

Economic and Employment Impacts of Small Modular Nuclear Reactors

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Purpose of Study

- What are the potential impacts of the manufacture, construction, and operation of SMRs in the U.S. through 2030?
- What impacts might domestic manufacture of SMRs have on the U.S. economy under given scenarios?
- Study period was November 2009 – April 2010
 - Data from external organization models are from 2009; IMPLAN is 2007
- Study team consisted of nine university researchers from Boise State University, the University of Idaho, Idaho State University, and the University of New Mexico
 - Draft study and models reviewed by national lab and NEI

Why Study SMRs?

- Budgetary support from the Department of Energy and leadership support from Secretary Chu
 - Creation of Office of Advanced Reactor Concepts
- Potential game changer for nuclear industry and for addressing climate change
- Potential for U.S. manufacture
- Worldwide interest and dozens of competing designs

Potential SMR Advantages

- Suitability to meet the demand requirements for smaller “off grid” energy markets
- Scalability to meet the increasing demand of developing energy markets
- Low “overnight” capital costs relative to gigawatt scale nuclear facilities
- Incremental cost benefits realized from modular factory construction of reactor and turbine components
- Transportation of unit to site results in reduced construction times
- Potentially longer refueling intervals
- Placement of the reactor vessel underground to improve security from terrorist and proliferation threats
- Incorporating off-site refueling and off-site spent fuel storage for use in undeveloped regions
- Incorporating inherent and passive safety features

Summary Finding

- A “generic” 100 MW SMR costing \$500 million to manufacture and install on-site is estimated to create nearly 7,000 jobs and generate \$1.3 billion in sales, \$627 million in value-added, \$404 million in earnings (payroll), and \$35 million in indirect business taxes.
- The annual operation of each 100 MW SMR unit is estimated to create about 375 jobs and generate \$107 million in sales, \$68 million in value-added, \$27 million in earnings (payroll), and \$9 million in indirect business taxes.

Study Design

- National-level study dependent upon size of overall nuclear market
 - Does not examine specific manufacturing locations nor specific generation sites
- Utilizes 100 MWe ‘typical’ or ‘generic’ SMR so as not to privilege specific designs or reactor types
- Simplicity for model and assumptions was stressed if adding complexity did not add to explanatory power

Study Design cont'

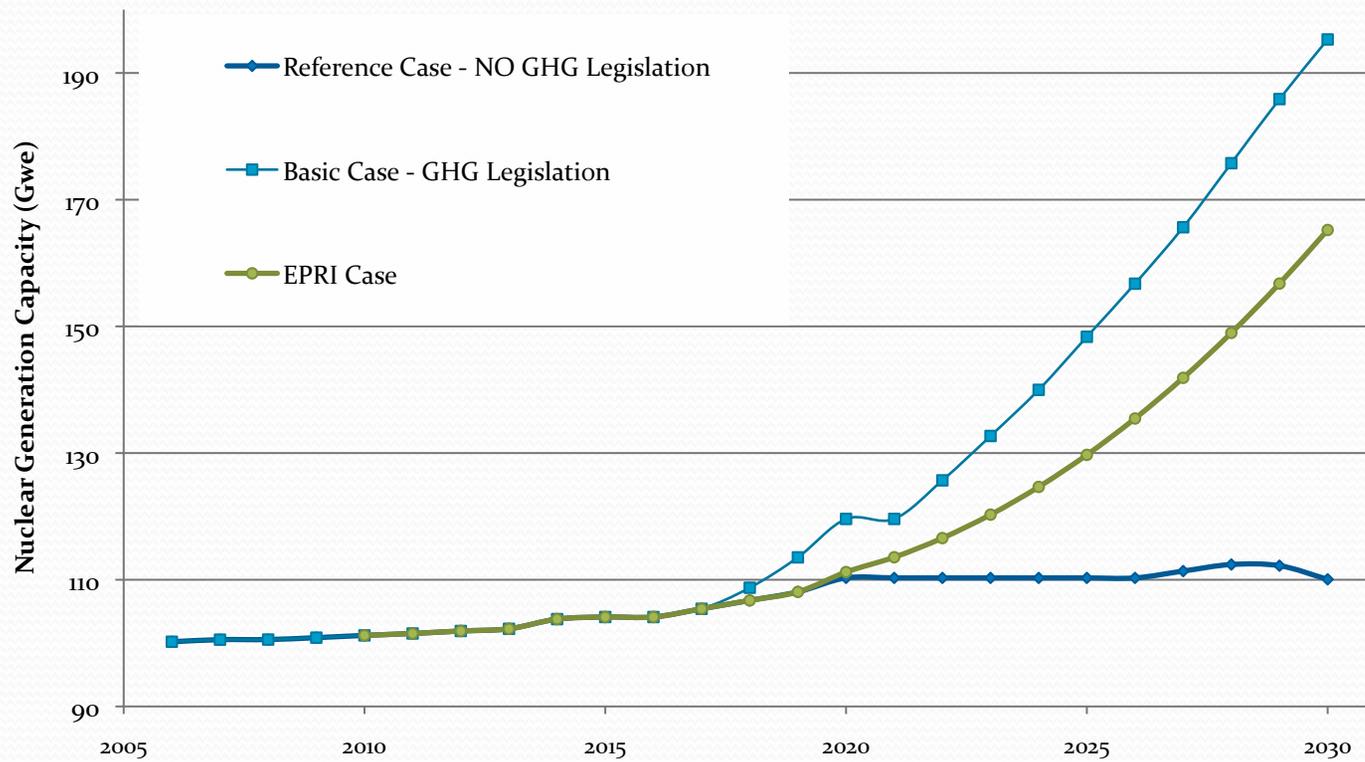
- Utilized four scenarios that include domestic and international markets for electricity generation, with specified market share of total nuclear market for SMRs
 - Input-Output Analysis and IMPLAN modeling software provides economic impacts
 - Report includes all assumptions and data, so study can be verified or customized by vendors, policy makers, or stakeholders using IMPLAN

Four Scenarios

- High Nuclear Adoption – strong greenhouse gas case
 - EIA’s analysis of HR 2454 (Waxman-Markey)
 - *IAEA Energy, Electricity, and Nuclear Power Estimates for the period up to 2030 (2009 Edition)*; IAEA High Case
- Moderate Nuclear Adoption – EPRI’s *The Power to Reduce CO₂ Emissions 2009 PRISM Analysis*
 - IAEA High Case
- Low Nuclear Adoption – Business As Usual or No Greenhouse Gas legislation
 - EIA Updated 2009 Annual Energy Outlook with ARRA (stimulus)
 - EIA International Energy Outlook 2009 Reference Case
- Disruptive Nuclear Adoption– “What-if?!” High Case with very high market share for SMRs versus traditional plants

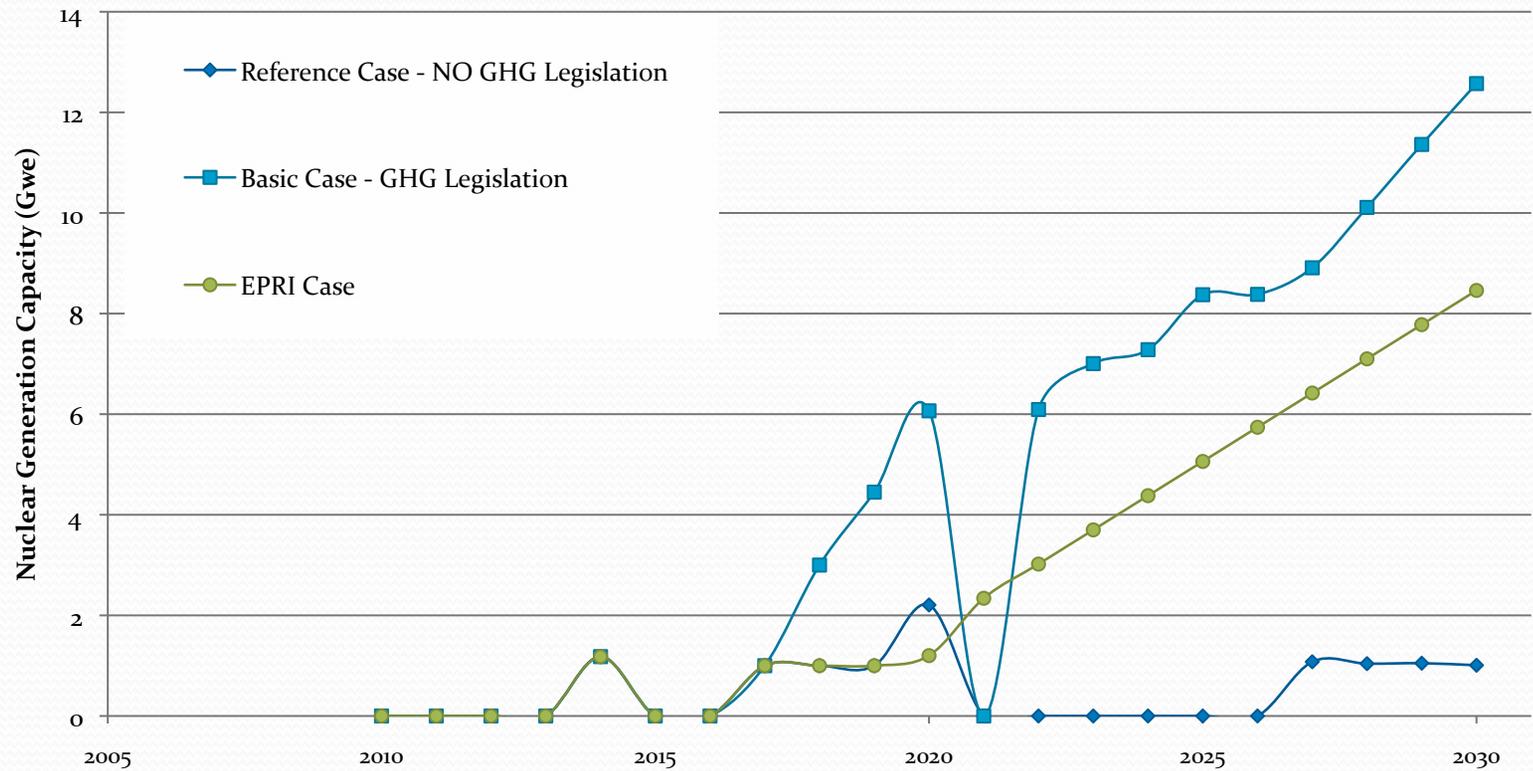
Projected Domestic Nuclear Capacity (Total)

