Southern Company

Biomass Potential for Electricity Production

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Southern Company R&D
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Presentation Outline

- Southern Company Biomass R&D History
- Biomass Potential in the Southeast
  - –Projections
  - –Regulations
  - –Competition
  - –Conclusions

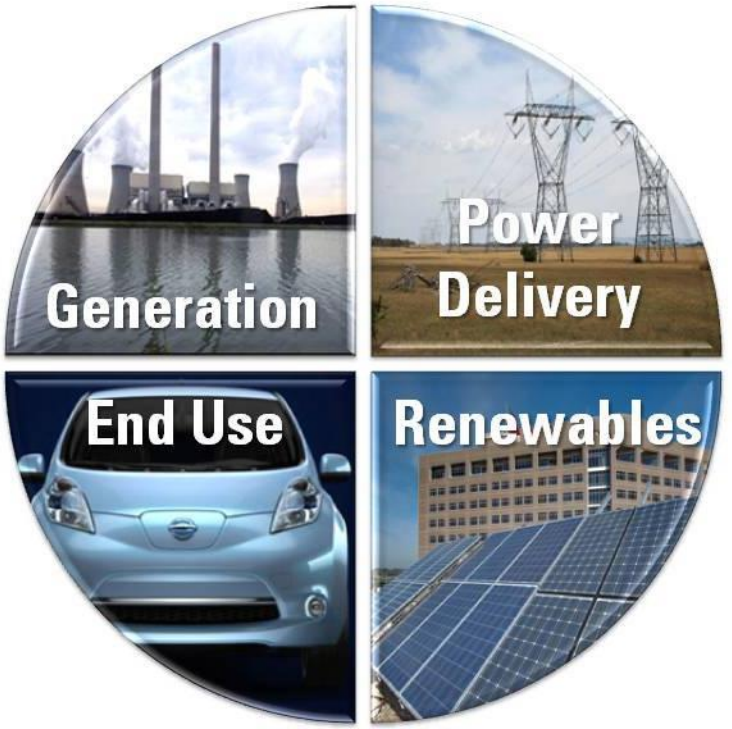
Southern Company R&D Overview

Mission: Ensure Southern Company is a technology leader in the production, delivery and end-use of electricity

Goals: Through a portfolio of new, hardened technology options, increase customer value, improve reliability, increase efficiency, minimize cost and/or reduce environmental impact

Leverage: DOE, EPRI, utility, and university partnerships provide extensive co-funding and collaboration

Results: Over the past 10 years, Southern Company's leveraged R&D investment of has returned a value of 10:1

