Appendix A. IMPLAN Analysis Methodology

Direct spending produces ripple effects across an economy, affecting supply chains and household spending. For instance, offering EV incentives will increase EV demand, which will affect not only automotive manufacturing but also automotive dealerships and transportation of durable goods. These changes in demand will affect the compensation of workers in these industries, who will then re-spend funds. As the money cycles through the economy, the amounts decrease over time through leakage, or spending on imports or other services from out of Vermont.

The purpose of the macroeconomic impact analysis is to quantify the broader Statewide effects of the mitigation scenario relative to the baseline. Cadmus used IMPLAN software based on Vermont's economy in 2019 (the latest year data are available) to analyze outputs from LEAP.

At its core, IMPLAN is based on an input-output matrix that captures how various parts of the economy are connected. It describes what industries buy and sell to each other and to households and the government. By inputting a direct change to one industry, the software can estimate impacts on connected industries.

IMPLAN produces the following indicators:

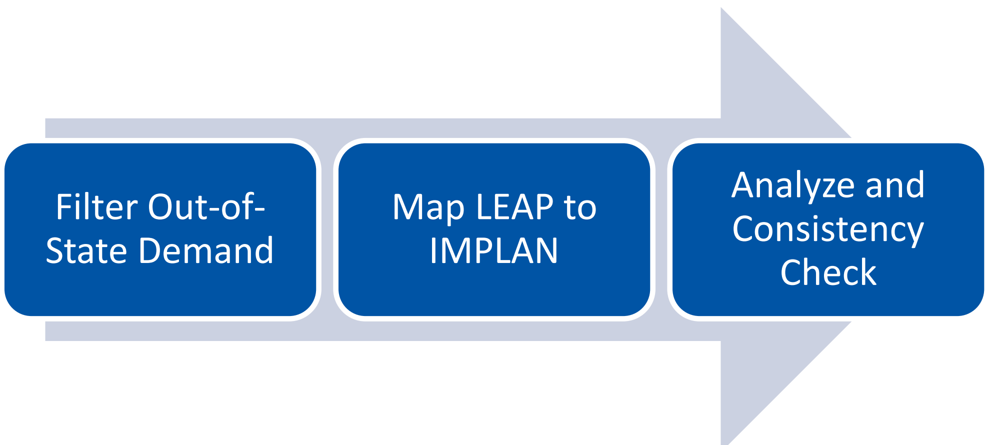
- Employment – a full or part time job lasting one year, consistent with the definition used by the US Bureau of Economic Analysis and Bureau of Labor Statistics. As person can have more than one job, this is not a count of employed persons.
- Labor income – The combination of employee compensation (wages, salaries, benefits, payroll taxes) and proprietor income (e.g., self-employed individuals).
- Output – The total annual production of each industry or commodity (e.g., total revenues adjusted for inventory changes). Example: A baker sells $10,000 worth of cake products. The output is $10,000.
- Value-add – Output minus the intermediate inputs. In other words, it is the increase in value that an industry contributes. Example: A baker sells $10,000 worth of cakes. The baker pays $3,000 in shop costs and $4,000 for ingredients. The value-add is $10,000 minus $7,000 in costs (intermediate inputs), or $3,000.

Since IMPLAN is based on 2019 data, the model is most accurate for changes in the near term. Economies evolve over time so an analysis for demand changes in 2050 will inherently be less accurate than one for 2030. In this study, the team looked at changes occurring from 2020-2050. Other limitations of the model include use of linear industry relationships, which may not hold true for marginal changes. For example, if an industry has an average employment of 10 per million in output, this would be over all production in one year. Adding an additional (marginal) million in output may not actually require 10 additional jobs, but the IMPLAN software would estimate the impact to be 10 direct jobs. As such, an IMPLAN analysis is intended to be order-of-magnitude in nature.

Modeling Process – Mitigation Scenario

Cadmus started with results generated by SEI from LEAP.[32] The process is summarized in Figure A-1. First Cadmus filtered out demand for any out-of-state spending. Since our IMPLAN model is for the state of Vermont, we are not able to model changes out of the study region. The second step was identifying the appropriate IMPLAN codes to use for each of the LEAP mitigation costs. In this step, any imports (such as fossil fuels) were removed from the analysis since the impacts would accrue out of the region. We kept supply chain (local) impacts that support those imports. Supply chain impacts include transportation and retail and wholesale operations. Finally, Cadmus modeled the remaining cost categories in IMPLAN and analyzed the results, checking to ensure that the largest impacts could be traced back to the inputs.

Figure A-1. Process of Translating LEAP Outputs to IMPLAN Inputs



Starting and final input amounts by sector are shown in Table A-1. The value that ultimately went into IMPLAN is greater than the original amount because the fuels sector increased significantly (most of the decreased demand is in imported fossil fuels).