Projected Domestic Nuclear Capacity (Total)



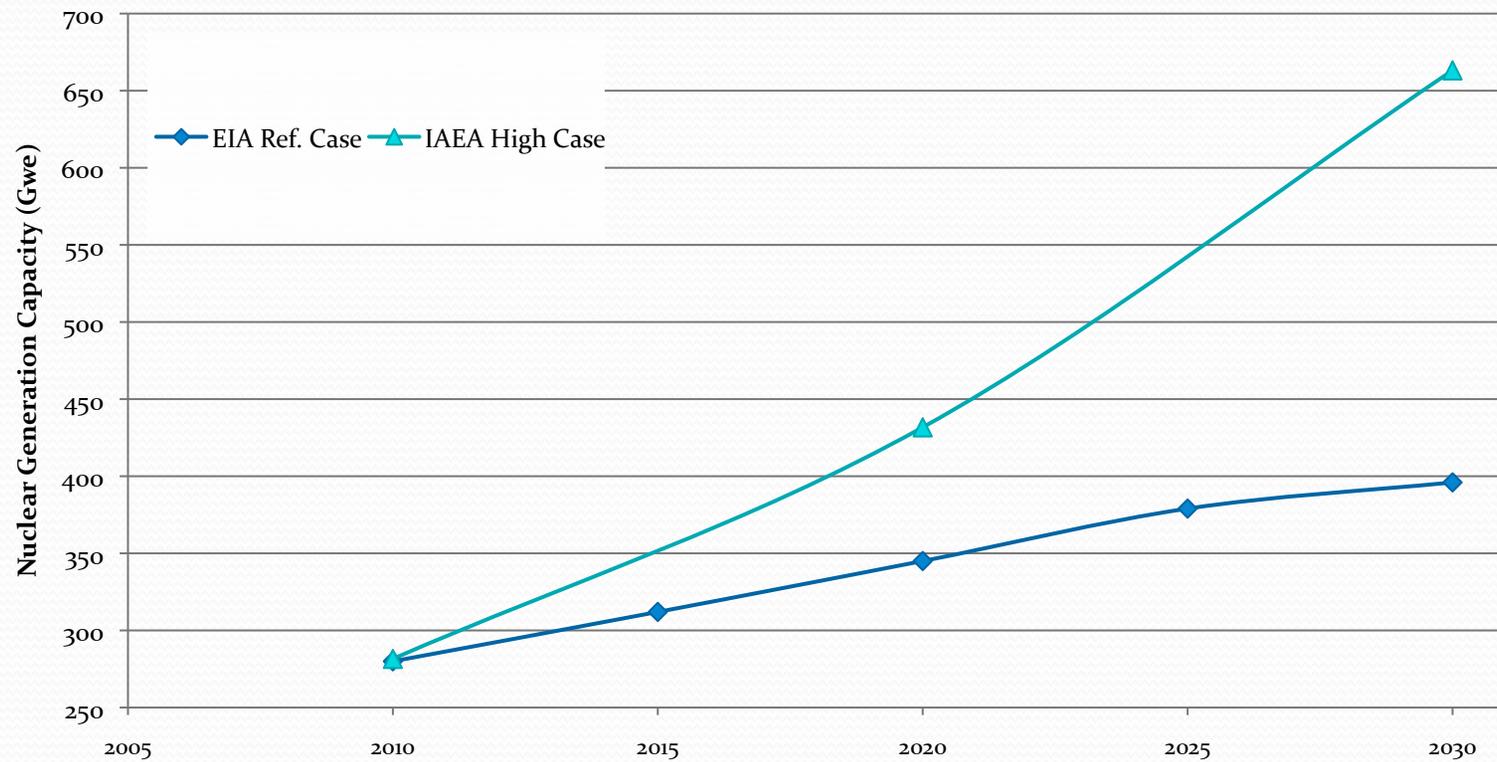
Projected Domestic Nuclear Capacity Additions

EIA's zero-added capacity in 2021 indicates expiration of production tax credit*



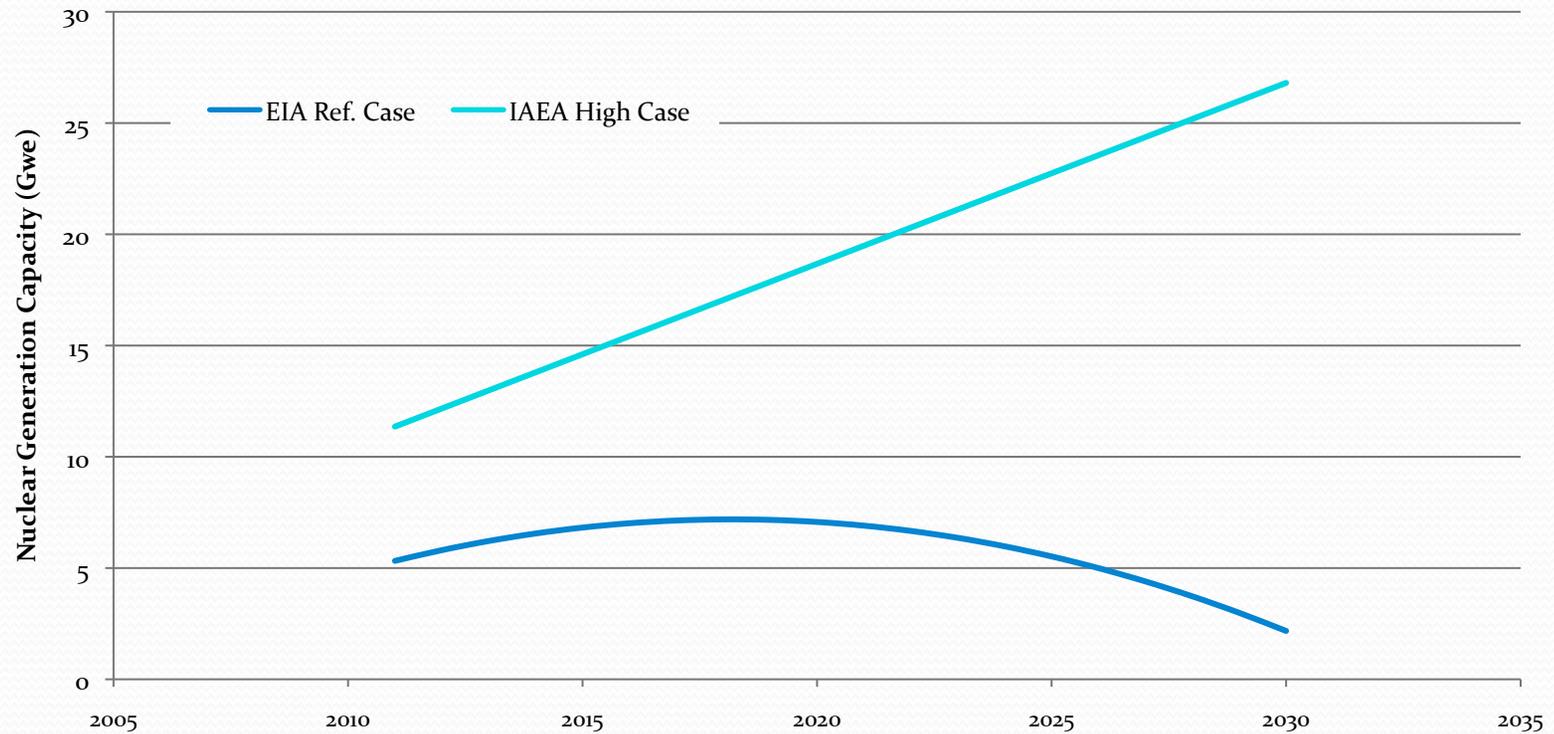
Projected International Nuclear Capacity (Total)

Projected International Nuclear Capacity (Total)



