Economic Impact Modeling for the RPS Study

RPS Work Group Meeting

November 14, 2018

Agenda

- HB1414 on Economic Impacts
- Types of Economic Modeling
- Basic Structure of Input-Output Models
- Research Tasks
- Example Results
- Work Plan
- Q&A

HB 1414 on Economic Impact Analysis

- The study shall be a comprehensive review of the history, implementation, overall costs and benefits, and effectiveness of the RPS… including:
  - 7-714(B)(2) The economic … impacts of the deployment of renewable energy sources in the State and in the surrounding areas of the PJM region

HB 1414 on Economic Impact Analysis (Cont'd)

- Particular subjects to be addressed in the study include:
  - 7-714(C)(4) What industries are projected to grow, and to what extent, as a result of the incentives associated with the standard;
  - 7-714(C)(7) Additional opportunities … to promote local job creation within the industries that are projected to grow as a result of the standard; and
  - 7-714(C)(10) The role of in-State clean energy in … promoting local jobs and economic activity in the State.

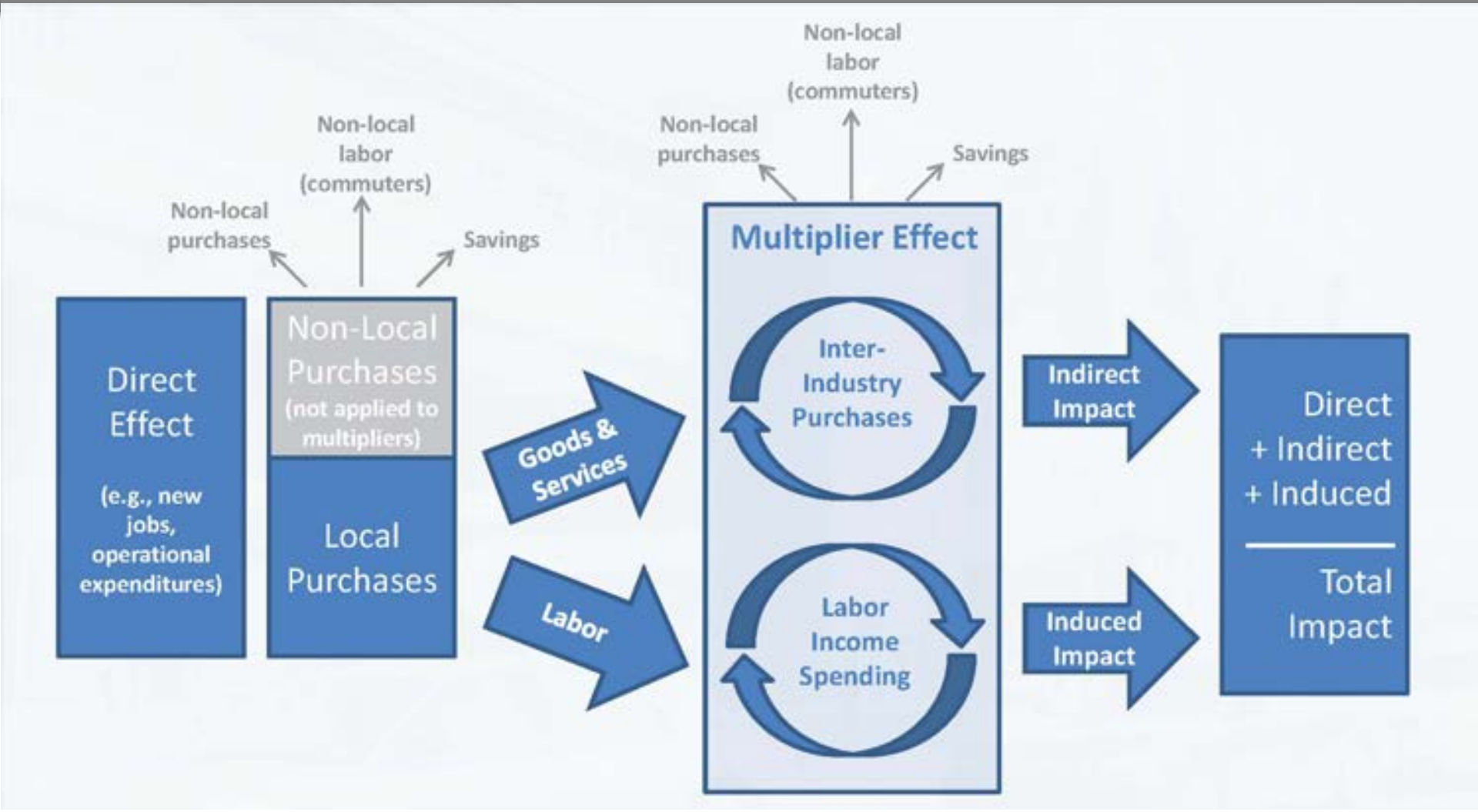
Types of Impact Analysis

- The economic impact of renewable energy technologies has been the subject of research since their introduction
  - Research has included sponsored reports by industry trade groups and peer-reviewed academic studies.
  - Most of these studies are national in scope, although several industry studies looking at a particular renewable technology also provide state-level estimates.

