Georgia Tech | University of Georgia | Emory University | the Ray C. Anderson foundation

DRAWDOWN GA

www.DrawdownGA.org

The Science Behind Drawdown Georgia:

Reducing Georgia's Carbon Footprint in Beneficial and Equitable Ways

October 21, 2020

Agenda

INTRO & OVERVIEW

Opening Remarks
John Lanier, Ray C. Anderson Foundation

Overview
Daniel Rochberg, Emory
Marilyn Brown, Georgia Tech

METHODS & FINDINGS

Electricity
Marilyn Brown, Georgia Tech

Transportation
Mike Rodgers, Georgia Tech

Buildings & Materials
Dan Matisoff, Georgia Tech

Food & Agriculture
Sudhagar Mani, UGA

Land Sinks
Jackie Mohan, UGA

Beyond Carbon
Michael Oxman, Georgia Tech

NEXT STEPS

Next Steps
Marilyn Brown, Georgia Tech

Q & A
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Climate change presents real risks to Georgia and the rest of the world.

Tackling those risks head-on presents real opportunities.

Addressing climate change at scale will require creativity and innovation.

Project Drawdown pioneered this type of new thinking at the global level.

Drawdown Georgia brings a Georgia lens to this analysis.

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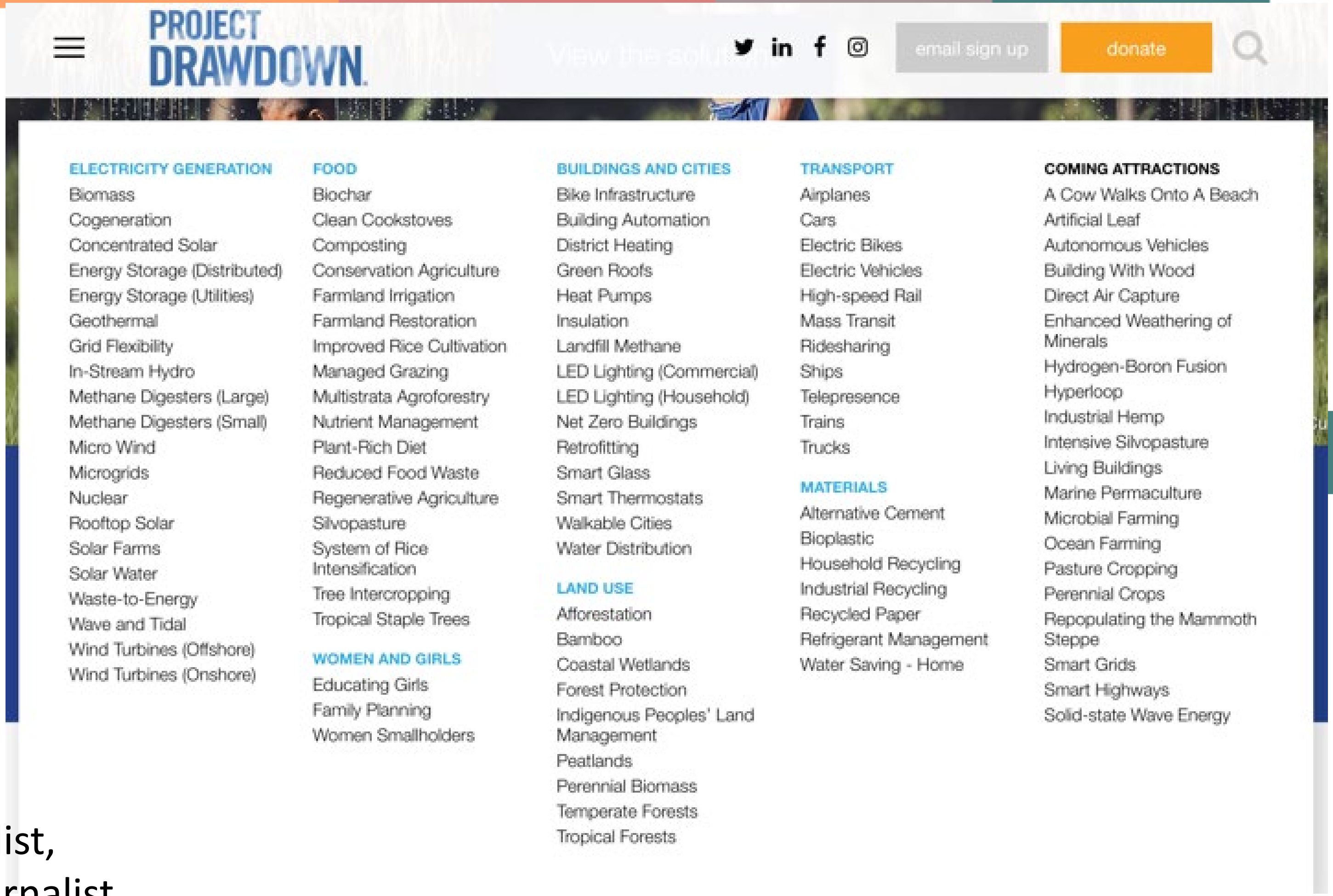
bringing climate solutions home

Drawdown Georgia Builds on a History of Multi-University Collaboration on Climate Change

Agnes Scott College
Columbus State University
Emory University
Georgia Southern University
Georgia State University
Georgia Tech
Spelman College – A Choice to Change the World
University of Georgia
UNG – University of North Georgia

Drawdown Georgia Research Methodology and Overview of Findings

Starting Point: Project Drawdown Solutions



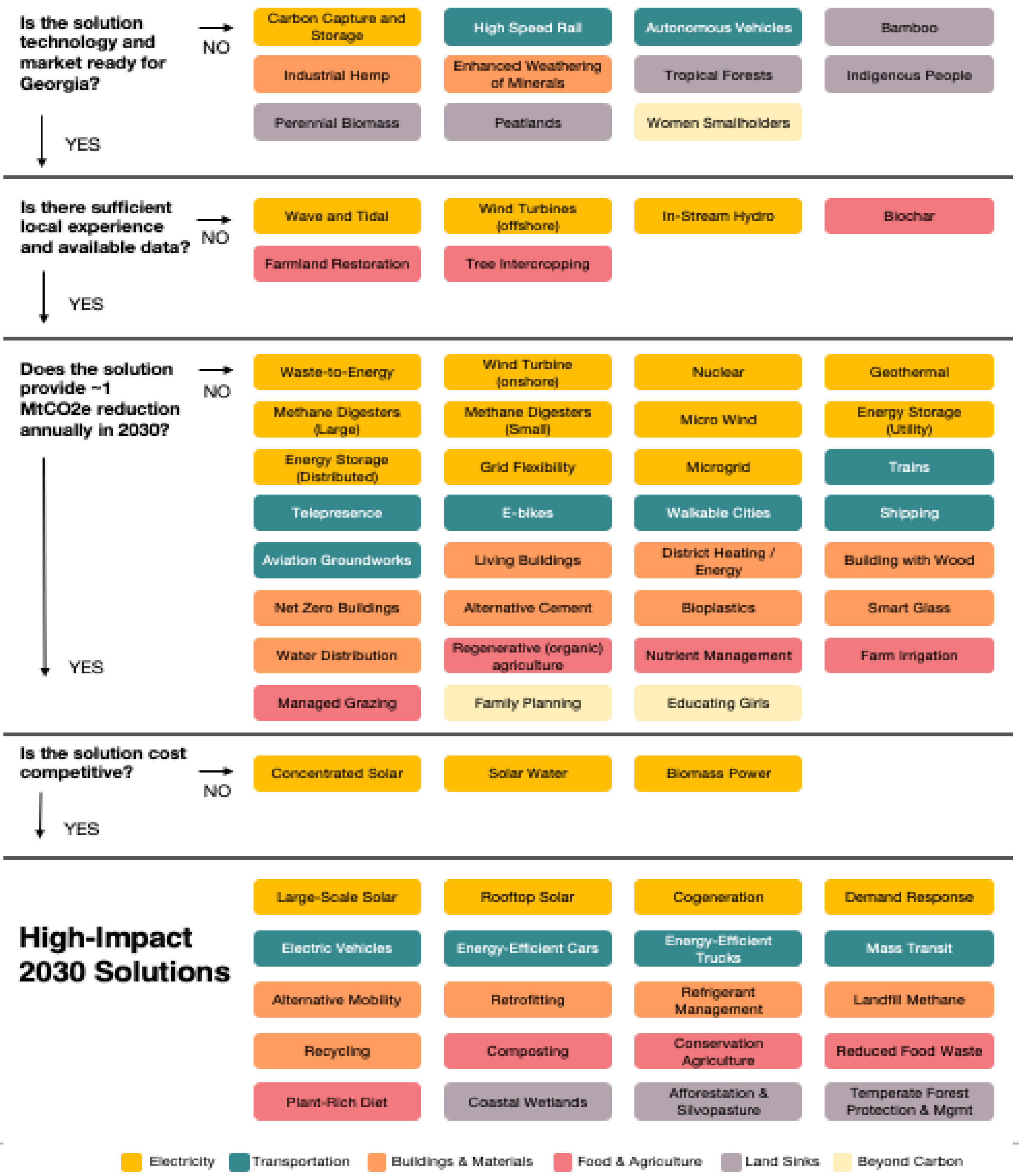
Which are best for Georgia?

Paul Hawken
an environmentalist, entrepreneur, journalist, and author
pioneer in sustainability

First we needed to listen and learn from numerous and diverse stakeholders—be inclusive and permeable

We designed a down-select system:

- Is the solution technology & market ready for Georgia?
- Is there sufficient local experience and available data?
- Can the solution reduce 1 $MTCO_2e$ annually by 2030?
- Is the solution cost-competitive?
- What are the “beyond carbon” issues?



20 Drawdown Georgia Solutions for 2030

Electricity

- Cogeneration
- Demand Response
- Rooftop Solar
- Large-Scale Solar
- Landfill Methane

Transportation

- Electric Vehicles
- Energy-Efficient Cars
- Energy-Efficient Trucks
- Mass Transit
- Alternative Mobility

Food & Agriculture

- Composting
- Conservation Agriculture
- Plant Rich Diet
- Reduced Food Waste

Buildings & Materials

- Recycling
- Refrigerant Management
- Retrofitting Buildings

Land Sinks

- Afforestation & Silvopasture
- Coastal Wetlands
- Temperate Forest Protection & Management

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What does 1 megaton of carbon reduction look like?

Rooftop Solar:
295,000 new 5 KW home solar systems by 2030

Photo Credit: Solar Crowdsource
https://www.solarcrowdsource.com/how-it-works-solarize/

Photo Credit – Food Well Alliance
https://www.foodwellalliance.org/communitybased-composting

Composting:
Divert ~2 million tons of organic waste from landfilling to composting by 2030

Alternative mobility:
Eliminate 2.5% of car trips

Photo Credit: Atlanta Journal-Constitution
https://www.ajc.com/news/local/gridlock-guy-safety-tips-for-cyclists-and-motorists-sharing-the-roads/

Drawdown Scenarios of the 20 High-Impact Solutions

Technical Potential: Maximum realistic application without regard to cost or other impacts, up to hard limits on resources such as available land and materials.

Recycling 95% of disposed recyclable materials

Covering 100% of south-facing + flat rooftops with solar panels.

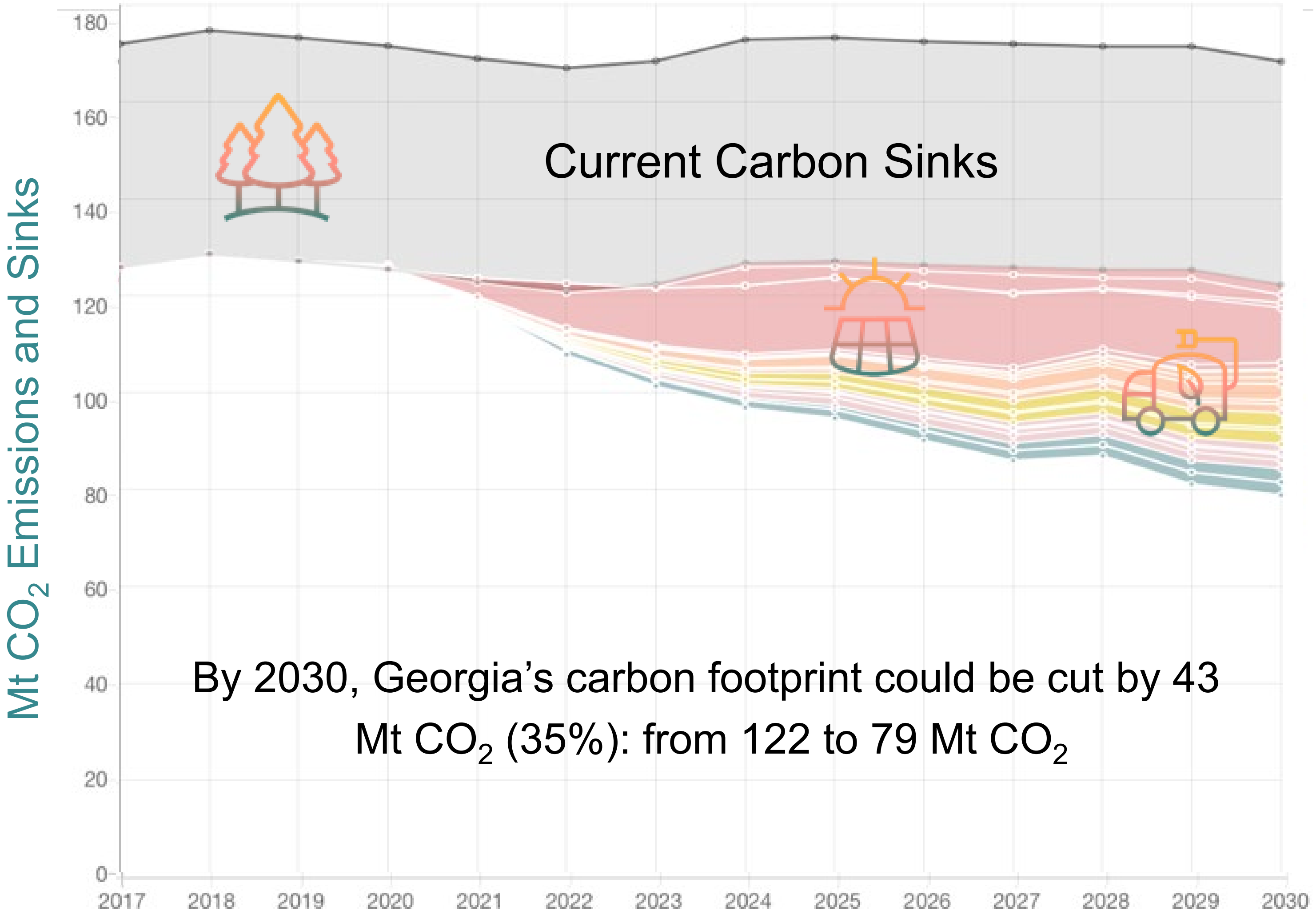
Achievable Potential: A realistic scenario that considers costs, impacts, and stakeholder acceptance, but consistent with a greater commitment to success.

EVs are 15% of new sales by 2030

Growing large-scale solar from 1 to 11% of electricity.