Potential International Capacity Additions

Projected International Nuclear Capacity Additions

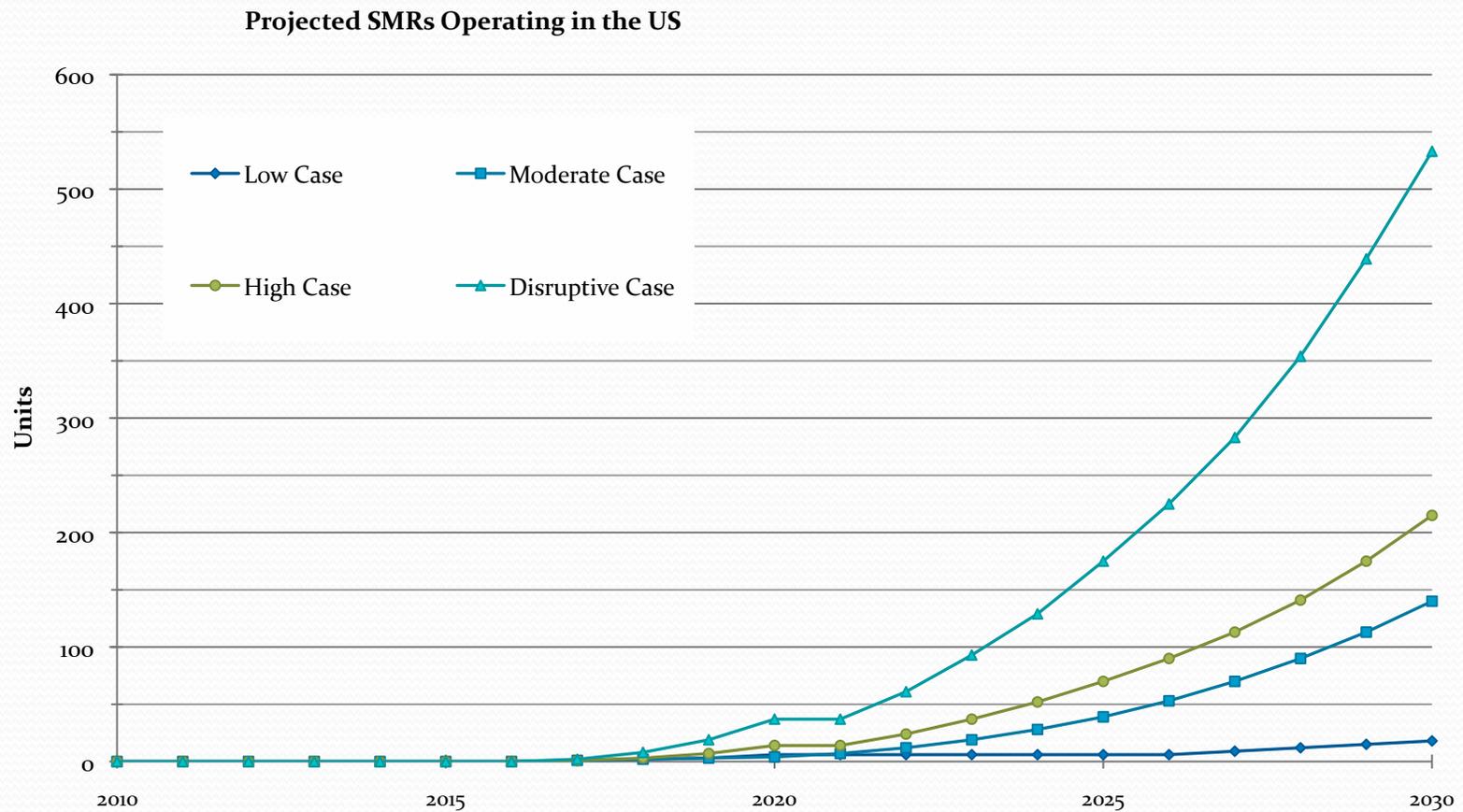


Market Share Assumptions

| SMR Market Share Scenario | 2015 | 2020 | 2025 | 2030 |
|---------------------------|------|------|------|------|
| Moderate Deployment | 2% | 12% | 22% | 32% |
| Disruptive Technology | 5% | 30% | 55% | 75% |

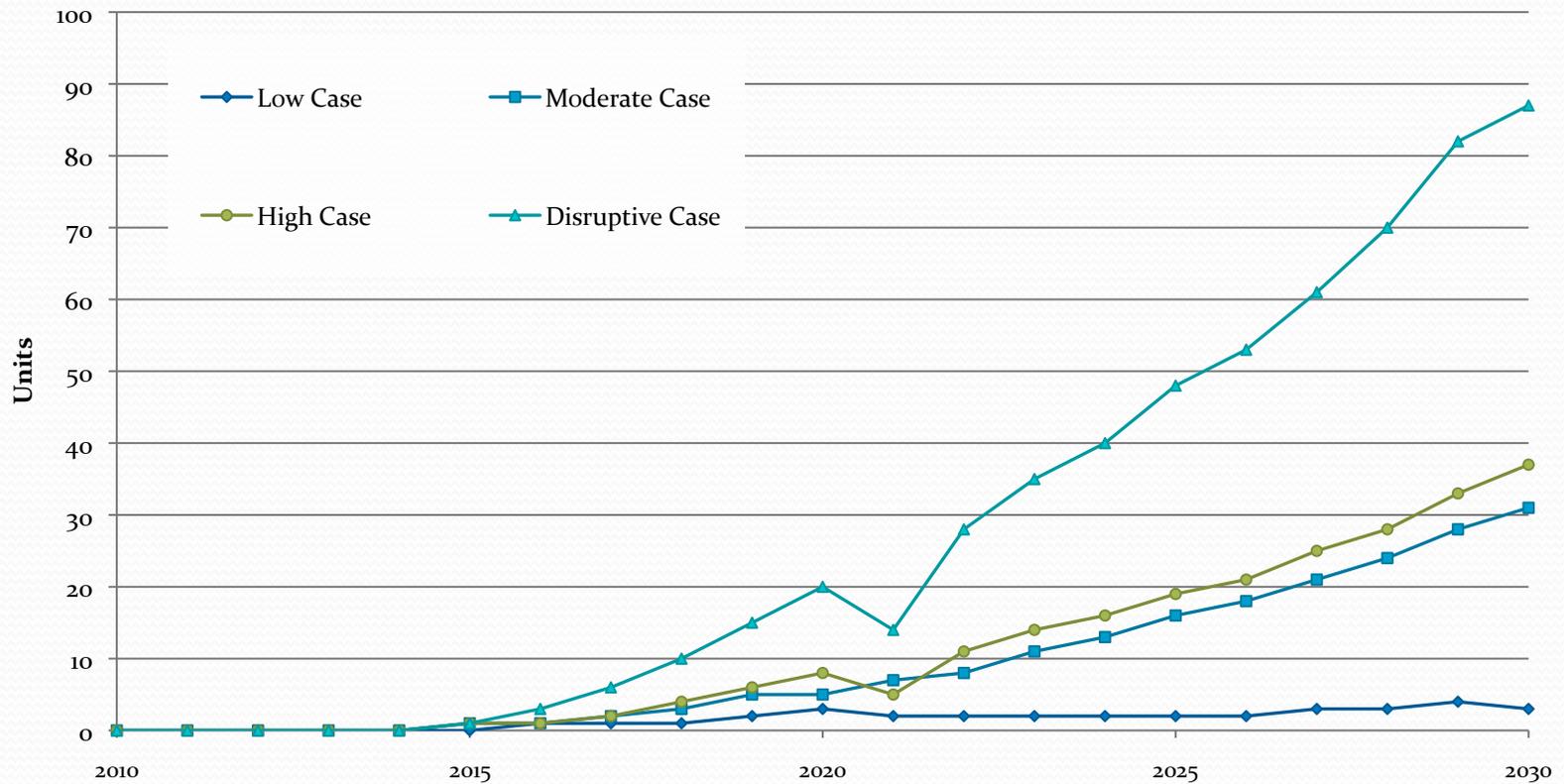
| SMR Economic Impact Case | Added Nuclear Capacity Scenario | SMR Market Share of Added Nuclear Capacity | SMR Market Share for U.S. Manufacturers |
|--------------------------|---------------------------------|--|---|
| Low | Low Adoption | Moderate SMR Deployment (32% by 2030) | 50% of Domestic, 20% of Int. |
| Moderate | Moderate Adoption | Moderate SMR Deployment (32% by 2030) | 50% of Domestic, 20% of Int. |
| High | High Adoption | Moderate SMR Deployment (32% by 2030) | 50% of Domestic, 20% of Int. |
| Disruptive | High Adoption | Disruptive Technology (75% by 2030) | 50% of Domestic, 20% of Int. |

Projected SMRs Operating in U.S.



Projected SMRs Manufactured Per Year in U.S.

Projected SMRs Manufactured in the U.S.



Economic Impacts - Input-Output (I-O) Analysis

- Study utilizes standard techniques collectively known as Input-Output Analysis
 - Industries are closely linked and activity in one industry ripples across other sectors, generating direct and indirect impacts
 - Direct examples – Employment and salaries in industry itself
 - Indirect examples – Purchase of inputs from other industries
 - Induced impacts – Direct and indirect dollars re-spent in the economy

I-O Analysis Cont'

- Presence of indirect and induced effects means an initial increase in demand for a given industry's output will have “multiplier” effects across the economy
 - Multipliers determine how the direct change in final demand of a single industry ripples throughout all other industries
 - Study incorporates Type II or Social Accounting Matrix (SAM) multipliers which are larger and broader based
 - Includes indirect and induced effects
- Study utilizes IMPLAN modeling software
 - Flexibility, transparency, and robustness – proven over decades
 - Widely used and study is replicable
 - Provides estimates of production, employment, employee compensation, business, and taxes in over 400 sectors

SMR Model – National in Scope

- Manufacturing and construction in planning and development
- Two IMPLAN models constructed
 - Disaggregated 440 sector model as a benchmark and simpler, aggregated 21 sector model
 - Aggregated model used to present results
 - Economic data is from 2007, and economic impacts are in constant 2007 dollars
 - Avoided forecast of U.S. economy over next 20 years

