

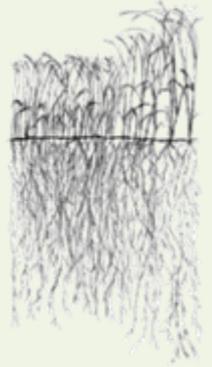


Renewable Energy Resources

*Biofuel from grassland
Sustainable and Local*

Opportunities for Vermont

What we do “Field to Flue”



RER inspecting grass in field prior to harvest



Delivery for processing



RER Compacting Switchgrass into Briquettes



Flue

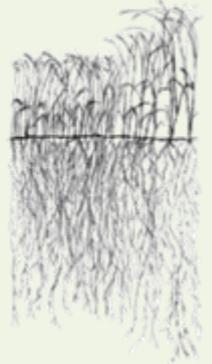


Boiler



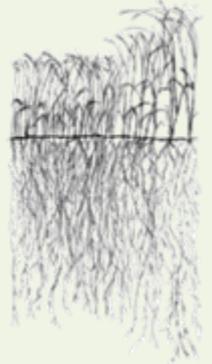
Delivery to boiler

Business Model



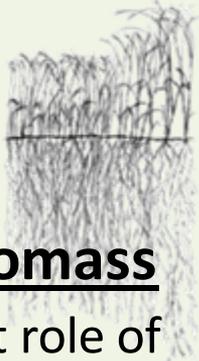
- To provide crop biomass for heating applications
- Work with customers to provide long term fuel plans
 - In-house expertise
 - Strategic alliances
 - Growers/harvesters
 - Boiler manufacturers
