USAID FROM THE AMERICAN PEOPLE | MUNICIPAL ENERGY REFORM IN UKRAINE

Low Emissions Development Strategies (LEDS) Training Series

Module 5: Impact Analysis of LEDS Policy Options

The Center for Climate Strategies

June 2015

LEDS Process

Step 1	Organization and Goals
Step 2	Baseline Development
Step 3	Policy Options Identification
Step 4	Policy Screening & Prioritization
Step 5	Initial Policy Option Design Specifications
Step 6	Direct (Micro) Impacts Assessment
Step 7	Policy Options Integration and Overlap
Step 8	Indirect (Macro) Impacts Assessment
Step 9	Final Recommendations, Report Transmittal
Step 10	Monitoring, Reporting, Evaluation, Updating

Key Concepts and Approaches

Analytical	Cost Benefit Analysis
	Cost Effectiveness Analysis
	Baseline shift scenario analysis
	Direct and Indirect policy impacts
	Integrated policy impacts
	Linkage between micro outputs and macro inputs
Strategic	Linkage between policy design and impact
	Synergistic design
	Links between policy and investment
	Iterative approaches to analysis and agreement
	Differences between lowest cost and highest value

Tools and Templates

Principles and Guidelines for Quantification
Comprehensive Toolkit for LEDS actions planning and analysis
Modules for Baselines, Options, Priorities, Micro, Integration, Macro
Worksheets (spreadsheet based) for policy option analysis
Cost Effectiveness and Cost Benefit Tools, including Net Present Value (NPV)
Risk and uncertainty tools (sensitivity analysis, Monte Carlo, etc.)
Other forms of direct impact models or analyses that feed into Toolkit
Macroeconomic models that are incorporated into Toolkit (REMI, CGE, etc.)
Visualization tools (e.g. Causal Chains, Cost Curves, ROI graphs, etc.)

Overview and Methods

DIRECT/MICRO IMPACTS

Direct Impacts Analysis Approach

Finalize BAU forecast	• Cross cutting, sector, policy specific baselines
Key parameters of policy design	• Timing, level of effort, coverage of parties, mechanisms
Key parameters of analysis	• Data sources, methods, assumptions
Initial impact analysis of each option	• Financial and societal costs, benefits
Review and revise as needed	• Alternative policy design and or analysis approach
Integrate results to aggregate level	• Overlaps within and across sectors
Summarize	• Cost curve, return on investment, etc.
Translate to macro inputs	• Outlays, spending, etc.

Direct Impact Analysis Objectives

Evaluate	Impacts of alternative design, implementation choices
	Timing, level, types of costs/benefits, risk/uncertainty
	Distribution of costs/benefits (consumers, producers, public, private, present, future, small or large business, etc.)
Enable	Consensus building (policy design and analysis choices)
	Macroeconomic and fiscal analysis
	Financing inputs (outlays, returns, risks)
	Spending shifts affecting economic security and investment

Evaluation Techniques

Approaches	Outcomes with and without intervention
	Net effects
	Comprehensive effects
	Granular, line item effects
	Integrated, system wide effects
Techniques	Econometrics
	Statistical models
	Net Present Value (NPV) and Discounted Cash Flow (DCF)
	Cost/Benefit, Cost Effectiveness formats

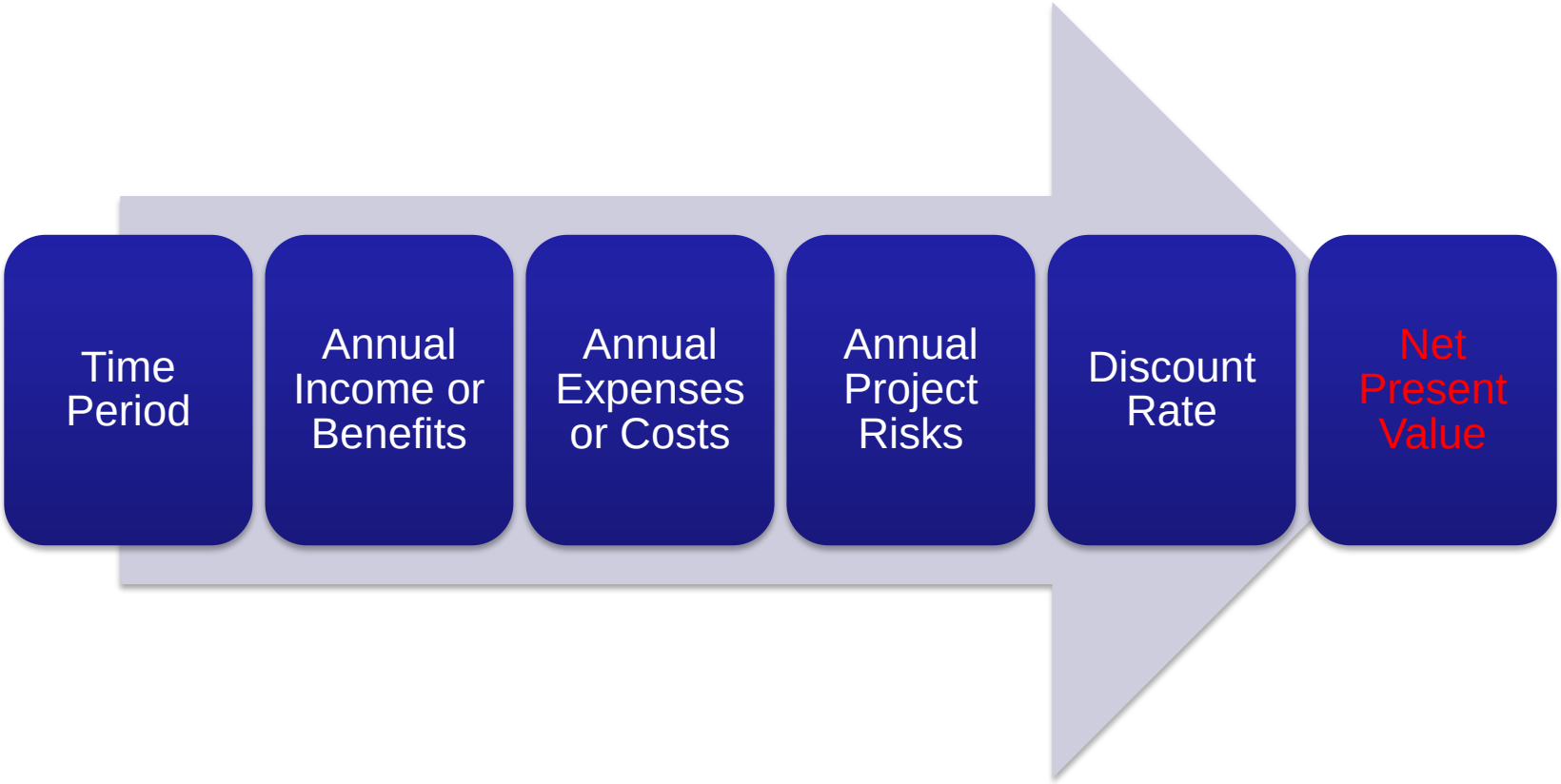
Key Issues

Market imperfections	Common property, nonmarket values, distributional impacts
	Imperfect information, collusion
Non monetized values	Avoided climate change damages (social cost of carbon)
	National security (security premiums)
Error	Estimation error
	Inclusion/exclusion error (type 1 and type 2)
Uncertainty	Lack of knowledge
	Statistical variation

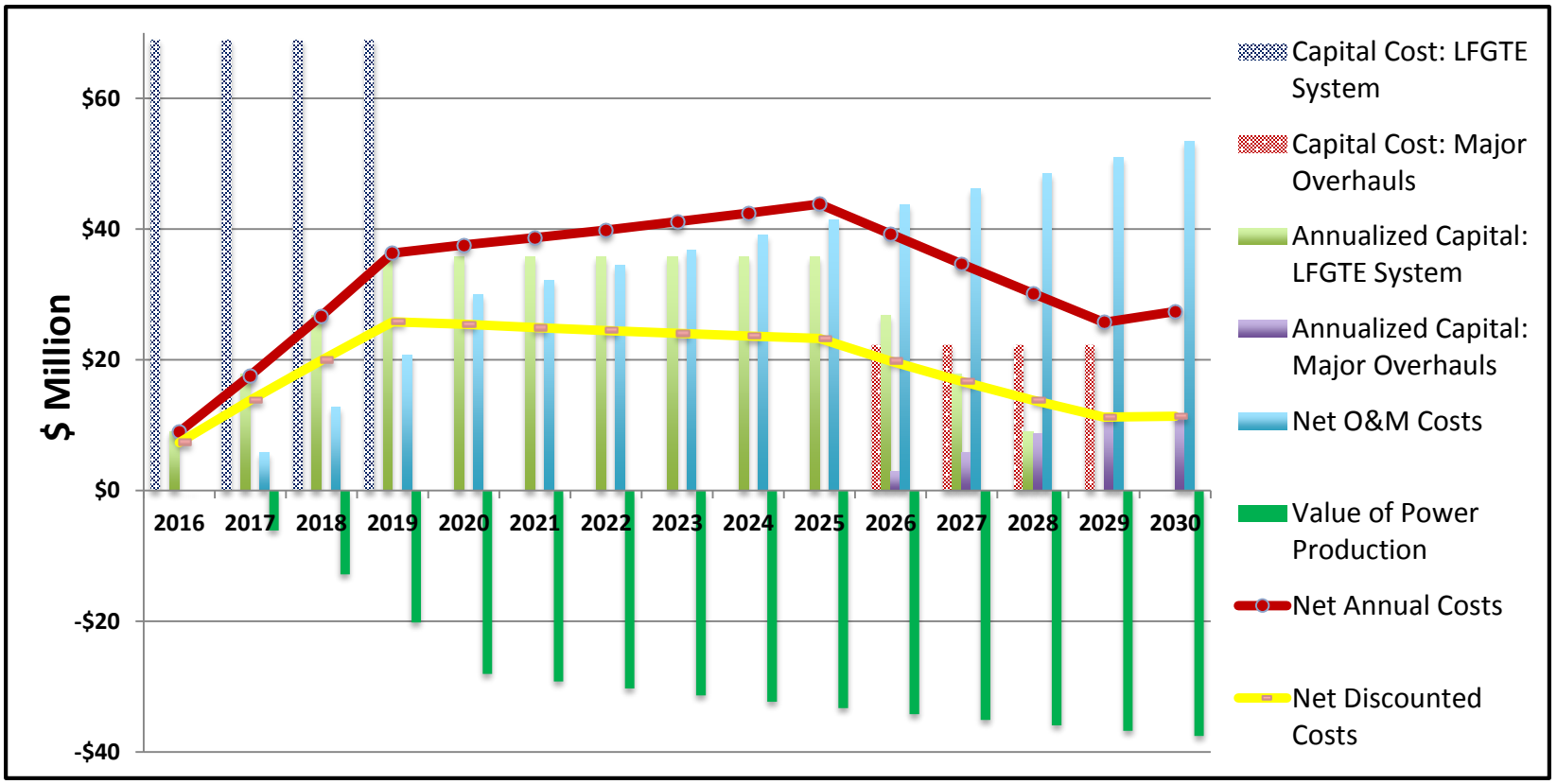
Net Present Value (NPV)

- Addition of annual income and expenses each year, adjusted for risk, discounted, and summed to a total net figure
- Also known as Discounted Cash Flow (DCF) Analysis when used for monetized (financial) calculations
- Enables calculation of:
  - Cost Effectiveness
  - Return on Investment
  - Payback Period
  - Cost/Benefit Ratio
  - Annuities
  - Levelized Costs/Savings
  - Financing Charges
  - Spending and Savings

NPV Inputs


Time Period
Annual Income or Benefits
Annual Expenses or Costs
Annual Project Risks
Discount Rate
Net Present Value

NPV Landfill Gas Energy Recovery



Key Steps

Identify and Quantify BAU Costs Affected/Avoided by the Policy
Energy/Resource and Other Costs

↓

Identify Policy Scenario Net Cost Components
Initial and Ongoing Energy/Resource Costs and Other Costs

↓

Quantify Policy Scenario Net Cost Components
Annual, disaggregated costs/savings

↓

Calculate Net Present Value of Policy Costs/Savings
Discounted Cash Flows, adjusted for uncertainty, annual basis

↓

Derive Cost Effectiveness of Policy Option
NPV/GHGs removed, energy shift, or other benefit

Key Equations

Marginal Resource Mix	• All GHG emitting supply sources
Emissions Factors	• GHG loading of each unity of supply
Avoided Emissions	• GHGs of each unit avoided supply
Avoided and Incremental Costs	• Cost/savings of each unit avoided supply
Net Policy Costs/Savings	• Net Policy Option Costs/Savings less Baseline Costs
Net Present Value (NPV)	• Sum, from start to end, of annual income and expenses, adjusted for risk, discounted by time period
Cost Effectiveness (CE)	• Cost/Benefit, or NPV/GHG Removed or Energy Change

Which Benefits and Costs?