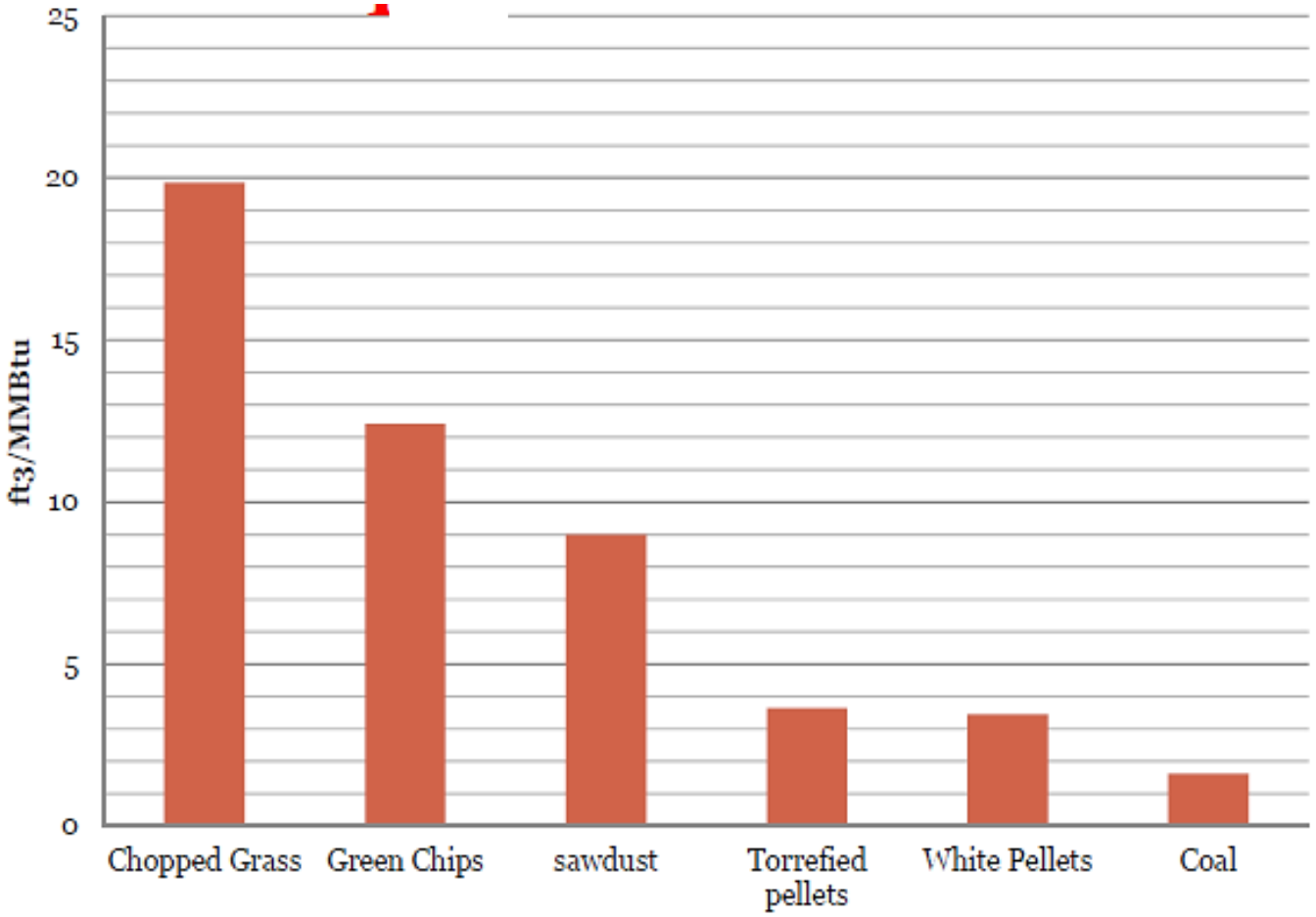


Biomass R&D History

- Biomass based electricity generation
  - 100% biomass facilities: new or conversion of existing plant
  - Co-firing: firing biomass with coal at existing generating facility
- Co-Firing Technologies
  - Co-Milling
  - Coal Pipe Injection
  - Direct Injection
  - Gasification
- Potential Advantages
  - **Dispatchable** renewable option
  - Existing power plants, reduced capital
  - Efficient power plants
  - Reduced financial risk
- Potential Concerns
  - Safety
  - Emissions
  - Operating
  - Performance

Designed to burn coal and "biomass" is not coal

Fuel Volume Requirements



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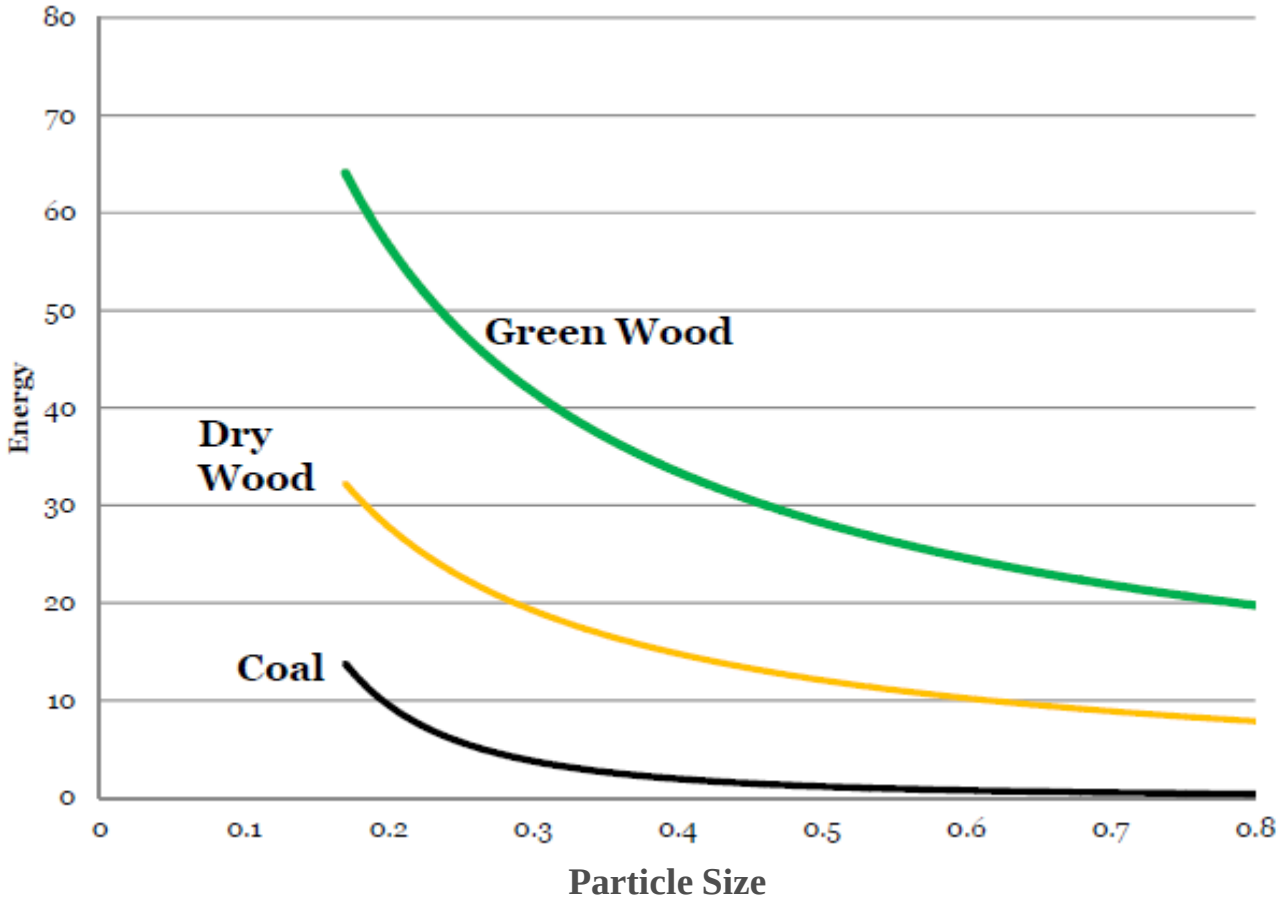
Energy for Size Reduction