I-O Sectors for Manufacturing, Construction, and Operations (Sector 31)

| IMPLAN Industry Number | IMPLAN Industry Description |
|------------------------|--|
| 125 | All other basic inorganic chemical manufacturing |
| 133 | Pharmaceutical preparation manufacturing |
| 186 | Plate work and fabricated structural product manufacturing |
| 188 | Power boiler and heat exchanger manufacturing |
| 189 | Metal tank (heavy gauge) manufacturing |
| 198 | Valve and fittings other than plumbing |
| 255 | Irradiation apparatus manufacturing |
| 256 | Watch, clock, and other measuring and controlling device manufacturing |
| 375 | Environmental and other technical consulting services |

| IMPLAN Industry Number | IMPLAN Industry Description |
|------------------------|--|
| 34 | Construct new nonresidential commercial |
| 35 | Construct new nonresidential manufacturing |
| 36 | Construct other new nonresidential structures |
| 39 | Maintenance & repair construct of nonresident structures |

Additional Assumptions for I-O Analysis

- Study team relied on public estimates from vendors for cost of manufacturing and construction
 - \$500 million per prototypical 100 MW SMR (\$3K to \$7K of installed capacity)
 - 87% of total cost in manufacturing
 - 13% in construction and operations
 - Manufactured and constructed within one year
 - Dependent on how many plants constructed each year
- Operations likewise estimated by midrange of vendor claims (.05-.09/kWh)
 - Dependent on cost of electricity, life of plant, and capacity
 - .075/kWh at 90% capacity

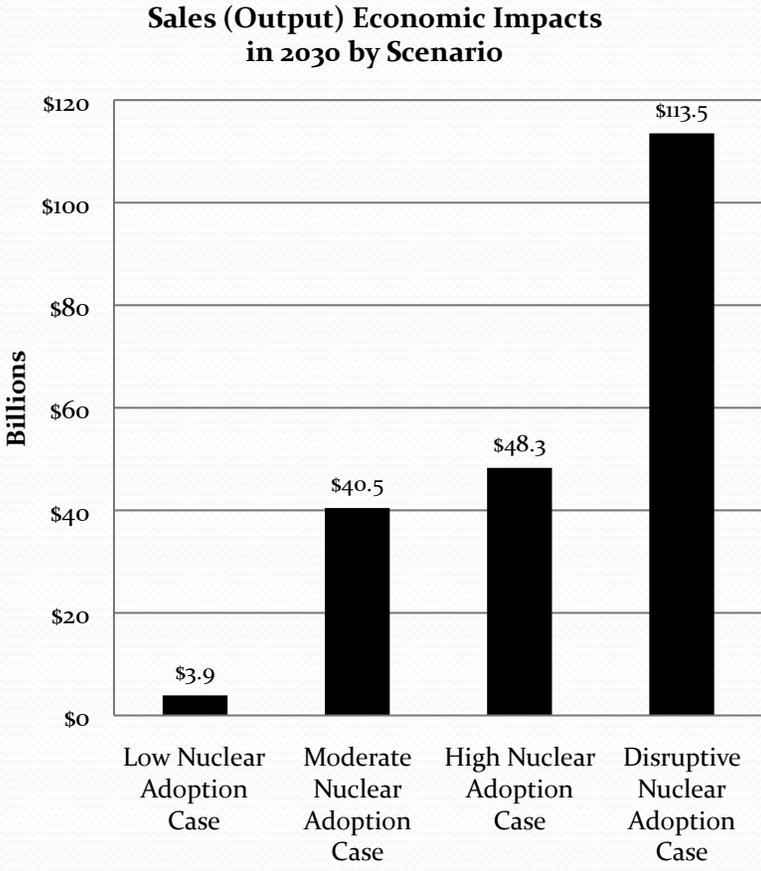
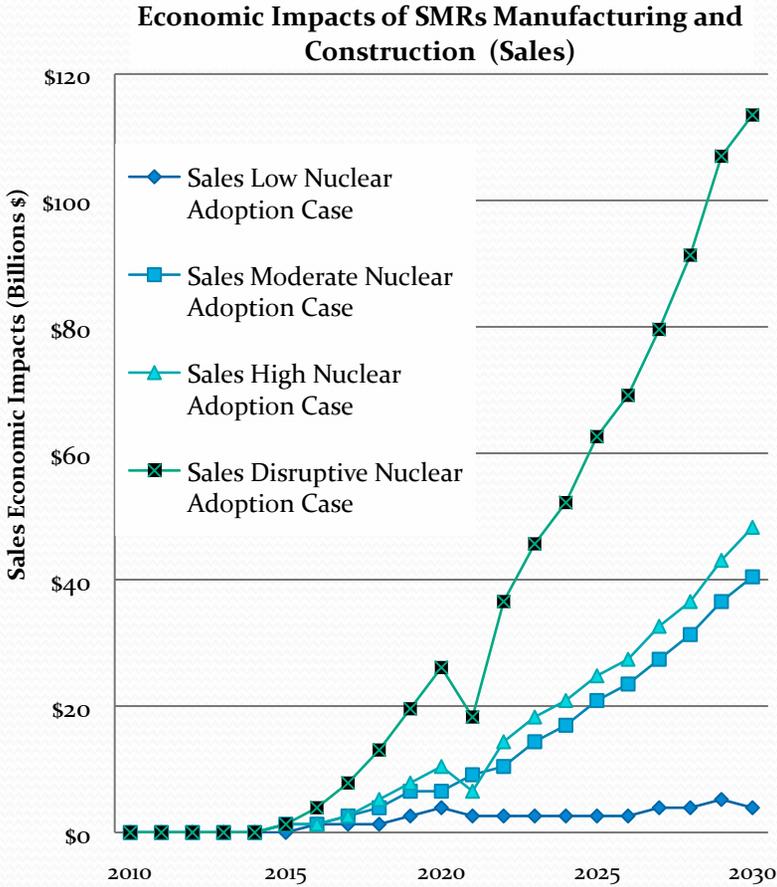
IMPLAN Output Multipliers

| Description | Direct Effects | Indirect Effects | Induced Effects | Total | Type I Multiplier | Type II (SAM) Multiplier |
|-----------------------------------|----------------|------------------|-----------------|----------|-------------------|--------------------------|
| Production Agriculture | 1.000000 | 0.996176 | 0.524671 | 2.520847 | 1.996176 | 2.520847 |
| Ag, Forestry, Fish & Hunting | 1.000000 | 0.443921 | 0.718608 | 2.162529 | 1.443921 | 2.162529 |
| Mining | 1.000000 | 0.654963 | 0.596948 | 2.251911 | 1.654963 | 2.251911 |
| Nuclear Power Generation | 1.000000 | 0.376339 | 0.435090 | 1.811429 | 1.376339 | 1.811429 |
| Utilities | 1.000000 | 0.746149 | 0.514559 | 2.260708 | 1.746149 | 2.260708 |
| SMR Construction | 1.000000 | 0.787949 | 0.885841 | 2.673790 | 1.787949 | 2.673790 |
| Construction | 1.000000 | 0.918940 | 0.722067 | 2.641007 | 1.918940 | 2.641007 |
| Food Processing | 1.000000 | 1.425418 | 0.612926 | 3.038344 | 2.425418 | 3.038344 |
| Manufacturing | 1.000000 | 1.019005 | 0.645757 | 2.664762 | 2.019005 | 2.664762 |
| SMR Manufacturing | 1.000000 | 0.872598 | 0.727505 | 2.600104 | 1.872598 | 2.600104 |
| Retail trade/Wholesale Trade | 1.000000 | 0.494960 | 0.766249 | 2.261208 | 1.494960 | 2.261208 |
| Transportation & Warehousing | 1.000000 | 0.767610 | 0.807901 | 2.575511 | 1.767610 | 2.575511 |
| Information/ Education/Social | 1.000000 | 0.759661 | 0.748092 | 2.507752 | 1.759661 | 2.507752 |
| Real Estate, Finance & insurance | 1.000000 | 0.563218 | 0.495409 | 2.058627 | 1.563218 | 2.058627 |
| Professional/Tech/Scientific/Tech | 1.000000 | 0.589225 | 0.953767 | 2.542991 | 1.589225 | 2.542991 |
| Health & Social Services | 1.000000 | 0.562431 | 0.945108 | 2.507539 | 1.562431 | 2.507539 |
| Arts- Entertainment & Recreation | 1.000000 | 0.584933 | 0.833100 | 2.418033 | 1.584933 | 2.418033 |
| Accommodation & Food Services | 1.000000 | 0.816050 | 0.772855 | 2.588905 | 1.816050 | 2.588905 |
| Other Services | 1.000000 | 0.716444 | 0.827296 | 2.543740 | 1.716444 | 2.543740 |
| Federal Govt. | 1.000000 | 0.073626 | 1.016510 | 2.090136 | 1.073626 | 2.090136 |
| State and Local Govt. | 1.000000 | 0.136605 | 1.106367 | 2.242972 | 1.136605 | 2.242972 |