Parties

- Implementing Parties (agencies, companies)
- Affected Parties (consumers, public)

Monetized impacts

- Financial costs and revenues, including cost savings and avoided costs
- Fixed and initial impacts, including variable and recurring costs
- Present and postponed effects
- Direct and indirect effects
- Subsidies and penalties
- Administrative and other transaction costs

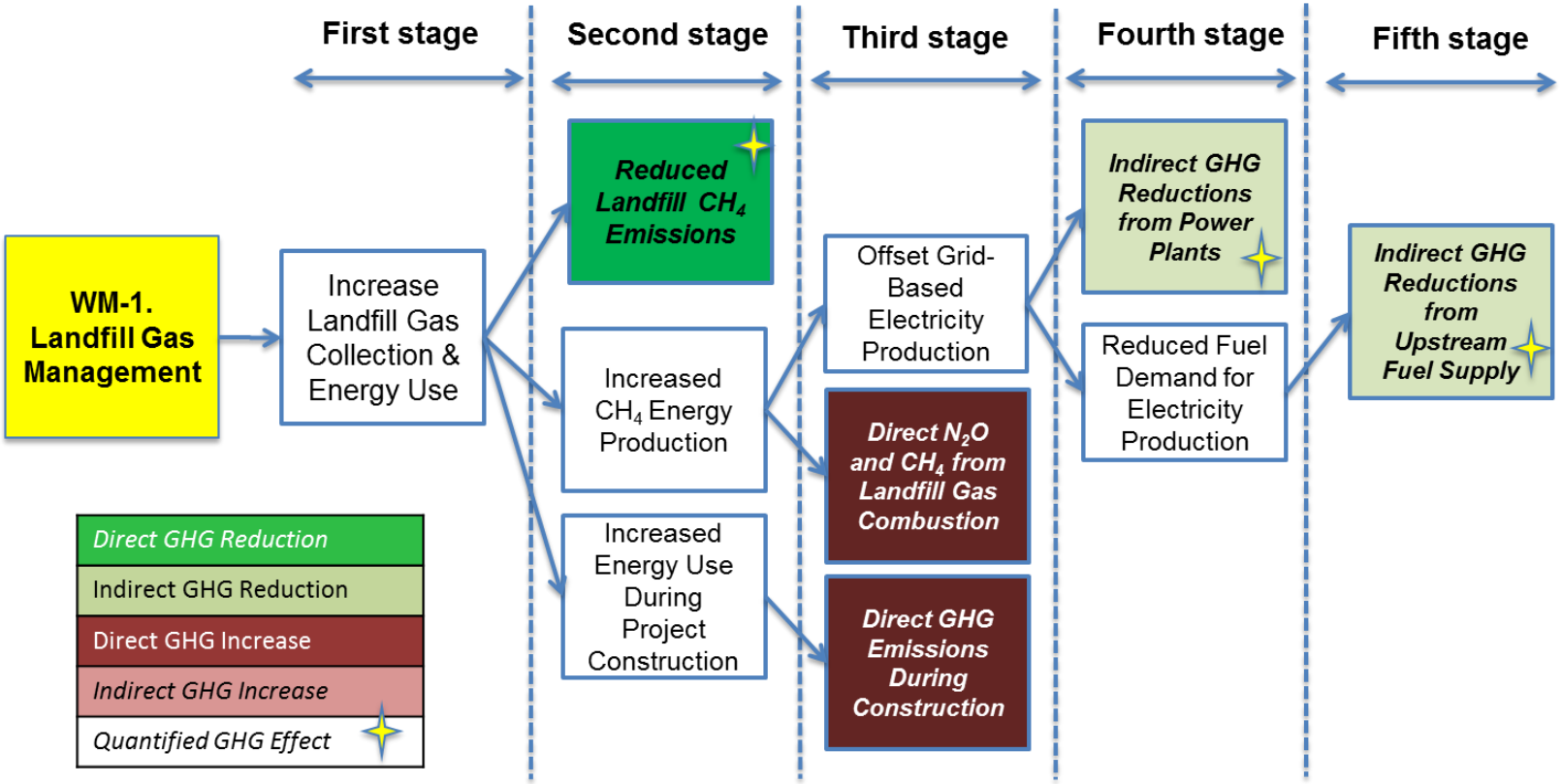
Non monetized impacts

- Societal costs and benefits (e.g. security impacts, health impacts, social costs of carbon)
- Direct and indirect effects
- Present and postponed effects

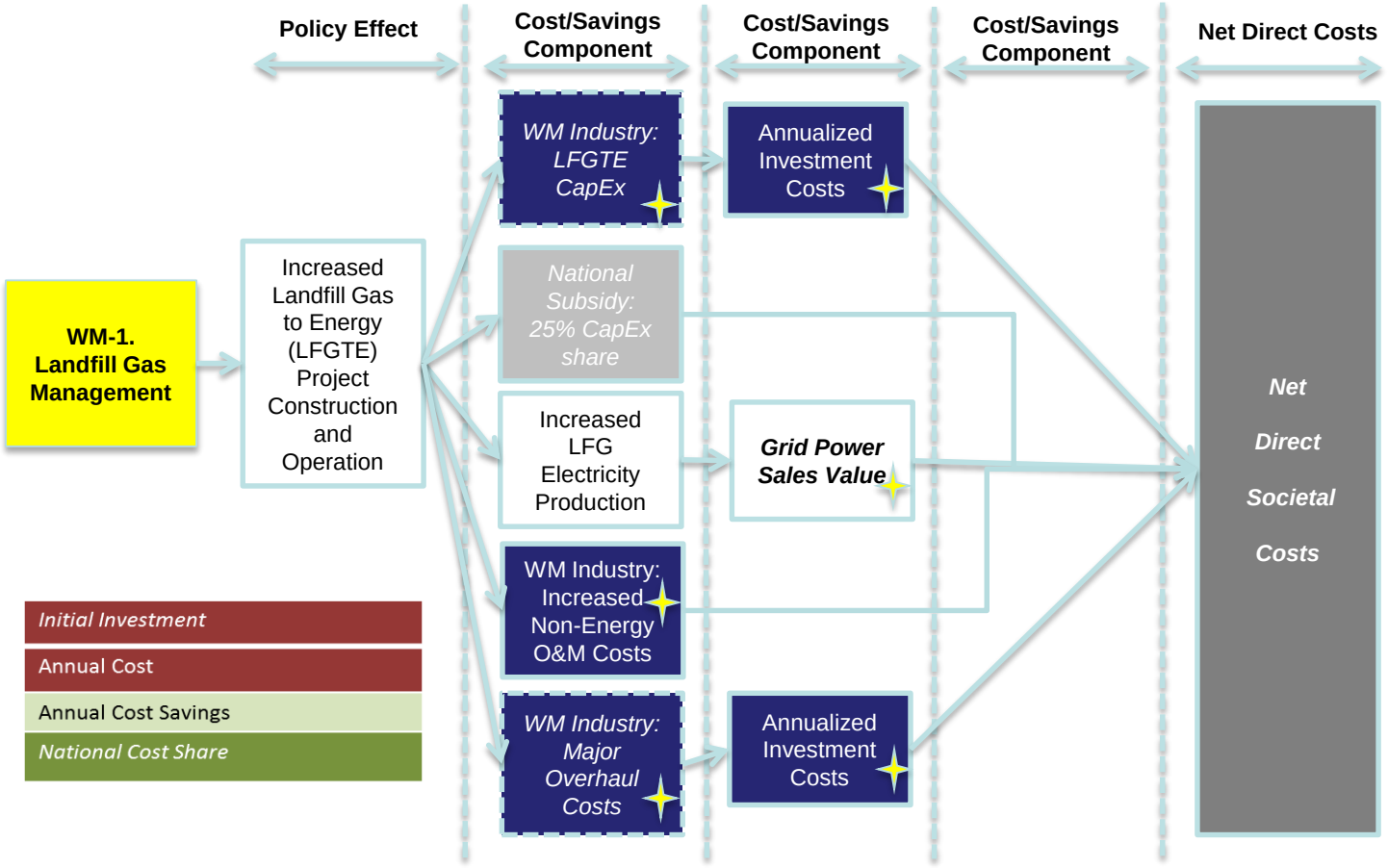
Distributional impacts

- Entity size and conditions (e.g. small business, emerging industry, recovering industry, etc.)
- Special populations (e.g. age, ethnicity, income, location, etc.)

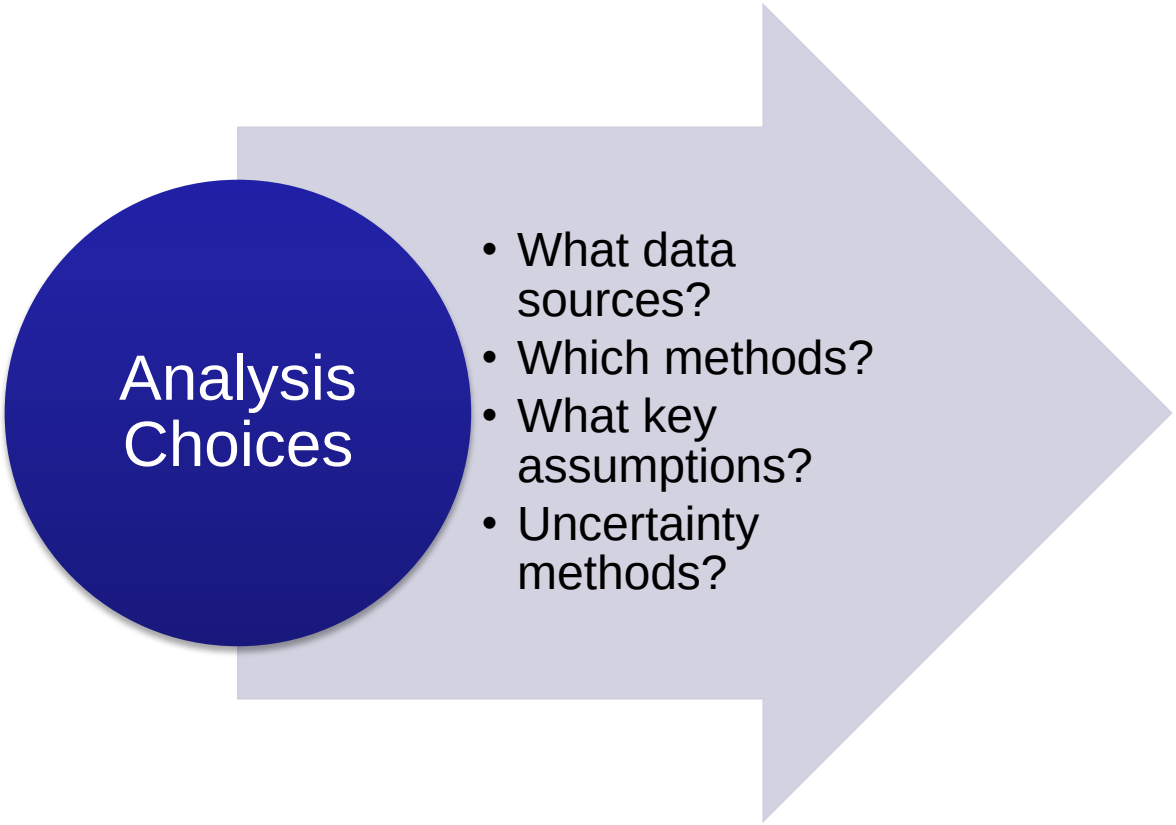
Causal Chain: GHGs, Energy System



Causal Chain: System Costs, Benefits



Key Questions



Key Methodological Choices

Simple worksheets	Transparent
	User friendly
	Low cost, fast, flexible
	Requires expert configuration
	May lack precision or interactive effects
Spread-sheet systems	May or may not be transparent
	Fast, flexible, relatively low cost
	Requires expert configuration and use
	May or may not capture complex interactions and details
Complex models	Often are not transparent
	Require high levels of expert input and use
	May or may not be flexible and fast
	Higher cost
	May capture greater levels of detail and interactive effects

Key Data Choices

Cross-Sector (Common) Forecasts	Demographic (population, number of households)
	Economic (gross product, employment, physical output, floor area…)
	Energy prices: electricity and fuels, wholesale & retail
Sector-Specific Forecasts	GHG emissions and associated emission factors (direct and upstream)
	Energy consumption
	Other emissions drivers: land use, industrial activity, others
Policy specific forecasts	Fixed and variable costs for specific technologies/best practices
	Energy or materials efficiencies of new technologies or practices
	Materials costs (for example fertilizer, industrial process inputs)

Key Assumptions

Common across sectors	Macroeconomic growth
	Population growth
	Interest rates
	Spending patterns
	Prices of goods and services
Sector Specific	Production capacity and growth
	Consumption capacity and growth
	Supply and demand elasticity (price sensitivity)
	Marginal resources and emissions factors
Policy Specific	Technology adoption rates
	Transaction and administration costs
	Technology demand and price sensitivity
	Marginal costs of replacement technologies and management

Uncertainty

Quantified	Alternate modeling approaches
	Sensitivity and scenario analysis
	Mathematical estimation of known statistical variation
	Mathematical simulation of unknown statistical variation
Non Quantified	Expert rankings and ratings
	Expert screening
	Strategic fit
	Removal of uncertain or risky policy design elements

Example Calculation of Avoided Emissions, Costs, Overlaps

ELECTRICITY SYSTEM

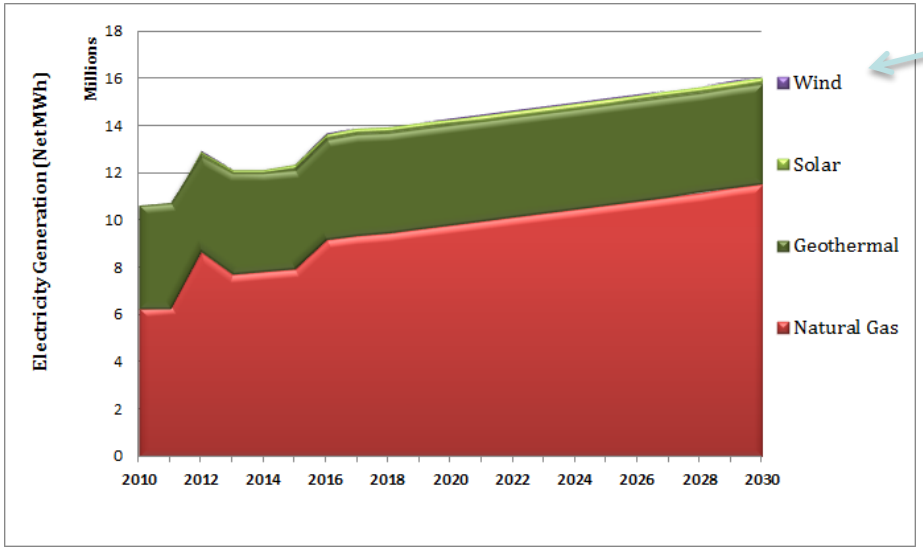
Electricity: Incremental and Avoided Costs GHGs