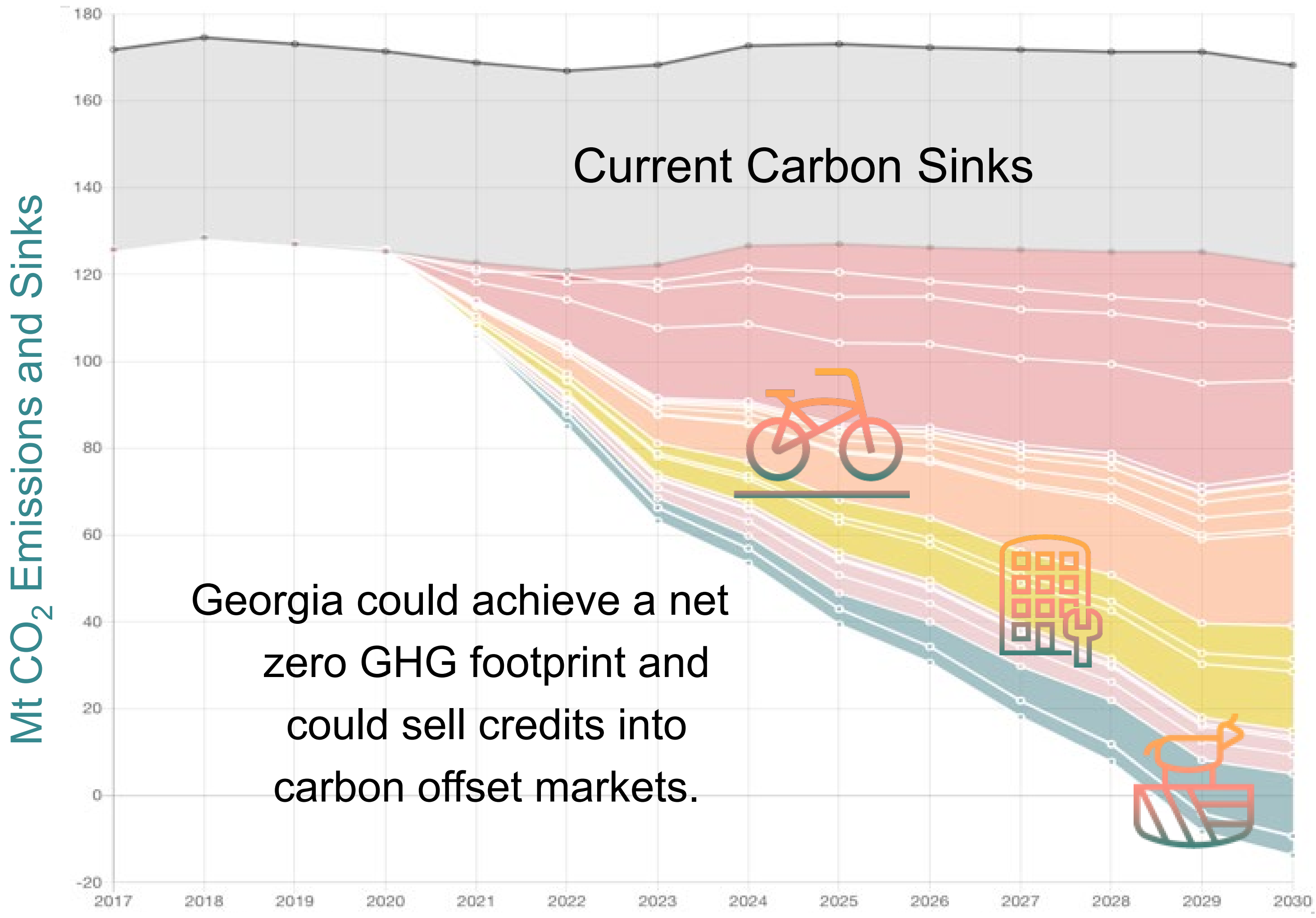
Baseline Forecast: The "no new action" scenario – status quo with slow change and continued trends.

Wedge Diagram – Achievable Potential



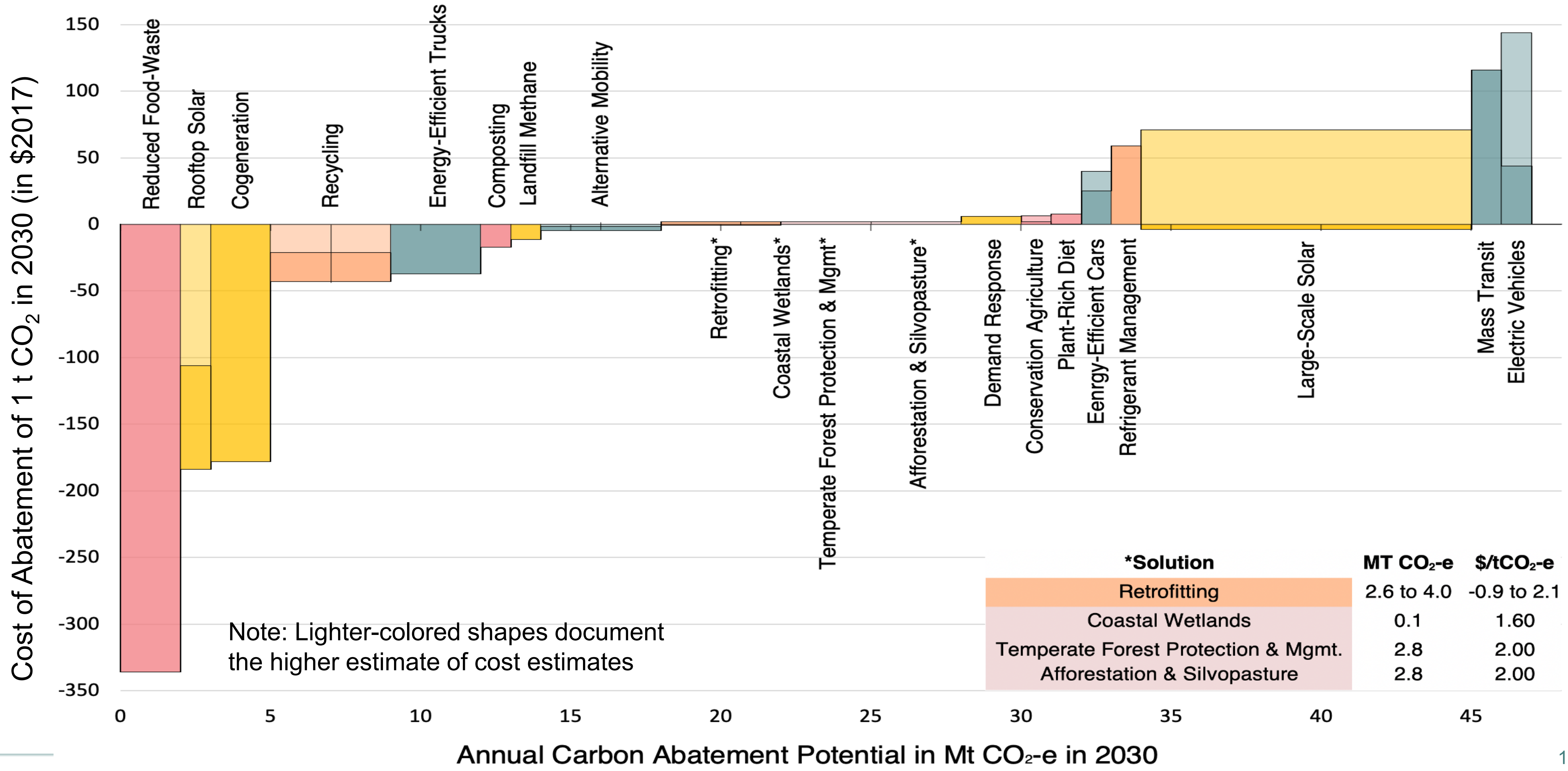
- Shows annual Mt CO_2 reductions relative to the Baseline (black) and current carbon sinks.
- Includes baseline annual sequestration (grey) at 46 Mt CO_2 per year from Georgia's natural carbon sinks
- All 20 solutions are set to their achievable potential
- The carbon impact of electric vehicles is enhanced by solar power

Wedge Diagram – Technical Potential



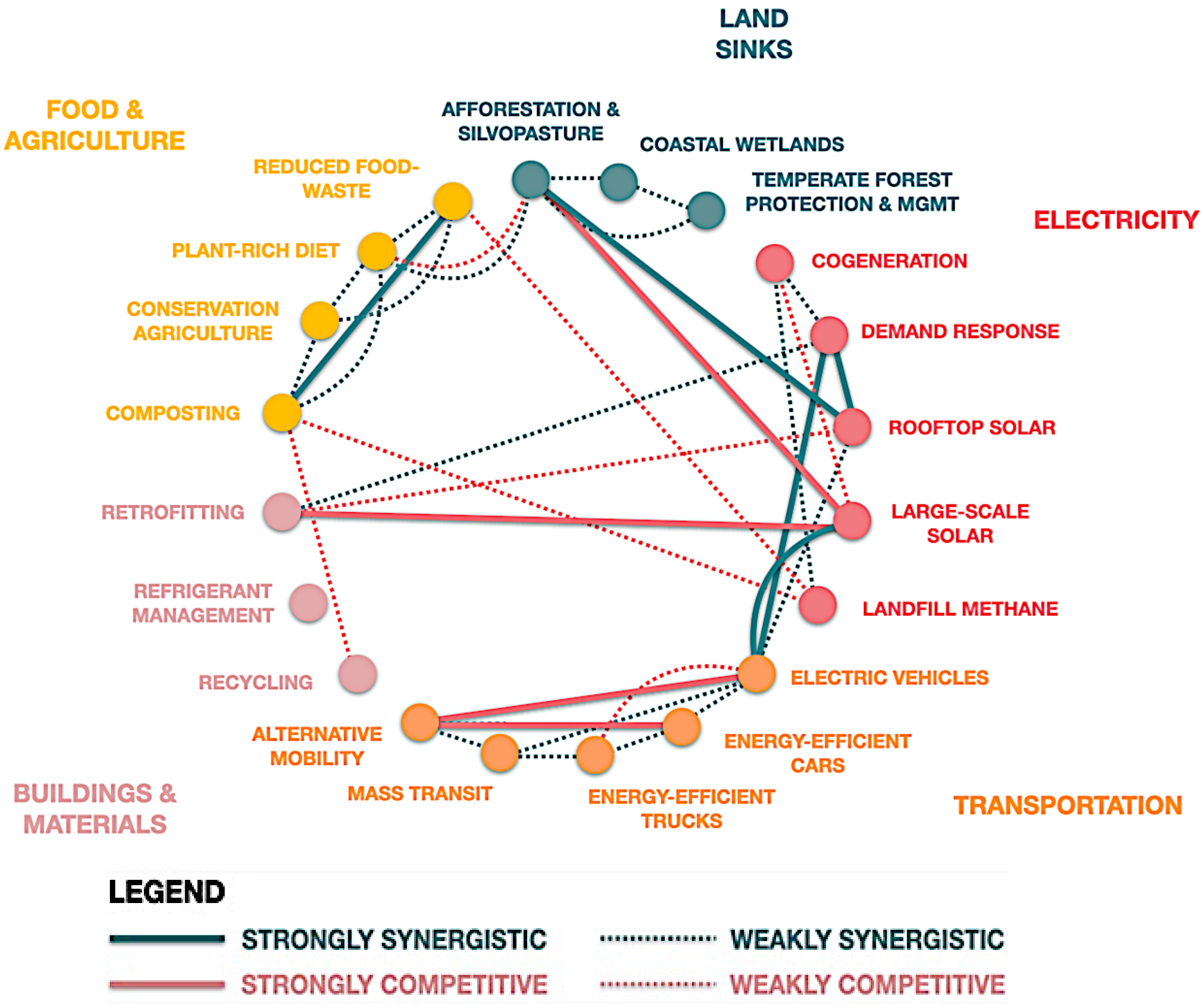
- All 20 solutions are set to their technical potential
- Carbon emission reductions overshoot zero by 11% in 2030.
- More carbon is sequestered than emitted in GA by 2025
- Retrofitting impacts are still large, even with low-carbon electricity.

What are the total private costs and benefits of all 20 “achievable” solutions in 2030: $140 M of costs to $12 B of benefits



*Solution	MT CO_2-e	$/t$CO_2$-e
Retrofitting	2.6 to 4.0	-0.9 to 2.1
Coastal Wetlands	0.1	1.60
Temperate Forest Protection & Mgmt.	2.8	2.00
Afforestation & Silvopasture	2.8	2.00

Abatement cost curves are tricky because solutions don't operate in isolation



If large-scale solar reaches its Achievable Scenario in 2030:

--EVs would reduce an additional 1.4 Mt CO_2

--Retrofitting would deliver 0.7 Mt CO_2 less reduction

Strategies need to consider interactions and "systems" of solutions.

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Electricity Generation

- Cogeneration
- Demand Response
- Large-Scale Solar
- Rooftop Solar
- Landfill Methane

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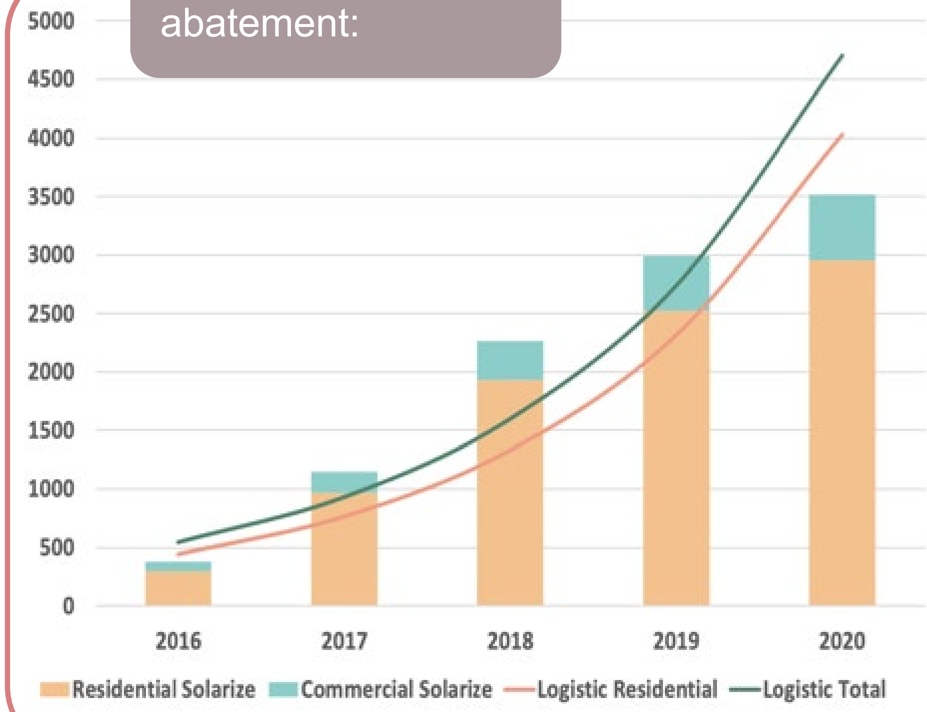
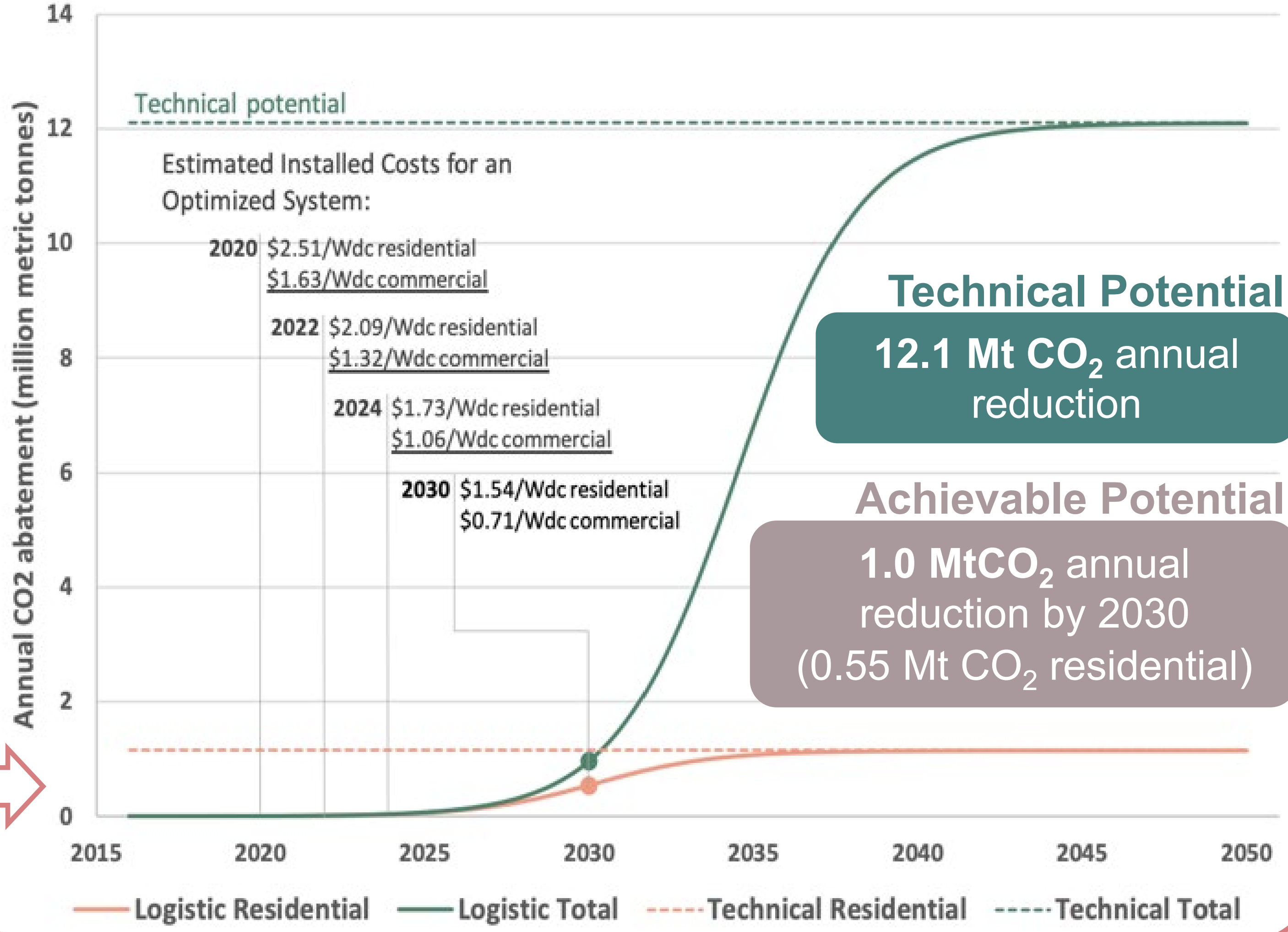
Rooftop Solar Achievable Potential: A megaton of carbon reductions is possible by 2030, and building owners with solar panels would save money