- Business growth
 - Market development
 - Operate mobile briquetting
 - Service several towns
 - Travel to local area
 - Operate many mobile machines
 - Mature market
 - Once demand exceeds 8,000 tons/yr within 30 mile radius
 - Set up fixed base processing plant
 - Set up many fixed based plants

RER's objectives in Vermont



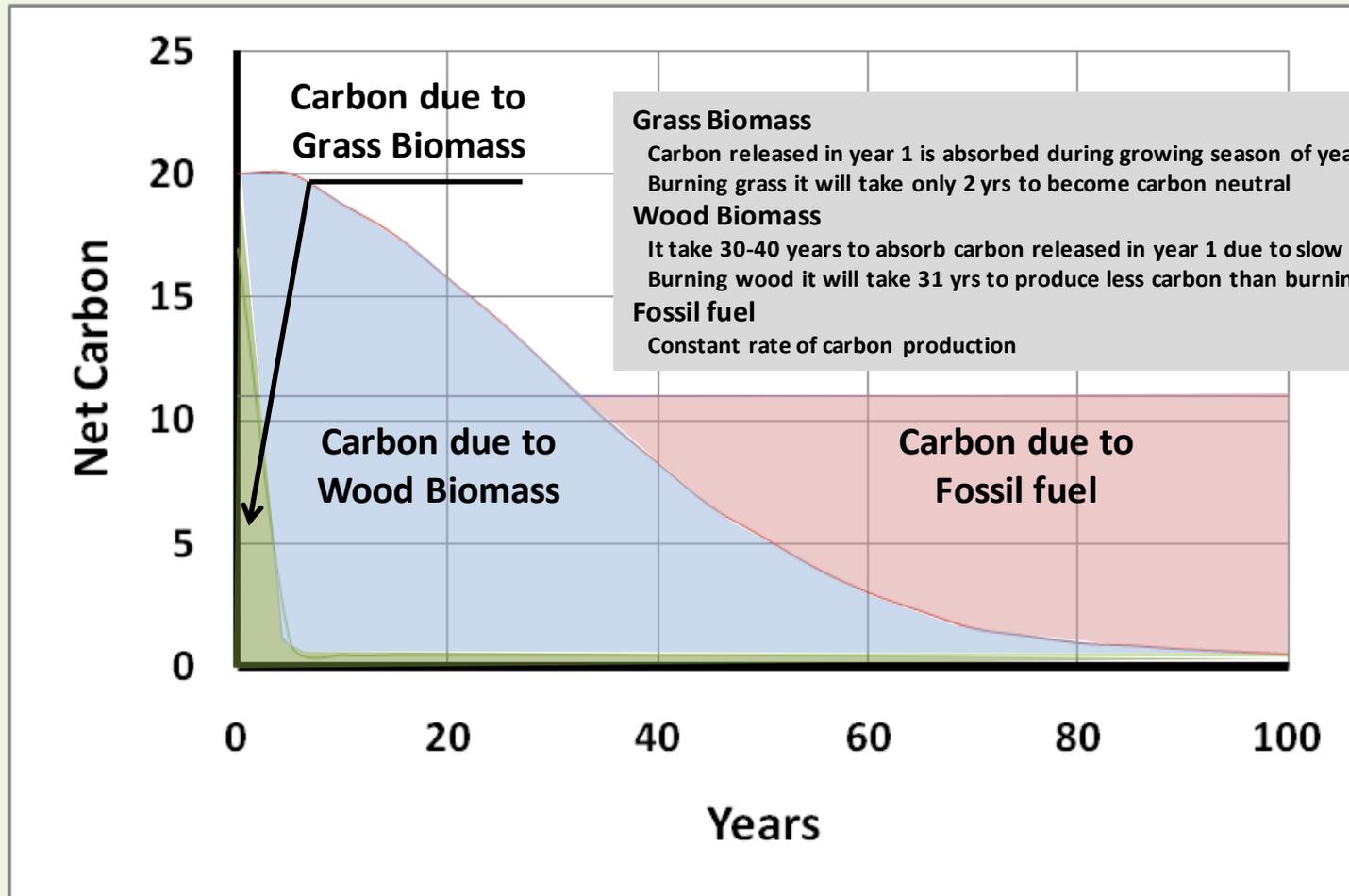
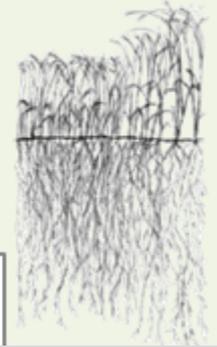
- RER has two major objectives in VT
 - Develop large scale pilot project in Vermont utilizing crop biomass
 - 2 MW combined heat and power
 - Change State energy policy to consider all biomass
 - Present policy favors wood
 - (recommendations for VT Energy Plan –next page)