Electricity Supply	MWh produced, Existing and New generation
	Carbon Intensity (tCO_2e/MWh) and Emissions Factors
	GHG emissions of generation fleet in the jurisdiction and net imported electricity
Electricity Demand	MWh consumed, Existing and New demand sources
	Carbon Intensity (tCO_2e/MWh) and Emissions Factors
	GHG emissions of a particular demand segment
System Costs	Construction and operation of new generation resources
	Beyond BAU application of energy efficiency measures
	$/MWh, incremental and or avoided
Marginal Mix and Generator	Marginal Mix = all GHG producing generation
	Marginal Generator = Last power plant brought online or taken offline
	Marginal Generation = MWh from the last set of power plants dispatched/taken off-line

Electricity Resource Mix

Step 1: Review "Marginal Resource Mix," Electricity Supply system

- Marginal Resource Mix and its carbon intensity
  - Example: Baja California, MX, All Natural Gas Generation



Marginal Resource Mix

0.44 tCO_2e/MWh net generation

with T&D losses of 9.0% =

0.48 tCO_2e/MWh of electricity demand

Avoided Generation

Step 2: Derive a set of *avoided generation* carbon intensities ("EFs"):

- for each year of the forecast, divide the total emissions from marginal resources by the total net generation plus net power imports* –

$$EF_{AG} =$$

Where:

- EF_{AG} = avoided generation emission factor (tCO_2e/MWh of generation)
- E_J = emissions from marginal generation resources within the jurisdiction (J), tCO_2e
- E_I = emissions from imported power (I), tCO_2e
- E_X = emissions from exported power (X), tCO_2e
- G_N = marginal resource net generation within the jurisdiction, MWh
- P_I = imported power, MWh
- P_X = exported power, MWh

*If net power imports have been included within the marginal resource mix.

Avoided Demand

Step 3: Derive a set of *avoided demand* (electricity sales) Efs

- Used for demand-side reductions with the following equation

$$EF_{AD} = EF_{AG} \times (1 + L)$$

Where:

- EF_{AD} = avoided demand (sales) emission factor (tCO_2e/MWh of avoided demand)
- EF_{AG} = avoided generation emission factor (tCO_2e/MWh of generation)
- L = losses associated with transmission and distribution (losses as % of demand)

Avoided Costs

Step 4. Establish the avoided electricity system costs ($/MWh) for the "Marginal Resource Mix":

1. Energy Costs
    1. Fuel: $/GJ [converted to *$/MWh with plant heat rates (GJ/MWh)]*
    2. *Variable Operations and Maintenance (O&M) costs: $/MWh*
2. Capacity Costs:
    1. Levelized capital costs (LCC—a function of capital cost, plant lifetime, interest or discount rate): $/MWh
    2. Fixed O&M costs: ₴/MW [converted to $/MWh with plant capacity factors (equal to annual generation/(MW capacity * 8760 hours/yr)]

Avoided Cost = Fuel + Variable O&M + LCC + Fixed O&M = AC_{ES}, $/MWh

Cost Effectiveness

- **Emissions**
  - 2020, Emission Factor Average Generation = 0.44 tCO_2e/MWh
  - 2020 T&D losses = 9.0%
  - Emission Factor Average Demand = 0.44 x 1.09 = 0.484 tCO_2e/MWh
- **Costs (O&M, fixed O&M and LCC)**
  - In 2020, Average Cost for Electricity = $1,200/MWh
- **Effectiveness**
  - EE policy reduces demand by 1,000 MWh in 2020
  - 2020 GHG benefit = 1,000 MWh x 0.484 tCO_2e/MWh avoided = 484 tCO_2e
  - 2020 Avoided costs associated with electricity generation = 1,000 MWh x $1,200/MWh = $1,200,000
  - Cost Effectiveness = $1,200/484 tCO2e = $2.48/tCO2e

Combined Heat/Power Natural Gas, Biomass

Policy Description: Combined heat and power (CHP) systems reduce fossil fuel use and reduce greenhouse gas (GHG) emissions by recovering heat that is usually wasted as reject heat in power plants for useful purposes (heating buildings, domestic hot water, industrial process heat, or conversion to cooling energy for air conditioning or industrial cooling energy).

Goals: Displacement of electric energy and purchased fossil fuels using the output of CHP systems fueled by renewable fuel, biomass. 34TBtu through Natural Gas and 800 MW through biomass.

Timing: Policy period: 2016-2030, Base year: 2010

Coverage of Parties: municipal energy systems, including district heating, as well as residential, commercial, industrial, and institutional buildings and facilities.

1. Business As Usual GHG Emissions

BAU Energy & Emissions		
Year	Avoided Electricity Generation and Heating Fuel Emissions	Avoided Heating Fuel Use
	Tg CO_2e	GBtu
2016	0.69	2,987
2017	1.38	5,975
2018	2.05	8,962
2019	2.72	11,950
2020	3.38	14,937
2021	3.99	17,925
2022	4.61	20,912
2023	5.23	23,900
2024	5.82	26,887
2025	6.36	29,874
2026	6.72	31,866
2027	7.05	33,858
2028	7.36	35,849
2029	7.67	37,841
2030	7.96	39,833
Sum	**73**	**343,556**

2. Policy Scenario GHG Emissions

Policy Scenario Energy & Emissions				
Year	Gas-fired CHP Emissions	Renewable-fired CHP Emissions	Total CHP Electrical Output	Total CHP Fuel Input (Natural gas plus renewable fuel)
	Tg CO_2e	Tg CO_2e	GWh	GBtu
2016	0.23	0.002	572	6,227
2017	0.45	0.005	1,144	12,453
2018	0.68	0.007	1,716	18,680
2019	0.91	0.010	2,288	24,907
2020	1.13	0.014	2,860	31,133
2021	1.36	0.018	3,432	37,360
2022	1.59	0.023	4,004	43,587
2023	1.81	0.028	4,576	49,813
2024	2.04	0.034	5,148	56,040
2025	2.27	0.040	5,720	62,267
2026	2.42	0.046	6,101	66,418
2027	2.57	0.051	6,482	70,569
2028	2.72	0.057	6,864	74,720
2029	2.87	0.063	7,245	78,871
2030	3.02	0.069	7,626	83,022
Sum	**26**	**0.47**	**65,776**	**716,068**

3. Energy and Emissions Change

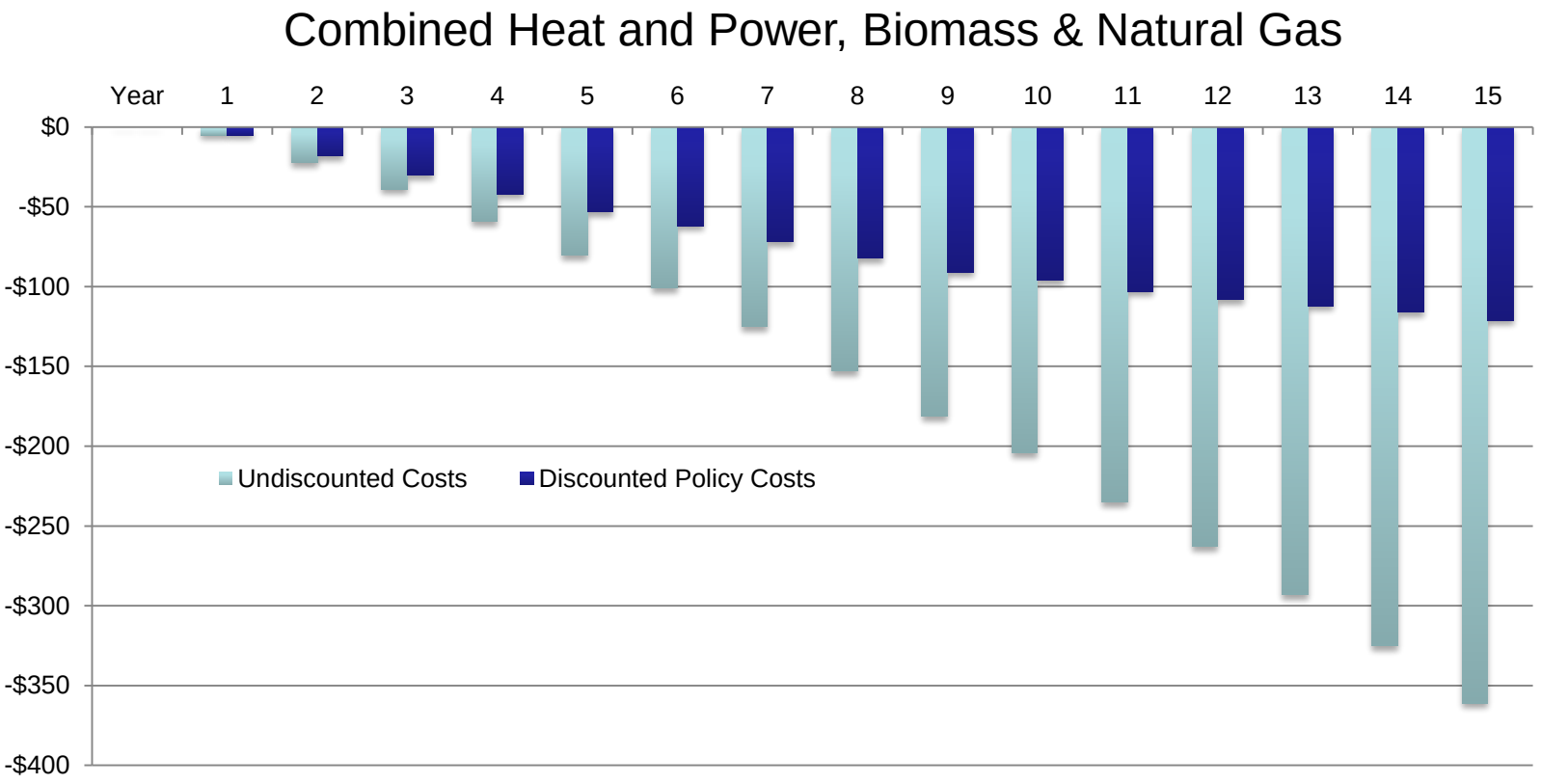
Energy & Emissions Change				
	Net Avoided Electricity Generation	Displaced Fossil Heating Fuel Use net of CHP Natural Gas Inputs	Net In-State GHG Reductions	Out-of-State GHG Reductions
Year	GWh	GBtu	Tg CO_2e	Tg CO_2e
2016	607	1,295	(0.46)	(0.02)
2017	1,215	2,590	(0.92)	(0.05)
2018	1,822	3,884	(1.36)	(0.07)
2019	2,429	5,179	(1.80)	(0.10)
2020	3,036	6,474	(2.23)	(0.14)
2021	3,645	7,769	(2.61)	(0.16)
2022	4,252	9,064	(3.00)	(0.19)
2023	4,860	10,358	(3.39)	(0.23)
2024	5,466	11,653	(3.75)	(0.26)
2025	6,071	12,948	(4.06)	(0.28)
2026	6,474	13,811	(4.25)	(0.31)
2027	6,885	14,675	(4.43)	(0.33)
2028	7,285	15,538	(4.59)	(0.35)
2029	7,690	16,401	(4.74)	(0.37)
2030	8,093	17,264	(4.87)	(0.39)
Sum	69,831	148,903	(46)	(3.3)