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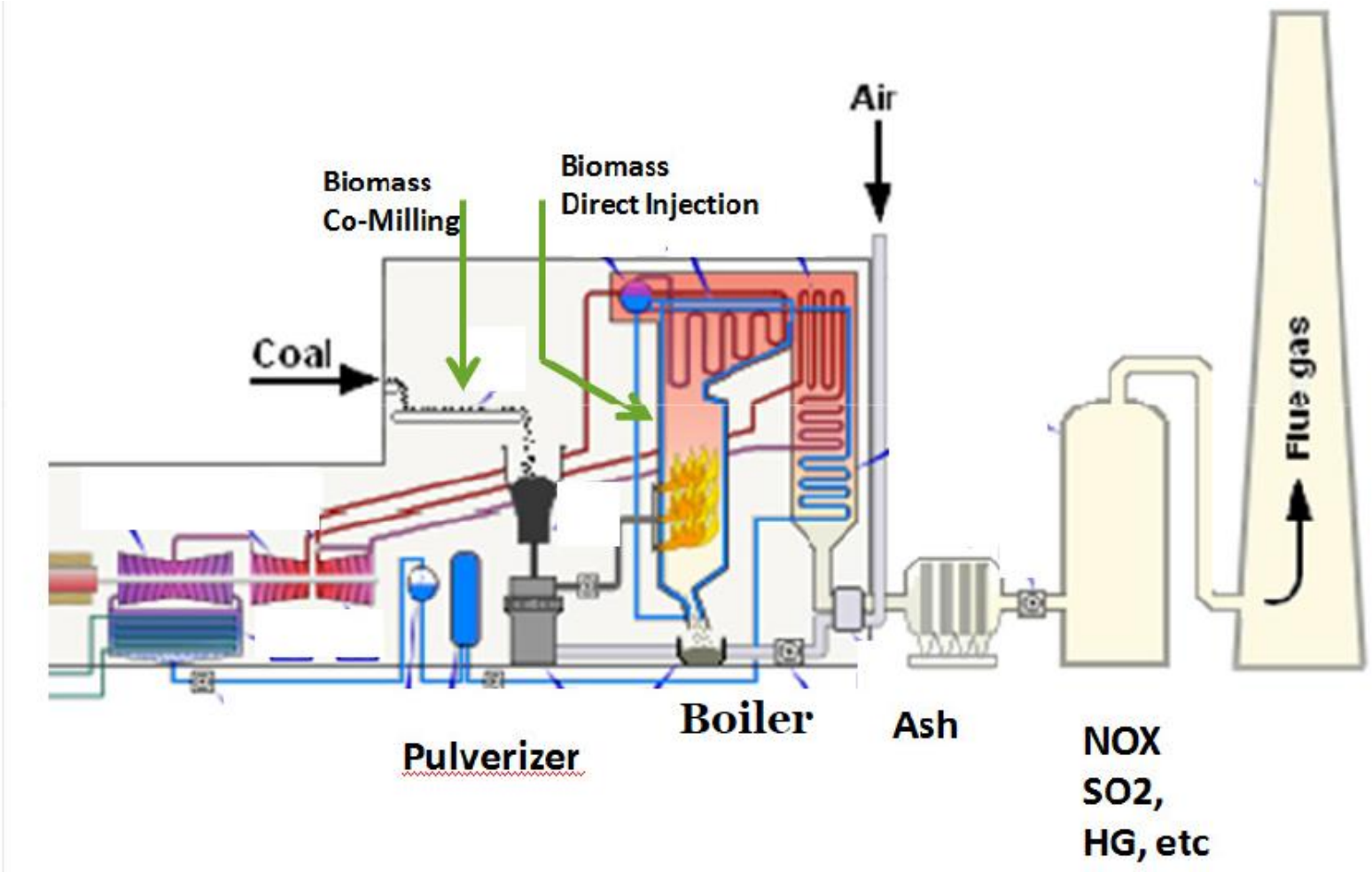
Coal Fired Power Plant



Biomass R&D Program

- Phase I- Physical & Laboratory Analysis
  - Physical Exam: fibers, brittle, dust, density
  - Ultimate & Proximate analysis
  - Ash minerals analysis and ash fusion temperature
  - Metals
- Phase II- Pilot Testing
  - Co-milling pulverizer tests (amps, plugging)
  - Combustion tests (emissions, slagging, fouling, flame stability, ash, unburned carbon)
- Phase III- Power Plant Testing
  - Emissions
  - Efficiency
  - Operating at different loads
  - Performance

Biomass Experience

Wood and Sawdust

- 0-15% by weight co-milling, limited by mill performance
- 30% direct injection

Biomass Experience

Wood pellets

- Co-milling limited by pulverizers ΔP
- 10% pellets with no issues during Plant Barry test runs
- Others have reached much higher percentages

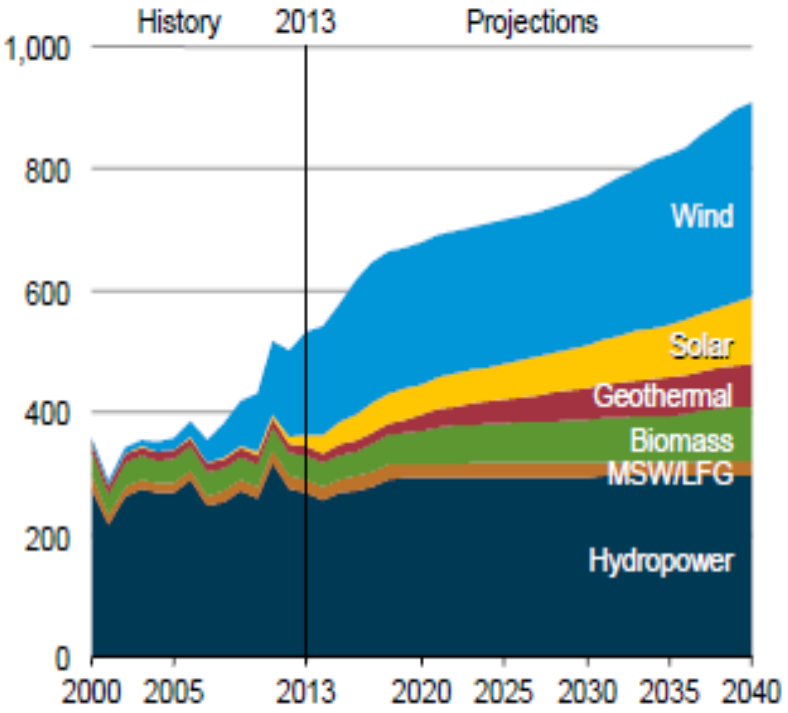
Biomass Experience

- Torrefied Wood
  - Wood is “roasted” without oxygen
  - More like “coal” with low moisture, higher BTU, friable, higher bulk density when pelletized
  - Potential for high percentage co-firing
- Tests at Plant Scholz (40 MW)
  - EarthCare portable system
  - Pelletized then torrefied
  - Dust can cause explosion hazard
  - Had TW pile fires
  - 0%, 20%, 50%, 75%, 100% TW
  - Should pelletize after torrefication