What is Economic Impact Analysis?

- Economic impact analysis estimates how an economy will respond to a change in spending by one or more industries
  - Final demand
- A change in spending creates both indirect and induced effects on the regional economy
  - Indirect effects stem from local industries' purchases of inputs (goods and services) from other local industries. These purchases are also known as intermediate expenditures.
  - Induced effects reflect the spending of wages from residents, essentially household spending earned from direct and indirect effects.
- Economic change is typically measured in terms of output, earnings and jobs

Economic Impact Analysis



Input-Output and Economic Impact Analysis

- Methodologies used in economic impact analysis vary from survey extrapolations to econometric models, but the majority of regional economic studies has applied input-output (I-O) models.
- In addition to estimating economic impacts, I-O modeling can be a powerful investigative tool.
  - **Supply Chain** – An I-O model has the potential to expose the supply chain of goods via industries in a region, revealing to what extent each industry is able to satisfy its purchasing needs in a region. This can be very helpful to economic development organizations that are looking to strengthen a local supply chain and increase in-region purchasing.
  - **Industry Importance** – An I-O model can be used to identify important industries in a region, not just those with a lot of jobs (like retail or healthcare), but also those that have an unusually large and positive economic impact, things like advanced manufacturing, technology, etc.

Limitations of I-O Modeling

- **Forecasting** – I-O models are NOT forecasting models and cannot be used to project the growth of an economy under various scenarios. Typically, econometric models are used for these applications.
- **Prices** – I-O models do not account for price elasticities, changes in consumer or industry behavior based on a direct effect, etc.
- **Static** – Relationships are both linear and fixed over time, which may not represent true industry behavior. For example, the model does not allow input substitution, which may occur during periods of scarcity.
- **Opportunity Costs** – I-O models do not account for opportunity costs. The investment modeled is not counterbalanced by a decrease in spending elsewhere in the economy.

What is IMPLAN?

- IMPLAN (IMpact analysis for PLANning)
  - Widely used regional Input-Output application
    - Private and public sector client base
      - Maryland Department of Commerce
  - Ideally suited for estimating economic impacts
- Economic data and analytical software for model construction and impact analysis
  - 536 Industrial Sectors
    - Most 3 or 4 digit NAICS
  - Geographically disaggregated
    - States
    - Counties
    - ZIP Code