5,858 kW existing installed rooftop capacity

4,008 kW capacity installed from **Solarize** projects

Annual Solarize abatement:





Technical Potential

12.1 Mt CO_2 annual reduction

Achievable Potential

1.0 $MtCO_2$ annual reduction by 2030 (0.55 Mt CO_2 residential)

Installing rooftop solar on suitable roofs in Georgia could provide cost savings to building owners

Panel Generation Decay (%/yr)	0.5
Capacity Factor (Generation/Nameplate)	14.7%
Year of installation/financing	2030
Financing Period = System Lifetime (yr)	25
Surplus Buyback Ratio (% of Retail Price)	100%

Residential

Nameplate (DC) Power (kW)	6.2
System Cost As Installed (2017$)	$9,533
Initial Year Generation (MWh)	8
Annual Consumption (MWh)	10.97
Initial Year Electricity Price (2017¢/kWh)	12.45
Financing Annual Interest Rate	5.00%
Financing Fee (2017$)	$1,000
Annual payments (current year $)	$832.55
PV of Net Savings vs. No Solar (2017$)	$7,619
CO_2 from outside generation avoided (tonnes)	72.0
Net Cost to Owner Per Tonnes CO_2 Abated	-$106
Initial Yr Elec Price for No Savings (2017¢/kWh)	8.32

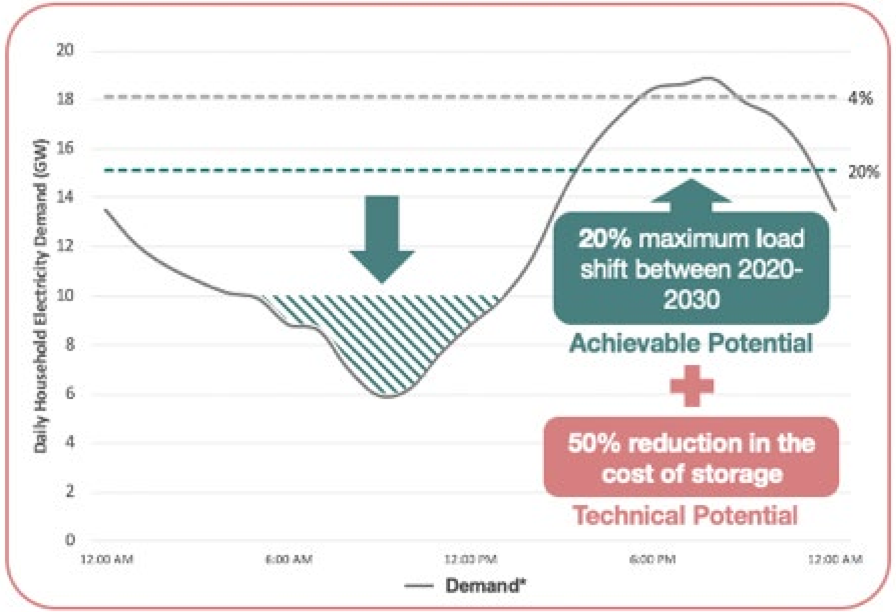
Commercial

Nameplate (DC) Power (kW)	200
System Cost As Installed (2017$)	$141,150
Initial Year Generation (MWh)	258.1
Annual Consumption (MWh)	354.8
Initial Year Electricity Price (2017¢/kWh)	10.50
Financing Annual Interest Rate	3.50%
Financing Fee (2017$)	$0
Annual payments (current year $)	$10,556
PV of Net Savings vs. No Solar (2017$)	$427,096
CO_2 from outside generation avoided (tonnes)	2324
Net Cost to Owner Per Tonnes CO_2 Abated	-$184
Initial Yr Elec Price for No Savings (2017¢/kWh)	3.16

Weighted Average of Residential and Commercial: $134/t$CO_2$

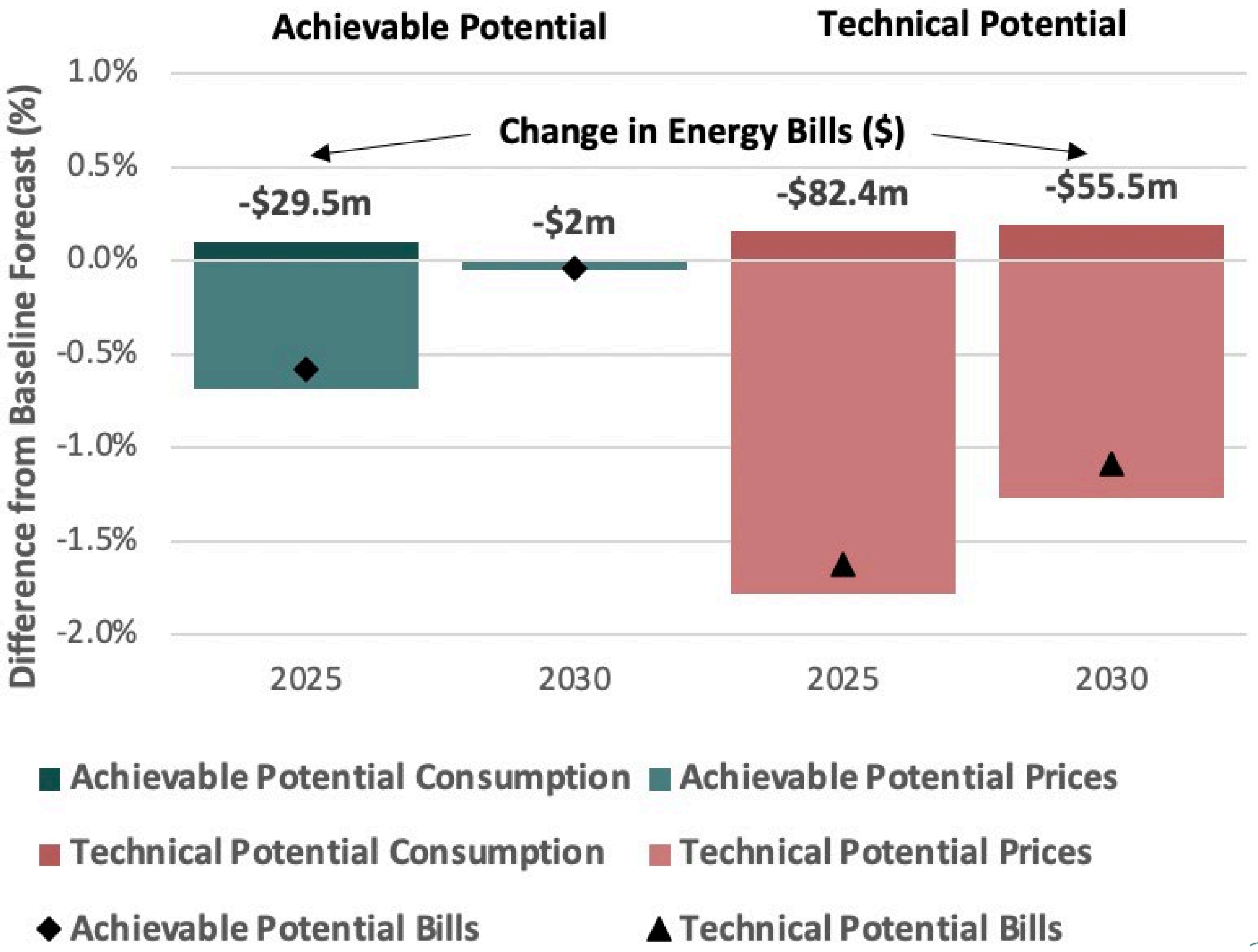
Demand response clips expensive and polluting peak electricity, and can lower bills for consumers

We used the GT-NEMS (National Energy Modeling System) to study demand response in Georgia.



Georgia businesses would see lower electricity prices and bills, saving ~$15.5 million each year over the decade

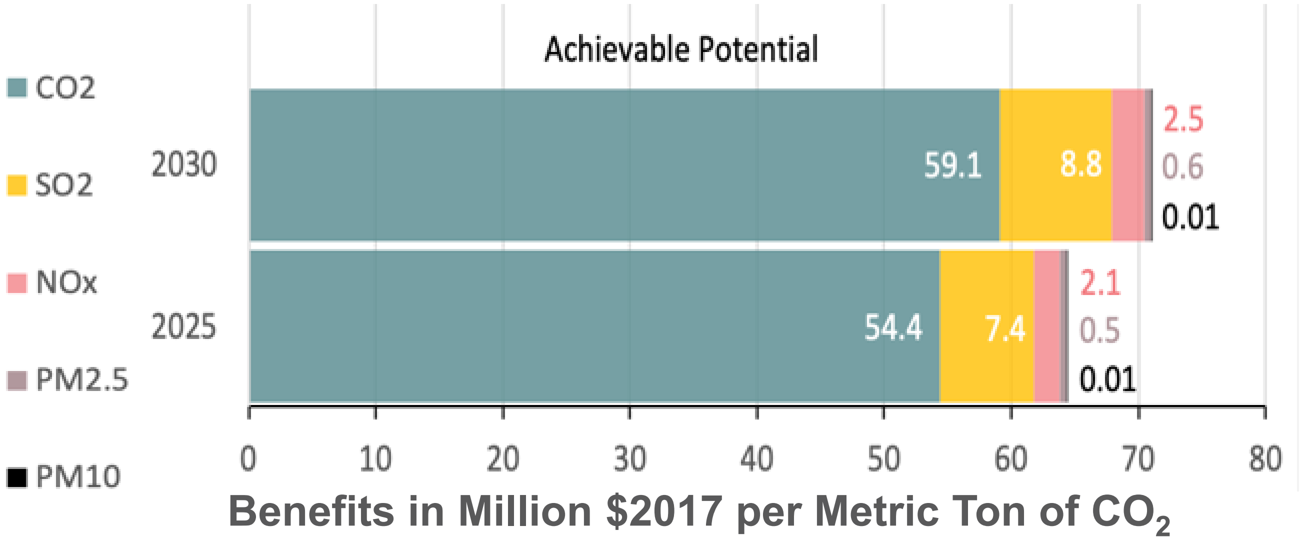
Business Sector:



Demand Response Also Delivers Significant Air Quality and Public Health Benefits

- Lower SO_2 and NOx levels result in fewer respiratory illnesses such as asthma, particularly in children.
- Reducing fine particulates has significant health benefits:
  - especially for children – lower incidence of preterm birth, low-birth weight, and autism spectrum disorder.
  - also for adults – fewer premature deaths, heart attacks, and respiratory illnesses.
- Other important benefits include increased workforce productivity and quality of life.

Environmental, public health, and ecosystem benefits of reduced air pollution from demand response



- Total benefits from reduced SO_2, NOx, PM10, and PM2.5 = $21 million in 2030.
- Total for CO_2 = $123 million in 2030.