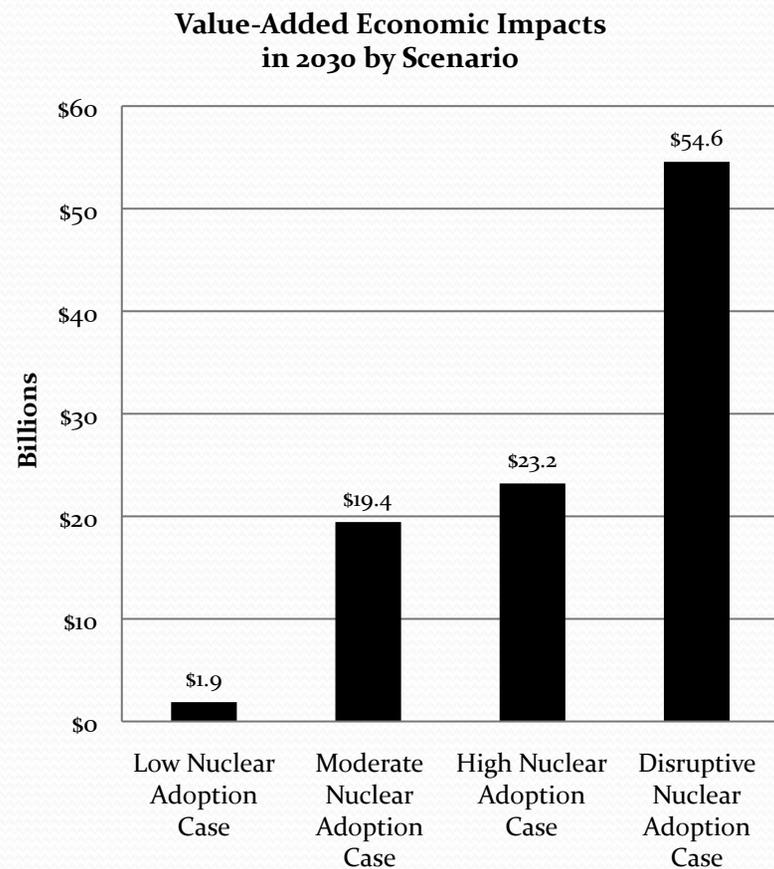
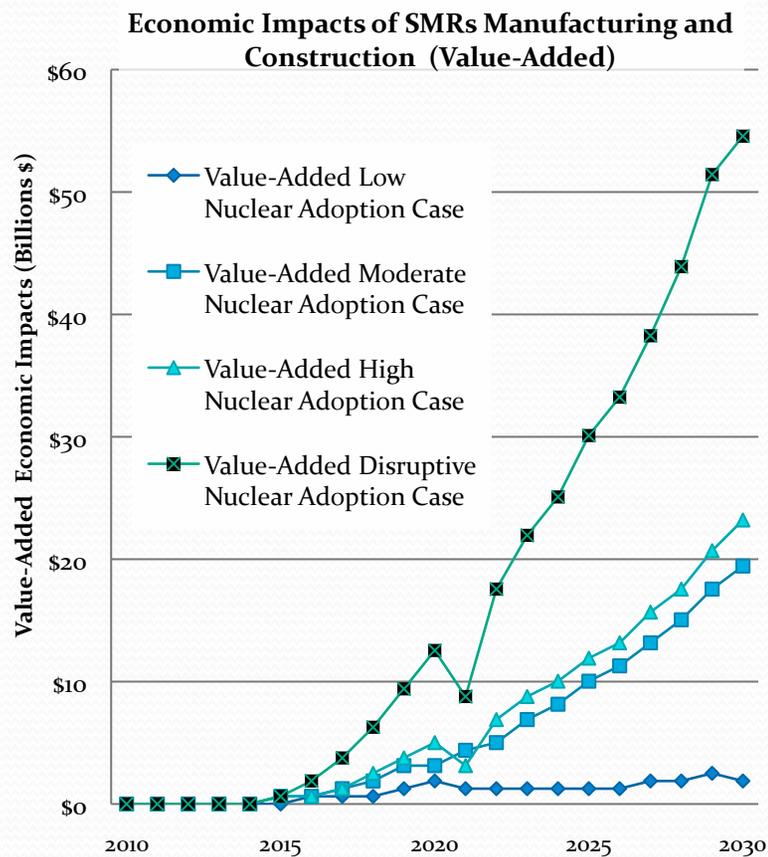
Economic Impacts of a Typical SMR

| | Sales | Value-Added | Earnings (Payroll) | Employment | Indirect Business Taxes |
|-----------------------------|-------------------------|-----------------------|-----------------------|--------------|-------------------------|
| Manufacturing | \$ 1,131,044,963 | \$ 540,660,687 | \$ 342,449,451 | 5,687 | \$ 30,722,980 |
| Construction | \$ 173,796,340 | \$ 86,517,571 | \$ 62,185,369 | 1,238 | \$ 5,030,832 |
| Total SMR Production | \$ 1,304,841,303 | \$ 627,178,258 | \$ 404,634,820 | 6,925 | \$ 35,753,812 |
| Annual Operations | \$ 107,109,777 | \$ 68,299,751 | \$ 27,732,333 | 374 | \$ 9,128,073 |
| Total | \$ 1,411,951,080 | \$ 695,478,009 | \$ 432,367,152 | 7,299 | \$ 44,881,885 |

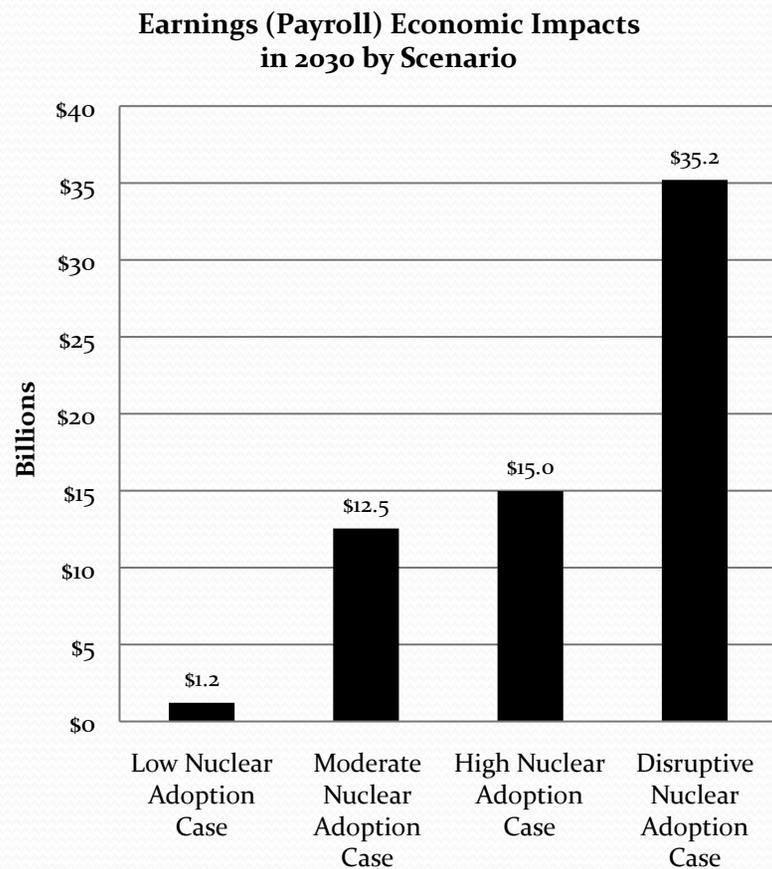
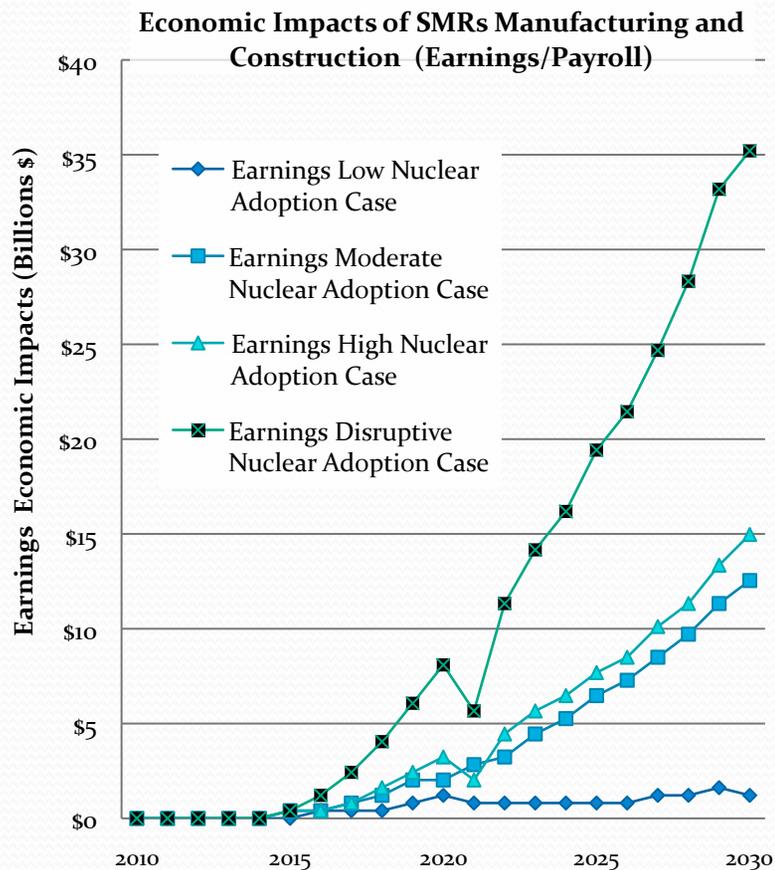
Economic Impacts of SMRs – Manufacturing and Construction (Sales)



Economic Impacts of SMRs – Manufacturing and Construction (Value-added)