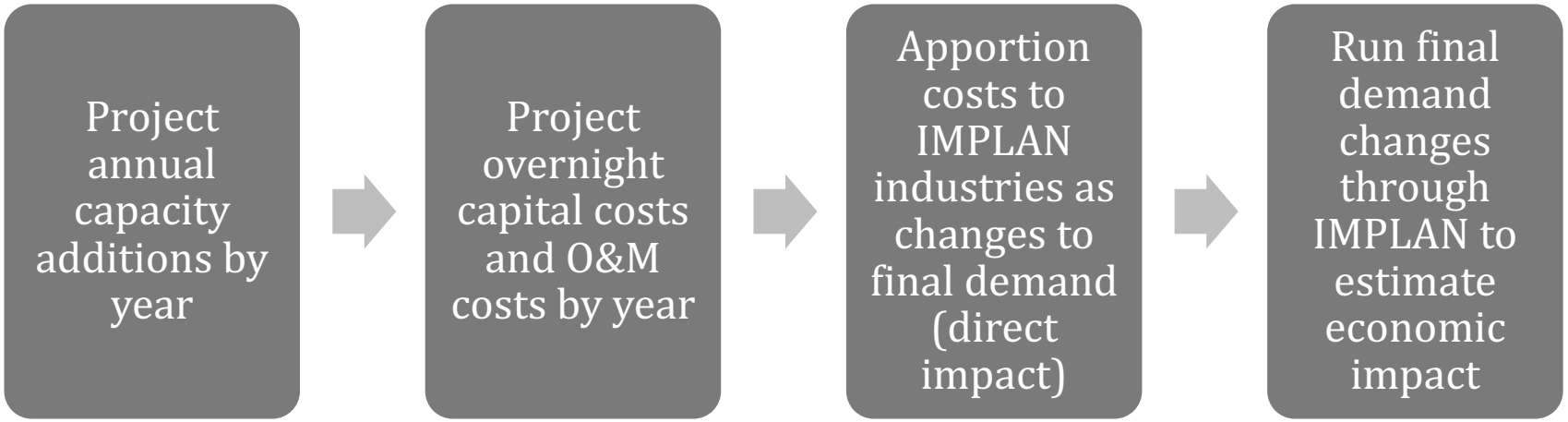
Scope of Current Project

- Geography: Maryland and surrounding PJM states (DC, DE, NJ, OH PA, VA, WV) + US
  - As specified in HB 1414
- Renewable technologies: PV, offshore wind, onshore wind
- Time period:
  - Initial look to 2025
    - IMPLAN is static
    - Extend to 2030 as needed
- Scenarios
  - Reference Case
  - 50% RPS

Source: PJM

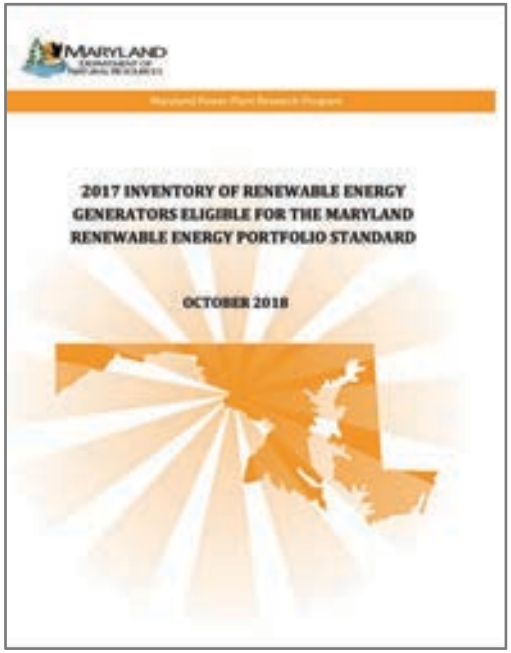
Basic Approach

- For each renewable technology, region, and scenario…



Projections of Annual Capacity Additions

- Primary Resource: PPRP's 2017 Inventory of Renewable Energy (PV)
- Other resources: PPRP's 2016 Long-Term Electricity Report (Wind), NREL, EIA



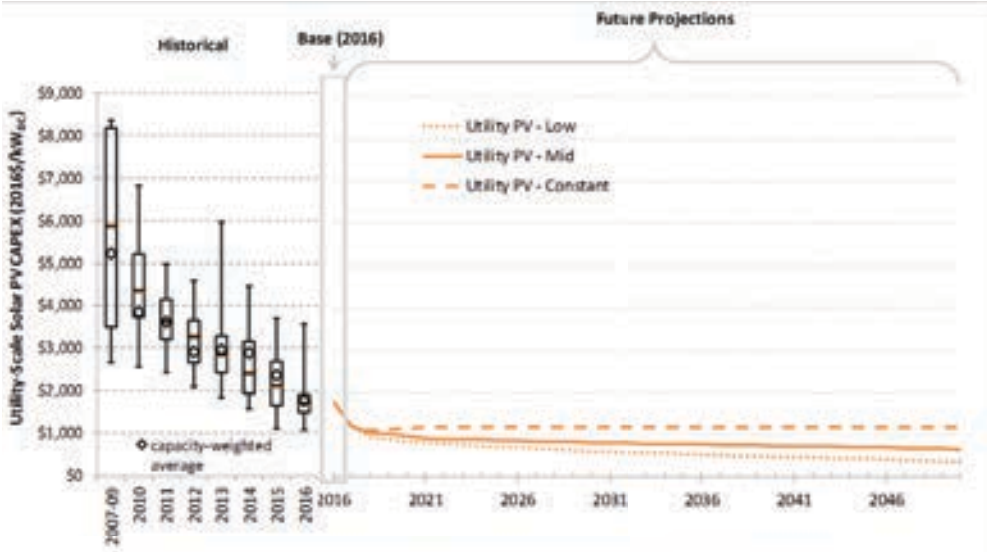
Sample Capacity Projections

Year	Total Solar
2018	1,066
2019	1,158
2020	1,249
2021	1,436
2022	1,652
2023	1,899
2024	2,184
2025	2,512
2026	2,889
2027	3,322
2028	3,820
2029	4,393
2030	5,053

Estimated Capacity of Total Solar Projects in Maryland (2018-2030) (MW)

Derivation of Overnight Capital and O&M Costs

- Primary Resource: NREL's 2018 Annual Technology Baseline (PV, Wind)
  - Each year, NREL provides a robust set of modeling input assumptions for energy technologies to help inform electric sector analyses in the U.S.
  - For example, NREL's cost projections for utility-scale PV are based on 15 short-term projections (from nine institutions) made in the last year and four long-term projections made in the last four years.



