings. *Reinventing Fire*'s net present values for sectoral savings (transportation, buildings, industry), if added together, differ from the summary in Fig. 6-3 because the latter allocates the net costs of the *Transform* electricity supply scenario to the end-use sectors according to their respective 2050 electricity consumption. That is why, for example, the NPV for the Buildings sector is shown in Fig. 6-3 as $0.7 trillion rather than $1.4 trillion.