R&D General Results & Findings

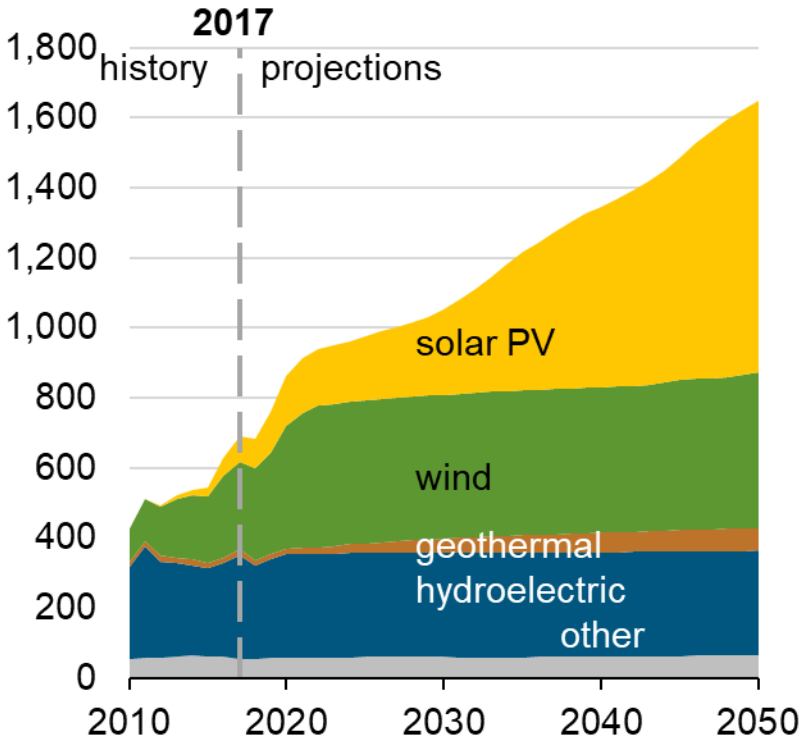
- Co-firing provides opportunity to use existing power plant fleet to produce renewable energy
- Coal fired plants are designed to burn coal, biomass has very different properties than coal
- The limitation in co-firing is generally related to handling and pulverizing of the fuel
- Dust and explosions are real safety issues at high percentages
- Making the biomass more like coal by drying or roasting and compressing into pellets is effective but expensive
- High percentages of co-firing with direct injection can be achieved, but at higher capital cost

Biomass Industry Projections



Renewable electricity projections, including hydropower (billion kWh/yr)
EIA, Energy Outlook 2015)

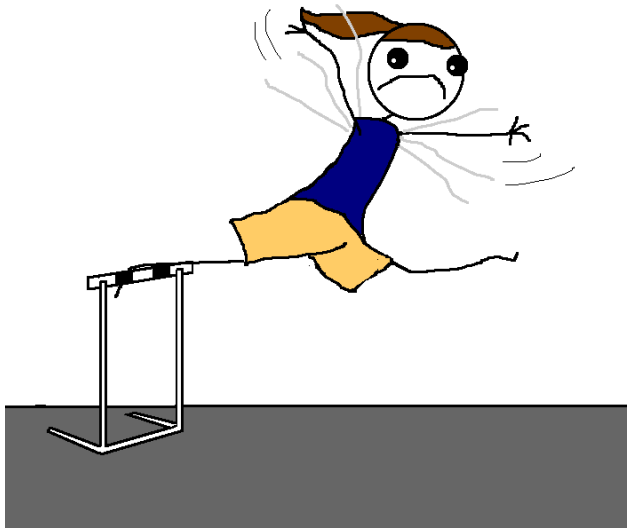
Renewable electricity generation, including end-use generation (Reference case)
billion kilowatthours



Renewable electricity projections, including hydropower (billion kWh/yr)
EIA, Energy Outlook 2018)

Biomass Hurdles

- Regulatory Uncertainty and Pressure
  - Uncertainty- RPS, Clean Power Plan, and EPA Biogenic Framework
  - Regulations forcing shut down of older, smaller coal plants: MATS, ELG, CCR, 316B, NAAQS
- Competition
  - Natural Gas
  - Solar
  - Wind
  - Fuel price risk vs capital certainty



EPA Biogenic - Carbon Accounting

Biomass Accounting Factor (BAF = 0 implies Carbon Neutral)

BAF = (GROW + AVOIDEMIT + SITETNC + LEAK)(L)

Where:

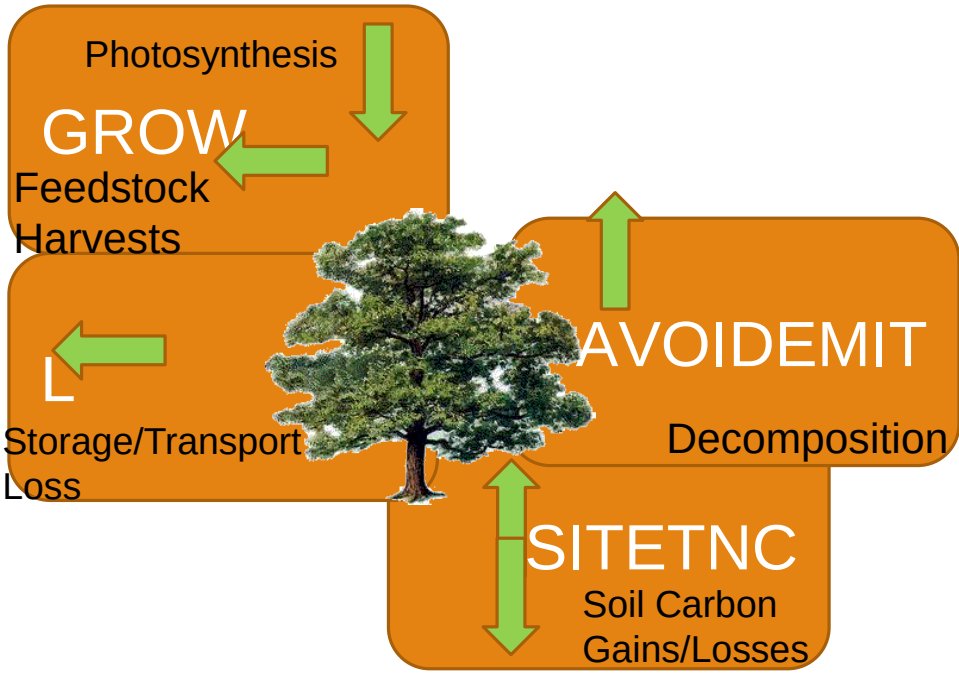
GROW = Net of above ground biomass on the ***production landscape***

AVOIDEMIT = Avoided emissions that could have occurred without feedstock use

SITETNC = Delta in non-feedstock

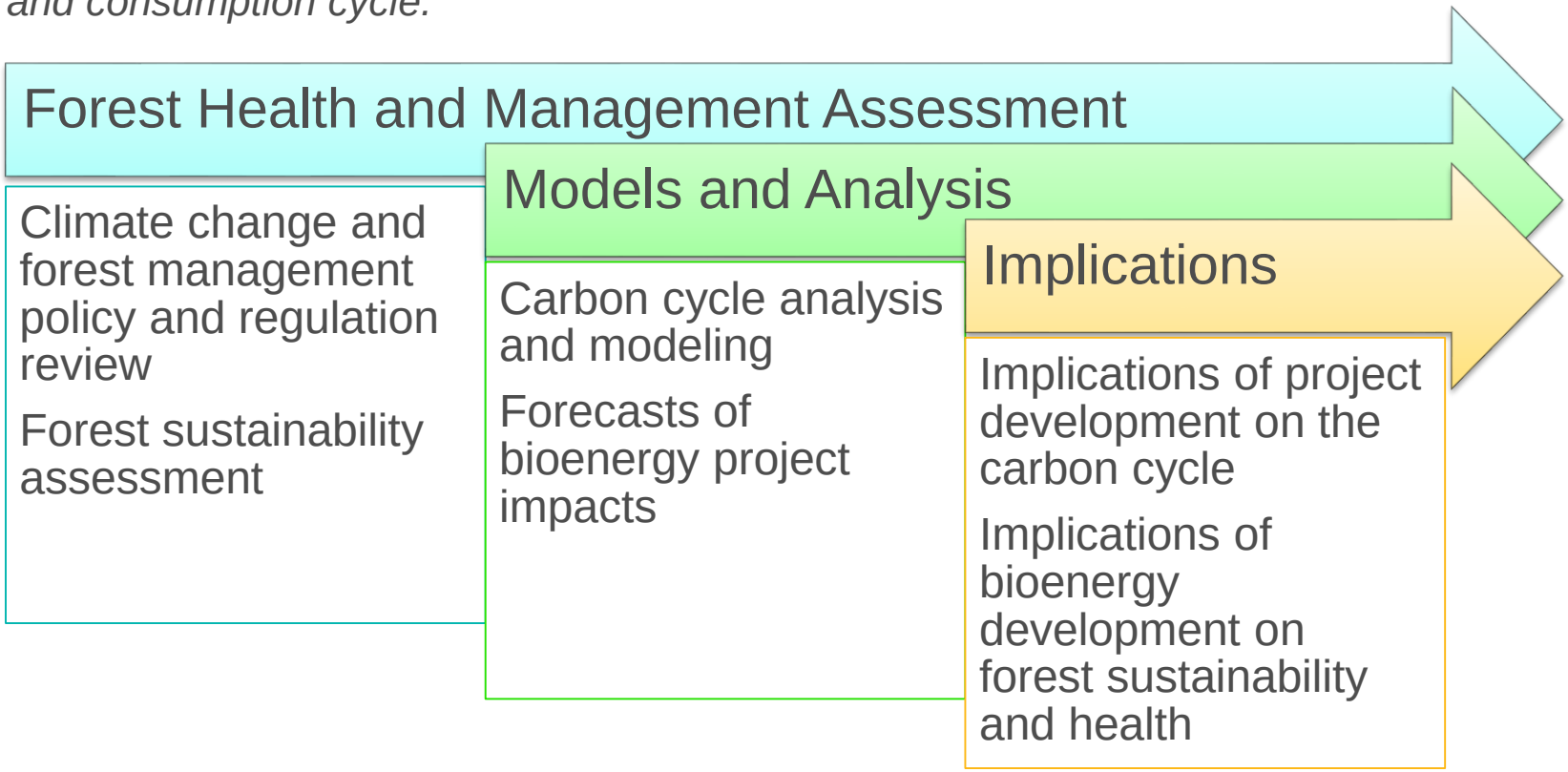
LEAK = Leakage due to indirect impacts of biomass use occurring outside the assessment boundary (e.g., land use change)