CAPEX historical trends, current estimates, and future projection for utility PV (DC)
Source: National Renewable Energy Laboratory Annual Technology Baseline (2018), http://atb.nrel.gov

Note that PPRP intends to use NREL's OCC projections, which exclude construction period financing and grid connection costs, and are therefore slightly lower than NREL's CAPEX Projections.

Apportioning Overnight Capital Costs to IMPLAN Final Demand

- Resources: NREL's U.S. Solar Photovoltaic System Cost Benchmark Q1 2017 (PV), 2016 Cost of Wind Energy Review, EIA's Capital Cost Estimates for Utility Scale Electricity Generation Plants, NAICS, others

Q1 2017 U.S. benchmark utility-scale PV total cost (EPC + developer), 2017 $/$W_{dc}$

Source: NREL 2017, Figure 28, p. 39

Apportioning Overnight Capital Costs (Cont'd)

- Translate cost categories to IMPLAN final demand sectors

Installation Cost Category	2012 NAICS Code		IMPLAN Sector	IMPLAN Sector Description
Module (25.5%)	334413	NAICS to IMPLAN Mapping	309	Semiconductor and related device manufacturing
Inverter (4.4%)	334311		332	Power, distribution, and specialty transformer manufacturing
Structural BOS (13.1%)	332312		238	Fabricated structural metal manufacturing
Electrical BOS (12.4%)	335925		339	Other communication and energy wire manufacturing
Install labor & equipment (11.7%)	237130		54	Construction of new power and communication structures
EPC overhead (8.8%)	5413		449	Architectural & Engineering Services
Sales tax (3.6%)				*
Permitting fee, land acquisition, interconnection, transmission (5.8%)	5411		447	Legal Services
Developer overhead (6.6%)	5413		449	Architectural & Engineering Services
Contingency (3.0%)				**
EPC/Developer net profit (5.1%)	237130		54	Construction of new power and communication structures

Source: NREL 2017, Figure 28, p. 39.

* Allocated to IMPLAN PV and BOS hardware sectors

**Allocated across all IMPLAN sectors

Apportioning Overnight Capital Costs (Cont'd)

- PPRP benchmarked four prior studies to see how OCC's have been allocated to IMPLAN final demand categories

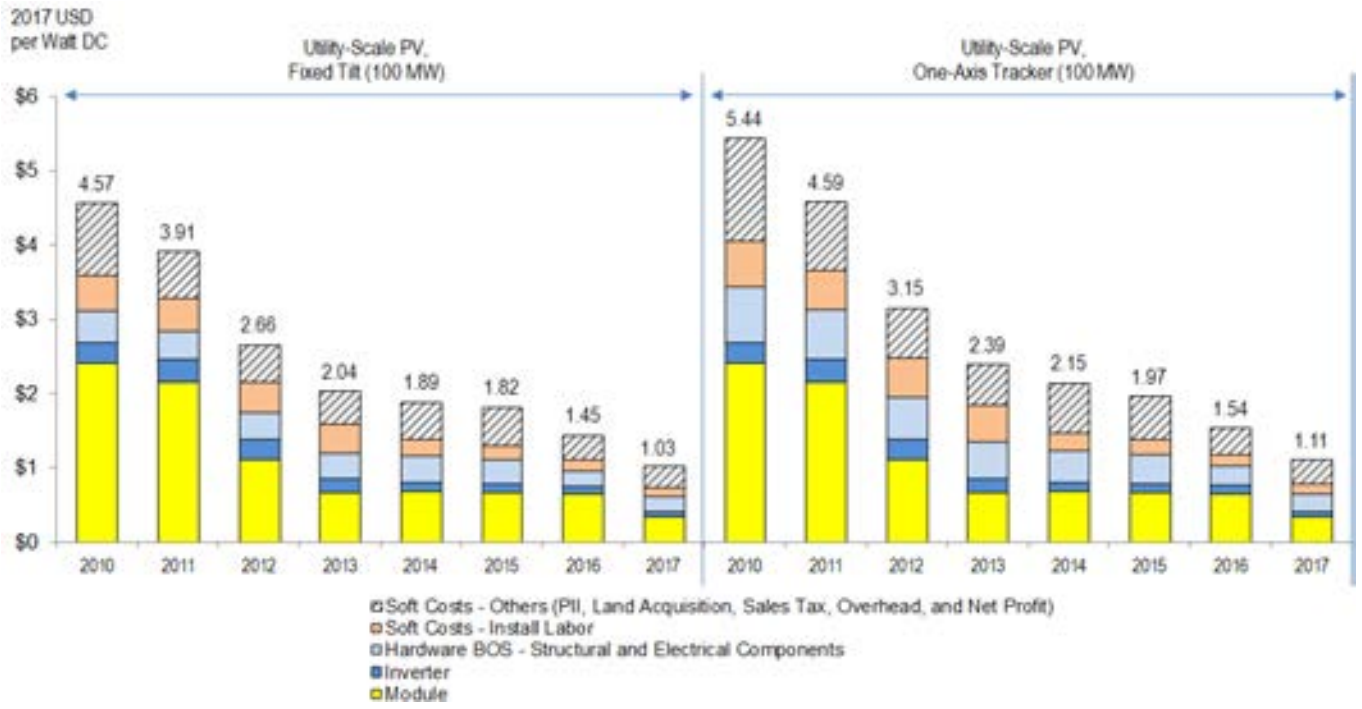
IMPLAN 536	IMPLAN 22	Burton et al	JEDI	EIA	NREL
Construction of new power and communication structures	Construction/installations - Non-residential	9%	8%	9%	17%
Total Construction		**9%**	**8%**	**9%**	**17%**
Semiconductor and related device manufacturing	Semiconductor manufacturing	55%	34%	47%	28%
Power, distribution & specialty transformer manufacturing	Electrical equipment		5%		5%
Fabricated structural metal manufacturing	Fabricated metals		5%		14%
Other communication and energy wire manufacturing	Energy wire manufacturing		1%	16%	14%
Total Manufacturing		**55%**	**46%**	**62%**	**61%**
Management of Companies & Enterprises		4%			
Architectural & Engineering Services	Architectural & engineering services		0.4%	4%	16%
Computer System Design Services		22%			
Legal Services				17%	6%
Banking		10%		8%	
	Office services		23%		
	Other services		23%		
	Government		0.1%		
Total Services		**36%**	**46%**	**29%**	**22%**
Total		**100%**	**100%**	**100%**	**100%**