RER's Input to State Energy Plan

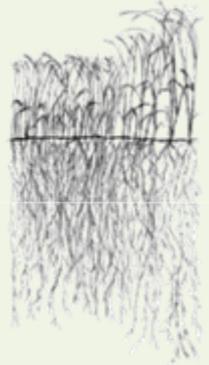


- **Recommendations for Increased Use of Agricultural Biomass**
 - A comprehensive energy policy should recognize the important role of crop biomass in the State's energy future. This could be accomplished by explicitly broadening the definition of “biomass” to include agricultural-based fuels, such as short rotation willow, switchgrass (pellets and briquettes) and other grass and hay crops currently available to Vermonters or in development.
 - Future and current state funded biomass incentive programs, such as Efficiency Vermont's “woody” biomass heating system incentive, should be broadened to include ALL biomass in keeping with the policy and energy goals cited above.
 - The Plan should incorporate the findings and recommendations of the Vermont 25x'25 report to the greatest extent possible.
 - Source: Vermont 25x'25 Initiative; *Preliminary Findings and Goals*. Spring Hill Solutions, 2008. URL: <http://www.vermontagriculture.com/energy/index.html>

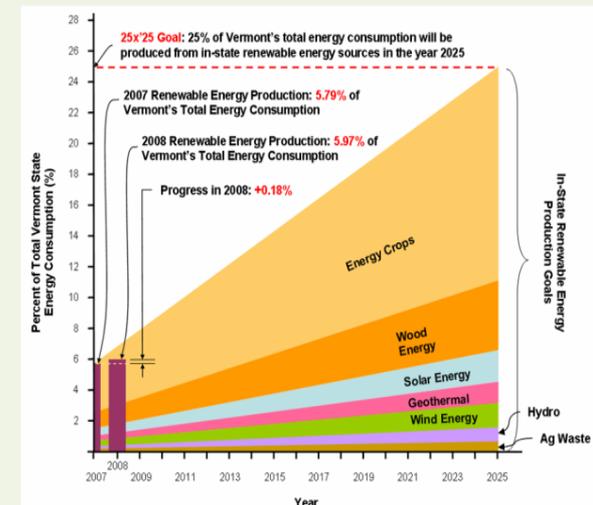
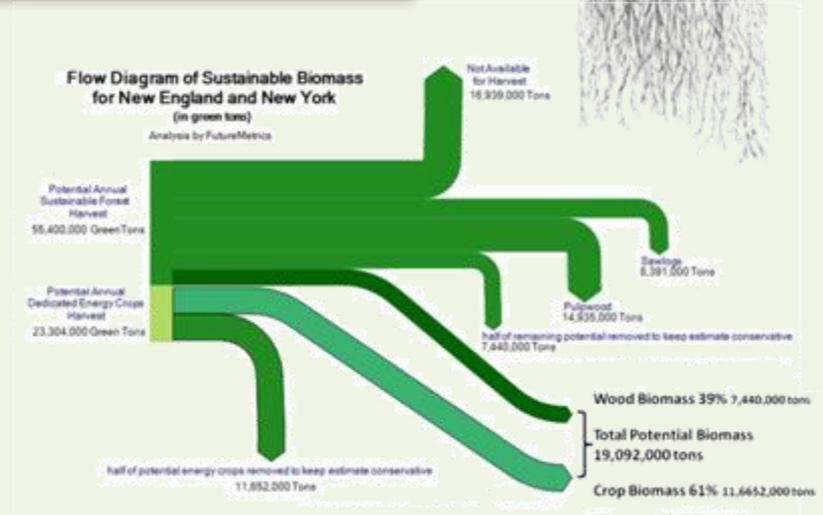
Grass Biomass is Cleanest Fuel



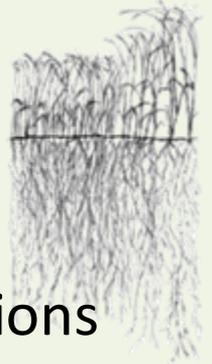
Benefits of Grass Biomass



- Lowest long-term cost for heating
- Grows on poor quality soils
 - Does not displace food crops
- Benefit to local community
 - Local job creation
 - Production, farming, trucking
 - \$\$ stay in local economy
- Local fuel (30 mile radius)
 - Low transport cost
 - Wood is often transported large distances
 - Fuel security
- Consistent with State & National objectives for energy use
- Environmental
 - Improved water quality, stabilize slopes, improved wildlife habitat

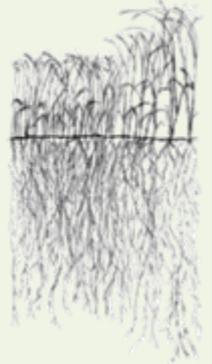


Benefits environmental



- Crop biomass is fastest method to reduce carbon emissions
- Improved wild life/bird habitat
 - Late harvested after birds have bred
- Deep roots
 - Improved soil quality
 - Improved water quality
 - Riparian barriers
 - Make water quality pay for itself
 - Lake Ontario
 - Lake Champlain
 - St Lawrence

Why Switchgrass??



- It all about the \$\$\$\$
 - Yield of hay 1 ½ tons/acre
 - Yield of switchgrass 3 ½ - 4 ton/acre
 - The higher the crop yield results in greater farm income
- All grasses have about the same energy content
 - ≈ 16 MBTU/dry ton
 - Grasses have different mineral contents,
 - % of leaves
 - » Ash content
 - » Slagging & Fouling
 - » Corrosion
 - » Emissions
- Test results show
 - Switchgrass burns cleaner than some other grasses