L = Losses during transportation, processing and storage

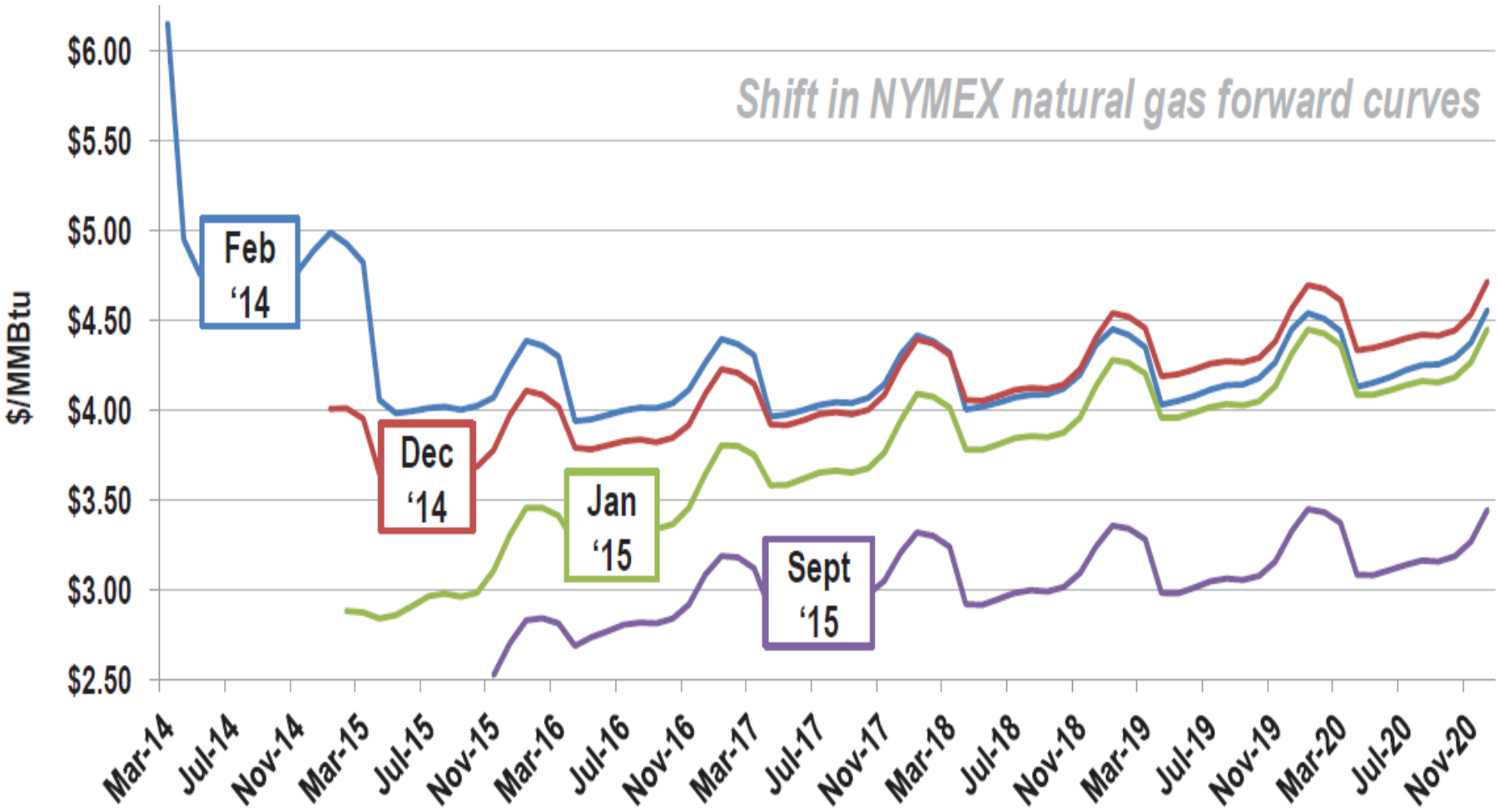


Sustainability and Biogenic CO2

e SAB Panel said "Carbon neutrality cannot be assumed for all biomass energy a priori. There are circumstances in which biomass is grown, harvested and combusted in a carbon neutral fashion but carbon neutrality is not an appropriate a priori assumption; it is a conclusion that should be reached only after considering a particular feedstock's production and consumption cycle.