Transportation

- Alternative Mobility
- Electric Vehicles
- Energy-Efficient Cars
- Energy-Efficient Trucks
- Mass Transit

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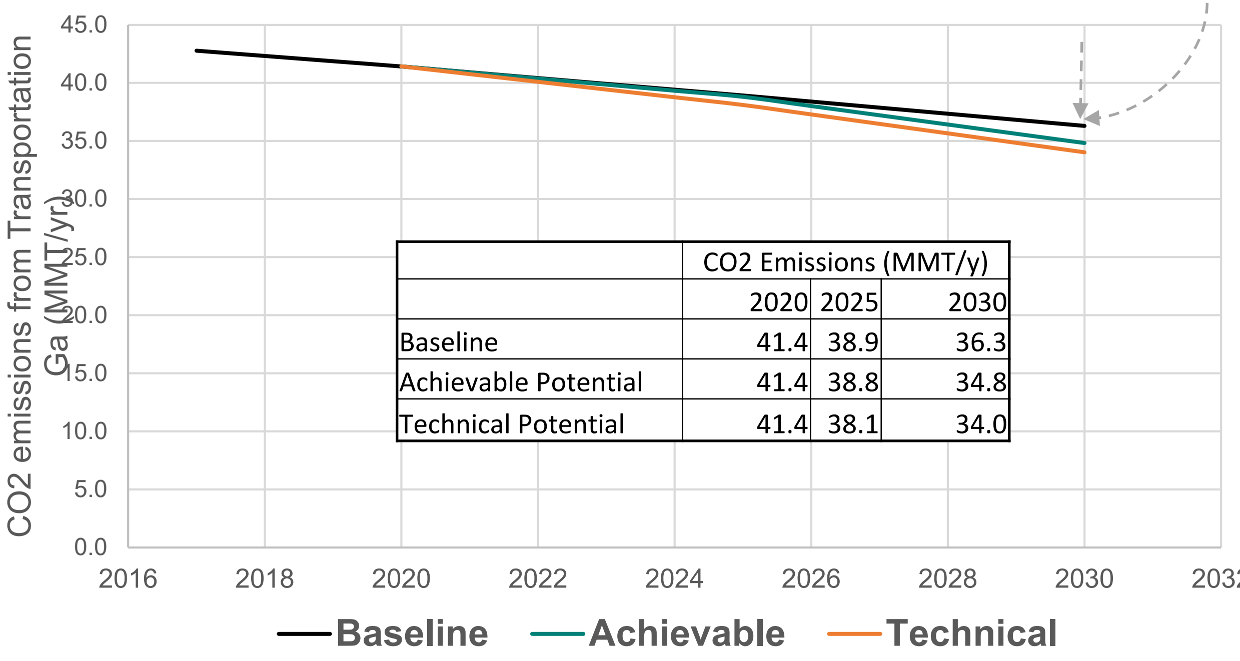
Electric Vehicles

EVs can contribute additional CO2 reductions beyond a favorable baseline trend by 2030



	CO2 Emissions (MMT/y)		
	2020	2025	2030
Baseline	41.4	38.9	36.3
Achievable Potential	41.4	38.8	34.8
Technical Potential	41.4	38.1	34.0

Baseline = Assumes business as usual for fuel economy and CO2 reductions, driven by new vehicle technologies and Federal CAFE regs

Achievable Potential =Approximately **310,000 EVs in** Georgia's Light Duty Vehicle Fleet (i.e., about 4% of the total fleet), and accounting for 15% of new LDV sales in 2030

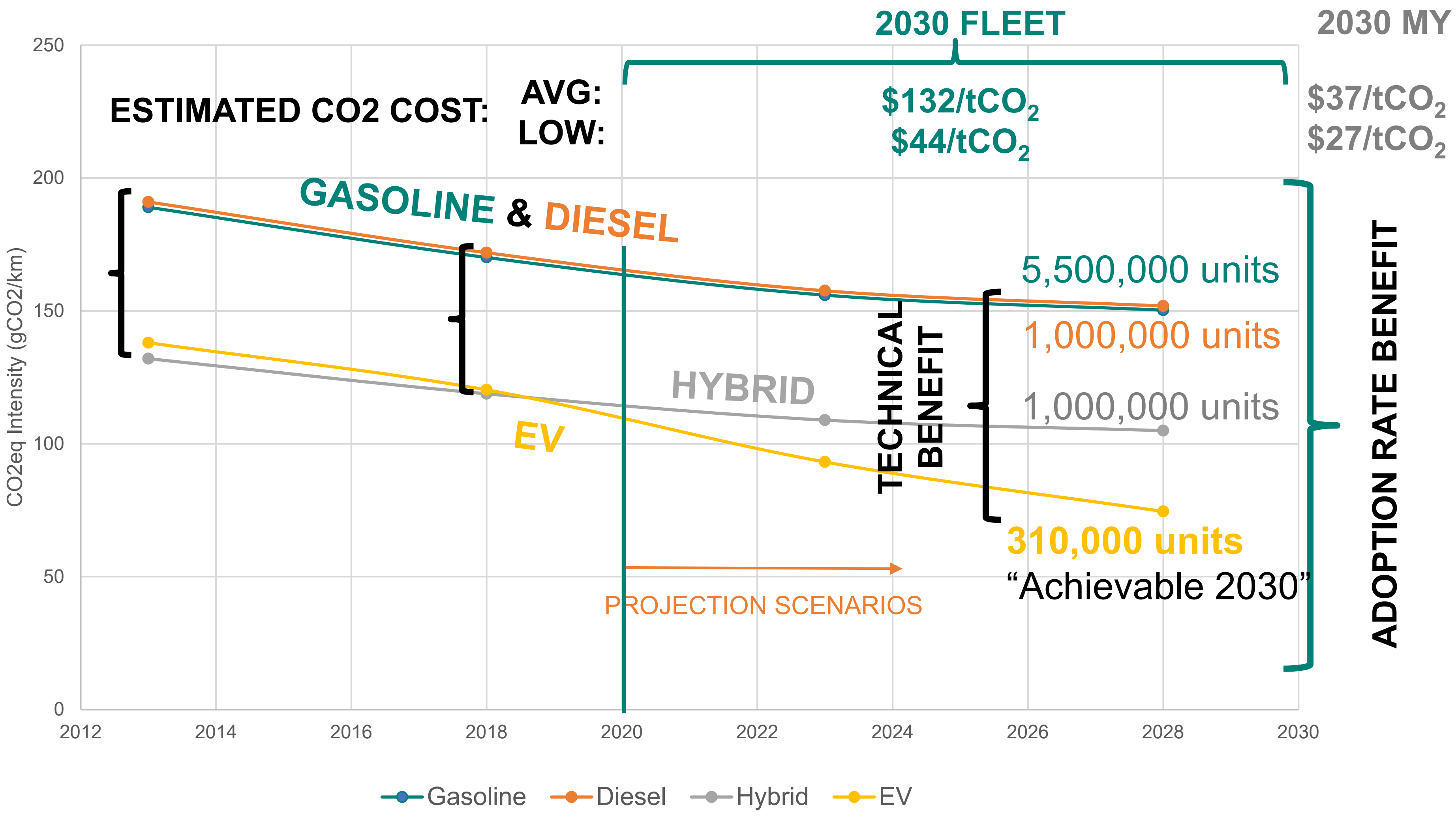
Technical Potential = Approximately **680,000 EVs** in the Georgia LDV fleet (9% of the total fleet), and 35% of new LDV sales by 2030. Contributing **2.3MtCO_2/yr** reductions compared to baseline.

1 MtCO_2e solution in 2030 = an additional 250,000 gasoline cars are replaced with electric vehicles.

+Improved Air Quality
+Approaching TCO price parity
+Lower operating & maintenance costs

-Affordability on capital cost basis

Despite an aggressive baseline, grid CO_2 intensity reductions propel per vehicle EV contributions



Conventional vehicles improve at 1.5% y/y through 2025

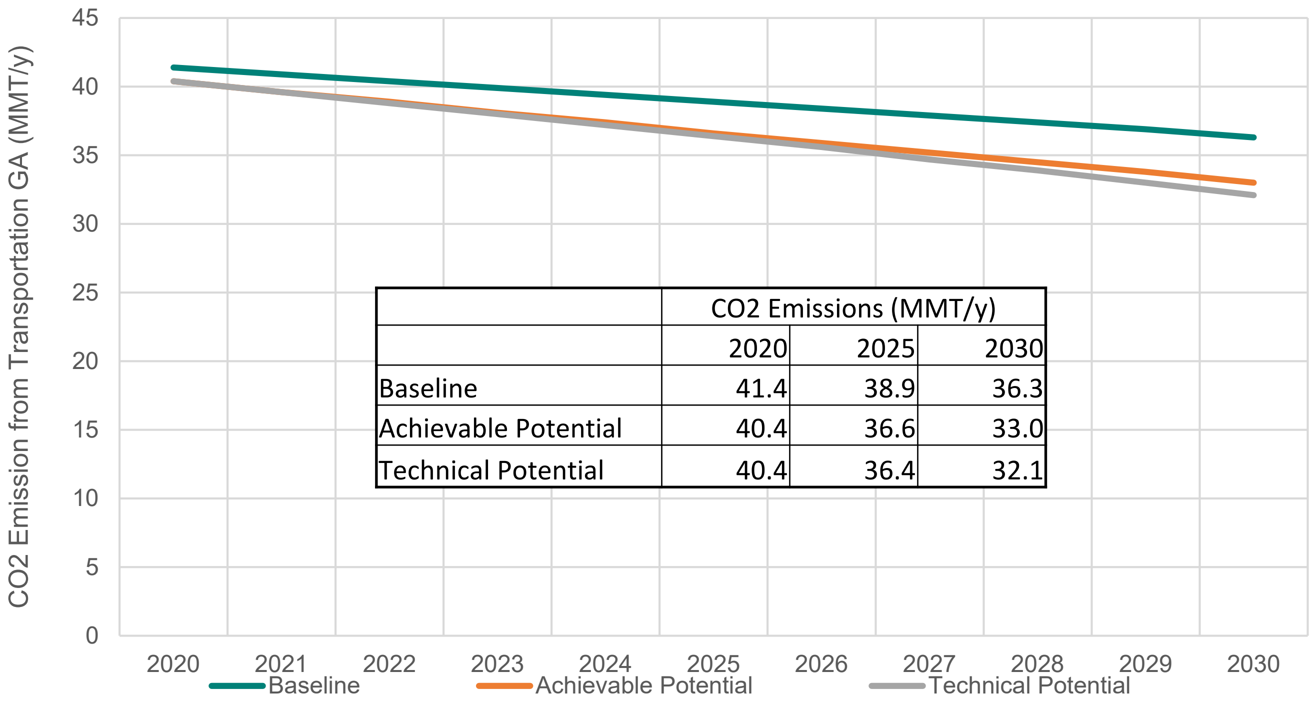
EVs approach a relative CO2 intensity of 50% compared to conventional cars

But, adoption rate will dictate overall impact from this solution

R. Simmons, Strategic Energy Institute, Georgia Institute of Technology, 2020

Energy-Efficient Trucks

M/HD Trucks can contribute additional CO2 reductions beyond a favorable baseline trend by 2030



	CO2 Emissions (MMT/y)		
	2020	2025	2030
Baseline	41.4	38.9	36.3
Achievable Potential	40.4	36.6	33.0
Technical Potential	40.4	36.4	32.1

Baseline = Assumes business as usual for fuel economy and CO2 reductions, driven by new vehicle technologies and Federal CAFÉ regulations

Achievable Potential = 25% overall reduction in truck fuel consumption by 2030.

Technical Potential = ~30% overall reduction in truck fuel consumption by 2030

Contributing 4.2 $MtCO_2e/y$ reductions compared to baseline.

1 $MtCO_2e$ solution in 2030 = net reduction of 100 million gallons of diesel fuel consumption (>1 billion gallons consumed by ~400k trucks in GA annually)

Majority of benefits derive from **Medium Duty** Applications

+Improved Air Quality
+Approaching TCO price parity
+Lower operating & maintenance costs

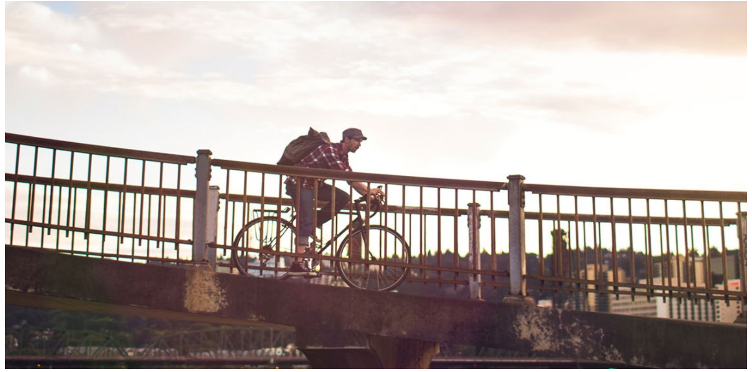
-Affordability on capital cost basis

Transportation KEY POINTS

Major Insights from our Analysis:

- **Baseline** CO_2 trends of the future fleet are already on pace to shed 5 MtCO_2-e/yr by 2030!
- "Electric Vehicle" (EV) technologies cut across **all 5** transportation solutions
- The **most significant** near-term opportunities are in Energy Efficient Medium Duty Trucks
- Alt mobility and transit both show potential, but include **behavioral and land use** considerations
- Energy efficient light duty vehicle technologies are **low-cost and high impact** during 2020-2025
- Light duty EVs may reach **TCO (cost) parity** by 2030 but subject to several unknowns:
    - E.g., the cost of fuel and batteries, tax credits, & charging
- Transportation solutions are **complementary & diverse**; benefits can stretch far beyond 2030
- Major **air quality** benefits are also expected, provided **affordability and access** are prioritized

Alternative Transportation



Current transportation mix (Atlanta)

Distance	Bike + Walk Share	Transit Share	Auto Share
<0.5 mile	35.4%	0.2%	64.4%
0.5-1 mile	24.6%	0.3%	75.0%
1-2 miles	17.6%	0.5%	81.9%
2-4 miles	12.2%	0.6%	87.2%
>4 miles	0.2%	1.5%	98.3%

Assumptions

- Shift 5 – 10% trips < 4 miles from cars to bike / walk / LIT
- Achievable potential increases bike / walk / LIT to 45-55% for <0.5 miles, 22-32% for <4 miles
- Eligible workers would telecommute 1 additional day per week for 20% increase
- Each additional mile of bike lane constructed increases bike ridership by 1% and costs $500k
- Private benefits reflect annual savings from avoided VMTs - $0.60 per mile

Results

Achievable CO2 Savings	PV Private Costs	PV Private Benefits
1.8-3.6 $MtCO_2e$	$1.3 Billion – 1.7 Billion	$7.4 Billion – 9.7 Billion

Technical Potential:

- **45% trips < 4 miles are walk / bike / LIT**
- **50% telecommuting**

21.5 $MtCO_2e$

Buildings and Materials

- Recycling/Waste Management
- Refrigerant Management
- Retrofitting

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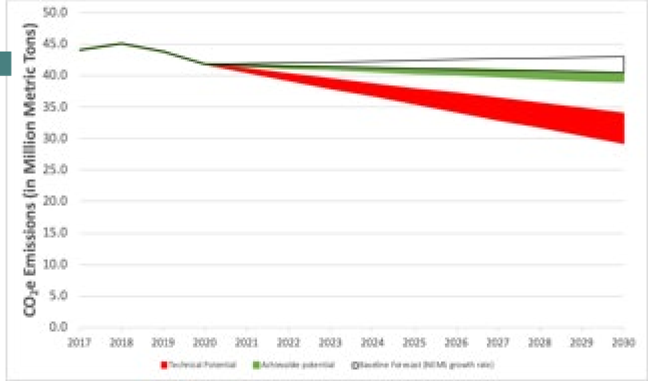
Retrofitting Buildings



Assumptions

Technologies (from focus group)

- Smart Thermostats/Building Automation
- LED Lighting
- Insulation
- Water Heaters
- Heat Pumps
- Windows (Residential)
- Recommissioning

Financial

- Discount rate = 12%
- Administrative costs excluded

+Less air pollution
+Local jobs
+Less energy burden
+Public health benefits
-High upfront cost

Cumulative retrofit rate by 2030

Technology	ST	LED	INS	WH	HP
Residential	20%	20%	20%	20%	20%
Technology	**BA**	**LED**	**RECOM**	**INS**	**HP**
Commercial	20%	20%	20%	0%	0%

Results

Achievable Potential	NPV Private Costs
Achievable Potential 2.6-4 Mt	**NPV Private Costs** $2.5B – $5.4B initial costs **NPV Private Benefits** $2.0B – $8.0B avoided energy costs