Grass Biomass Fuels

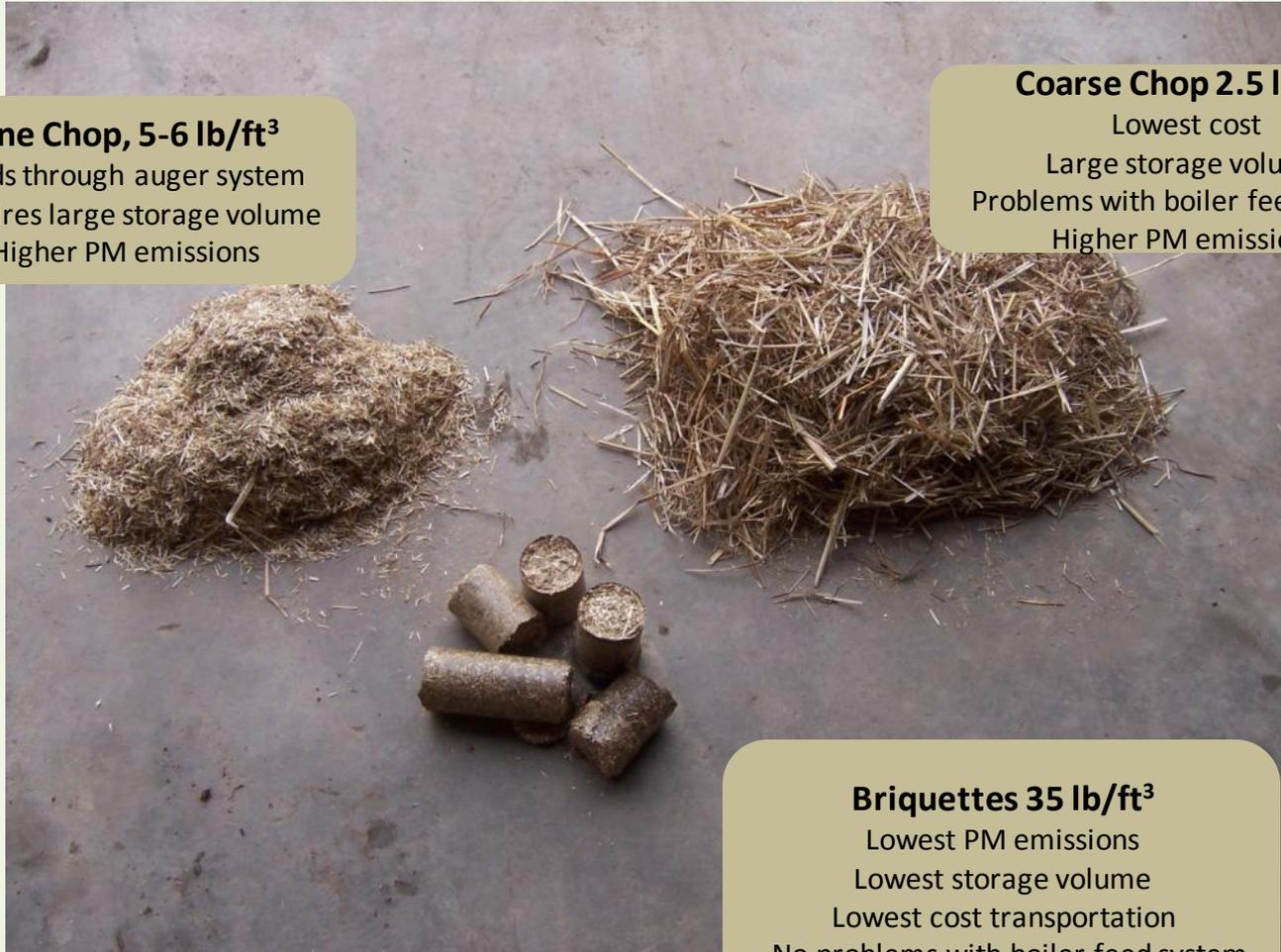


Fine Chop, 5-6 lb/ft³

Feeds through auger system
Requires large storage volume
Higher PM emissions

Coarse Chop 2.5 lb/ft³

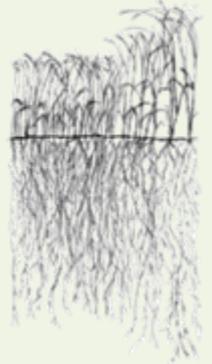
Lowest cost
Large storage volume
Problems with boiler feed system
Higher PM emissions



Briquettes 35 lb/ft³

Lowest PM emissions
Lowest storage volume
Lowest cost transportation
No problems with boiler feed system

Boiler System



- Crop Biomass is reliable and well proven
 - Hospitals, schools, colleges, etc.
 - Examples
 - Benton, PA, Burkeville: VA, Schools: MD & NY, Ski area and hotels, VT: Power plants, Mid-west
- Many system manufacturers
 - Challenger, Skanden, Messersmith, Hurst, Viessmann, Chiptech, Etc.
 - Not all are multi-fuel
- Recommendation
 - True multi-fuel boiler system
 - Capable of burning any biomass
 - Automatic computer controlled fuel feed systems
 - Automatic ash removal system
 - Remote monitoring
 - Greater fuel security can burn any biomass fuel
 - Results in high reliability & great security