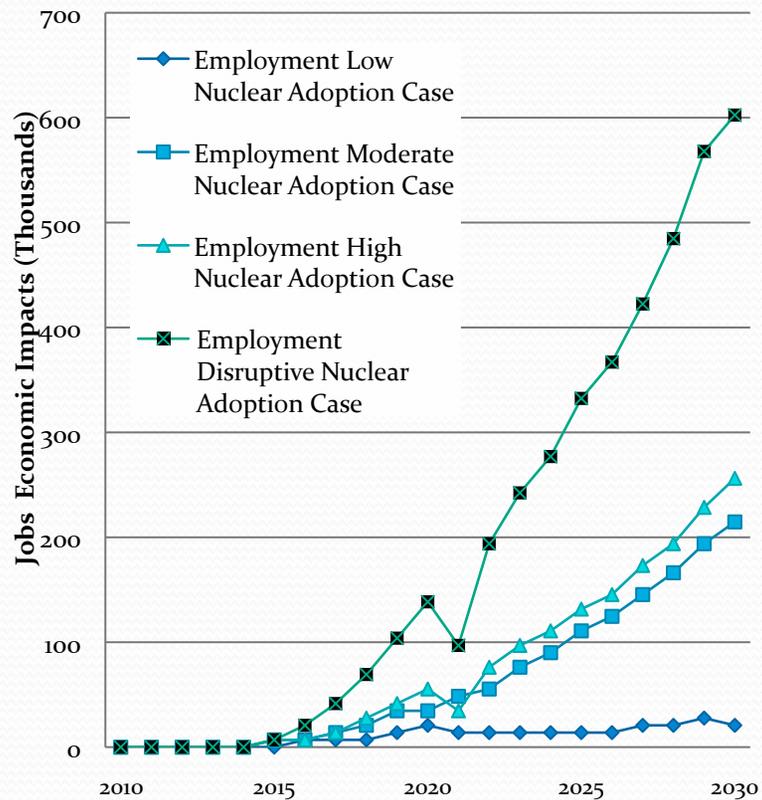


Economic Impacts of SMRs – Manufacturing and Construction (Earnings/Payroll)

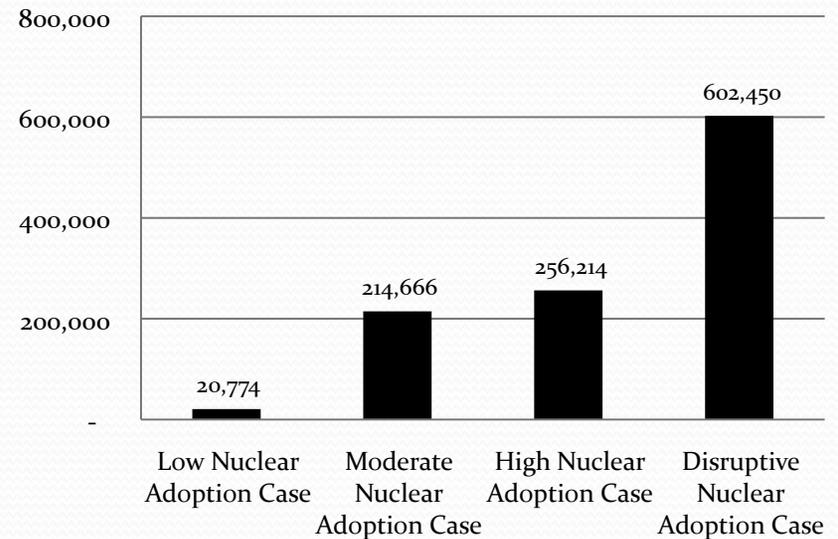


Economic Impacts of SMRs – Manufacturing and Construction (Jobs)

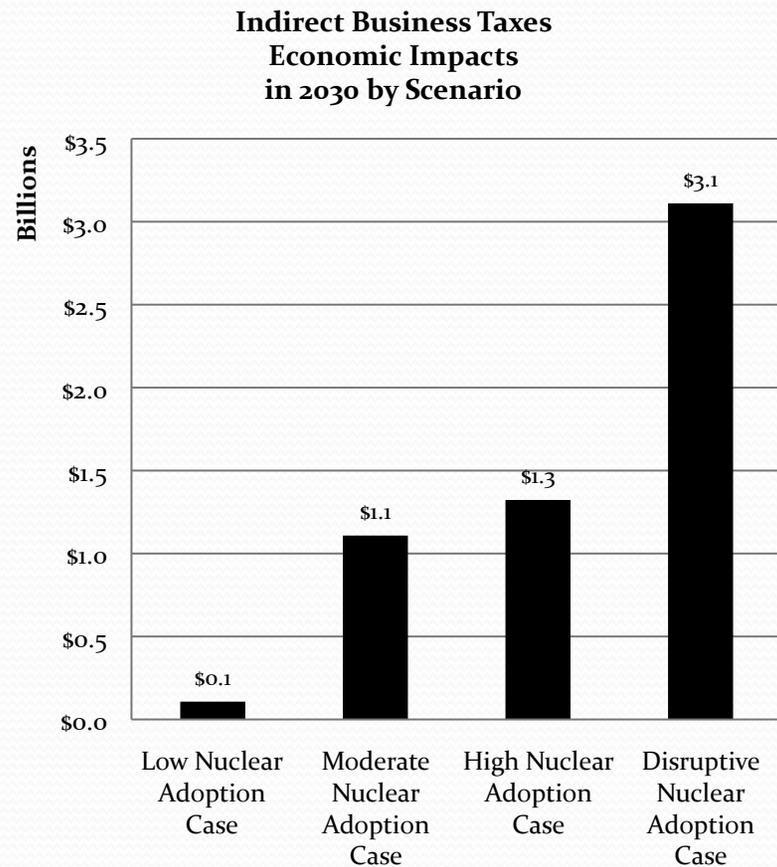
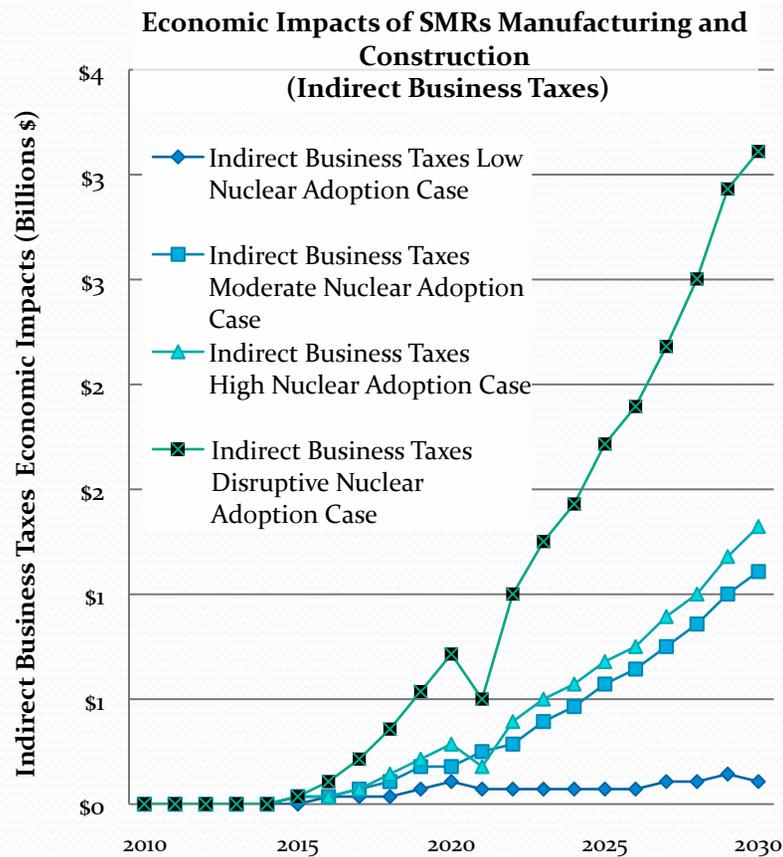
Economic Impacts of SMRs Manufacturing and Construction (Jobs)



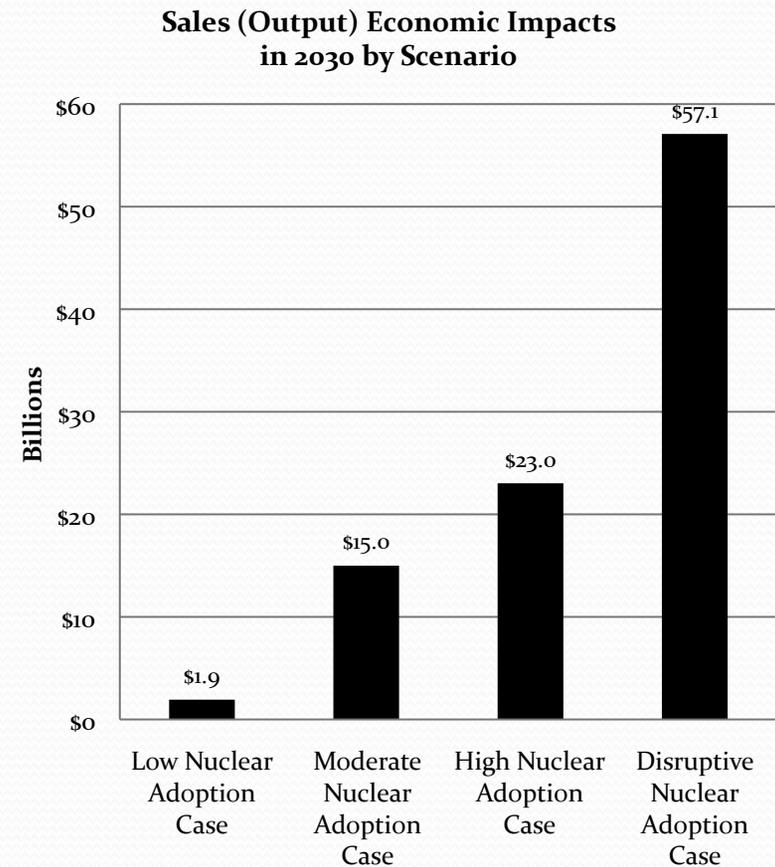
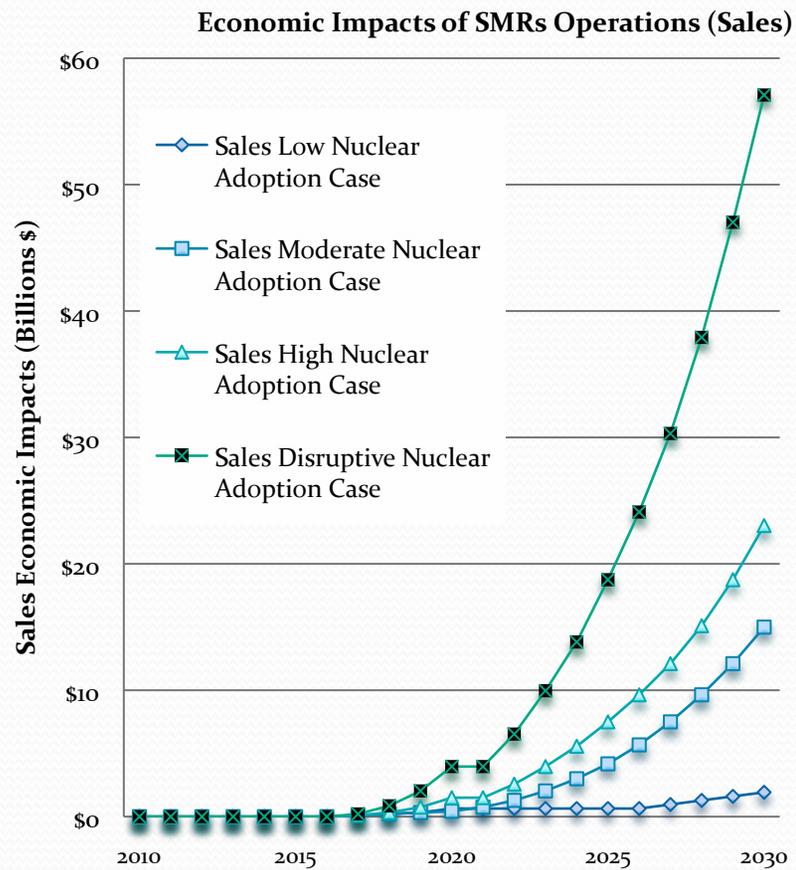
Jobs Economic Impacts in 2030 by Scenario