Discounted and Undiscounted Costs

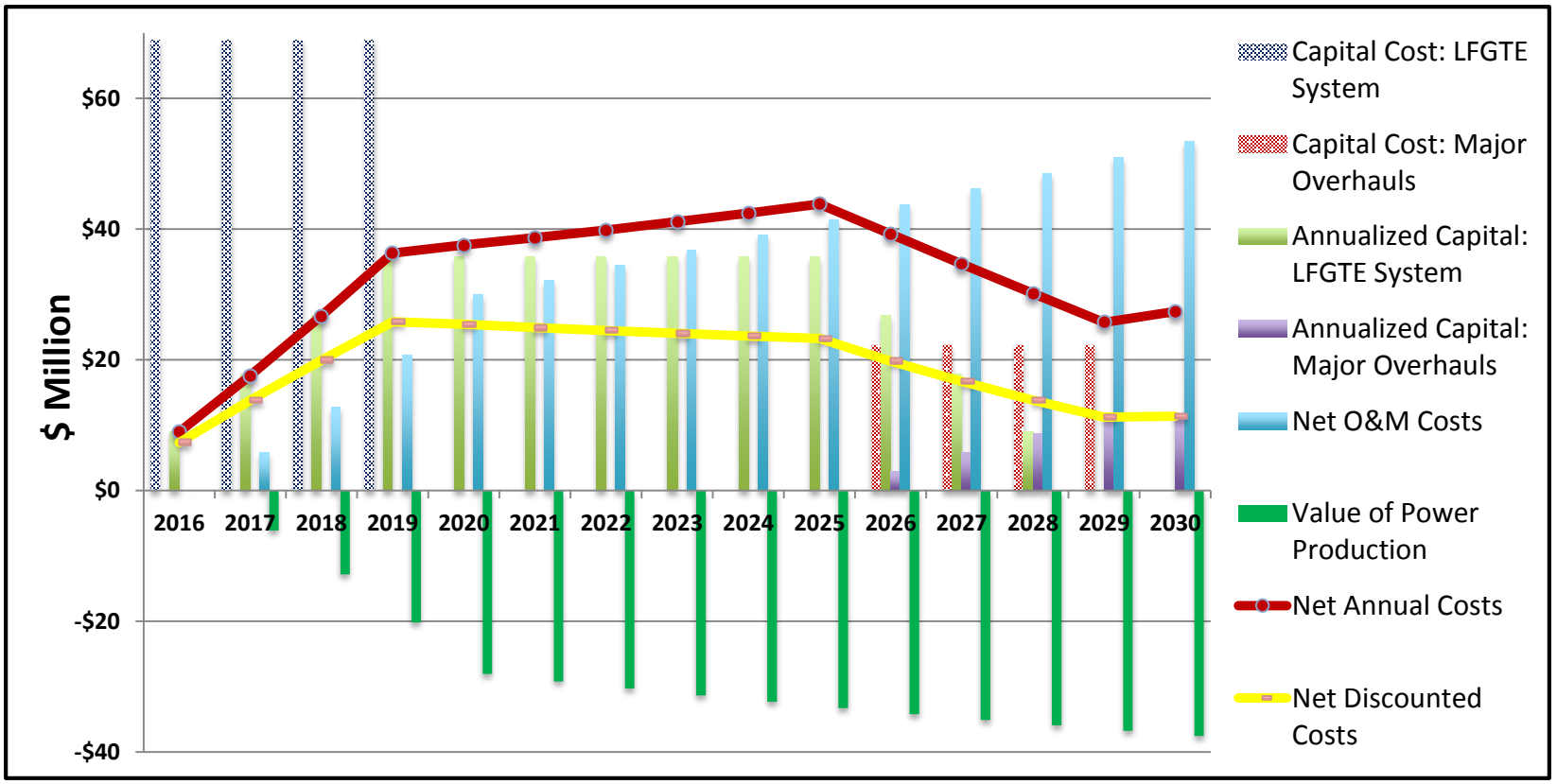
	BAU Costs	Policy Scenario (PS) Costs						Net Policy Costs	
	Avoided Due to the Policy	3a. Initial CapEx	3b. Major OH CapEx	3b. Annualized Initial CapEx	3b. Annualized Major OH	3C. O&M Costs (non-energy)	3d. Electricity Value	4. Net Annual Costs	5. Discounted Net Costs
Year	MM$	MM$	MM$	MM$	MM$	MM$	MM$	MM$	2012 MM$
2016	None Identified	$69	$0.0	$8.9	$0.0	$0.0	$0.0	$8.9	$7.4
2017	None Identified	$69	$0.0	$18	$0.0	$5.8	($6.1)	$18	$14
2018	None Identified	$69	$0.0	$27	$0.0	$13	($13)	$27	$20
2019	None Identified	$69	$0.0	$36	$0.0	$21	($20)	$36	$26
2020	None Identified	$0.0	$0.0	$36	$0.0	$30	($28)	$38	$25
2021	None Identified	$0.0	$0.0	$36	$0.0	$32	($29)	$39	$25
2022	None Identified	$0.0	$0.0	$36	$0.0	$34	($30)	$40	$24
2023	None Identified	$0.0	$0.0	$36	$0.0	$37	($31)	$41	$24
2024	None Identified	$0.0	$0.0	$36	$0.0	$39	($32)	$42	$24
2025	None Identified	$0.0	$0.0	$36	$0.0	$41	($33)	$44	$23
2026	None Identified	$0.0	$22	$27	$2.9	$44	($34)	$39	$20
2027	None Identified	$0.0	$22	$18	$5.8	$46	($35)	$35	$17
2028	None Identified	$0.0	$22	$9	$8.7	$49	($36)	$30	$14
2029	None Identified	$0.0	$22	$0	$12	$51	($37)	$26	$11
2030	None Identified	$0.0	$0.0	$0	$12	$53	($38)	$27	$11
Sum		**$276**	**$89**	**$357**	**$40**	**$496**	**($403)**	**$490**	**$286**

Note: $ = Mexican Peso

Discounted and Undiscounted Costs

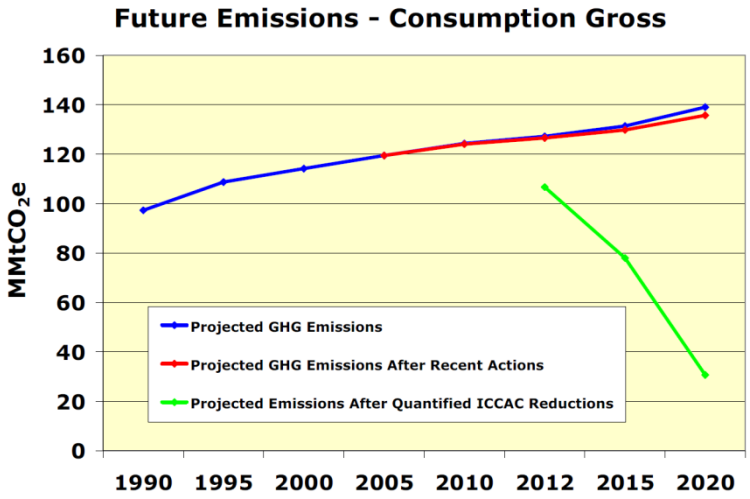


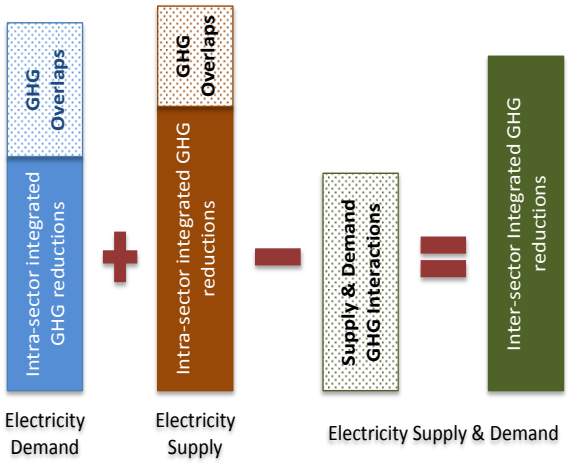
NPV Landfill Gas Energy Recovery



Overlap and Interaction (Integration) Analyses

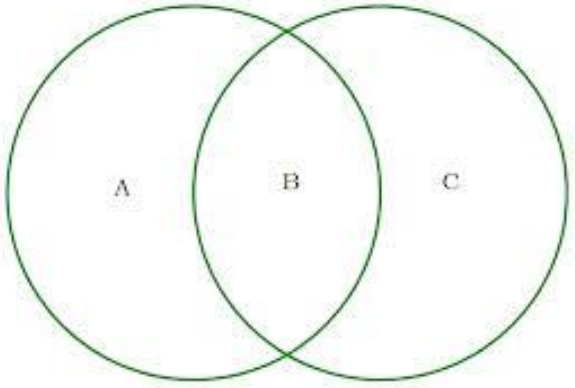
- Initial micro-economic analysis of each policy is done on a "stand-alone" basis.
- This assumes policy implementation all by itself with results calculated against business as usual (BAU) conditions.
- There are both intra-sector and inter-sector overlaps/ interactions to address





Goal

- Reduce the possibility of “double-counting” of GHG reductions and errors in economic impacts
- Double-counting occurs when the two different policies take credit for the “same” GHG reductions
- Double-counting can occur *within* each sector (intra-) as well as *across* sectors (inter-; e.g. AFF/WM/TLU/RCII → ES)
- The *net* GHG effect needs to be calculated and one set of results produced during the inter-sector integration analysis.



e.g. Policy effects A & C have an overlap = Area B

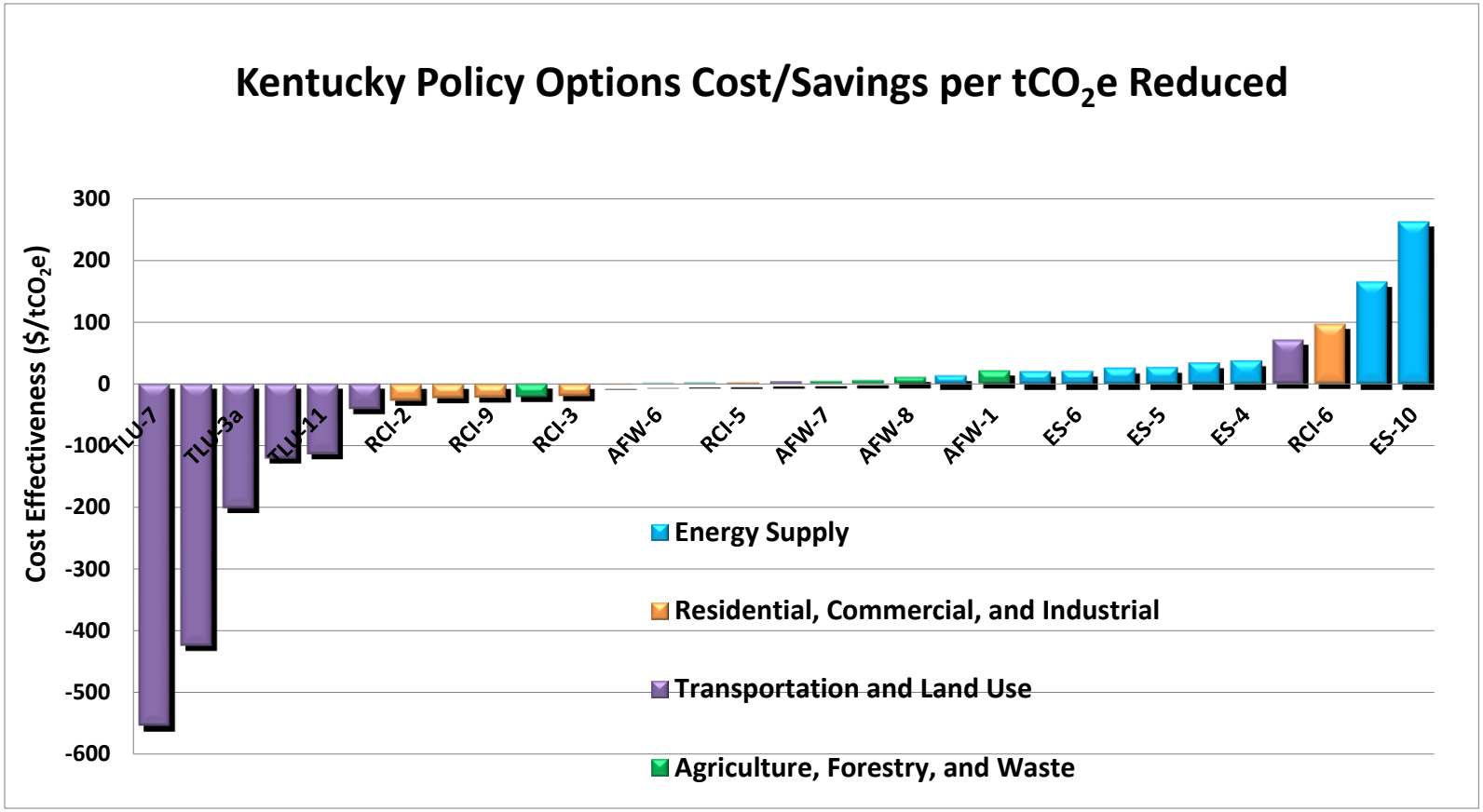
Steps For Overlapping Policy Options

- Review the "Marginal Resource Mix," such as for the Electricity Supply system
- Aggregate Electricity System Impacts (and other export metrics)
- Compare the size of the plan's aggregate electricity system impacts to the BAU marginal resource
- Adjust GHG impacts & costs based on the LCD Plan Marginal Resource Mix
- Multiply "Stand-Alone" Results by the ratio of LEDS Plan/Baseline metric

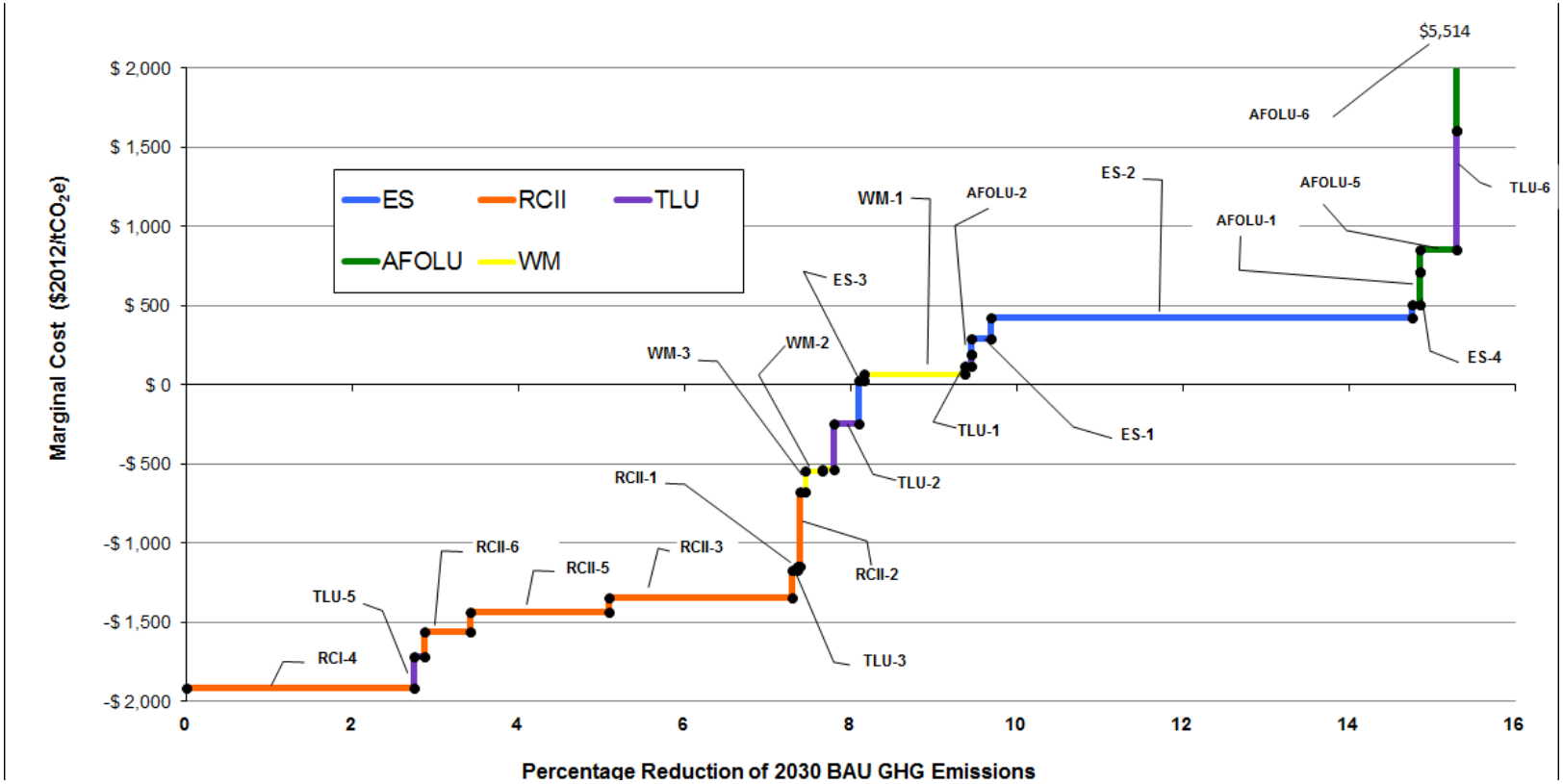
NPVs (Net Social Cost)