Typical Boiler Systems



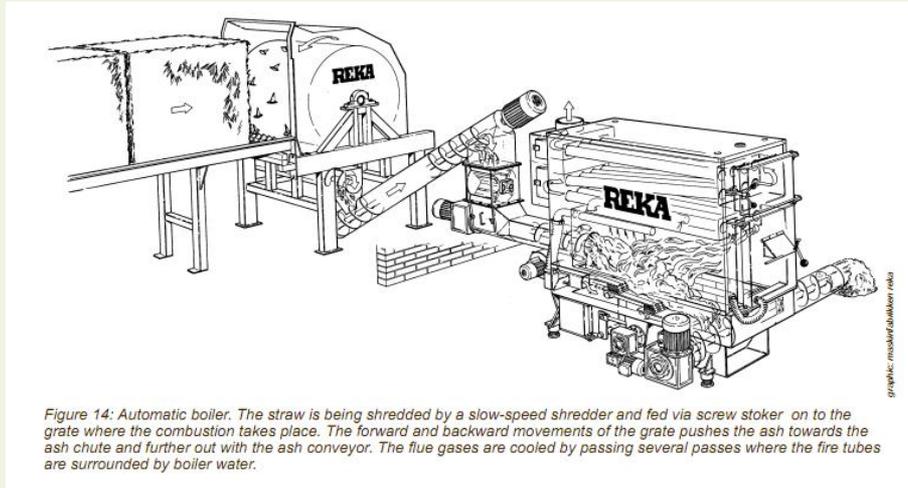
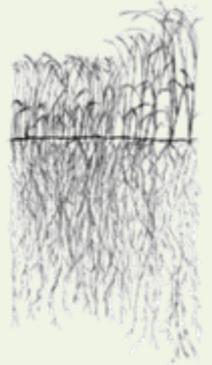
- 45 yr old biomass boiler
 - 220 HP
- 10 tons/day
 - Chopped switchgrass
 - Chopped miscanthus
- Fixed grate
- Clear ash by hand
 - 1 time per day
- No slagging or fouling issues



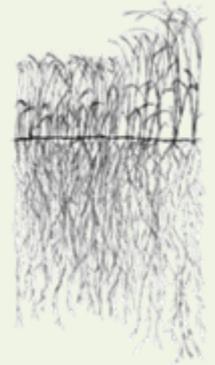
- 2 yr old biomass boiler
 - 225 HP
- 3.5 tons/day
 - Briquetted switchgrass
 - Cleanest burn
 - Chopped switchgrass
- Firing on demand
- Automatic ash removal augers
- No slagging or fouling issues

Grass biomass burns efficiently in commercial boilers

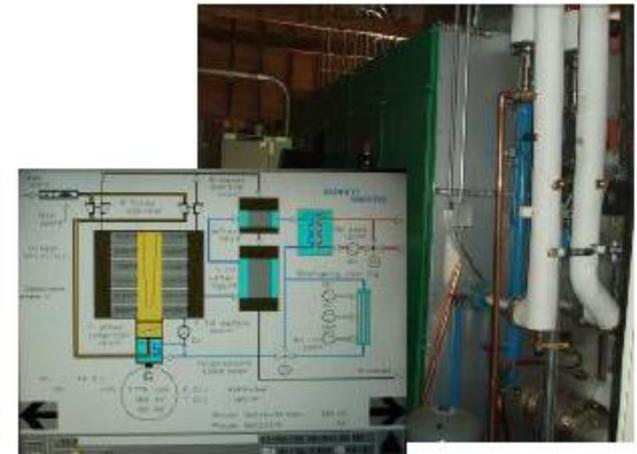
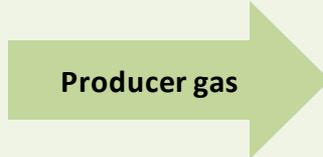
Bale Burning Systems