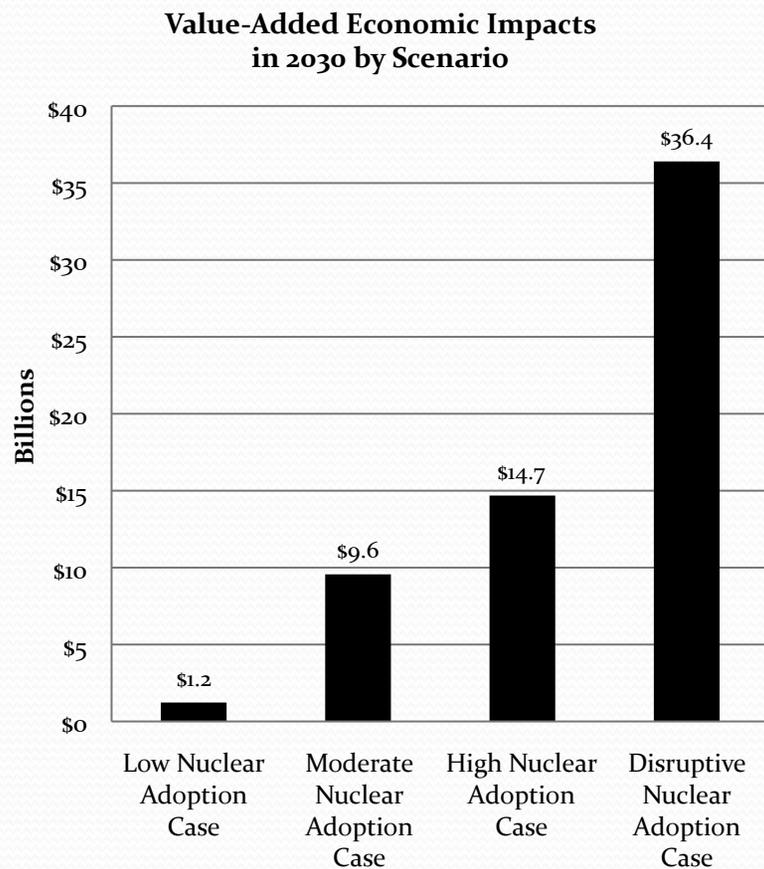
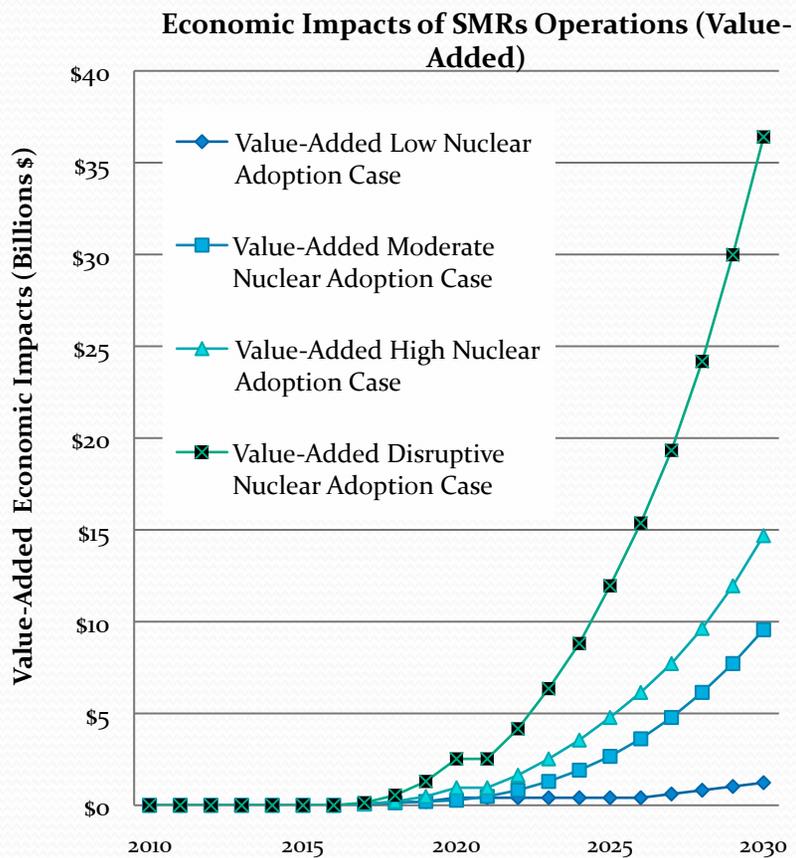
Economic Impacts of SMRs – Manufacturing and Construction (Indirect Business Taxes)



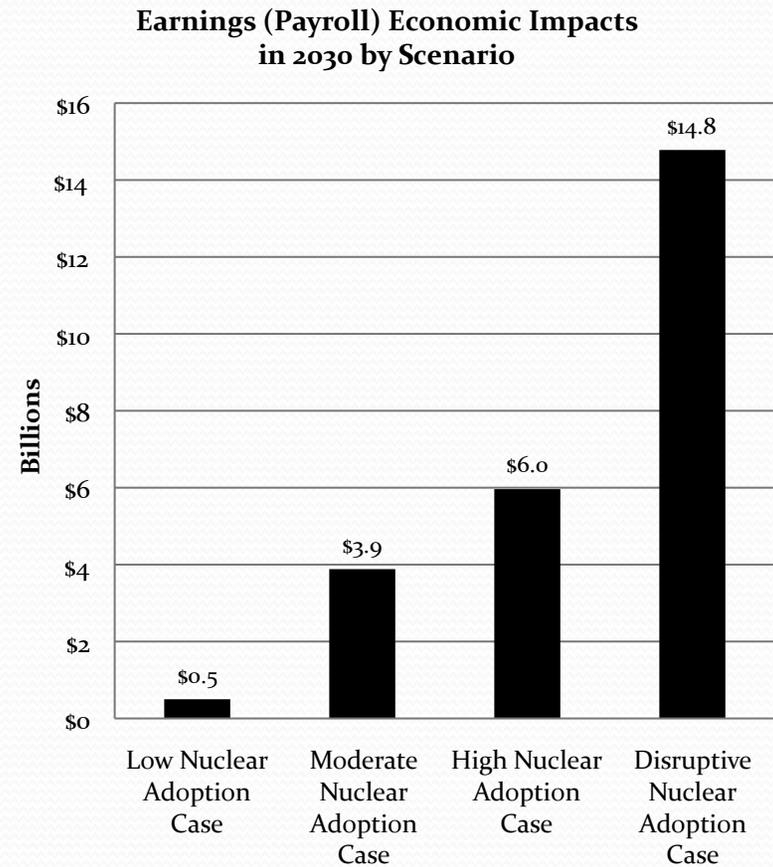
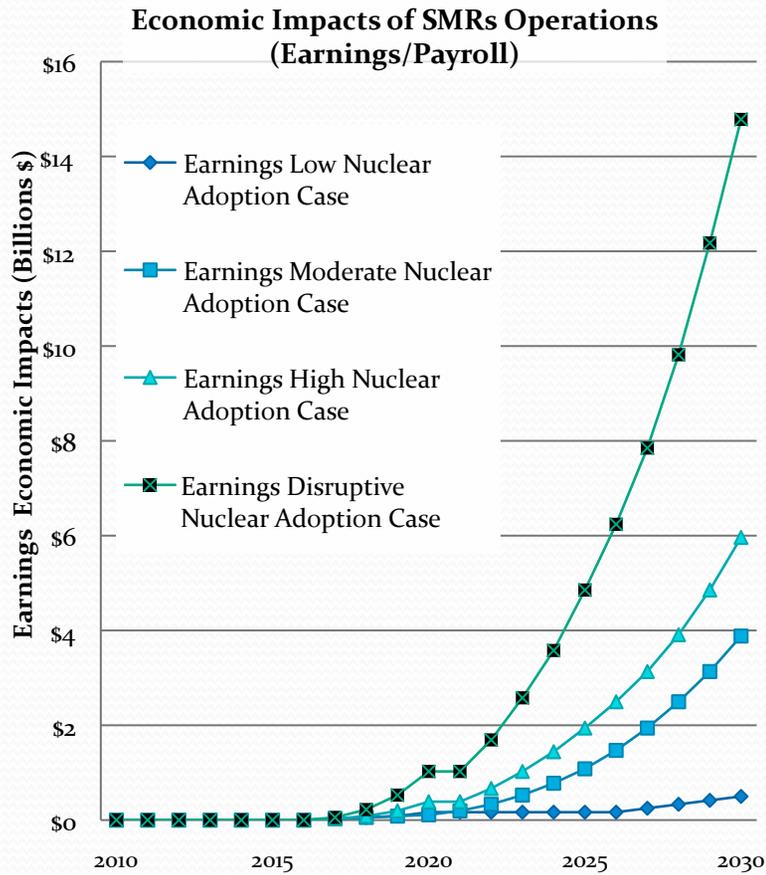
Economic Impacts of SMRs – Operations (Sales)