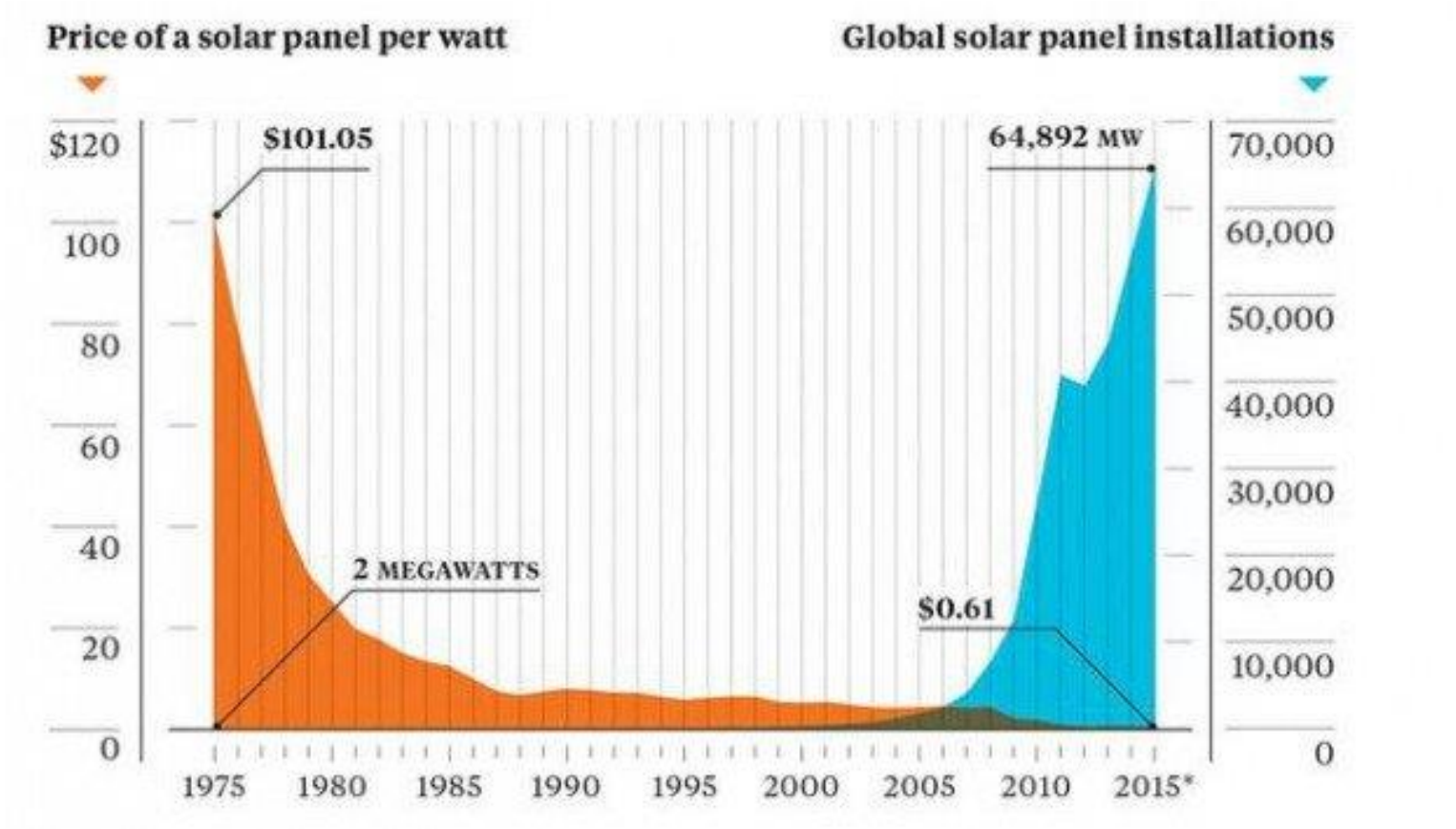


Traditional Generation Competition



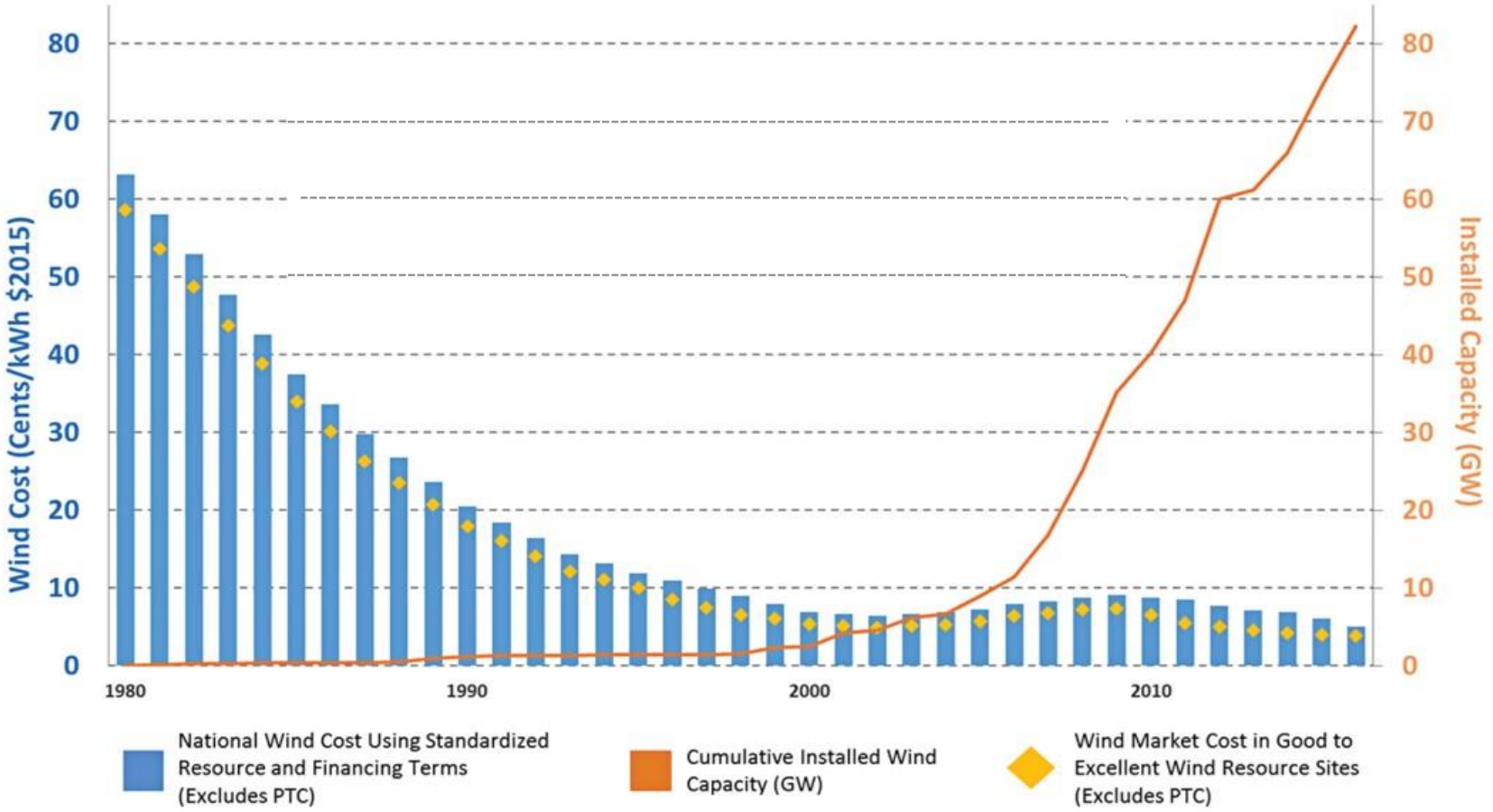
Gas price reductions with shale gas revolution