Improving Recycling in Georgia

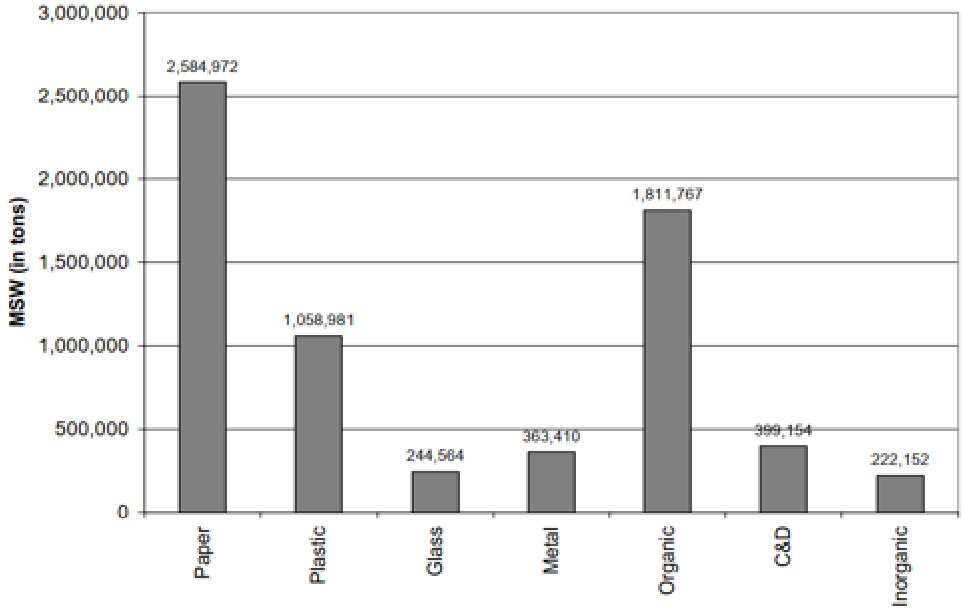
Assumptions:

- Improve efficiency of existing programs with information programs
- Focus on improving paper and plastic recycling (quality & quantity)
- Georgia's recycling rate is just 6.6% - far below U.S. average of 22.6%
- Increase recycling rate to 13-20%
- A $1 per-household increase on spending for recycling information programs can increase recycling rates by 1-3%

Conclusions:

- Waste management and recycling data are outdated
- Economics are highly dependent on *HOW* recycling programs are improved

Statewide MSW Tons Disposed (2005)



Results

Achievable CO_2 Savings	PV Costs	PV Benefits
2.0-4.1 $MtCO_2e$	$21M - $59M	$104M - $147M

Food & Agriculture Systems

- Composting
- Conservation Agriculture
- Plant-Rich Diet
- Reduced Food Waste

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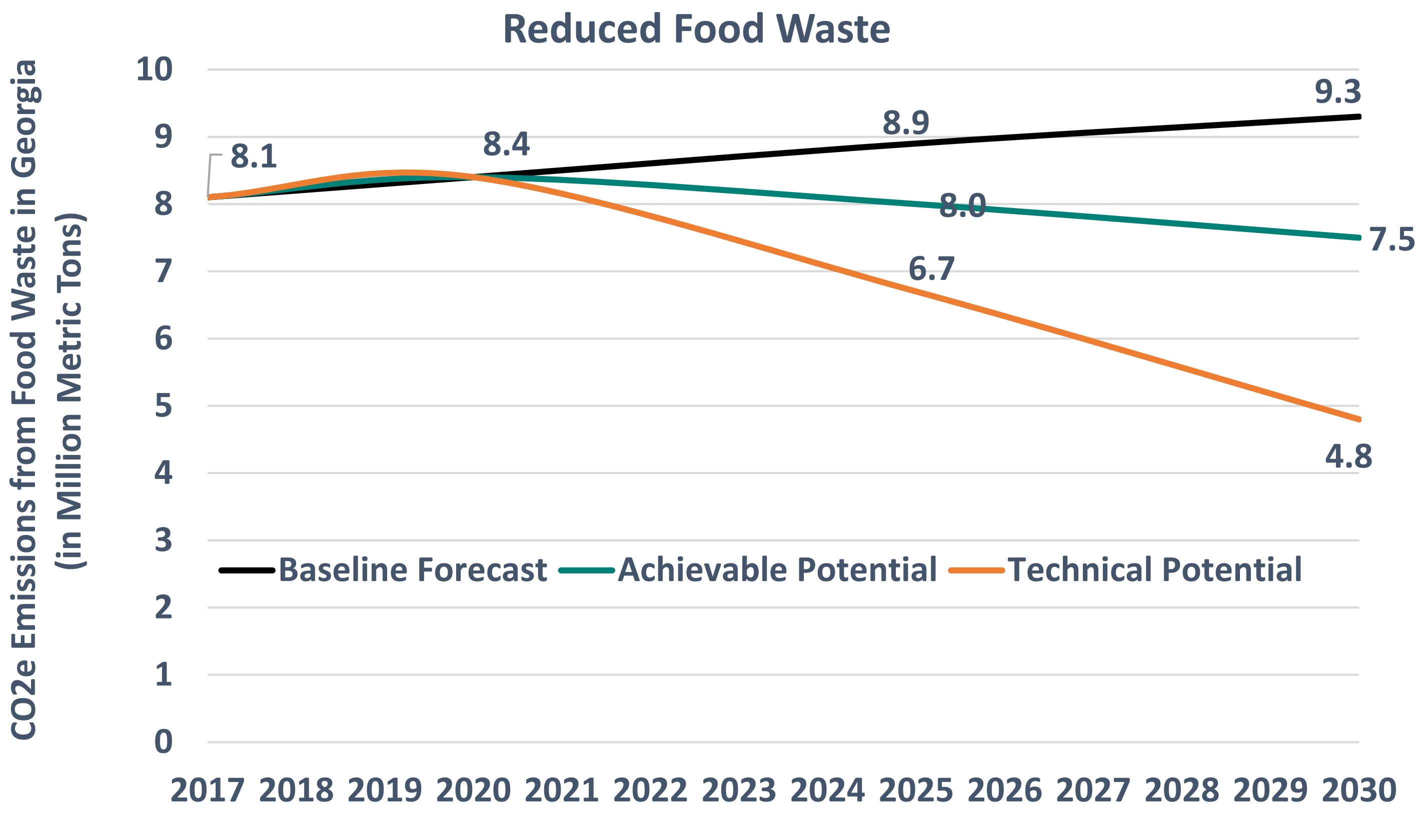
Reduced Food Waste

A path towards zero food waste



Baseline = Estimate based on emissions due to food production and current disposal methods.

Achievable Potential = 20% reduction of food wastes/losses reduces **1.8 $MMtCO_2$** in 2030 (equivalent to about 0.5 million ton)

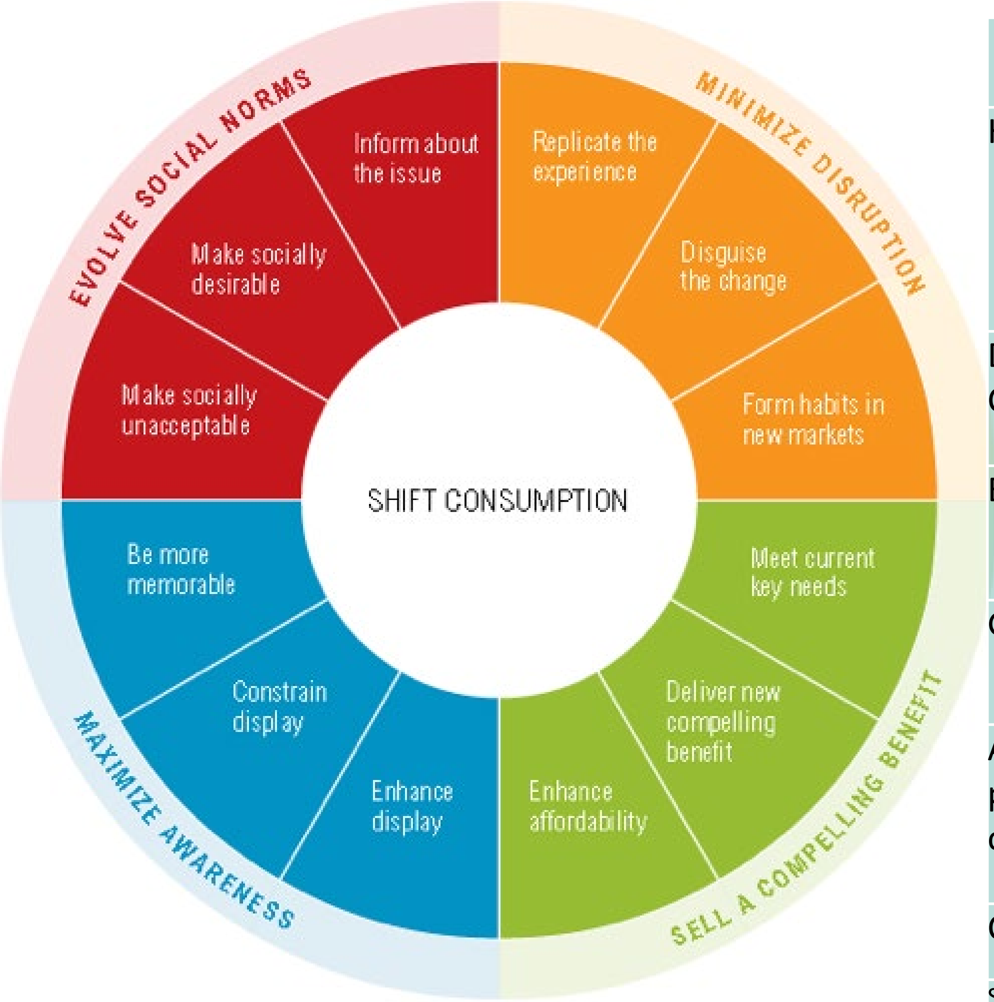
Technical Potential = 50% reduction of food waste/losses reduces **4.5 $MMtCO_2$** in 2030.

	Avoided $CO_{2\text{-e}}$ (Mt CO_2) in 2030
Achievable	1.8
Technical	4.5

+ More job creation
+ Cost saving
+ Less food insecurity
+ Less air and water pollutions
+ Food donation tax benefits

Annually, about 2.1 million tons of food wastes along the supply chain from production to final disposal.

Plant-Rich Diet – Strategies to shift diet/consumption



Source: http://worldresourcesreport.org

Potential Strategies	Expected impact (%)	Remarks
Health Awareness Campaign	high	Implement awareness campaign about the health, social and environmental benefits of plant-rich diets, reduce over consumption of beef and animal-based protein,
Development of New Veg. Foods Challenge	medium	Funds to promote the development of new vegetarian foods that adds taste, flavor and display
Enhance display and affortability	medium	Empower retails to display plant-rich foods and keep them affordable to public
Govt. policies and regulations	high	Policies and regulations that promote general health of public and diet choices
Advertisement (various venues) in partnership with private companies/non-profits	medium	Use media to bring awareness of the veg. products and health benefits and health issues of animal-rich diets, especially red meat
Community/Social groups	Medium/Low	Promote community groups

Source: Ranganathan, J. et al. 2016. “Shifting Diets for a Sustainable Food Future.” Working Paper, Installment 11 of Creating a Sustainable Food Future. Washington, DC: World Resources Institute. Accessible at http://www.worldresourcesreport.org.

Composting

Negative costs and a simple solution to zero landfill Georgia

Current Capacity:
2.6 million tons of organic wastes including food wastes landfilled

Technical Potential:
Reduction of
1.4 Mt CO_2 in 2030

Achievable Potential:
Reduction of
0.7 Mt CO_2 in 2030

Negative Costs:
**-$17/t**$CO_2$ in 2030

Biological aerobic process to decompose organic wastes by microorganisms into stable organic materials - compost

A valuable soil conditioner or fertilizer that improves plant growth, sequesters soil carbon and prevents soil erosion

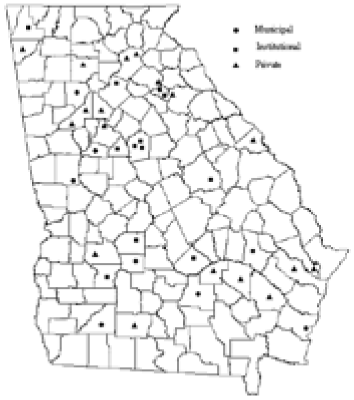
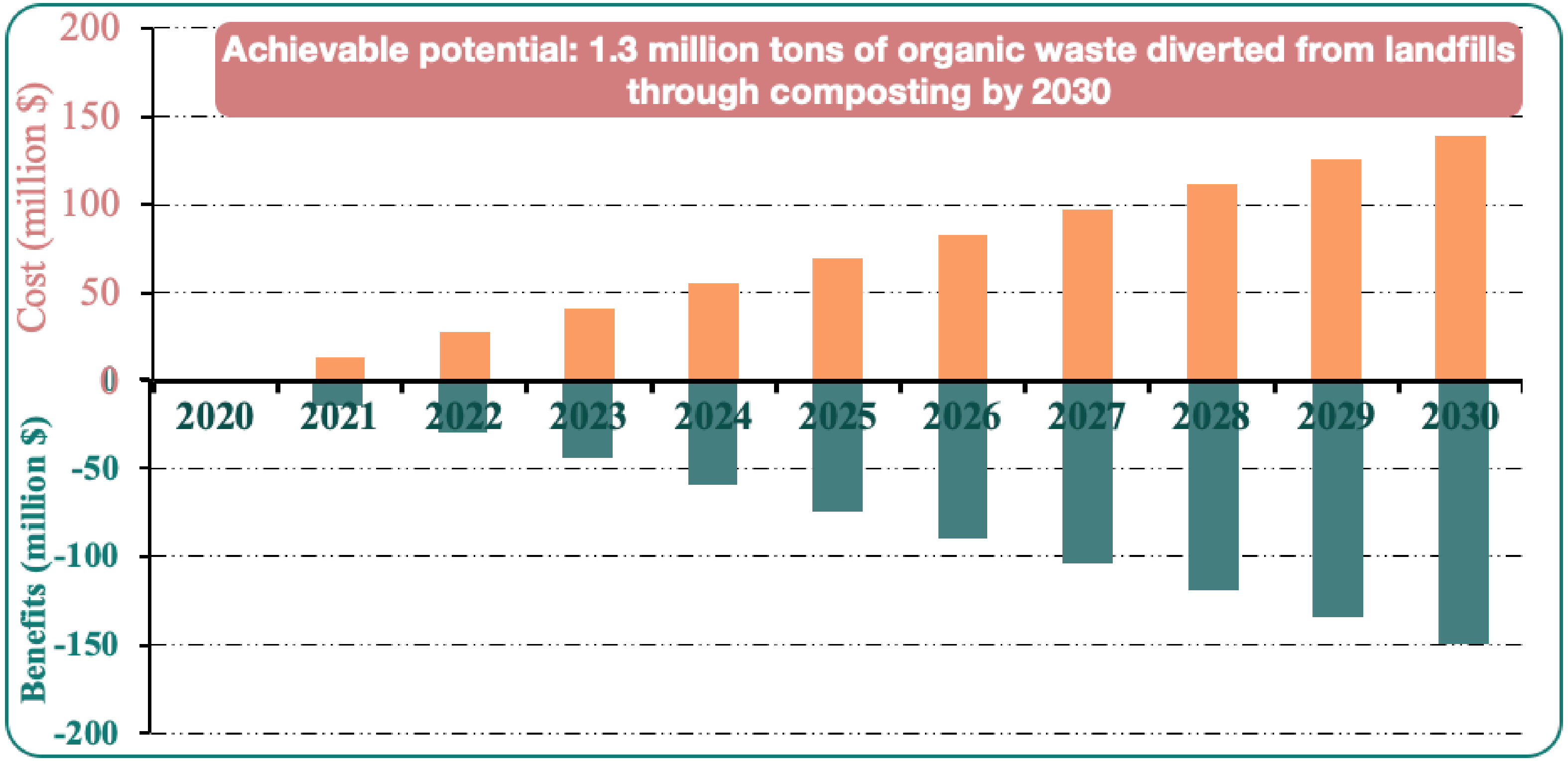
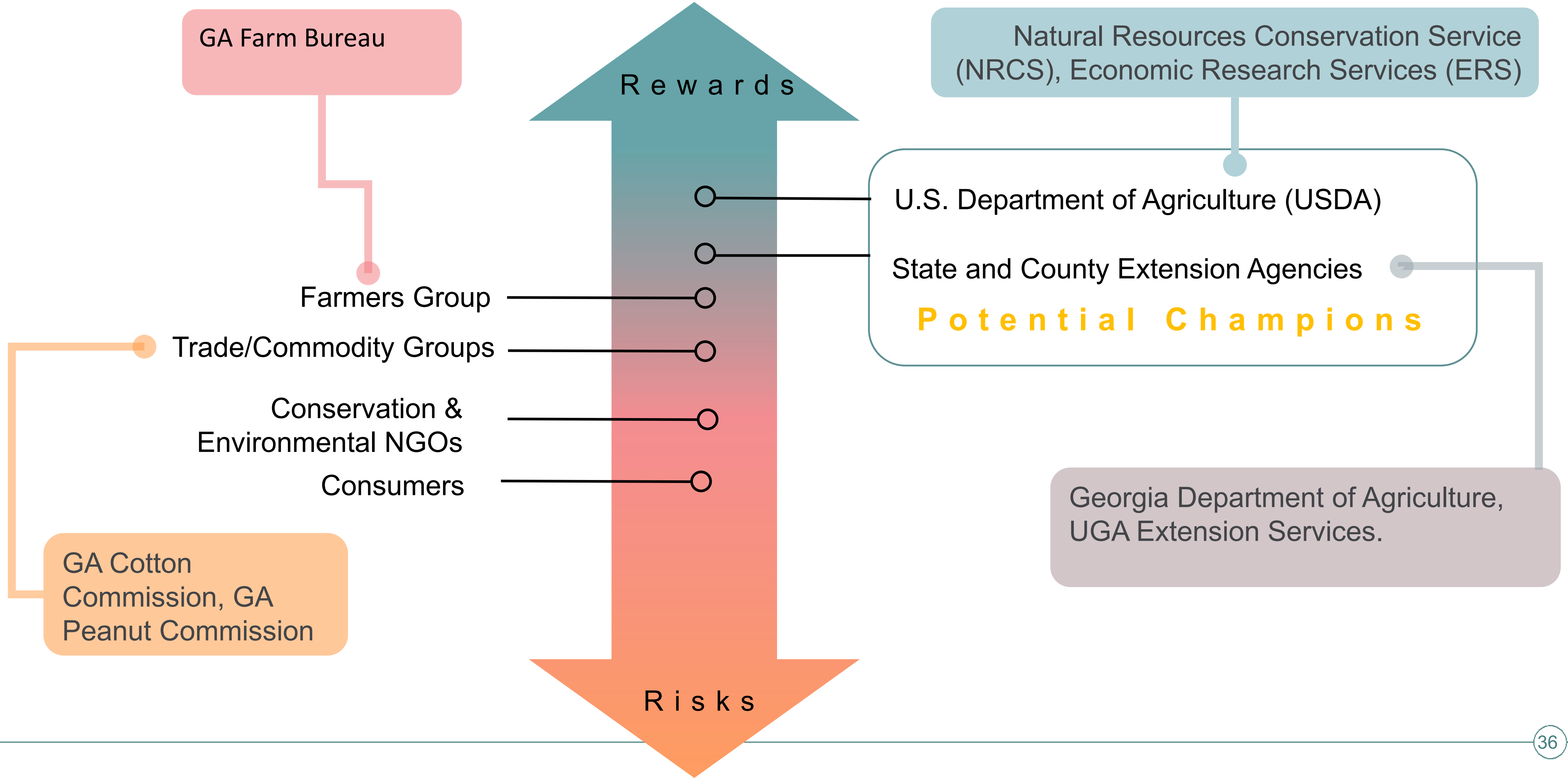