Economic Impacts of SMRs – Operations (Value-added)

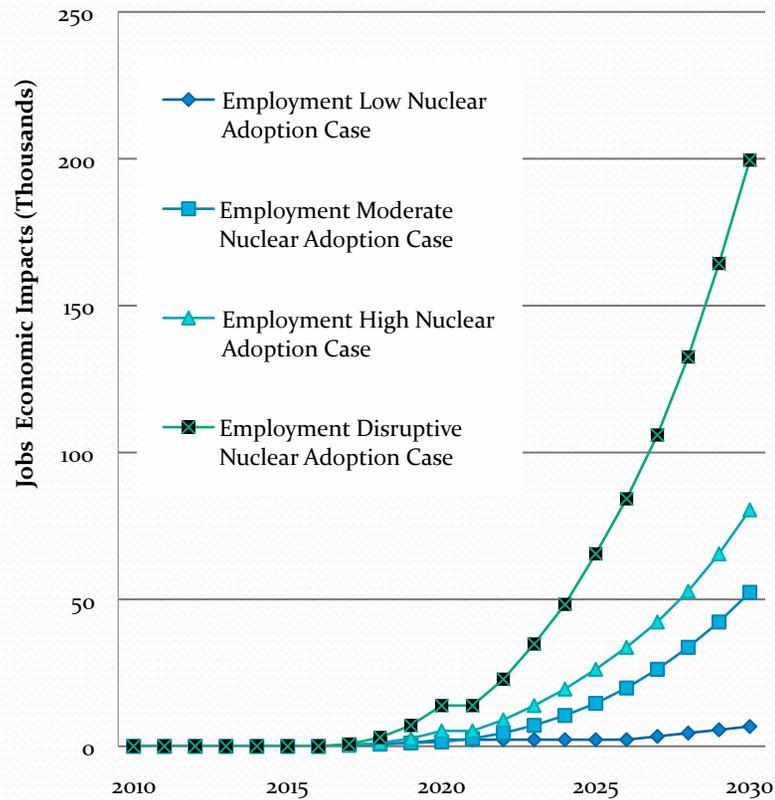


Economic Impacts of SMRs – Operations (Earnings/Payroll)

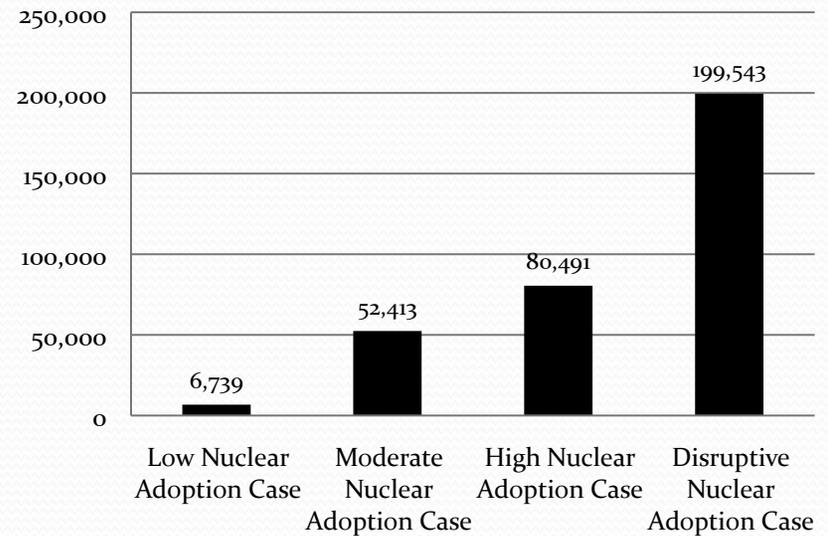


Economic Impacts of SMRs – Operations (Jobs)

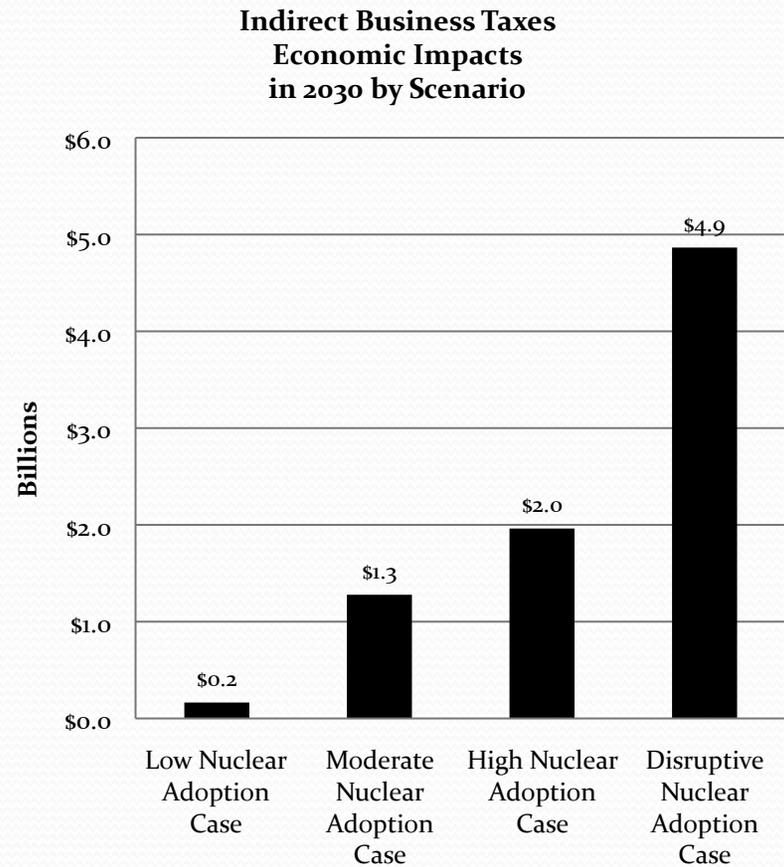
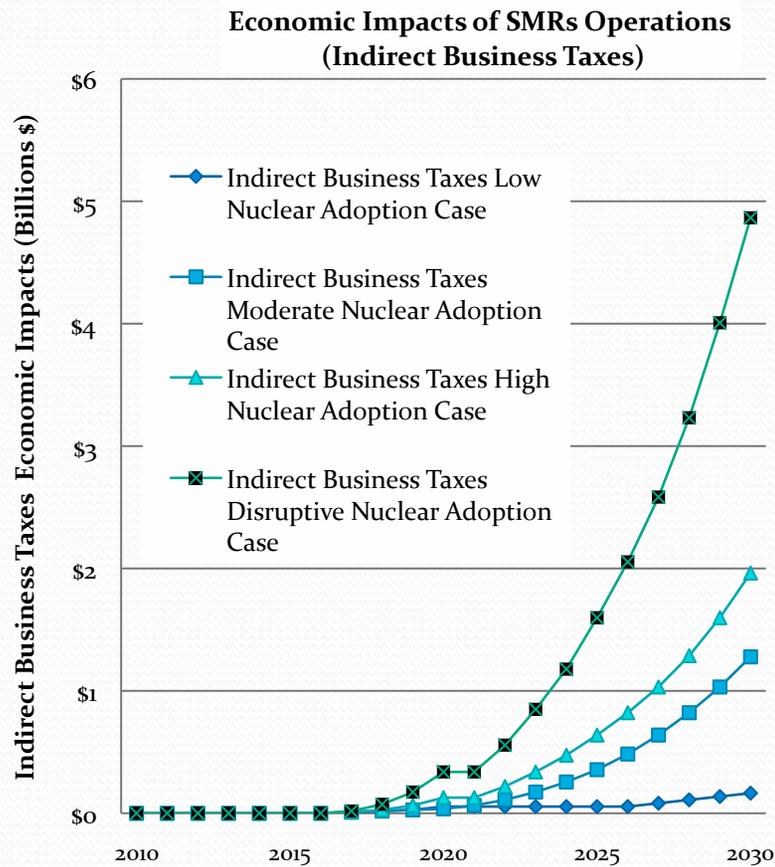
Economic Impacts of SMRs Operations (Jobs)



Jobs Economic Impacts in 2030 by Scenario



Economic Impacts of SMRs – Operations (Indirect Business Taxes)



Concluding Thoughts

- SMRs have significant potential for achieving multiple goals
 - Combating climate change
 - Strengthening the U.S. manufacturing base
 - Job creation
 - Modularity has capacity to advance technological change in a wide variety of industries, potentially enhancing economic growth

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