# Woody Biomass Supply Chains (Potential Alternatives to Charcoal)

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# Woody Biomass Supply Chains

- Purpose:
  - To outline the benefits and gaps in the application of dried and sized biomass fuels in comparison to charcoal
- Outline:
  - Background
  - Efficiencies & Value Chains
  - Size Reduction
  - Drying
  - Transport Considerations
  - Fuel Utilization
  - Kenya Stove – A Pilot Project
  - Prerequisites – Where does this approach fit?
  - Next Steps (Gaps)

# Background

- Charcoal Use
  - Sub-Saharan Africa
    - 11% of population use charcoal as primary fuel.
    - 69% use woody biomass as primary fuel.
  - Kenya, 30% of urban dwellers use charcoal as primary fuel
  - Uganda, 60% of urban population use charcoal

# Background – cont.

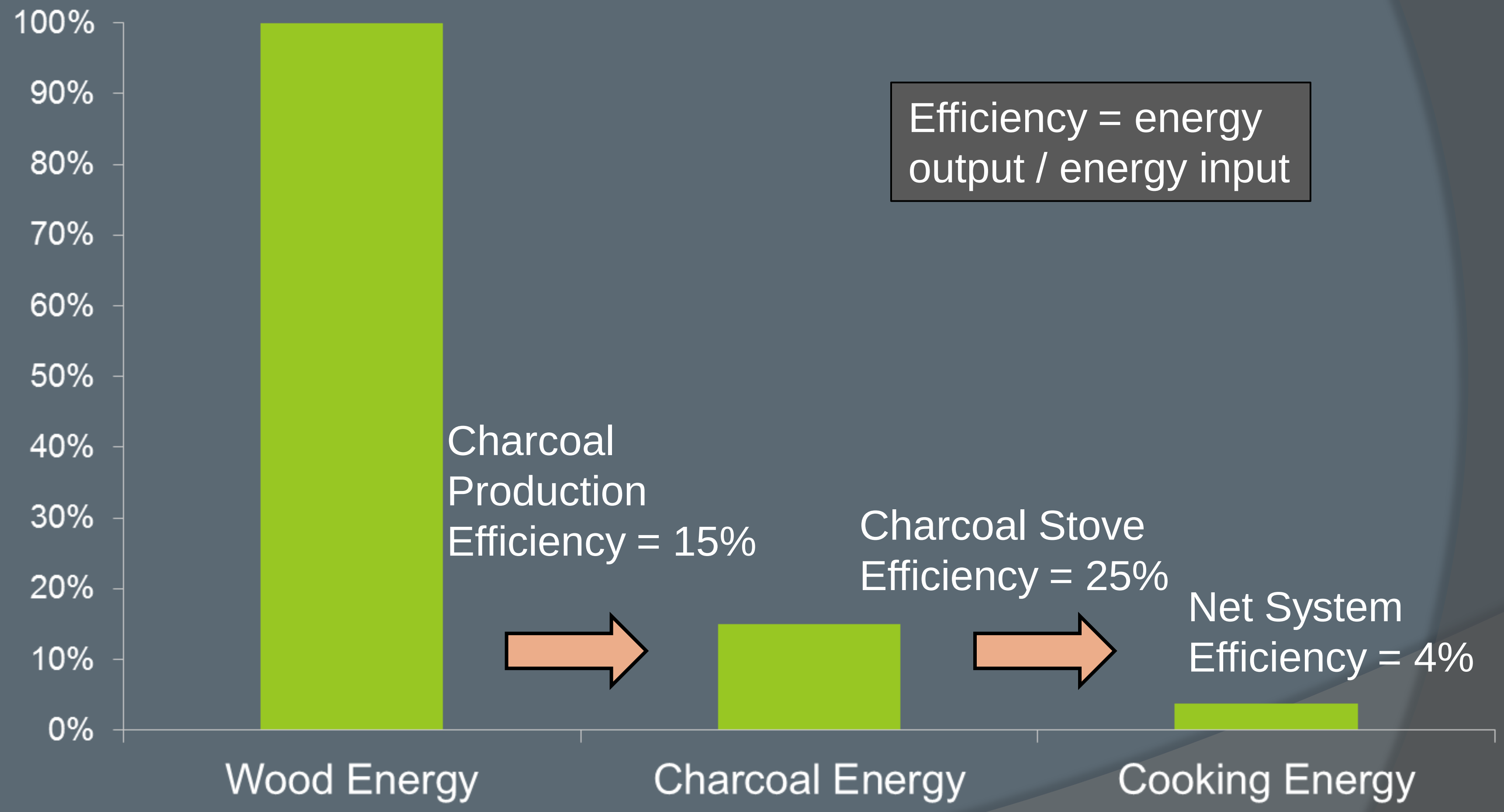
- Advantages to Charcoal
  - Employment
    - The estimated charcoal producers in Kenya is 200,000.
    - Approximately 500,000 people engage in downstream-processing and trade.
    - the economic value of the charcoal industry in SSA may exceed US$12 billion by 2030, employing almost 12 million people.