20 New Policy Measures		Net Direct Societal Cost M2007$		New Employment (person-years)		Change in GDP M2007$		Change in Societal Investment M2007$
Sector	Policy Description	2020	2010-2030	2020	2010-2030	2020	2010-2030	2010-2030
EHS-1	National Renewable Electricity Standard	$6,579	$162,323	12,523	991,393	-$6,425	-$165,734	$94,638
EHS-2	Incentives for Combined Heat and Power	-$2,388	-$16,349	40,364	652,658	$4,964	$57,667	$21,500
EHS-AGG	**Electricity and Heat Supply**	**$4,191**	**$145,974**	**52,887**	**1,644,051**	**-$1,461**	**-$108,067**	**$87,188**
RCI-1	Industrial Process Efficiency and DSM Measures	-$7,489	-$99,918	103,898	2,156,391	$6,926	$88,214	$45,188
RCI-2	DSM Programs for Building Electricity & Natural gas Use	-$1,335	-$112,010	54,177	2,659,139	$4,376	$106,641	$6,886
RCI-3	Zero Net Energy Buildings	-$17,161	-$194,131	164,335	3,132,090	$10,009	$118,852	-$34,940
RCI-4	Appliance Standards	-$17,566	-$156,890	130,965	2,122,703	$7,907	$82,653	-$26,054
RCI-5	Advanced Building Codes - Commercial & Residential	-$16,336	-$180,425	161,941	3,217,089	$8,664	$106,517	-$1,706
RCI-AGG	**Residential, Commercial, Industrial**	**-$59,887**	**-$743,374**	**615,316**	**13,287,412**	**$37,882**	**$502,877**	**$25,772**
TLU-1	Rebates for PHEVs and EVs	-$30,661	-$279,488	103,354	831,569	$11,016	$90,575	$32,745
TLU-2	National Renewable Fuel Standard - Post 2022	$153	$45,608	22,034	231,610	$1,902	$11,625	$8,977
TLU-3	Smart Growth - Land Use - Strong	-$19,443	-$237,576	73,644	1,446,169	$7,137	$87,404	-$127,432
TLU-4	Public Transit	$5,048	$32,784	32,365	658,515	$2,873	$42,016	$59,858
TLU-5	Anti-Idling Technologies and Practices - Rapid response	-$2,797	-$28,091	34,333	666,909	$2,878	$34,473	$1,788
TLU-6	Mode Shift from Truck to Rail	-$22,526	-$291,016	109,526	2,079,596	$10,538	$130,728	-$71,034
TLU-7	National CAFE Standard - Post 2025 targets	$2	$116,470	-4,184	-626,082	$249	-$29,332	$53,619
TLU-AGG	**Transportation and Land Use**	**-$70,225**	**-$641,310**	**371,071**	**5,288,285**	**$36,594**	**$367,488**	**-$38,338**
AFW-1	Crop Production & Nutrient Management Practices	$1,033	$11,265	20,476	350,753	$4,464	$56,987	$11,279
AFW-2	Agricultural Livestock Manure Management Practices	$254	$2,941	31,383	645,108	$3,880	$49,913	$1,284
AFW-3	Forest Retention Practices	$47	$576	18,903	395,316	$2,036	$26,223	$2,617
AFW-4	Reforestation Management Practices	$166	$1,768	21,023	428,171	$2,044	$26,271	$1,039
AFW-5	Urban Forest Management Practices	$4,853	$41,117	124,676	2,438,463	$2,106	$35,082	-$12,922
AFW-6	Integrated Waste Reduction, Recycling and LGF Utilization	-$7,706	-$89,707	69,932	1,495,543	$8,009	$98,542	$2,845
AFW-AGG	**Agriculture, Forestry and Waste**	**-$1,352**	**-$32,039**	**286,393**	**5,753,354**	**$22,539**	**$293,019**	**-$9,117**
ALL-AGG	**Total Aggregated Impact**	***-$127,273***	***-$1,270,749***	***1,325,666***	***25,973,101***	***$95,554***	***$1,055,317***	***-$72,798***

Cost Effectiveness Ranking



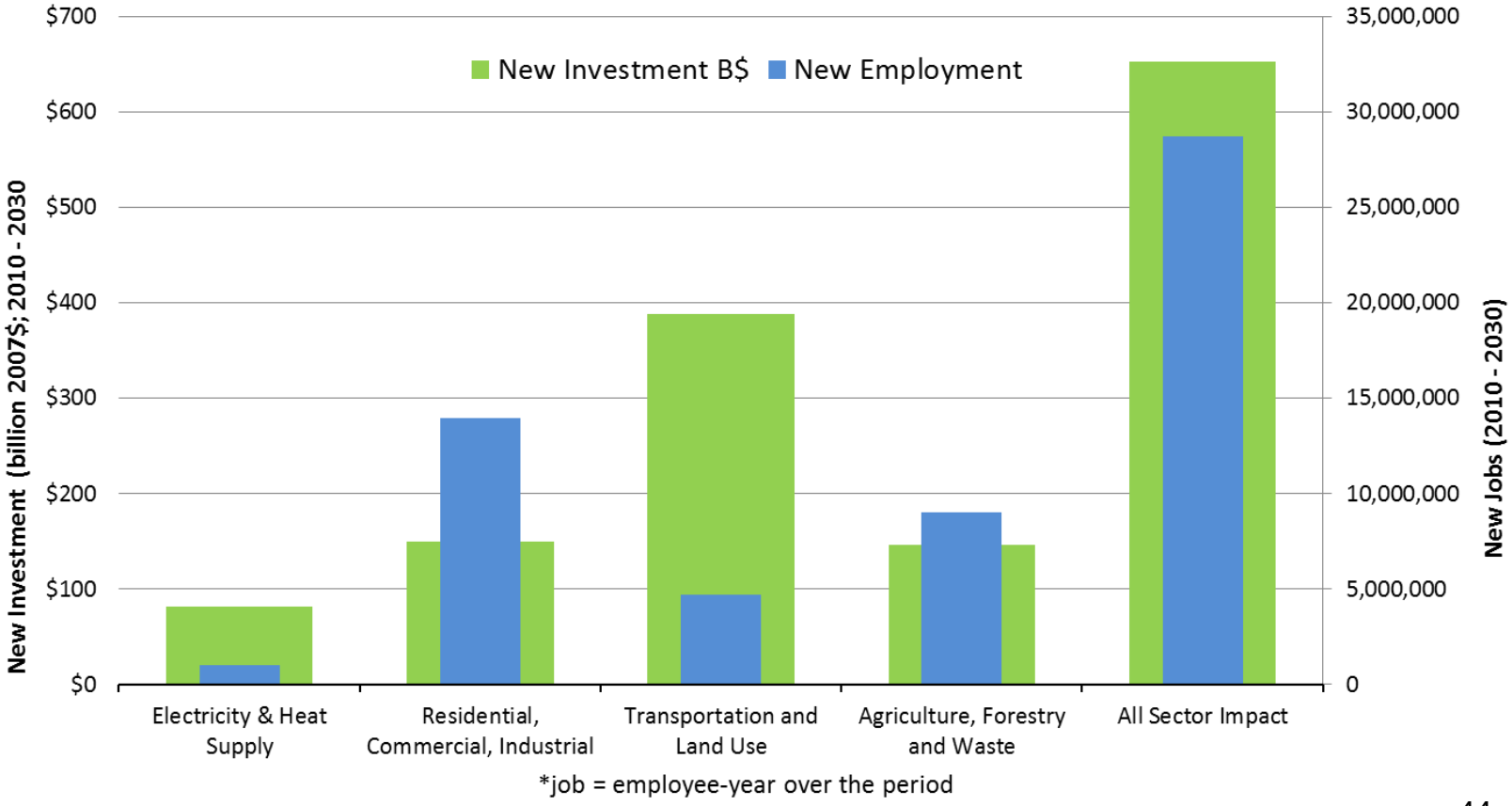
Marginal Abatement Curve (MAC)



Non-Monetized Benefits

- Lowest Cost Options does NOT equal greatest return on Investment
- MAC curves do not incorporate non-monetized benefits like:
  - Energy Security
  - Social Cost of Carbon
  - Health