Combined Heat & Power

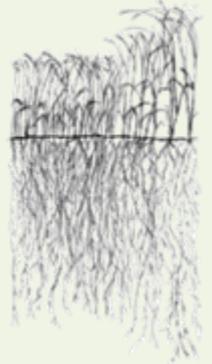


Gasifier – producer gas



Electrical generator

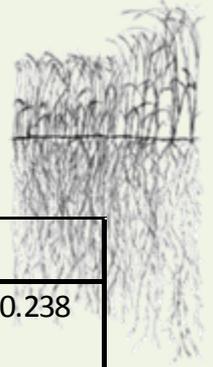
Typical Hot Water System



- Biomass boiler +
 - Old oil boiler for back up
 - Biomass boilers to be multi-fuel
 - Photograph show 225 HP Challenger boiler burning switchgrass
- On site storage for 5 days at peak load
- Automatic auger feed to boiler
- Automatic ash removal



Emissions



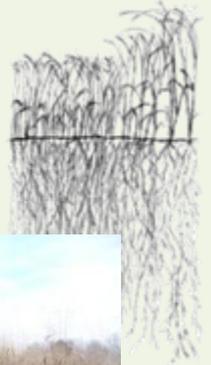
- Clean Air Permits
 - Particulate matter limited to 0.07 lb/MMBTU to comply with new EPA regulations
 - Will require Multi-cyclone and bag-house to achieve new EPA levels
 - If existing systems where being built new today bag houses would be required
 - Monitor CO to ensure clean burn

Emissions		
Filterable Particulate	LB/MBTU	0.238
Nitrogen Oxides	LB/MBTU	0.289
Carbon Monoxide	LB/MBTU	0.130
Switchgrass Consumed	LB/HR	420

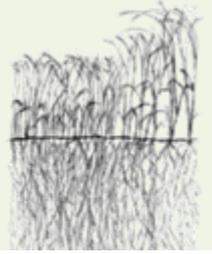
Fuel analysis				
		Moisture & Ash Free	Mositue Free	As Received
Moisture Total	%			13.58
Ash	%		3.25	2.81
Volatile Matter	%	86.89	84.07	72.65
Fixed Carbon	%	13.11	12.68	10.96
Gross Heating Value	BTU/lb	8432	8158	7050
Sulfur	%	0.3	0.29	0.25
Carbon	%	49.98	48.36	41.79
Hydrogen	%	6.06	5.88	6.6
Nitrogen	%	0.38	0.37	0.32
Oxygen	%	43.26	41.85	48.23

Standards

- Standards are important to produce a consistent high quality product with low emissions
- RER are preparing a general standard that will include
 - Species
 - Switchgrass
 - Big Blue Stem
 - Indian Grass
 - Wild Flowers & Legumes
 - Harvest time
 - Moisture content
 - Mineral content
 - Cutter height
 - Avoid stones
 - Bale
 - Size – shape and size for ease handling and processing
 - Sisal – natural fiber

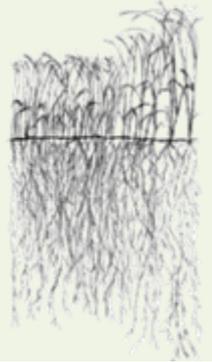


Grass Biomass



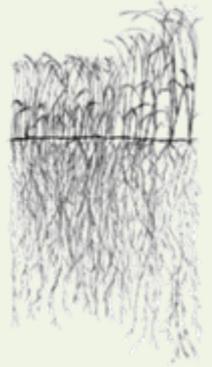
RER inspecting switchgrass prior to harvest
Harvesting using conventional farm equipment

Baling



Measuring the moisture content of the bales
Ideally between 10-13%
Sisal is preferred to nylon baling twine

Transporting



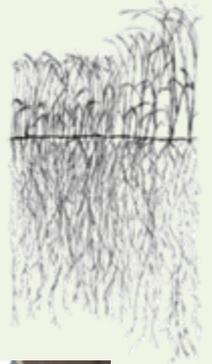
Moisture content is measured prior to unloading
(It is more efficient to transport square bales)

Processing



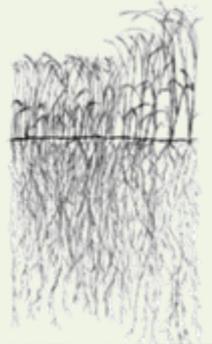
Switchgrass bales are delivered to local processing facility where RER will compact grass into briquettes

Compacting



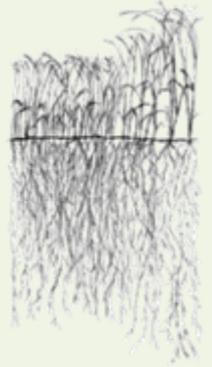
Bales are busted---- (density 2-3 lb/ft³)
'grass is compacted into briquettes--- (density 30-35 lb/ft³)
Briquetting reduces the storage volume required and improves combustion