Figure 1. Location of 38 Georgia composting facilities, which participated in the survey, represented as municipal, institutional and private operations



Stakeholder Analysis of Conservation Agriculture



Land Sinks

- Temperate Forest Protection & Management
- Afforestation & Silvopasture
- Coastal Wetlands

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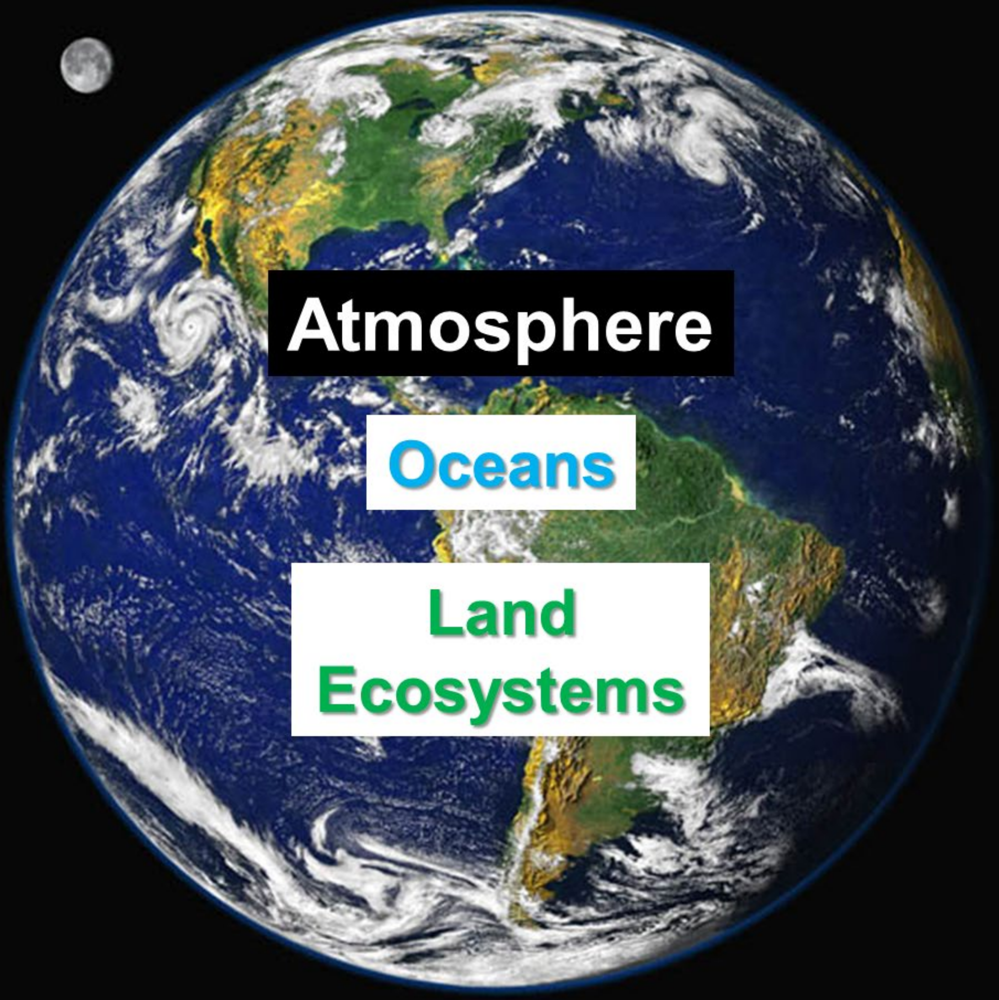
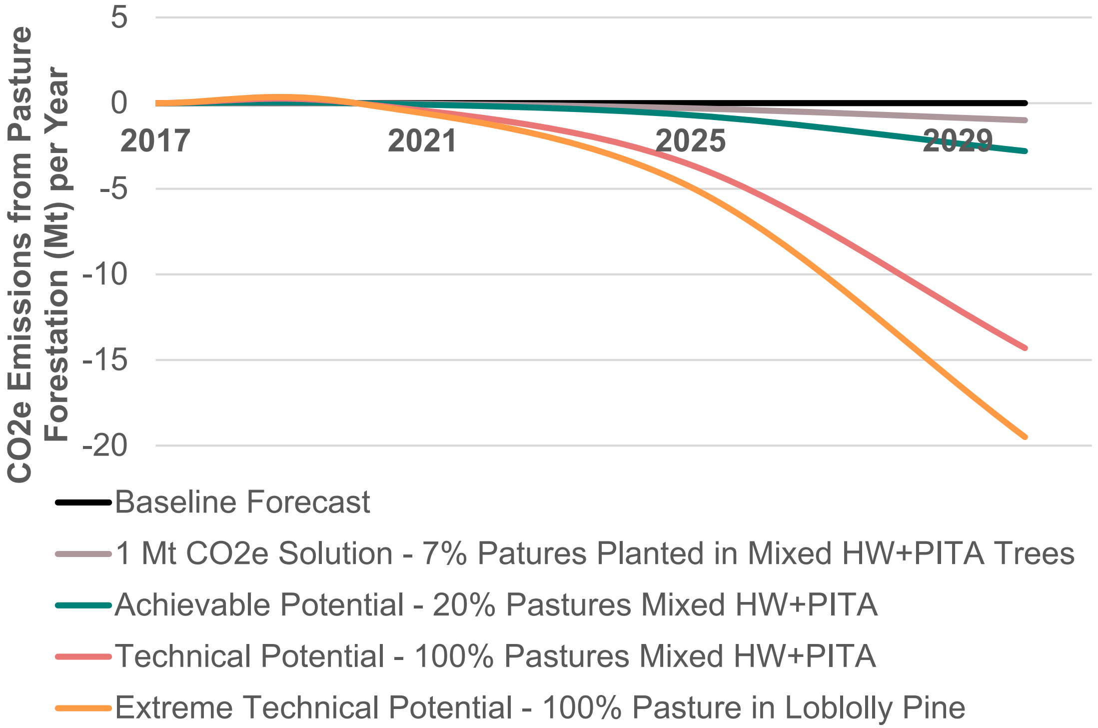
Earth Has 3 Natural Carbon “Sinks”



NASA

Annual CO_2 Storage from Afforestation & Silvopasture (in Pastures Only)



1 $MtCO_2e$ solution in 2030 = Planting **7%** of current Pasture lands with mixed hardwood & loblolly tree species using staggered planting times.

+Improved health & productivity of livestock
+Biodiversity
+Improved stream water quality
- Potential slight reduction in forage availability

Baseline = Currently very little Silvopasture efforts in Georgia.

Achievable Potential = Planting 20% of current Pasture lands with mixed tree species (loblolly pine + hardwoods) stores **2.8 $MtCO_2$** per year by 2030. Uses staggered tree planting half in 2020-2021 timeframe; half around 2025. Includes CO_2e stored in trees and soil.

Technical Potential = Planting 100% of current Pasture lands with mixed tree species (loblolly pine + hardwoods) stores **14.3 $MtCO_2$** per year by 2030. Uses staggered tree planting half in 2020-2021 timeframe; half around 2025.
Includes CO_2e stored in trees and soil.

Extreme Technical Potential = Planting 100% of current Pasture lands with loblolly pine (PITA) stores **19.5 $MtCO_2e$** per year by 2030. Uses staggered tree planting half in 2020-2021 timeframe; half around 2025.
Includes CO_2 stored in trees and soil.

Afforestation & Silvopasture

Plant Rich Diet

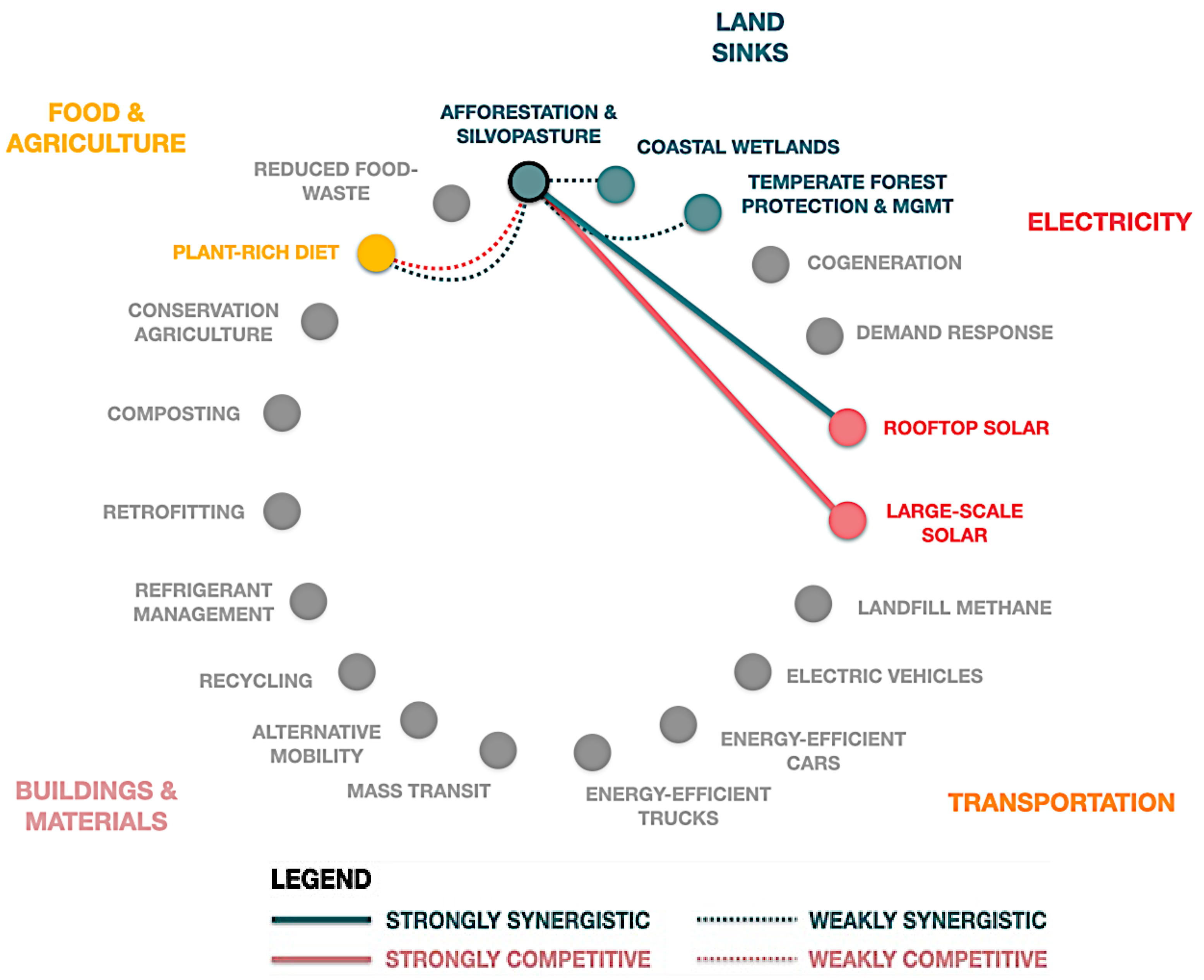
- More silvopasture would not support plant rich diets