Other Considerations

- Local/Non-local Final Demand
  - Several industries in renewable supply chain have no presence in Maryland or other states in study
    - Manufacturing
      - Solar PV
        - » Solar panel manufacturing
        - » Inverters
        - » Cabling
        - » Racking
      - Offshore wind
        - » Port facilities
        - » Ocean construction trades
  - Final demand entries set to zero for out-of-state industries (JEDI)
  - Use industry publications and County Business Patterns data

Other Considerations (Cont'd)

- Allocating Capital and O&M cost reductions
  - OCC for UPV Solar projected to decline from $1,196/kW in 2017 to $861/kW in 2025 (NREL 2018 Annual Technology Baseline)
  - Historically, cost savings not distributed evenly among cost categories



Other Considerations (Cont'd)

- NREL
  - Distribution of cost reductions between 2010 & 2017
    - 64% hardware
    - 11% labor
    - 25% soft costs
- PPRP applied these proportions to PV capital costs for calculating changes to final demand by industry
  - Assumes distribution of cost reductions over forecast period will be similar to historical trends

Other Considerations (Cont'd)

- Validation
  - Need to make sure results make sense
  - Comparison made difficult
    - Time-series vs. single event/year
    - Multiple states vs. single region
    - "Black box" models
      - Structural differences
      - Data
      - Assumptions
  - Approach
    - JEDI
    - Consistency with published studies

Prototyping the Analysis

- Utility-scale PV Solar
  - Incremental capacity additions
- Reference scenario
  - Maryland
  - 2018-2025
  - Projections exceed current RPS
- Capital + O&M

Overnight Capital Costs

Utility-scale Solar PV			
Year	2017	2018	2025
Total Generation Capacity (MWdc)	975	1066	2512
(Source: RPS Inventory 8-20-18 Table V-2)			
Year to Year Growth Rate		9%	15%
Total Generation Capacity > 2MWdc	316	345	814
Incremental capacity addition (MW)		29	106
Overnight capital costs (2016$/kW)	$1,196	$1,050	$861
Overnight capital costs (2016$)	$135,092,891	$30,974,841	$91,518,186

IMPLAN Description	NREL	NAICS 2012	IMPLAN 536	Local	Distribution of Cost Reductions	
Construction of new power and communication structures	17%	237130	54	Y	11%	Construction
Semiconductor and related device manufacturing	28%	334413	309	N	64%	Manufacturing
Power, distribution & specialty transformer manufacturing	5%	335311	332	N	25%	Services
Fabricated structural metal manufacturing	14%	332312	238	Y		
Other communication and energy wire manufacturing	14%	335929	339	N		
Architectural & Engineering Services	16%	5413	449	Y		
Legal Services	6%	5411	447	Y		