- Clean  burning – low particulate emissions
- Very convenient
- Fuel Conservation – user can save unused fuel.
- Low capital production

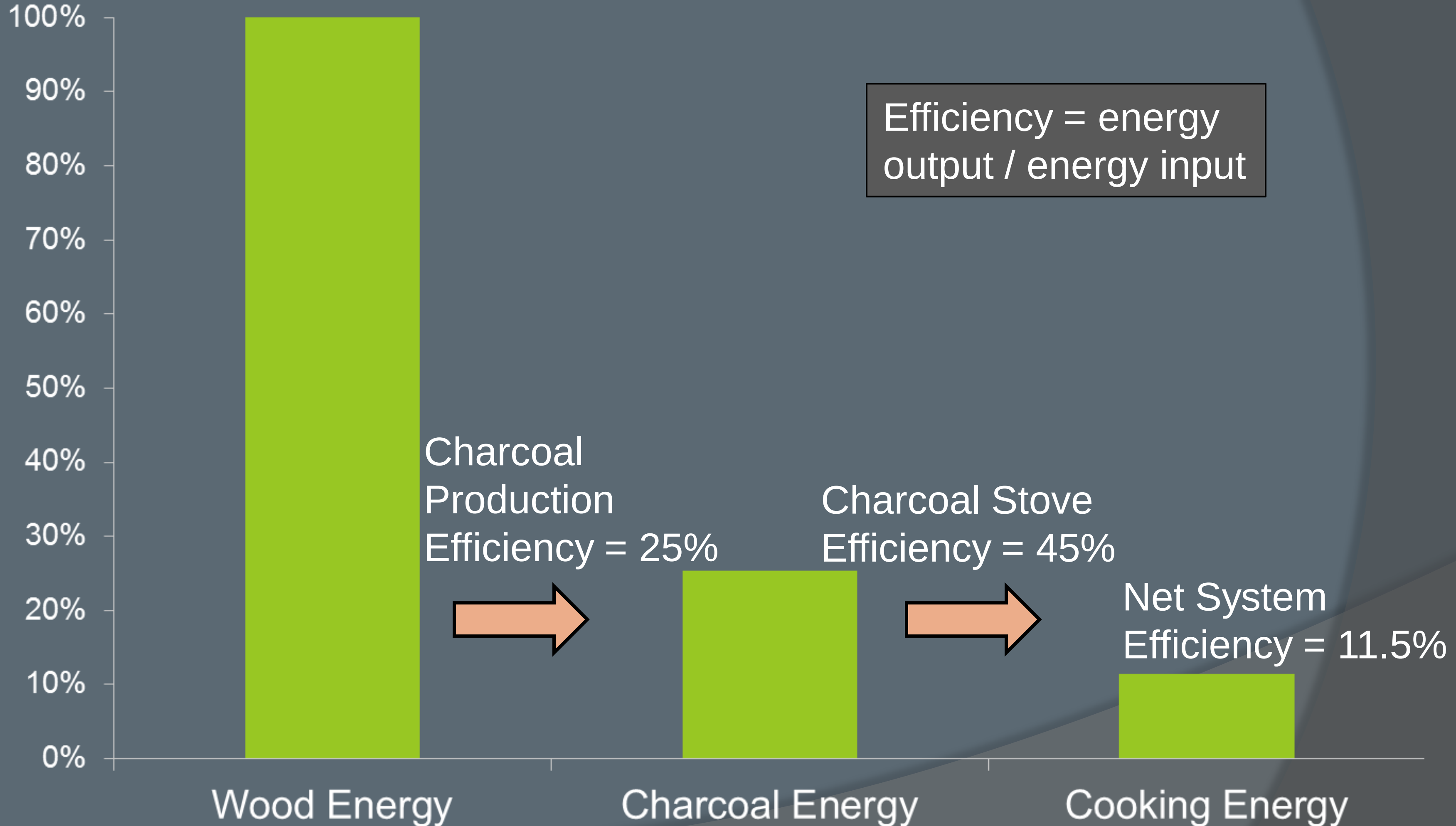
# Background – cont.