[32] LEAP v 2.03 Outputs, values provided in MM $2019 with 2% discount rate

Table A-1. Comparison of LEAP Output and IMPLAN Inputs

Sector	Description	LEAP Output (Millions 2019$)	IMPLAN Inputs (Millions 2019$)
Residential	Maintenance and equipment	1,840	1,311
Commercial	Maintenance and equipment	348	348
Road Transport	Vehicles and charging	2,744	659
VMT	Road improvements and public transit	2,642	2,642
Non-Energy	Agriculture support services, refrigeration	779	495
Delivered Heat	Construction and power boiler	154	154
Electricity	Construction of power structures, generation, natural gas, batteries and solar	1,489 – in state 6,033 – out of state	1,483
Fuels	Fossil fuels, biogas, biodiesel, ethanol, imported electricity, wood pellets, cord wood, wood waste solids	-14,048 non-wood fuels -839 wood-based fuels	-4,041
Total		**1,142**	**3,052**

The final IMPLAN inputs are provided in Table A-2 by industry or commodity code.

Table A-2. Final IMPLAN Inputs

IMPLAN Code	Description	Amount (2019$MM)
418	Transit and ground passenger transportation	1,321
62	Maintenance and repair construction of highways, streets, bridges, and tunnels	1,321
56	Construction of other new nonresidential structures	1,254
3039	Electricity	1,177
3052	Newly constructed power and communication structures	1,175
61	Maintenance and repair construction of residential structures	779
3412	Retail services - Miscellaneous store retailers	390
19	Support activities for agriculture and forestry	250
60	Maintenance and repair construction of nonresidential structures	244
3307	Semiconductors and related devices	113
143	All other miscellaneous wood product manufacturing	90
45	Electric power generation - Biomass	86
275	Air conditioning, refrigeration, and warm air heating equipment manufacturing	78
272	Other commercial service industry machinery manufacturing	69
241	Power boiler and heat exchanger manufacturing	61
222	Other aluminum rolling, drawing, and extruding	61
3395	Wholesale services - Machinery, equipment, and supplies	56
52	Construction of new power and communication structures	39
42	Electric power generation - Solar	37
55	Construction of new commercial structures, including farm structures	31
3405	Retail services - Building material and garden equipment and supplies stores	22
3404	Retail services - Electronics and appliance stores	22
3415	Rail transportation services	11
3394	Wholesale services - Household appliances and electrical and electronic goods	7
333	Storage battery manufacturing	6
39	Electric power generation - Hydroelectric	6
479	Waste management and remediation services	2

IMPLAN Code	Description	Amount (2019$MM)
48	Natural gas distribution	2
3396	Wholesale services - Other durable goods merchant wholesalers	0
3400	Wholesale services - Other nondurable goods merchant wholesalers	(12)
274	Heating equipment (except warm air furnaces) manufacturing	(43)
3342	Heavy-duty trucks	(79)
3401	Wholesale services - Wholesale electronic markets and agents and brokers	(105)
3417	Truck transportation services	(134)
3392	Wholesale services - Motor vehicle and motor vehicle parts and supplies	(175)
3402	Retail services - Motor vehicle and parts dealers	(310)
413	Retail - Non-store retailers	(981)
3399	Wholesale services - Petroleum and petroleum products	(1,843)
3408	Retail services - Gasoline stores	(1,975)
Total		**$3,052**

Opportunity Cost

While increased spending typically translates to greater economic activity, any expenditure could have been spent on other activities that produce alternative economic effects. To model opportunity costs, Cadmus allocated 70% of net mitigation scenario costs to changes in household income, with the other 30% of costs assumed to fall in the nonresidential sectors.[33]

As was shown in Table A-2, the net cost of the mitigation scenario is $1.1 billion. Taking 70% of this amount yields $799 million in opportunity costs that we will model as being spread over Vermont households. Cadmus modeled two allocation schemes, shown in Table A-3, which outlines the percentage for each income group and the effective amount modeled. The first scheme is proportional to the household population distribution by income group, meaning everyone pays a similar level for decarbonization. The second scheme is based on air transportation demand, which we obtained from the underlying IMPLAN household demand data. The results show that wealthier households have relatively greater demand for air transportation.

33 IMPLAN cannot be used to model nonresidential sector opportunity costs, so those were not included.

Table A-3. Opportunity Cost Allocations

Description	Air Transportation Demand	Air Transport Amount ($MM)	Proportional to Population	Proportional to Population Amount ($MM)
Households LT15k	2%	-16	10%	-80
Households 15-30k	4%	-32	14%	-112
Households 30-40k	5%	-40	9%	-72
Households 40-50k	5%	-40	8%	-64
Households 50-70k	11%	-88	16%	-128
Households 70-100k	18%	-144	17%	-136
Households 100-150k	22%	-176	15%	-120
Households 150-200k	12%	-96	5%	-40
Households GT200k	20%	-160	5%	-40

Employment Impacts by Industry

Table A-4 shows the impacts for industries with employment changes greater than 2,000.

Table A-4. Employment Impacts by Industry (Absolute Value Greater than 2,000)

IMPLAN Code	Description	Employment Impact
418	Transit and ground passenger transportation	32,600
52	Construction of new power and communication structures	12,900
56	Construction of other new nonresidential structures	9,500
19	Support activities for agriculture and forestry	9,000
62	Maintenance and repair construction of highways, streets, bridges, and tunnels	8,800
61	Maintenance and repair construction of residential structures	5,500
412	Retail - Miscellaneous store retailers	5,000
405	Retail - Building material and garden equipment and supplies stores	4,200
413	Retail - Non-store retailers	-2,100
408	Retail - Gasoline stores	-4,000

Appendix B. Additional Resources

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