Rooftop Solar

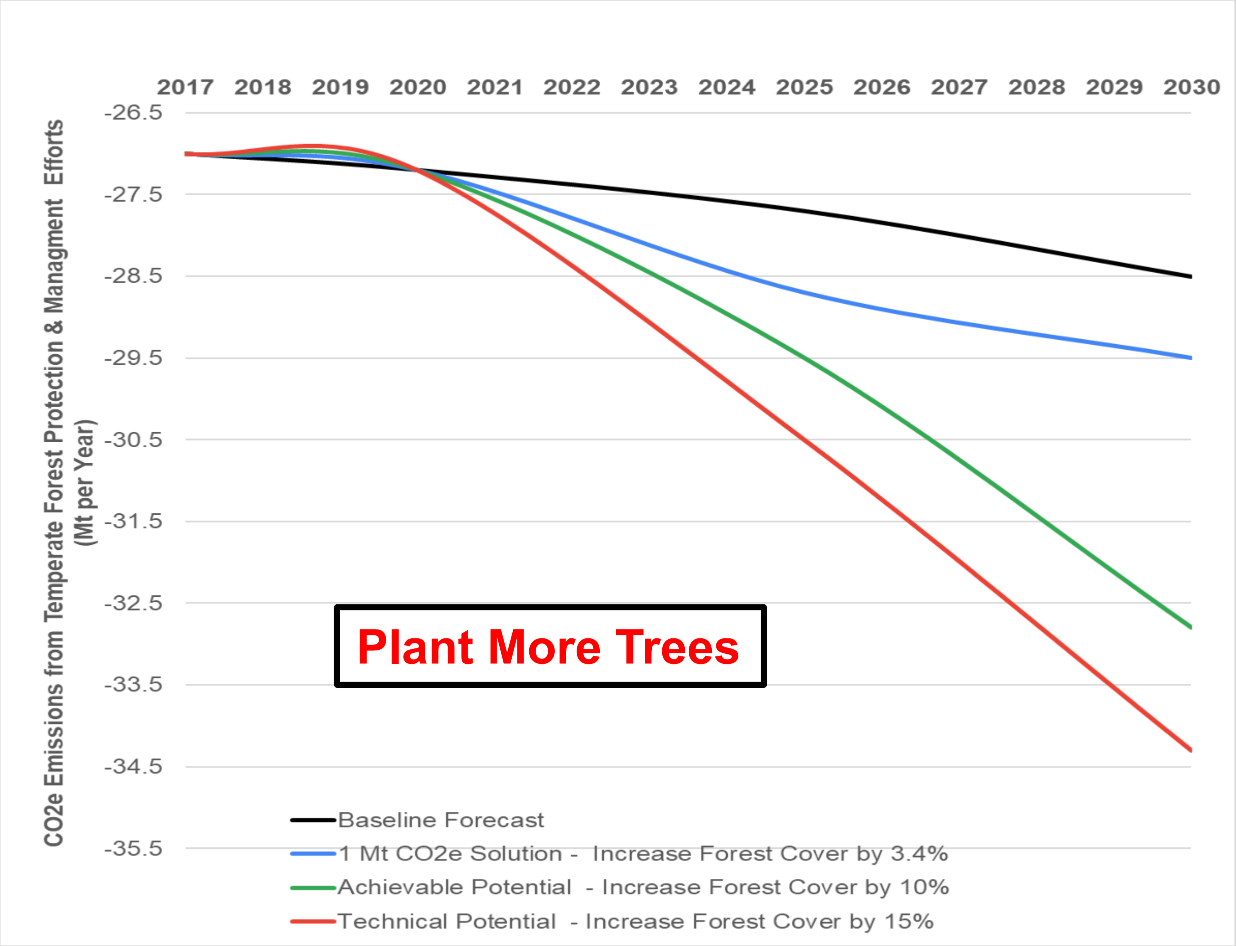
- Would not compete with new forest acreage and croplands

Large-Scale Solar

- New forest and croplands would occupy lands that otherwise could be used for solar farms



Temperate Forest Annual CO_2 Storage (Trees + Soil)



Baseline = Currently Georgia's Temperate Forests store around **27 $MtCO_2e$** each year in trees & soils. This amount will increase over time as trees continue to grow.

1 Mt CO_2e= Increasing forest cover by 3.4% would increase annual CO_2e storage by **1 Mt per year** by 2030. All Planting times are staggered with half around 2021 and half around 2025.

Achievable Potential = Increasing forest cover by 10% would increase annual CO_2e storage by **2.8 Mt** per year by 2030.

Technical Potential = Increasing current forest cover by 15% would increase annual CO_2e storage by an additional **4.3 $MtCO_2e$.** Planting time is staggered with half around 2021 and half around 2025.

1 $MtCO_2e$ solution in 2030 = Increasing forest cover by **3.4%** with mixed tree species would enhance annual CO_2e storage by 1 Mt by year 2030. Equivalent here to "Achievable Potential."

- \+ Jobs
- \+ Biodiversity
- \+ Low-cost, healthy recreational opportunities
- \+ Improved stream/river water quality
- \+ - Potential increased property values/costs

Beyond Carbon

- Environment
- Economy
- Public Health
- Equity

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Professor of the Practice, Georgia Tech Scheller College of Business
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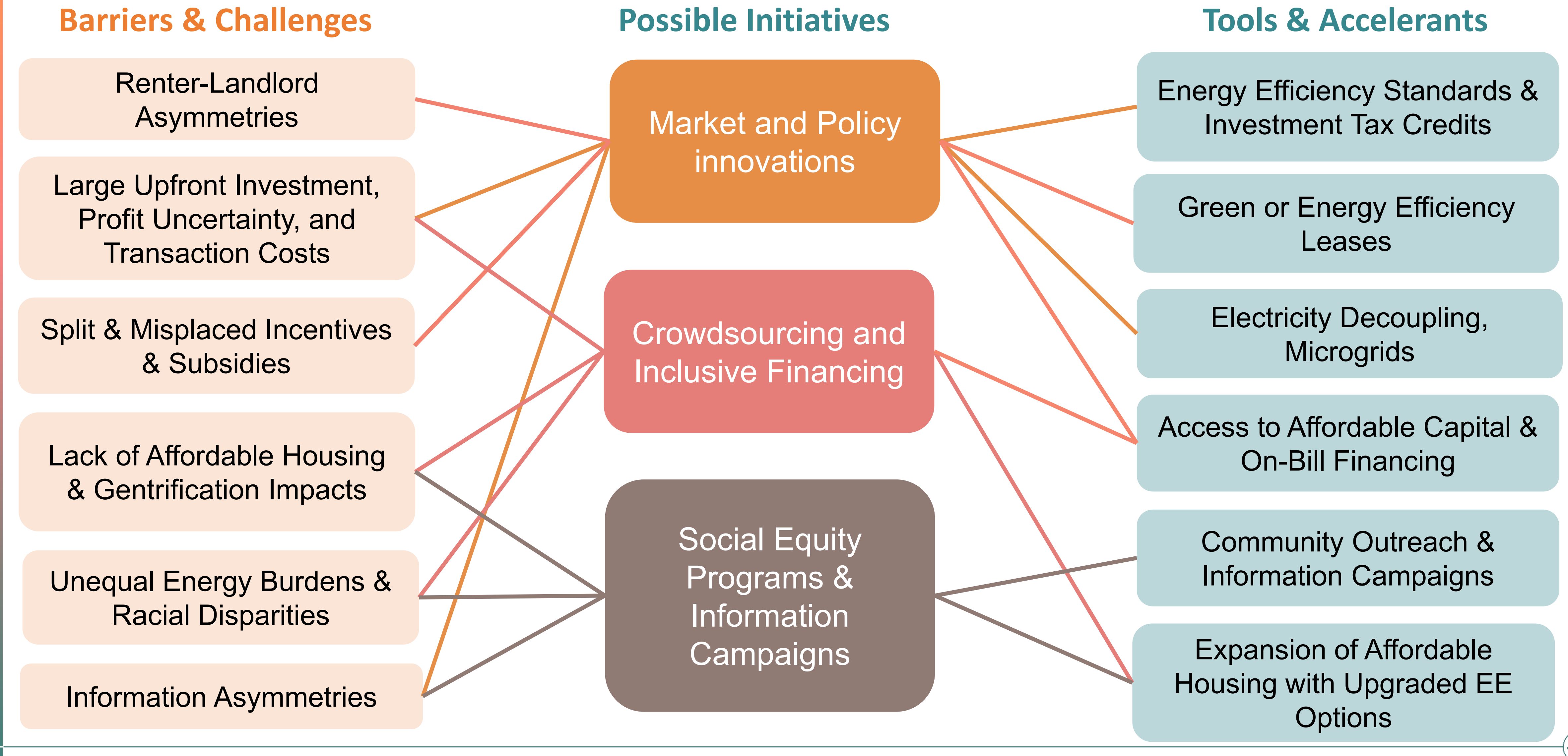
Beyond Carbon Working Group

A 6th working group to consider other societal impacts

ENVIRONMENT	EQUITY	ECONOMICS/JOBS	PUBLIC HEALTH
Air quality	Affordability	Local Economy & Employment	Premature Mortality
Water quality, quantity, and access	Workforce/Business Diversity	Input Prices/System Costs	Morbidity
Land use	Distribution of Public Health Impacts	Workforce job quality	Quality of Life
Ecosystems/ biodiversity	Accessibility of Solutions	Wages and benefits	Education
Material disposability	Cultural Fit & Way of Life	Property values / Tax Base	Public Safety
		Infrastructure requirements	

Retrofitting Example: Equity Challenges, Opportunities, and Possible Initiatives

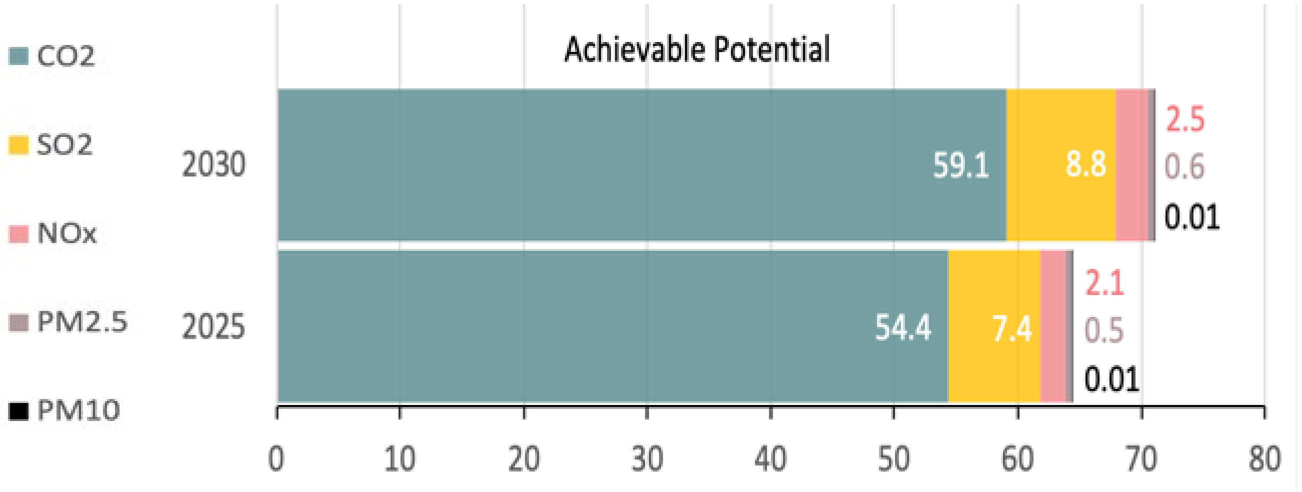


Forthcoming Quantification of Solution Beyond Carbon Benefits

Quantification of Selected Solution Benefits (Public Health and/or Job Creation)

- Electric Sector
  - Cogeneration
  - Demand Response
  - Large-Scale Solar
  - Rooftop Solar
  - Landfill Methane
- Transportation
  - Electric Vehicles
  - Energy-Efficient Light & Heavy DVs
  - Mass Transit & TOD
  - Alternative Mobility
- Built Environment
  - Recycling/Waste Management
  - Refrigerant Management
  - Retrofitting

Benefits of reduced air pollution from “zero-carbon” electricity solutions in Georgia

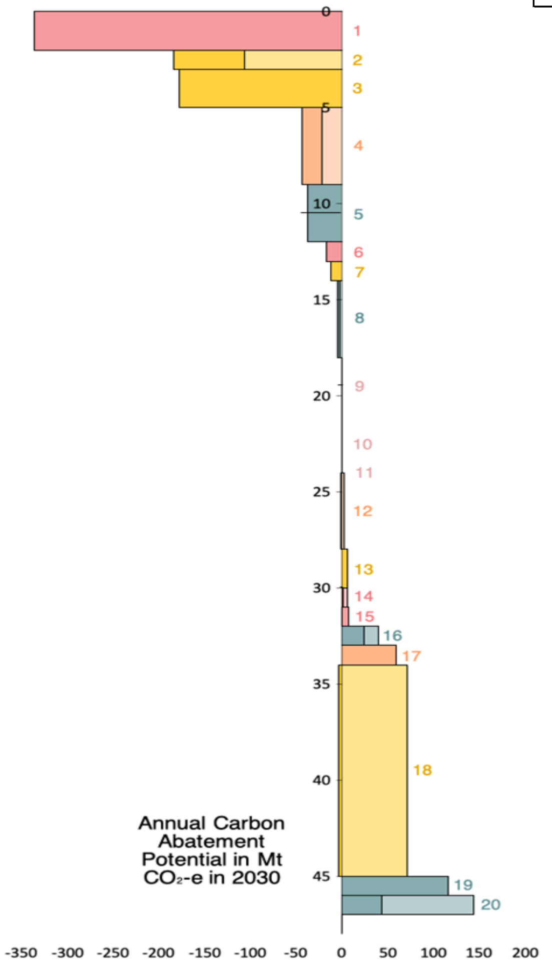


Benefits in Million $2017 per Metric Ton of CO_2

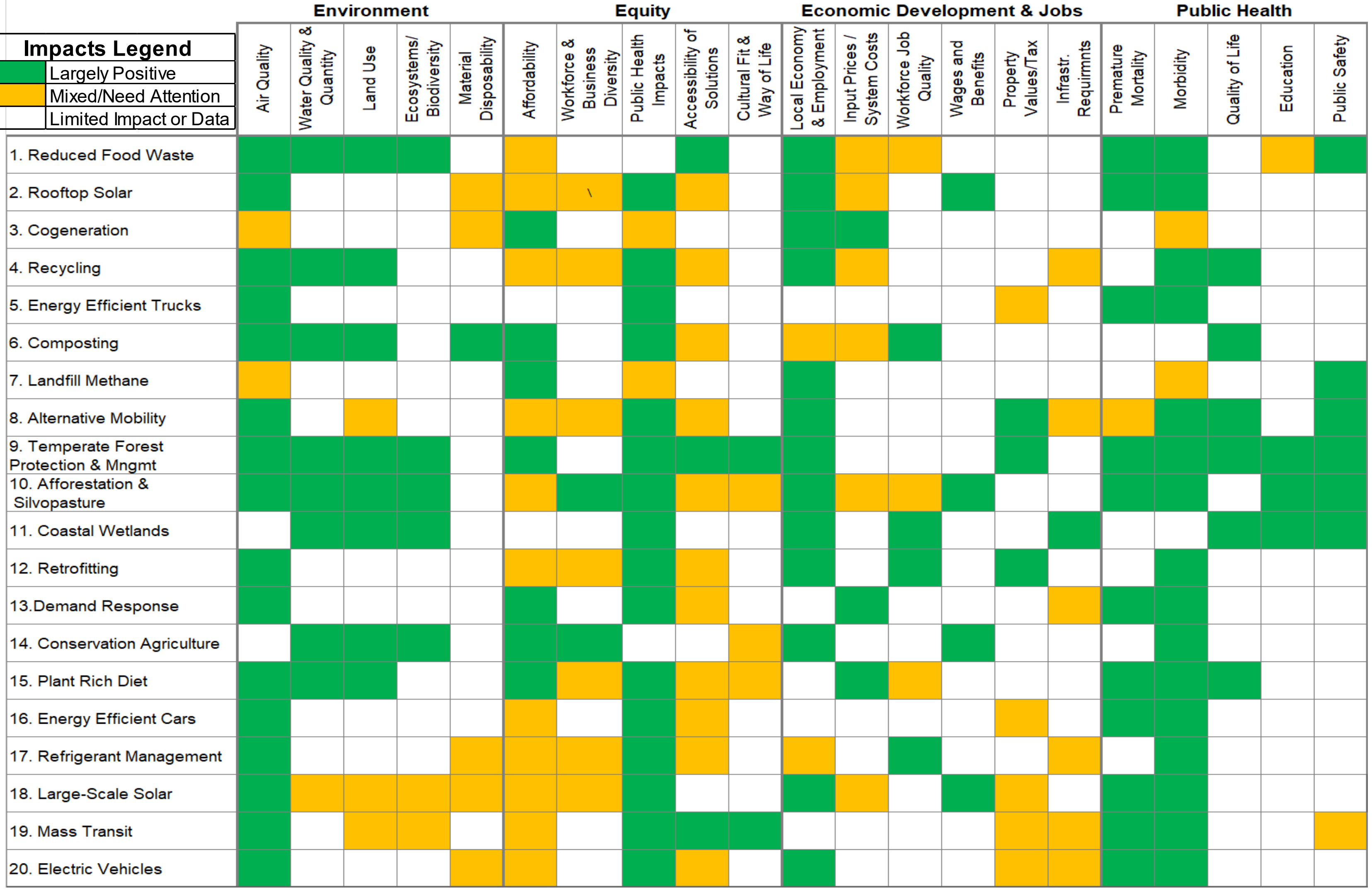
Initial Assessments Across Multiple Solutions