Final Demand by Industry in Maryland

- Total

IMPLAN Description	IMPLAN 536	2018	2020	2025
Construction of new power and communication structures	54	$ 5,626,204	$ 4,961,555	$ 15,894,554
Semiconductor and related device manufacturing	309	$ 8,626,415	$ 7,842,950	$ 25,652,752
Power, distribution & specialty transformer manufacturing	332	$ 1,478,814	$ 1,344,506	$ 4,397,615
Fabricated structural metal manufacturing	238	$ 4,436,442	$ 4,033,517	$ 13,192,844
Other communication and energy wire manufacturing	339	$ 4,189,973	$ 3,809,433	$ 12,459,908
Architectural & Engineering Services	449	$ 4,791,615	$ 4,388,801	$ 14,425,200
Legal Services	447	$ 1,825,377	$ 1,671,924	$ 5,495,314

- Maryland

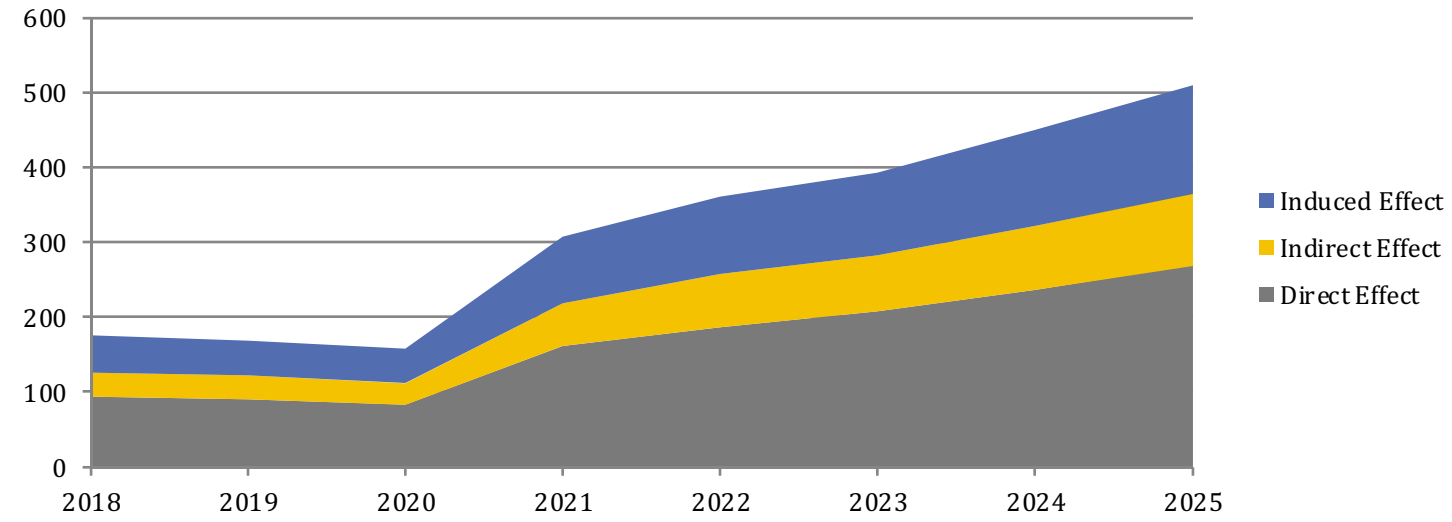
IMPLAN Description	IMPLAN 536	2018	2020	2025
Construction of new power and communication structures	54	$ 5,626,204	$ 4,961,555	$ 15,894,554
Semiconductor and related device manufacturing	309	$ -	$ -	$ -
Power, distribution & specialty transformer manufacturing	332	$ -	$ -	$ -
Fabricated structural metal manufacturing	238	$ 4,436,442	$ 4,033,517	$ 13,192,844
Other communication and energy wire manufacturing	339	$ -	$ -	$ -
Architectural & Engineering Services	449	$ 4,791,615	$ 4,388,801	$ 14,425,200
Legal Services	447	$ 1,825,377	$ 1,671,924	$ 5,495,314