Material Handling



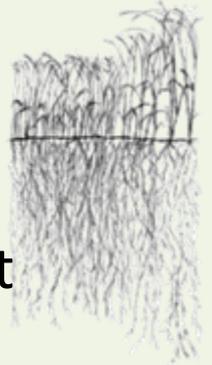
- Grass briquettes are dumped into storage pit
 - On-site storage- 3-5 days supply at peak load
- Fuel is feed by auger from storage pit to boiler
 - Multi-fuel handling capability able to handle and burn either wood chip or grass biomass

Processing chopped biofuel



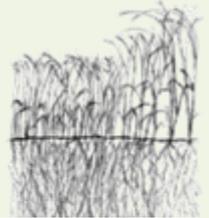
Measuring moisture content – 6 measurements and average
Weight using mobile scale
Chop into delivery truck

Lessons

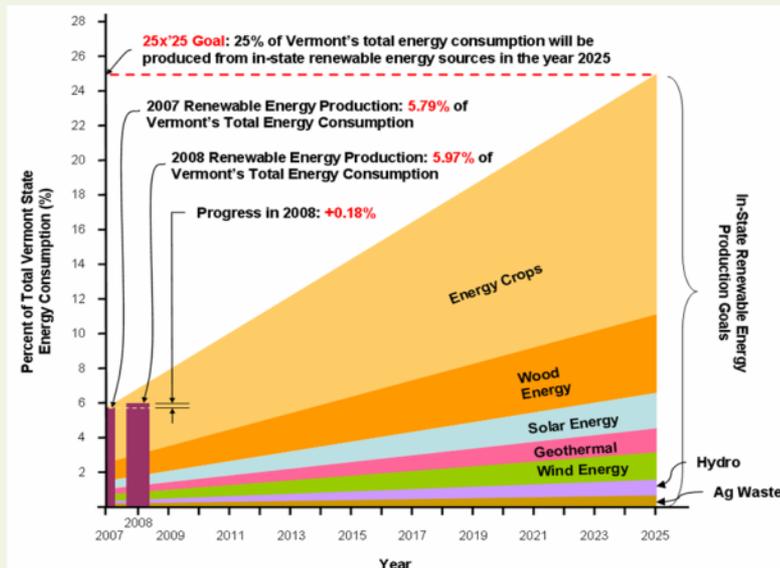


- How and when Grass- biomass is harvested is important
 - Grass for biomass is different than grass to feed cows
 - Biomass standards are necessary
 - Time of harvest is important if grass harvested early then high emissions
- Benefits of Briquettes
 - Briquettes are more dense than chopped grass
 - Lower transport costs
 - Less frequent fuel deliveries
 - Burns better
 - PM increased with chopped grass
 - Easier to manage boiler

Summary

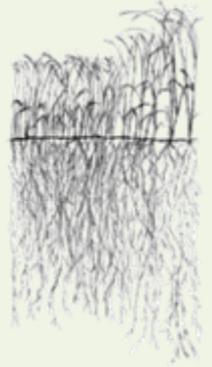


Fuel	Risk	Supply	Cost
Oil	Traditional	Limited Unstable?	Highest
Wood chips	Popular in NEUSA	Competition Out of state	Lowest short term
Grass biomass	Widespread in Europe	Local 30 mile radius	Lowest project life



- **Benefits of grassy biomass**
 - Fuel security
 - Grown within 30 mile radius
 - \$\$\$ stay in local economy
 - Lowest long term cost
 - Consistent with State objectives for energy use
 - Fastest method to reduce carbon footprint
 - More information
 - John Bootle
 - Renewable Energy resources
 - JohnBootle@Switchgrass-RER.com
 - 802-379-8553

Final Comments



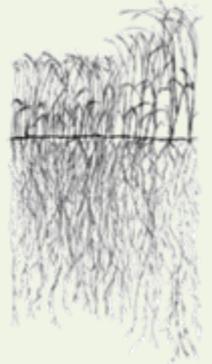
- RER are the leaders in crop biomass production and supply for heating applications



- How can we work with you?