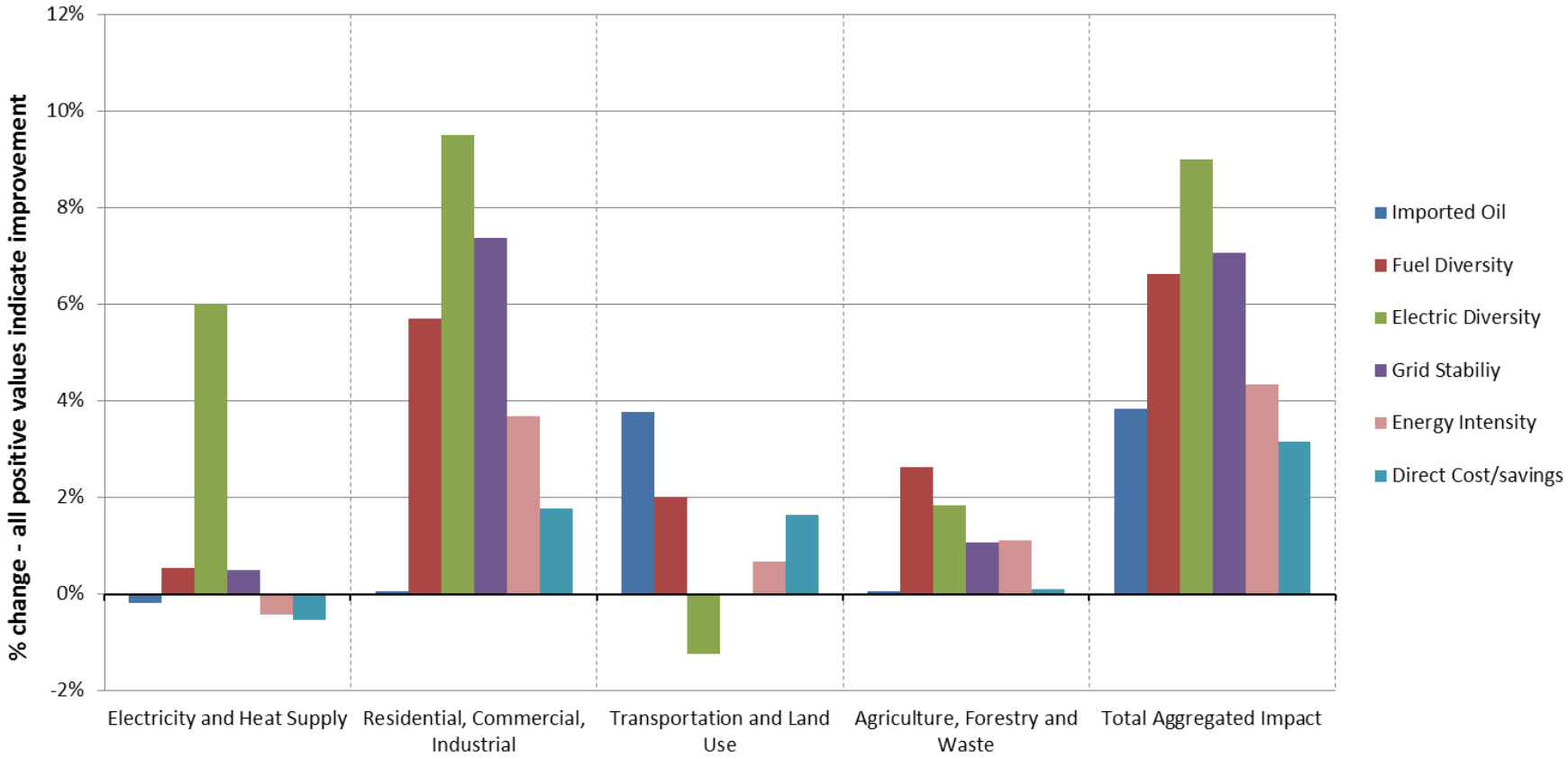
Return On Investment, Jobs



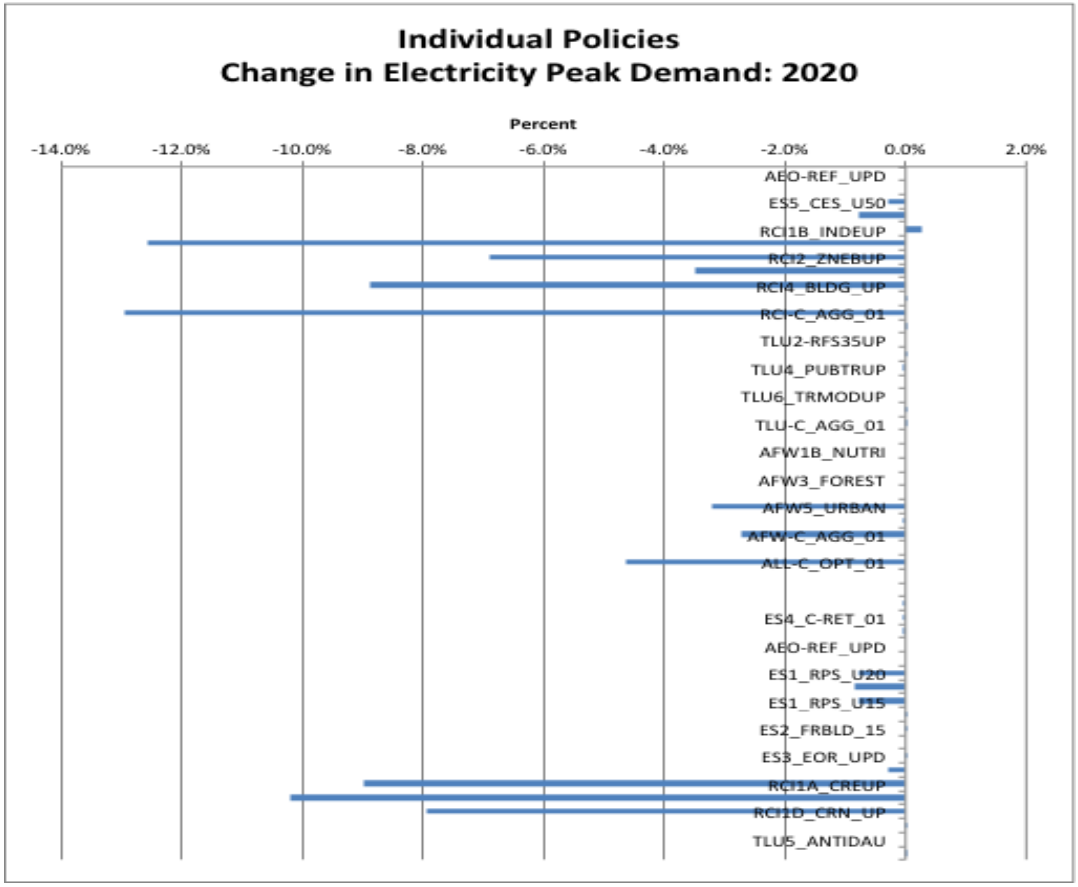
Energy Security

20 New Policy Measures		Change in imported oil	Change in primary energy diversity	Change in electric generation diversity	Change in grid summer peak demand	Change in energy intensity
Sector	Policy Description	2010-2030 levelized	2010-2030 levelized	2010-2030 levelized	2010-2030 levelized	2010-2030 levelized
EHS-1	National Clean Electricity Standard	0.2%	0.5%	6.0%	-0.5%	0.4%
EHS-2	Incentives for Combined Heat and Power	0.0%	0.5%	-0.1%	0.0%	0.0%
EHS-AGG	**Electricity and Heat Supply**	**0.2%**	**1.0%**	**6.1%**	**-0.5%**	**0.3%**
RCI-1	Industrial Process Efficiency and DSM Measures	-0.1%	3.0%	1.0%	0.0%	-1.3%
RCI-2	DSM Programs for COM & RES Electricity & Natural gas Use	0.8%	3.6%	8.1%	-6.3%	-1.8%
RCI-3	Zero Net Energy Buildings	0.0%	2.3%	5.3%	-3.6%	-0.9%
RCI-4	Appliance Standards	0.0%	0.8%	2.4%	-2.5%	-0.3%
RCI-5	Advanced Building Codes - Commercial & Residential	0.0%	3.1%	7.0%	-4.5%	-1.4%
RCI-AGG	**Residential, Commercial, Industrial**	**0.0%**	**5.6%**	**9.6%**	**-7.4%**	**-3.5%**
TLU-1	Rebates for PHEVs and EVs	-1.0%	0.8%	-0.4%	0.0%	-0.2%
TLU-2	National Renewable Fuel Standard - Post 2022	-1.5%	0.0%	0.1%	0.0%	0.1%
TLU-3	Smart Growth - Land Use - Strong	-0.7%	0.6%	0.0%	0.0%	-0.2%
TLU-4	Public Transit	-0.3%	0.2%	-0.1%	0.0%	0.0%
TLU-5	Anti-Idling Technologies and Practices - Rapid response	-0.5%	0.5%	0.0%	0.0%	-0.1%
TLU-6	Mode Shift from Truck to Rail	-2.2%	1.5%	0.0%	0.0%	-0.5%
TLU-7	National CAFE Standard - Post 2025 targets	-0.7%	0.3%	-0.4%	0.0%	-0.1%
TLU-AGG	**Transportation and Land Use**	**-4.9%**	**2.7%**	**-0.6%**	**0.0%**	**-1.0%**
AFW-1	Crop Production & Nutrient Management Practices	0.0%	0.0%	0.0%	0.0%	0.0%
AFW-2	Agricultural Livestock Manure Management Practices	0.0%	0.0%	0.0%	0.0%	0.0%
AFW-3	Forest Retention Practices	0.0%	0.0%	0.0%	0.0%	0.0%
AFW-4	Reforestation Management Practices	0.0%	0.0%	0.0%	0.0%	0.0%
AFW-5	Urban Forest Management Practices	0.0%	0.3%	1.1%	-1.2%	-0.1%
AFW-6	Integrated Waste Reduction, Recycling and LGF Utilization	0.0%	2.5%	0.6%	0.0%	-1.0%
AFW-AGG	**Agriculture, Forestry and Waste**	**0.0%**	**2.6%**	**1.8%**	**-1.1%**	**-1.1%**
ALL-AGG	***Total Aggregated Impact***	***-5.0%***	***6.8%***	***9.3%***	***-7.5%***	***-4.8%***

Energy Security Impacts



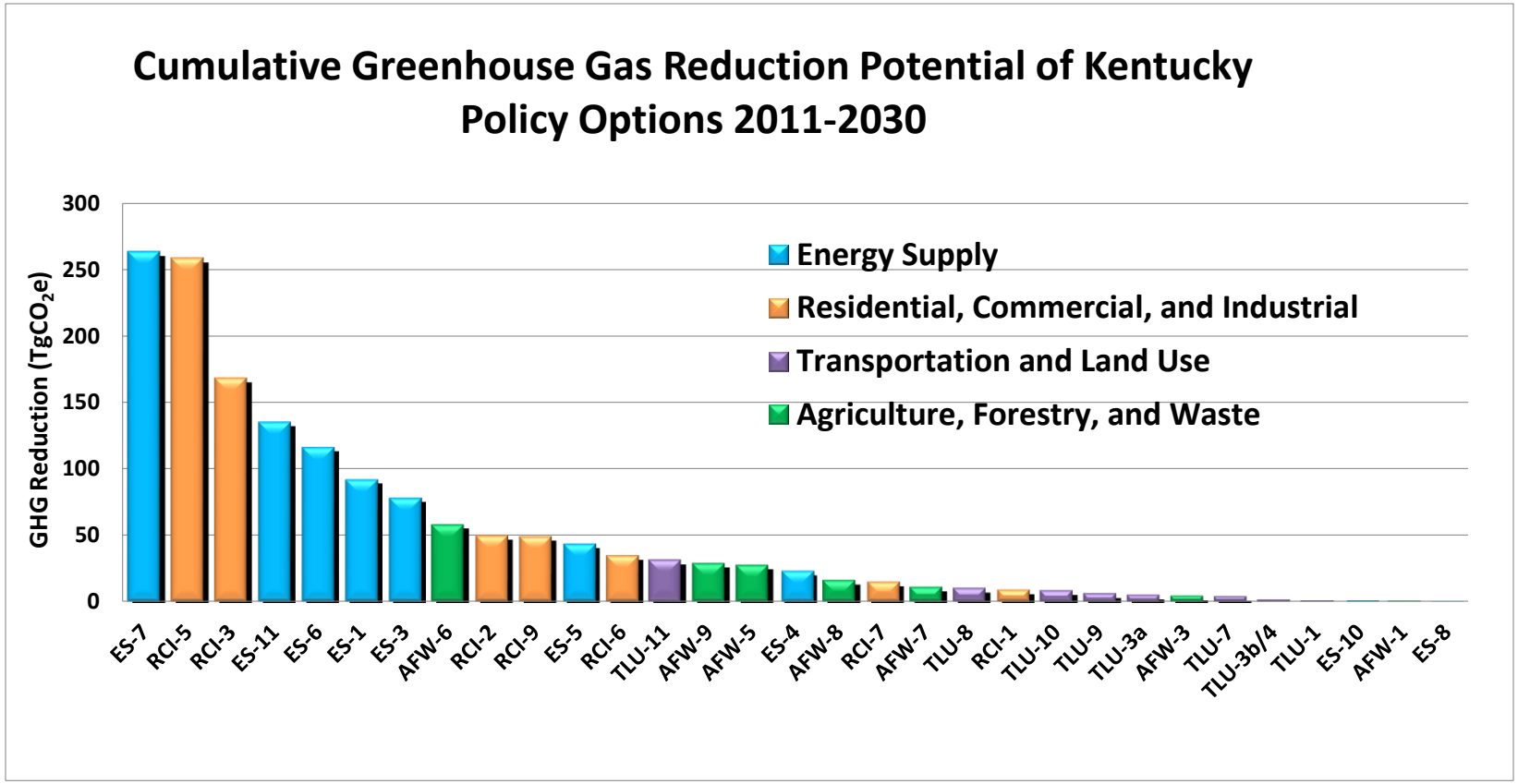
Energy Security Impacts



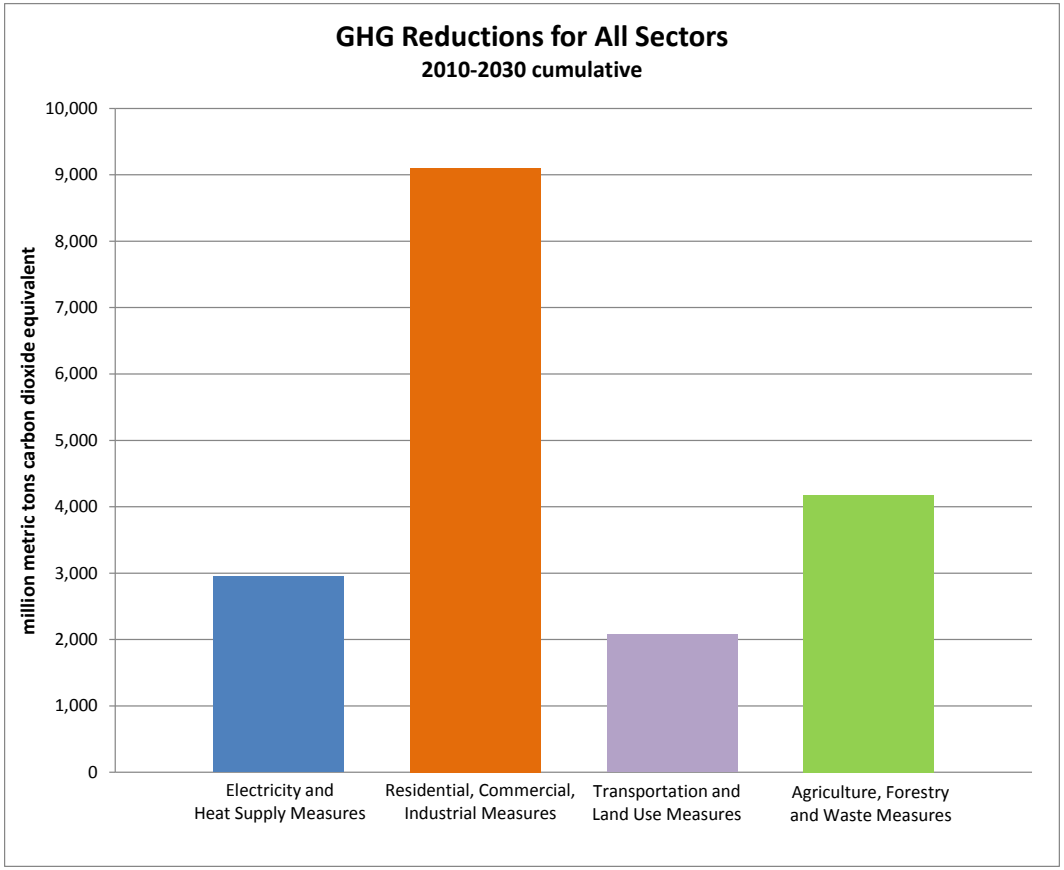
GHG Reductions

20 New Policy Measures		GHG emissions reductions MMtCO2e		Cost effectiveness $/tCO2e
Sector	**Policy Description**	**2020**	**2010-2030**	**2010-2030**
EHS-1	National Clean Electricity Standard	30.03	2,559	49.08
EHS-2	Incentives for Combined Heat and Power	9.02	236	-57.65
EHS-AGG	**Electricity and Heat Supply**	**44.26**	**2,947**	**39.08**
RCI-1	Industrial Process Efficiency and DSM Measures	127.09	2,773	-29.96
RCI-2	DSM Programs for COM & RES Electricity & Natural gas Use	160.28	4,869	-19.16
RCI-3	Zero Net Energy Buildings	73.65	2,329	-68.61
RCI-4	Appliance Standards	30.99	529	-253.93
RCI-5	Advanced Building Codes - Commercial & Residential	97.78	3,687	-40.22
RCI-AGG	**Residential, Commercial, Industrial**	**298.13**	**9,103**	**-46.08**
TLU-1	Rebates for PHEVs and EVs	8.06	351	222.02
TLU-2	National Renewable Fuel Standard - Post 2022	-1.94	629	54.63
TLU-3	Smart Growth - Land Use - Strong	14.23	339	-570.18
TLU-4	Public Transit	5.60	109	264.54
TLU-5	Anti-Idling Technologies and Practices - Rapid response	12.24	235	-98.53
TLU-6	Mode Shift from Truck to Rail	43.00	953	-252.55
TLU-7	National CAFE Standard - Post 2025 targets	3.06	184	447.17
TLU-AGG	**Transportation and Land Use**	**51.67**	**2,077**	**-80.93**
AFW-1	Crop Production & Nutrient Management Practices	19.18	495	5.64
AFW-2	Agricultural Livestock Manure Management Practices	5.79	198	12.03
AFW-3	Forest Retention Practices	4.00	100	4.62
AFW-4	Reforestation Management Practices	14.41	371	3.96
AFW-5	Urban Forest Management Practices	6.82	334	98.12
AFW-6	Integrated Waste Reduction, Recycling and LGF Utilization	106.69	2,622	-28.28
AFW-AGG	**Agriculture, Forestry and Waste**	**156.57**	**4,175**	**-6.49**
ALL-AGG	***Total Aggregated Impact***	***465.66***	***13,448***	***-44.61***