IMPLAN Output

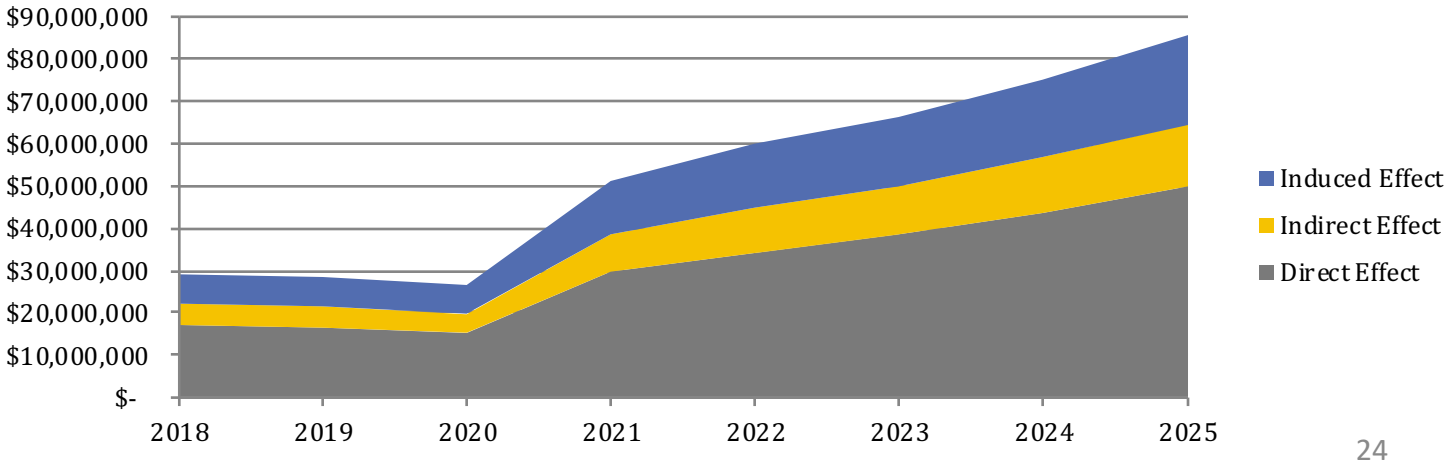
Year		2018	2020	2025
Employment (FTE)				
Direct Effect		94	83	271
Indirect Effect		32	29	96
Induced Effect		49	44	144
Total Effect		176	157	511
Labor Income (2016$)				
Direct Effect	$	7,168,502	$ 6,439,330	$ 20,958,642
Indirect Effect	$	2,051,486	$ 1,859,668	$ 6,070,671
Induced Effect	$	2,452,759	$ 2,207,906	$ 7,191,309
Total Effect	$	11,672,746	$ 10,506,904	$ 34,220,622
Total Value Added (2016$)				
Direct Effect	$	9,191,582	$ 8,246,658	$ 26,823,699
Indirect Effect	$	3,045,926	$ 2,759,338	$ 9,003,641
Induced Effect	$	4,405,434	$ 3,965,633	$ 12,916,324
Total Effect	$	16,642,942	$ 14,971,629	$ 48,743,663
Output (2016$)				
Direct Effect	$	16,989,998	$ 15,335,811	$ 49,919,095
Indirect Effect	$	4,973,855	$ 4,504,477	$ 14,694,946
Induced Effect	$	7,183,241	$ 6,466,153	$ 21,060,725
Total Effect	$	29,147,094	$ 26,306,441	$ 85,674,765

UPV Construction Impact in Maryland

- Jobs (FTE)



- Output



Top 10 Industries Affected by UPV Construction in 2025

Sector	Description	Employment	Labor Income	Value Added	Output
54	Construction of new power and communication structures	120.4	$7,291,030	$9,893,093	$15,894,554
449	Architectural, engineering, and related services	89.0	$8,986,206	$8,980,365	$15,926,321
238	Fabricated structural metal manufacturing	41.3	$2,907,998	$4,287,339	$13,242,234
447	Legal services	31.0	$2,562,061	$4,527,798	$5,927,023
440	Real estate	11.2	$391,163	$2,080,179	$2,726,780
464	Employment services	10.7	$510,967	$789,378	$995,069
501	Full-service restaurants	10.4	$258,611	$305,359	$548,008
395	Wholesale trade	9.2	$781,031	$1,476,289	$2,216,786
502	Limited-service restaurants	9.1	$194,279	$492,067	$819,072
482	Hospitals	7.6	$572,278	$688,335	$1,195,212

Utility-scale PV O&M

Year	2017	2018	2025
Total Generation Capacity (MWdc)	975	1066	2512
(Source: RPS Inventory 8-20-18 Table V-2)			
Year to Year Growth Rate		9%	15%
Total Generation Capacity > 100 kwdc	486	531	1252
Total Generation Capacity > 2MWdc	316	345	814
Incremental capacity addition (MW)	113	29	106
Cumulative capacity after 2017 (MWdc)		29	498
Annual fixed O&M expenses (2016$/kWdc)		$ 9	$ 7
Cumulative annual fixed O&M expenses		$ 265,440	$ 3,487,019