Additional information



- John Bootle
- 802-379-8553
- Email - JohnBootle@Switchgrass-RER.com

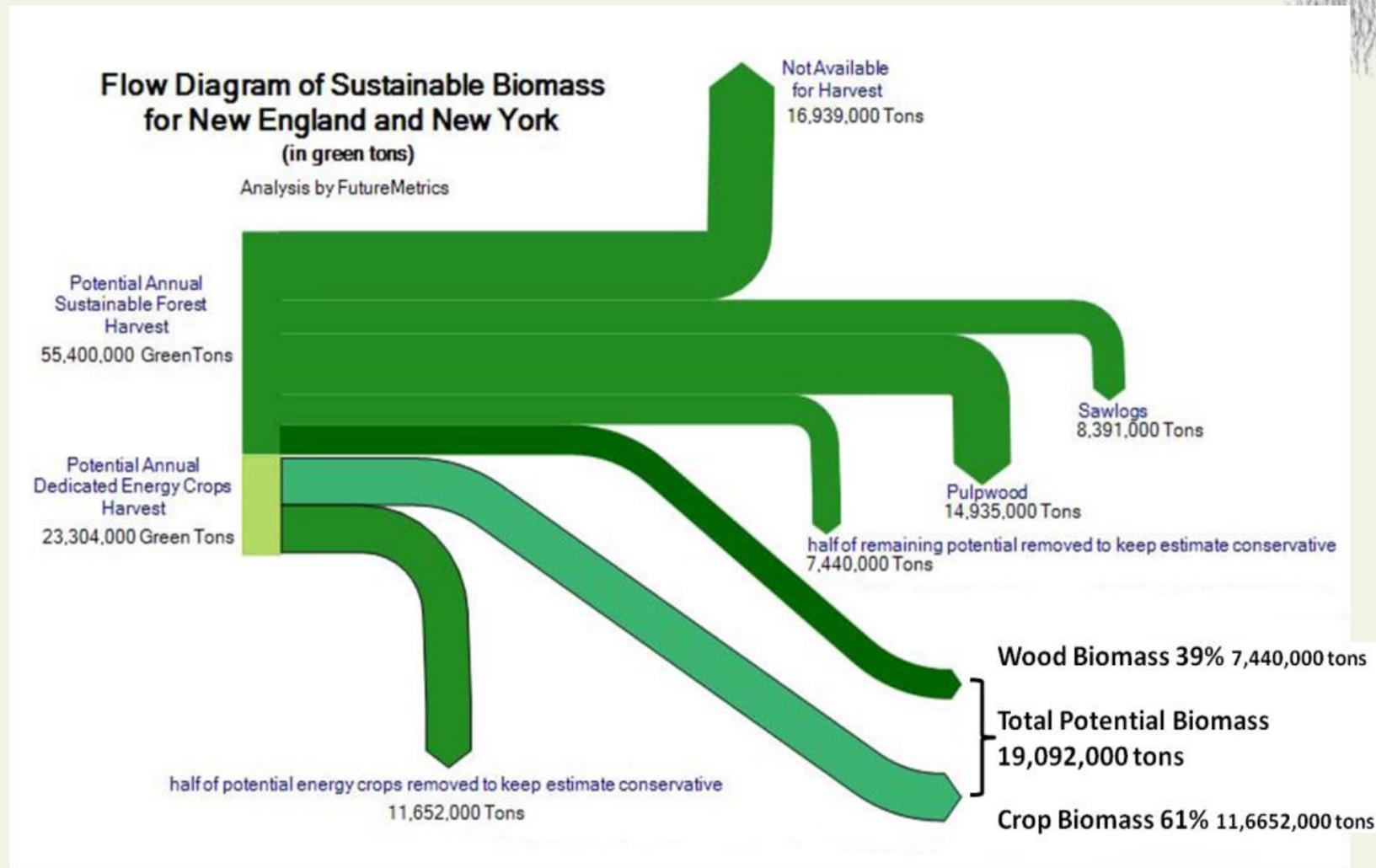
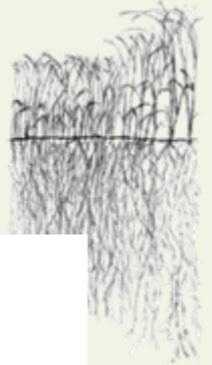


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Sources of Biomass



VT 25x'25