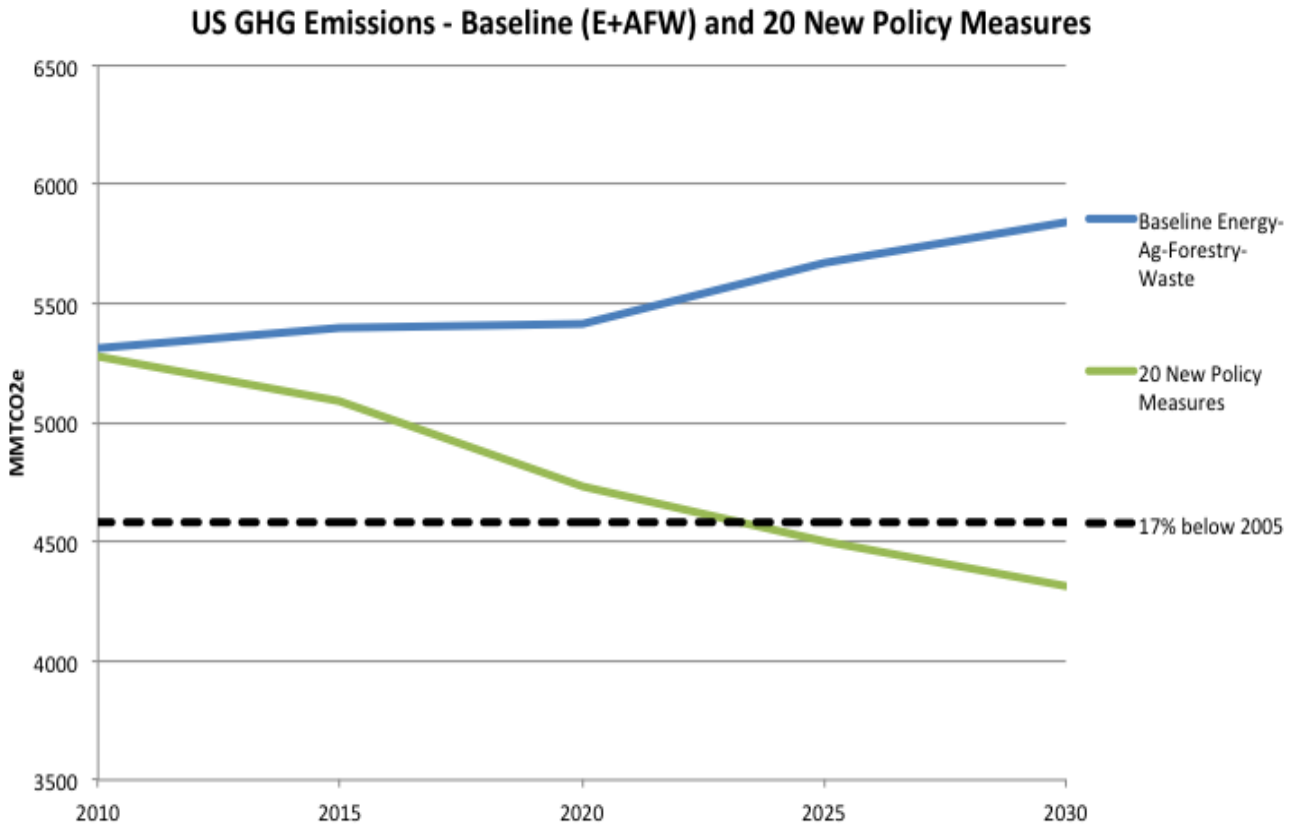
GHG Reduction Rankings



GHG Impacts


GHG Reductions for All Sectors
2010-2030 cumulative
million metric tons carbon dioxide equivalent
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Electricity and Heat Supply Measures
Residential, Commercial, Industrial Measures
Transportation and Land Use Measures
Agriculture, Forestry and Waste Measures

GHG Impacts


US GHG Emissions - Baseline (E+AFW) and 20 New Policy Measures
MMTCO2e
6500
6000
5500
5000
4500
4000
3500
2010
2015
2020
2025
2030
Baseline Energy-Ag-Forestry-Waste
20 New Policy Measures
17% below 2005

Translating Microeconomic Results to Macroeconomic Analysis

- Allocate annual net cost streams to the applicable economic sector
- Categorize costs by macro-economic category
- Provide expected schedule for investment costs

Macro Sector (REMI PI+ Industries plus residential, commercial and government sectors)
Agriculture, Hunting, Forestry and Fishing
Mining and Quarrying
Food, Beverages and Tobacco
Textiles and Textile Products
Leather, Leather and Footwear
Wood and Products of Wood and Cork
Pulp, Paper, Paper , Printing and Publishing
Coke, Refined Petroleum and Nuclear Fuel
Chemicals and Chemical Products
Rubber and Plastics
Other Non-Metallic Mineral
Basic Metals and Fabricated Metal
Machinery, Nec
Electrical and Optical Equipment
Transport Equipment
Manufacturing, Nec; Recycling
Electricity, Gas and Water Supply
Construction
Wholesale and retail
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
Post and Telecommunications
Financial Intermediation
Real Estate Activities
Renting of M&Eq and Other Business Activities
Public Admin and Defense; Compulsory Social Security
Education
Health and Social Work
Other Community, Social and Personal Services
Residential
Commercial
Municipal Government
State Government
National Government

GHG and Energy Impacts Exercise

- Following Q&A, break into sector workgroups and construct an analysis of energy and emissions impacts for a sample policy.

Q & A Micro-Economic Analysis

- Following Q&A, break into sector workgroups and construct an analysis of costs/savings impacts for a sample policy.

Overview

INDIRECT/MACRO IMPACTS

Indirect (Macro) Analysis Topics

Concepts	Macro-economic evaluation of policy
	Fiscal impacts of policy
	Line item budget review
	Links to investment and spending
	Links to Micro and Macro analyses
Relevance	Employment
	Income
	Growth
	Investment
	Prices
	Productivity

What is Macroeconomics?

Study of Trends in the Larger Economy

- Changes in total economic activity (GDP), total employment (number of jobs), output – how many goods/services are produced
- Impacts of changes in monetary policy, inflation, interest rates
- Understanding how money spent/saved in one sector flows through to affect other sectors of the economy

Difference from Microeconomics:

- Micro: What types of costs/savings can be attributed to implementing a policy? What are the total direct costs/savings to society?
- Macro: Who pays/receives savings? How will those costs and savings affect the larger economy?

Why Do We Care?

- Good analysis is *Multi-Criteria Analysis*
  - Cannot look at GHG impacts alone
  - GHG impacts, costs & savings, technical feasibility, health benefits…
  - And Economic Impacts!
- Need to understand impacts on:
  - Entire economy
  - Areas of economy not directly affected by a policy
- Economic Analysis Affects Policy Design:
  - Want policies to have the best possible effect on the economy
  - Need to meet other goals (in this case, GHG reduction & cost-effectiveness)
- Positive Economic Impacts: Important to Political Support!

Most Common Results of Macroeconomic Analysis

Macro analysis can estimate a wide range of impacts to economies

Key indicators of greatest interest are:

- Gross Domestic Product (indicator of total economic activity)
- Incomes (indicator of total ability to consume)
- Employment (indicator of number of people working, earning income)

Key Concept 1: GDP

GDP is calculated by adding up the total spending by three different groups:

1. ***C****onsumer Spending*
2. ***I****nvestment (spending by businesses)*
3. ***G****overnment Spending*

This total is then adjusted for two factors:

1. *Level of* ***Ex****ports (goods produced domestically, but not consumed)*
2. *Level of* ***Im****ports (goods consumed, but not produced domestically)*

$$GDP = C + I + G + Ex - Im$$

Key Concept 2: Income

Income, defined:

- Wages, salaries, benefits, and any other form of earning…
- *Any other accumulation of opportunity to consume goods and services*

Levels of income represent, fundamentally, the ability to consume goods and services.

Higher incomes ➔ higher potential GDP without deficit spending by consumers and/or businesses

GDP: Income, Borrowing & Saving

It is easy to think the following:

- Income defines spending power
- GDP measures spending by consumers, businesses and government
- Therefore, incomes and GDP are linked

But remember:

- Borrowing & spending = spending *beyond* income level now (and spending below income level later
- Earning & saving = spending below income level now (and spending above income level later)

Key Concept 3: Employment

Measured by number of persons at work, or in total hours worked (number of people X number of hours)

Driven by:

- Level of total GDP: labor is an input to productivity
- Intensity of labor in each sector: labor hours/year required per unit of employer income
  - Low intensity: 2-3 jobs per 5 million Yuan
  - High intensity: 20-25 jobs per 5 million Yuan
- Economic changes in sectors (changes in intensity of labor)
- Economic changes across sectors (shift of activity across sectors)

Key Concept 4: Intermediate Demand

Sectors buy inputs from other sectors - in unique ways

- To produce its final good/service, each sector needs *inputs* from other sectors of the economy.
- A portion of each dollar spent in one sector is, in turn, spent in other sectors.
- Each sector has a "fingerprint" – a unique breakdown of how its income is spent in other sectors
- Each *other* sector, in turn, spends shares of its share in other specific sectors, and those sectors in turn spend their shares

Intermediate Demand

- Key mechanism for understanding Indirect Impacts in Macroeconomic Modeling

Intermediate Demand: Washington State

Petroleum/Coal Manufacturing

General Split of Spending:

- 20% on capital
- 2% on direct labor (low!)
- 78% on inputs from other sectors
  - Almost all oil/gas extraction sector spending
    - Subsector: only 9% on labor, 56% capital, 27% back to Petroleum/Coal Manufacturing
- Overall, less than 10% of intermediate demand goes to labor

Construction

General Split of Spending:

- 22% on capital
- 36% on direct labor (pretty high)
- 42% on inputs from other sectors
  - 5% to architectural services
  - 4% to petroleum/coal manufacturing
  - 3% structural metals
  - 3% concrete & cement
  - Many other sectors < 3%

Key Concept 6: Imports and Exports

$$GDP = C + I + G + \underline{\mathbf{Ex}} - \underline{\mathbf{Im}}$$

Spending on goods & services produced within a jurisdiction:

- Increases GDP!
- Increases Employment and Income within the jurisdiction

Spending on *imported* goods & services:

- Decreases GDP!
- Supports Employment and Income in *another* jurisdiction

Attracting spending from another place (i.e. selling exports)

- Increases GDP, employment and incomes
- Does NOT displace spending by those within the jurisdiction

Macro-Analysis in LCD Planning

- Understanding impact of policies on overall economy
  - Common assumption: environmental policy conflicts with economic growth
  - Truth: every policy is different
    - some produce expenses, others produce great savings
    - some involve building new infrastructure (transit, buildings, power facilities) - costs a lot, but often increases economic activity
    - some involve taxes to reduce polluting activities, which can reduce economic activity too
    - many create *efficiencies*, which are very good for

Cost-Effectiveness (Micro) and Economic Impact (Macro)

What is the link between direct costs (Lesson 5) and economic impact?

- Are cost-effective policies (low $/ton) always better than costly policies (high $/ton) for the overall economy?

No reliable connection between $/ton and economic impacts!

- High costs can drive economic growth, by:
  - Increasing corporate spending
  - Increasing employment and incomes
  - Shifting capital from low-employment sectors to high-employment sectors
- Or, high costs can hurt economic growth by:
  - Increasing import consumption and displacing local production
  - Diverting capital from high-employment to low-employment sectors
  - Reducing private spending (through taxes) and driving government spending to low-employment sectors

Basic Steps in Macroeconomic Analysis

- Begin with direct costs & savings developed in policy analyses
  - Macro analysis *always* consistent with micro, and with scenarios developed in inventory, forecast, policy designs
- Identify macro category for each cost & savings stream
- Identify induced changes
- Identify other variables affecting Macro analysis
  - Type of effect (consumption, price, demand, sales,…)
  - Boundary issues (export/import)

Start from Micro-Analysis

- Identify which scenario(s) to model
  - Individual policies? Groups of policies? Entire plan?
- Prepare cost streams
  - Keep all costs & savings separate, without any accounting changes (Micro analysis step)
  - Actual expenditures, in year of expense
  - Undo any discounting, levelizing, averaging, etc.