IMPLAN Description	NREL	NAICS 2012	IMPLAN 536	Local
Office & administrative services	5%	5611	462	Y
Services to buildings	16%	56171-2, 56174-9	468	Y
Landscape and horticultural services	10%	56173	469	Y
Commercial and industrial machinery and equipment repair	53%	8113	507	Y
Architectural & Engineering Services	16%	5413	449	Y

O&M Final Demand in Maryland

IMPLAN Description	IMPLAN 536	2018	2020	2025
Office & administrative services	462	$ 13,272	$ 35,522	$ 174,351
Services to buildings	468	$ 42,470	$ 113,669	$ 557,923
Landscape and horticultural services	469	$ 26,544	$ 71,043	$ 348,702
Commercial and industrial machinery and equipment repair	507	$ 140,683	$ 376,529	$ 1,848,120
Architectural & Engineering Services	449	$ 42,470	$ 113,669	$ 557,923

UPV O&M Impact in Maryland

Year	2018	2020	2025
Employment (FTE)			
Direct Effect	3	7	35
Indirect Effect	0	1	5
Induced Effect	1	2	12
Total Effect	4	11	52
Labor Income (2016$)			
Direct Effect	$ 137,576	$ 368,214	$ 1,807,306
Indirect Effect	$ 24,500	$ 65,573	$ 321,853
Induced Effect	$ 43,116	$ 115,398	$ 566,411
Total Effect	$ 205,192	$ 549,185	$ 2,695,569
Total Value Added (2016$)			
Direct Effect	$ 181,231	$ 485,055	$ 2,380,798
Indirect Effect	$ 38,885	$ 104,074	$ 510,828
Induced Effect	$ 77,441	$ 207,268	$ 1,017,334
Total Effect	$ 297,558	$ 796,397	$ 3,908,960
Output (2016$)			
Direct Effect	$ 265,439	$ 710,432	$ 3,487,019
Indirect Effect	$ 61,596	$ 164,858	$ 809,173
Induced Effect	$ 126,440	$ 338,410	$ 1,661,023
Total Effect	$ 453,475	$ 1,213,700	$ 5,957,215

Top 10 Industries Affected by UPV O&M in 2025

Sector	Description	Employment	Labor Income	Value Added	Output
468	Services to buildings	13.2	$322,486	$368,205	$575,246
507	Commercial and industrial machinery and equipment repair and maintenance	11.9	$863,114	$1,342,321	$1,858,236
469	Landscape and horticultural services	5.5	$198,663	$241,303	$358,927
449	Architectural, engineering, and related services	3.4	$341,954	$341,732	$606,078
462	Office administrative services	2.1	$141,486	$153,996	$191,954
440	Real estate	0.9	$32,876	$174,830	$229,174
501	Full-service restaurants	0.8	$18,812	$22,212	$39,863
502	Limited-service restaurants	0.7	$14,865	$37,650	$62,670
464	Employment services	0.6	$30,266	$46,757	$58,941
482	Hospitals	0.6	$45,638	$54,894	$95,317

Summary

- Preliminary results
- Validation
  - JEDI
  - Daymark
- Comparable?
- JEDI
  - Year 2025 construction impact comparison
    - Output $87.1m (JEDI) vs. $85.7m (PPRP)
    - Jobs 636 vs. 511
- Daymark
  - 2.4GW incremental solar (2019-28)
    - Significant differences in all metrics
      - OCC allocation to Maryland

PPRP Work Plan

- IMPLAN Purchase and Training
- Literature Review
- Determination of Data Sources
- Reference Case Modeling
- Review of RC Inputs and Results
- Scenarios Development
- Scenario Modeling
- Documentation

Questions for Discussion

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IMPLAN vs. JEDI

- JEDI is a user-friendly spreadsheet model with simplified inputs and default data
- Translates capital cost + annual O&M expenditures into local purchases by industry sector (direct impact)
  - IMPLAN multipliers translate change in final demand into direct, indirect and induced impacts
- Input: User-entered, project-specific data or default inputs (based on interviews with industry experts and project developers)
  - Construction, Equipment, Annual O&M
  - Other (financial, engineering, etc.)

IMPLAN vs. JEDI (Cont'd)

- Output: Local area jobs & economic impacts
  - Project Development and Onsite Labor Impacts
  - Local Revenue and Supply Chain Impacts
  - Induced Impacts
- Can override default data by entering own cost and regional multipliers
- Produces summary results of local economic impact

Limitations of JEDI

- JEDI has three major limitations:
  1. Sector aggregation
     - 21 for most renewables; 22 for solar PV
     - We need more sector detail to address RFP requirements, i.e., what industries might grow as a result of incentives associated with the RPS
  2. Multiplier (IMPLAN-based) from 2012
  3. Some allocations of capital cost to final demand arbitrary