Renewable Competition



Solar price reductions as market scale increased

Renewable Competition



Wind price reductions as market scale increased

Comparing Fuels

Fuel	$/MMBtu	$/ton	HHV (Btu/lb)	Bulk Density (lb/ft3)	Energy Density (Btu/ft3)
Coal	$1-3	$13-70	12,000	50	600,000
Green Chips	$3-4	$30	4,700	34	159,800
White Pellets	$8-10	$137	8,169	35	285,915
Torrefied*	~$10	~$200	10,300	50	550,000
Steam Exploded*	~$11	~$200	8,700	45	320,000

*limited or no commercial availability at this time

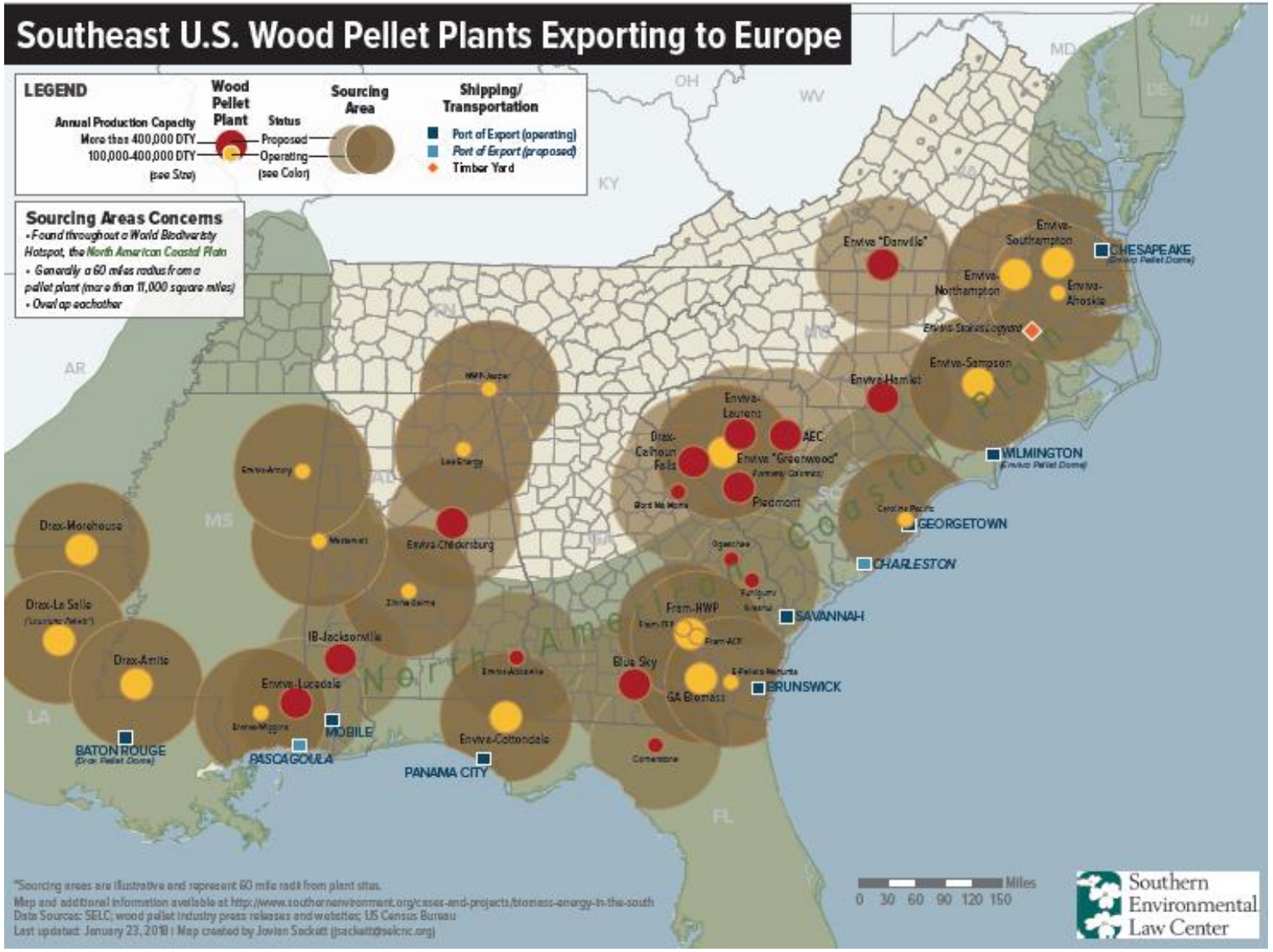
Values shown are indicative pricing, not to be used for project evaluation

Estimated Renewable Cost Breakout

	White Pellets	Steam Exploded Pellets	Torrefied Pellets	Co-fire Chips	Refurb Small Coal Unit	New Wood Fired Unit	Wind Turbines	Solar PV
Est. LCOE ($/MWH)	**$148**	**$150-$200**	**$150-180**	**$60-$70**	**$85-$130**	**$175**	**$30 - $70**	**$40-$70**
Capital (%)	8%	2%	5%	16%	20%	40%	**77%**	**95%**
O&M (%)	5%	3%	5%	7%	25%	25%	23%	5%
Fuel (%)	**87%**	**95%**	**90%**	**77%**	**55%**	35%	0%	0%

Values shown are indicative pricing, not to be used for project evaluation

Future of Biomass in the Southeast



Biomass Perspectives

- Technically proven approaches
  - Biomass co-milling is lowest cost but also lowest percentage
  - Co-firing limits are generally due to handling rather than combustion
  - Direct injection achieves higher biomass % but requires modifications
  - White pellets are commercially available and can achieve 100% biomass with equipment modifications
  - Black pellets can also achieve 100% biomass but do not yet have a stable market
  - Biomass Co-firing generation is dispatchable, but…
- Competition from “other” renewables
  - Cheap Solar and Wind Energy
  - Capital vs O&M (relatively expensive fuel)
- Uncertain regulatory framework for biomass in the U.S.

Questions?