Identify Type of Economic Change

- Each cost stream – what kind of change is it?
  - Consumer spends more – a price change or a demand change?
  - Business sells more – domestic sales or new exports? Research helps understand source of demand
  - Government spending – on construction, hiring, program costs, goods & services? Each has a different effect on the economy

More Inputs Based on Policy Costs

- Macroeconomic Modeling Needs *More Information*
  - Direct costs and savings are not enough
  - How will people, business, government respond to these costs and savings?
- Key Questions:
  - Change in spending: How is other spending affected? (Reallocation)
  - Change in spending: A change in demand, or a change in price?
  - Change in taxes: How will government spend that tax money?
  - Identities: Who is spending money? Who is saving? Who is selling more? Who is selling less?
  - Where is money for infrastructure coming from? Is it displacing other investment?
  - Import/Export: Are goods/services/investment entering or leaving?

Identify & Quantify Induced Changes

Rule of Macro-analysis: do not create or destroy money!

- If consumers spend more on one good/service, they have less to spend elsewhere
- If businesses invest in a new facility, must account for what is displaced. Savings? Other investment?
- Exception: money can leave (through imports) or enter (through exports)
- Must define and model these reactions in analysis

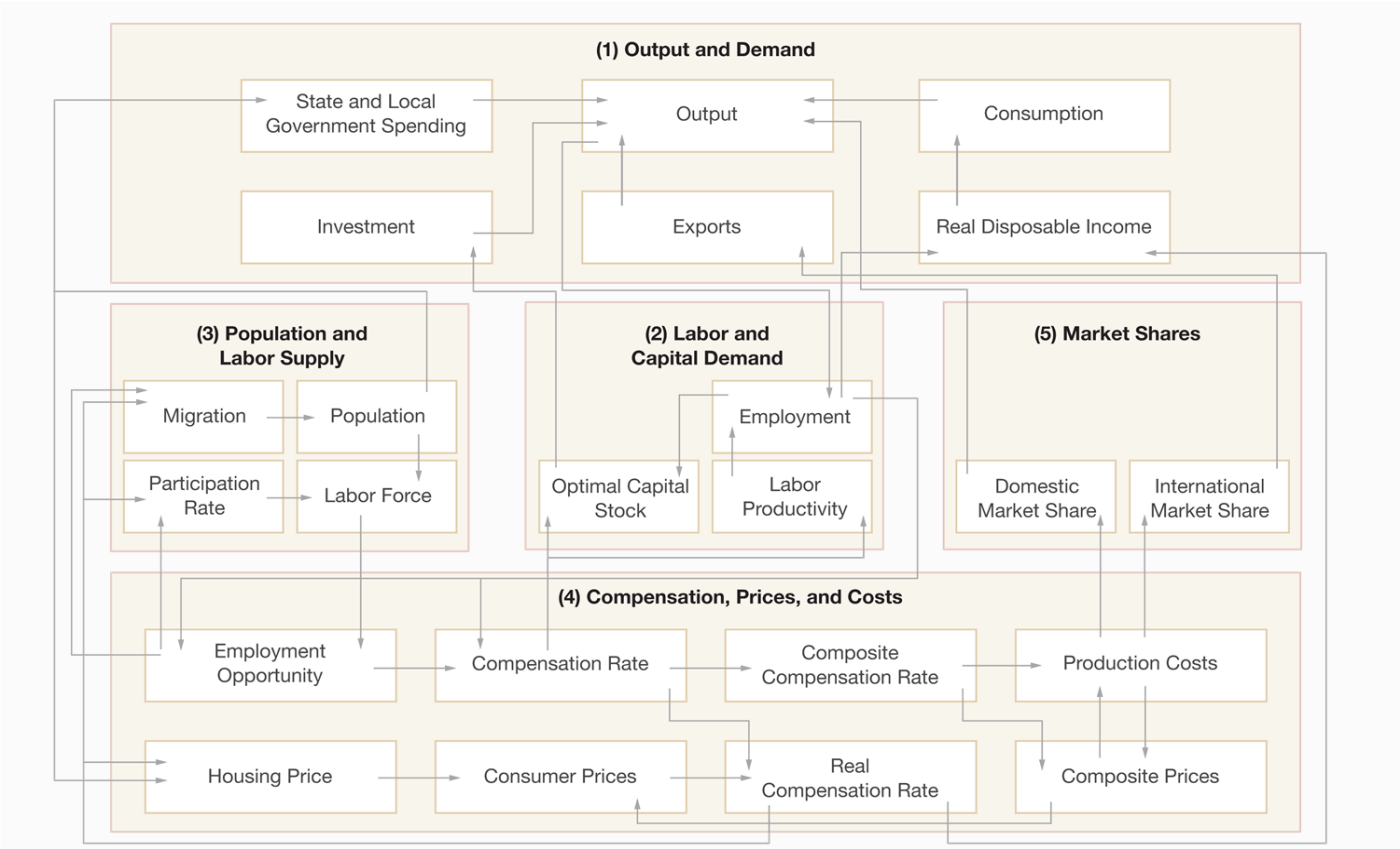
Other Factors Affecting Analysis

- Responsive changes: displacement or something else? (Engaging idle capital, reducing cash reserves)
- Boundary Issues
  - Changes in spending – how much on imports vs. domestic goods/services?
  - Business spending – are materials/labor local or imported?
  - Investment – where does the capital come from? Displacing local investment or not? Interest paid to local investors, or to outside entities?

Using a Macroeconomic Model

- Software that models flows of money around the economy, changes to productivity, output, inflation, incomes, employment
- Models of different types (REMI, CGE, I-O)
- Data must reflect a specific economy. Each economy has different:
  - Labor productivity
  - Intermediate demand for each sector
  - Elasticities of demand
  - Costs for goods and services
  - Levels of activity in different sectors
  - And Many Other Unique Characteristics!

Exercise: REMI Model Blocks



Examples

STATE REMI MODELING, U.S.

Washington State Clean Fuel Standard

Washington (US Northwest)

Policy: Vehicle fuels 10% cleaner by the year 2026

Industry, fuel users select which fuel option is most attractive

- Electricity
- Natural Gas
- Biofuels

Flexible Policy!

How to Analyze a Flexible Policy?

- Create **8** Possible Future Scenarios!
  - Cover range of likely outcomes
  - Test the importance of key differences, such as
    - Fuel type adopted
    - Infrastructure and Capital (pipelines, manufacturing plants, charging stations) associated with different fuels
    - Domestic vs. imported source of clean fuels
    - Use of tradable credits to fund new investment
  - Understand range of possible economic impacts from Clean Fuels policy – best vs. worst case scenario

Summary Of The 8 Scenarios

- Scenario A – The auto industry complies through the use of advanced vehicles (electric, hydrogen) and some biofuels
- Scenario B – The industry complies through the use of advanced low-emission cellulosic biofuels
- Scenario C – The industry relies primarily on a small set of vehicles that can utilize conventional biofuels for 85% of their fuel
- Scenario D – The industry relies primarily on a large fleet of vehicles that can utilize conventional biofuels for 15% of their fuel
- Alternative version of each scenario: additional financing mechanism to transfer money from petroleum fuel sales to fund investment in clean-fuels technology and infrastructure

Identifying Inputs for Macro Modeling

Fuels & Vehicles (10 Cost/Saving Streams)

Changes in Spending on:

- Gasoline/Diesel
- Ethanol, Biodiesel, Cellulosic Fuel
- Natural Gas, Electricity, Hydrogen

Changes in Prices of:

- Gasoline and Diesel (tax increase)
- Vehicles (electric and hydrogen)

Impacts:

- Consumption changes
- Price Impacts

Infrastructure & Equipment (14 Cost/Saving Streams)

Requiring The Purchase of:

- Electric charging stations
- Liquid fuel stations (natural gas, biofuels)
- Specialized tanks & storage
- Trucks for transportation of fuel
- New manufacturing plants! $1.8 billion RMB each

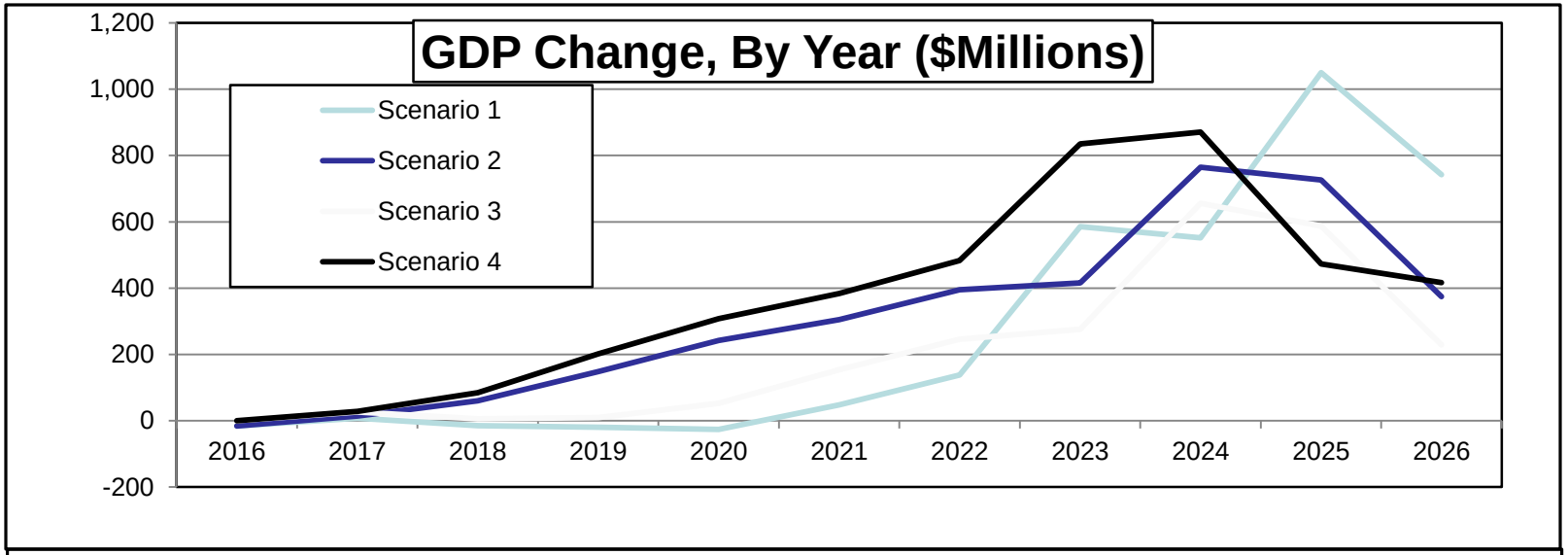
Impacts:

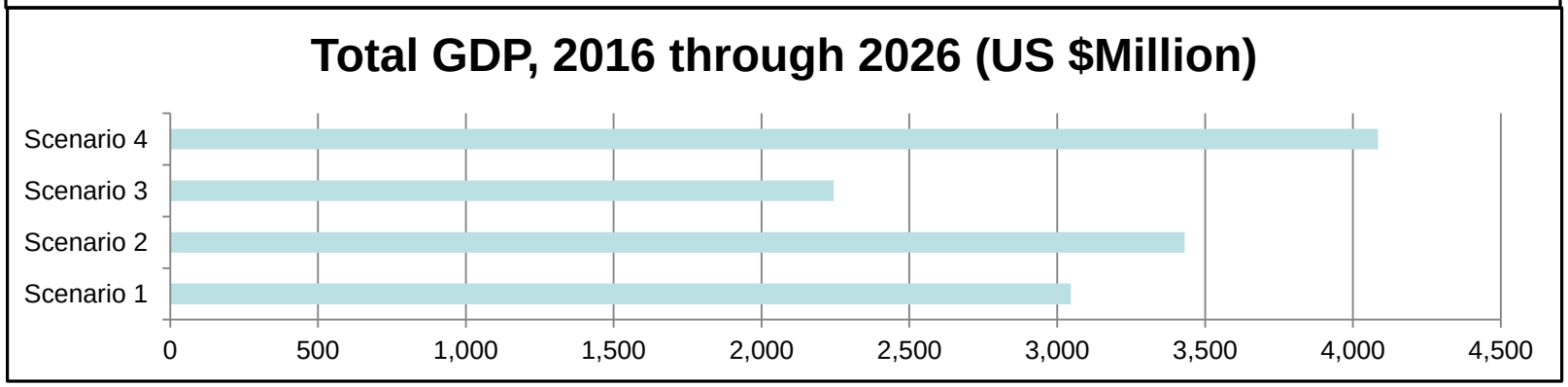
- Investment displacement
- Imports/exports

Example of Inputs

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Petroleum Fuel	$ -	$ (31.47)	$ (66.13)	$(146.45)	$(199.74)	$(230.67)	$(252.53)	$(253.96)	$(322.35)	$(473.12)	$(658.93)
Other chemical products	$ 0.15	$ 27.45	$ 27.11	$ 27.25	$ 27.27	$ 27.30	$ 27.19	$ 27.08	$ 109.95	$ 252.77	$ 428.91
Electric power	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other chemical products	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Basic organic chemicals	$ -	$ 16.36	$ 59.24	$ 152.23	$ 225.26	$ 278.18	$ 335.03	$ 367.32	$ 376.17	$ 384.69	$ 392.98
Basic organic chemicals	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Natural gas	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Basic chemicals	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
All Consumption Categories	$ (0.15)	$ 4.02	$ 39.02	$ 119.20	$ 172.47	$ 203.38	$ 225.34	$ 226.88	$ 212.40	$ 220.35	$ 230.02
New motor vehicles	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Electrical equipment	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Manufacturing structures	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other structures	$ -	$ 14.95	$ -	$ -	$ -	$ -	$ 17.25	$ 8.63	$ 99.82	$ 151.98	$ 60.79
Motor vehicles	$ -	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ 0.00	$ -	$ -	$ 0.00	$ 0.00
Fabricated metals	$ -	$ 0.02	$ 0.00	$ -	$ -	$ 0.00	$ 0.00	$ 0.00	$ 0.04	$ 0.06	$ 0.09

Example of Results 1 Policy, 4 Designs





Thank you for your time and attention!
Questions?

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