Material Benefits/Concerns Flagged

Cost of Abatement of 1 t CO_2 in 2030 (in $2017)



Impacts Legend	
(green)	Largely Positive
(yellow)	Mixed/Need Attention
(white)	Limited Impact or Data



Agenda

INTRO & OVERVIEW

Opening Remarks
John Lanier, Ray C. Anderson Foundation

Overview
Daniel Rochberg, Emory
Marilyn Brown, Georgia Tech

METHODS & FINDINGS

Electricity
Marilyn Brown, Georgia Tech

Transportation
Mike Rodgers, Georgia Tech

Buildings & Materials
Dan Matisoff, Georgia Tech

Food & Agriculture
Sudhagar Mani, UGA

Land Sinks
Jackie Mohan, UGA

Beyond Carbon
Michael Oxman, Georgia Tech

NEXT STEPS

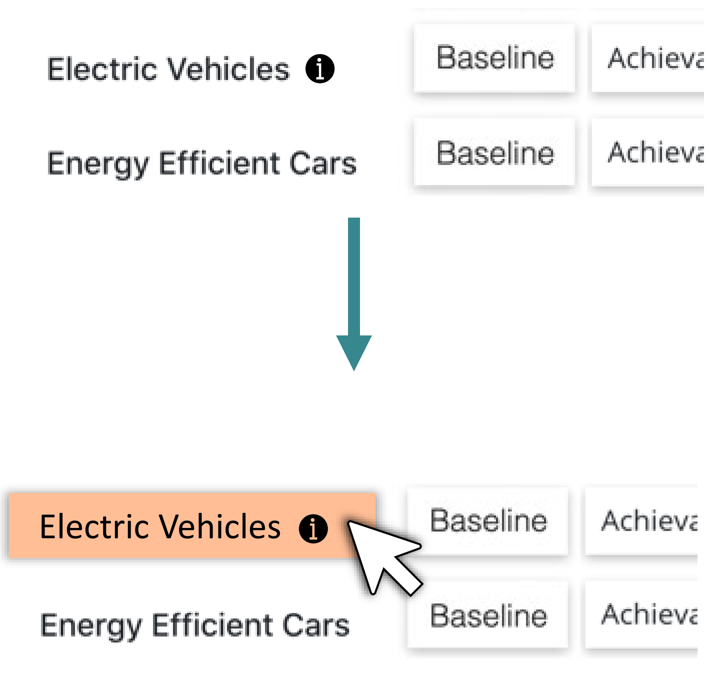
Next Steps
Marilyn Brown, Georgia Tech

Q & A
Kim Cobb, Georgia Tech
Blair Beasley, Emory
Marshall Shepherd, UGA

Preview of Future Research Products & Goals

Coming Attractions:

We will soon have a calculator tool that you can play with



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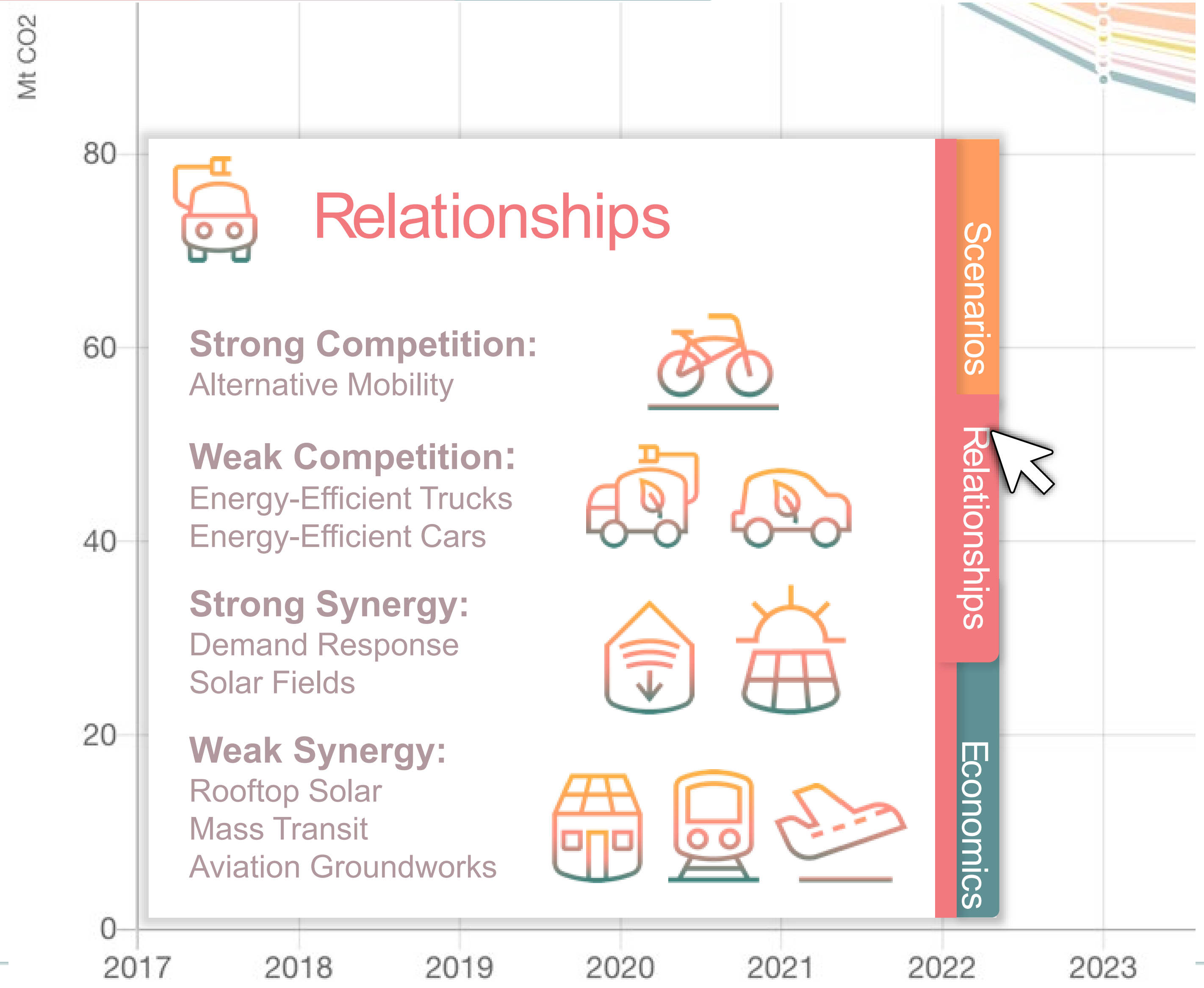
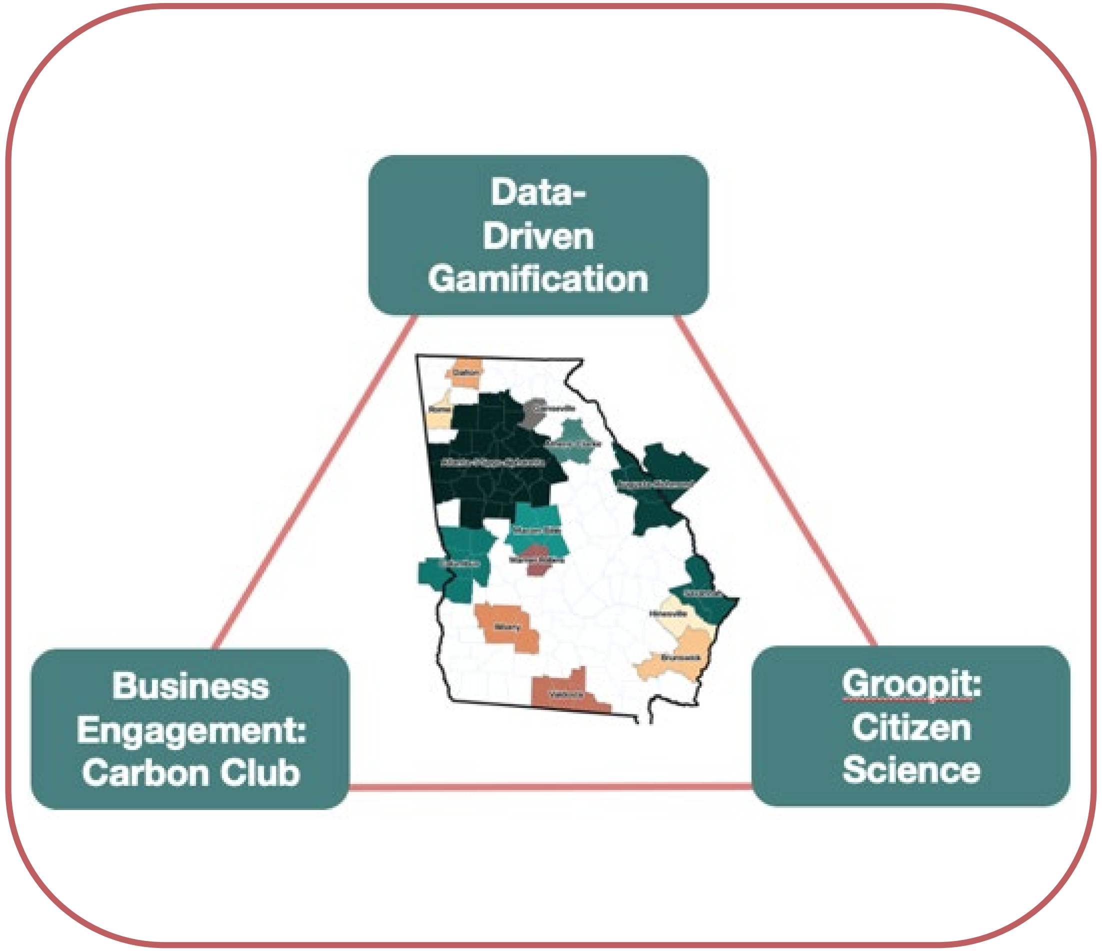


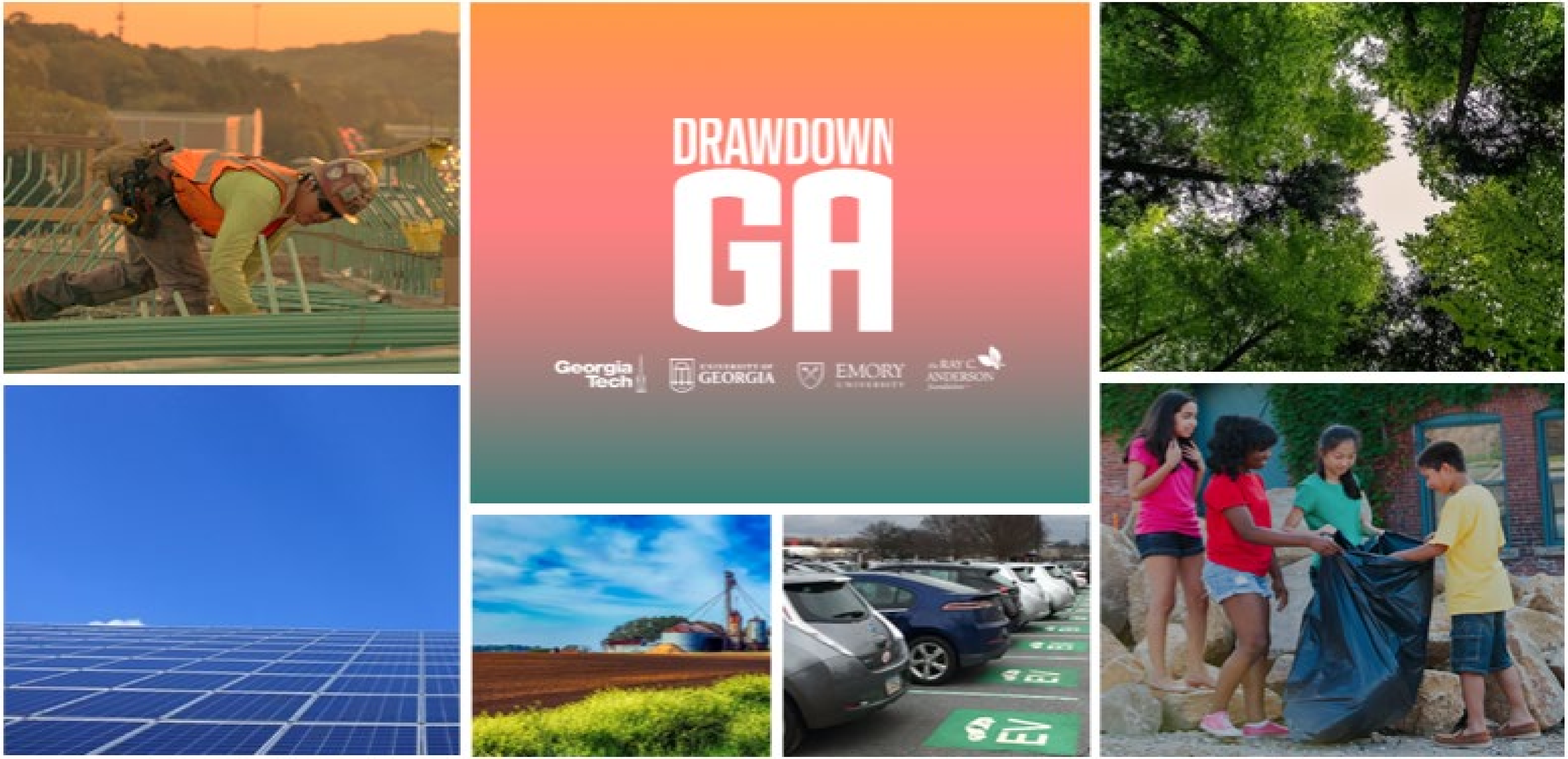
What's next for the research team: Geospatial tracking & business engagement to activate Drawdown solutions in Georgia

1. Track the GHG Footprint of Georgia's Counties and Metro Areas
Goal: Develop a GHG tracking system for Georgia to underpin Drawdown Georgia activation

2. Engage Business
Goal: Make the output of Georgia Drawdown accessible to business decision makers to stimulate interest in individual and collective commitments

3. Evaluate, Plan and Track Activation of Five Solutions
Goal: Triangulate approaches to activate high-impact solutions in Georgia





For more information contact us: Drawdown@gatech.edu, https://drawdownga.org, https://cepl.gatech.edu/projects/Drawdown-Georgia