- Issues with Charcoal
  - Environmental Impact – charcoal made from live trees (Deforestation rate in Sub-Saharan Africa ~0.8%)
  - In Kenya 2006, biomass demand was estimated at 38.1 million tonnes against a sustainable supply of 15.4 million tonnes, creating a demand-supply deficit of 60 percent.
  - High CO emissions from burning charcoal
  - Low production efficiency

# System Efficiency – Traditional Charcoal Production & Use



# System Efficiency – Improved Charcoal Production & Use



# Value Chains

- Charcoal

| Wood Production | Charcoal Production | Transport | Wholesale / Retail | Use |
|---|---|---|---|---|
| • High Consumption | • Low Efficiency<br>• Low Capital | • High Energy Density | • Well Established | • Variable Efficiency<br>• Low Particulate<br>• High CO |

# Value Chains

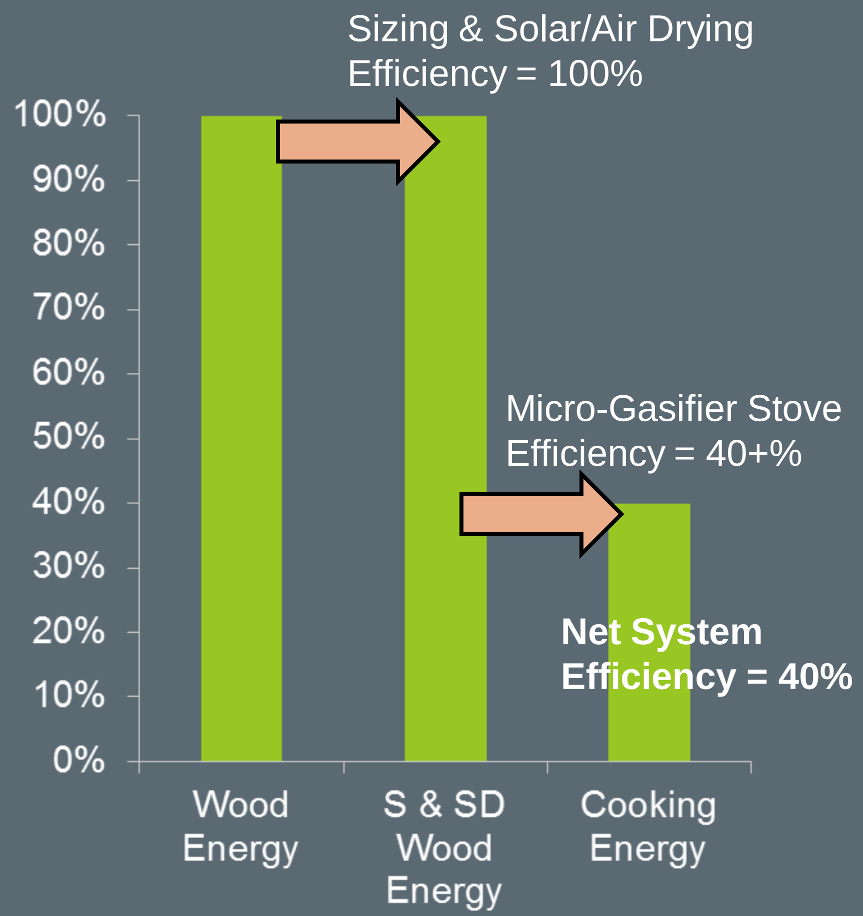
- Sized & dried biomass

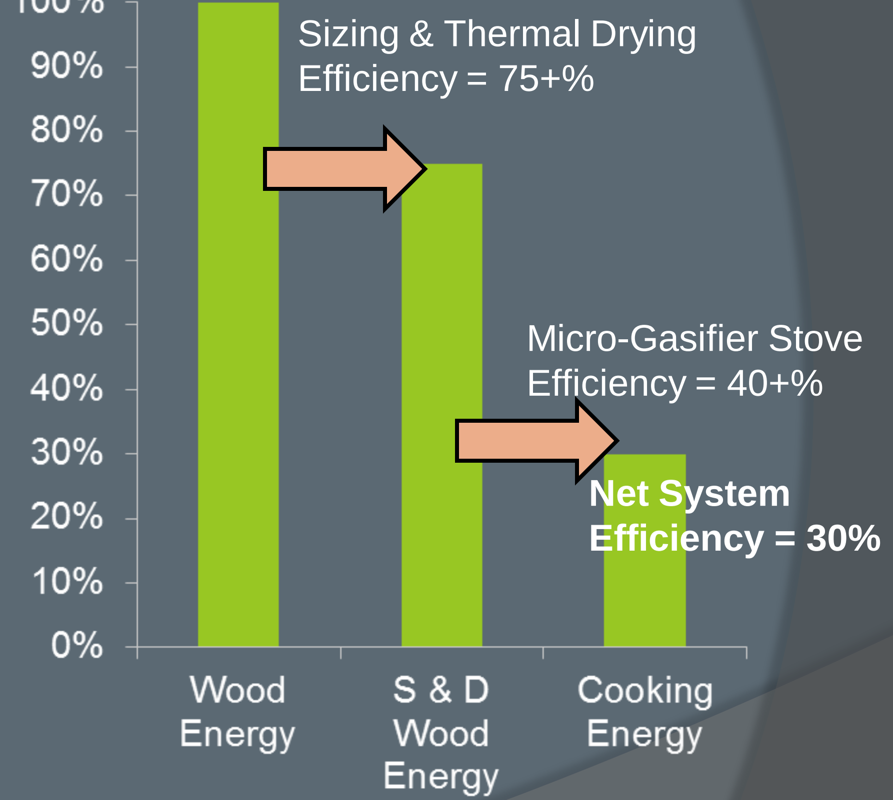
| Wood Production | Size Reduction & Drying | Transport | Wholesale / Retail | Consumption |
|---|---|---|---|---|
| • Low Consumption | • High Efficiency<br>• Moderate Capital | • Moderate Energy Density | • Not Established | • High Efficiency<br>• Low Emissions |

- Pelletized biomass

| Wood Production | Size Reduction, Drying & Densification | Transport | Wholesale / Retail | Consumption |
|---|---|---|---|---|
| • Low Consumption | • Moderate Efficiency<br>• High Capital | • High Energy Density | • Not Established | • High Efficiency<br>• Low Emissions |

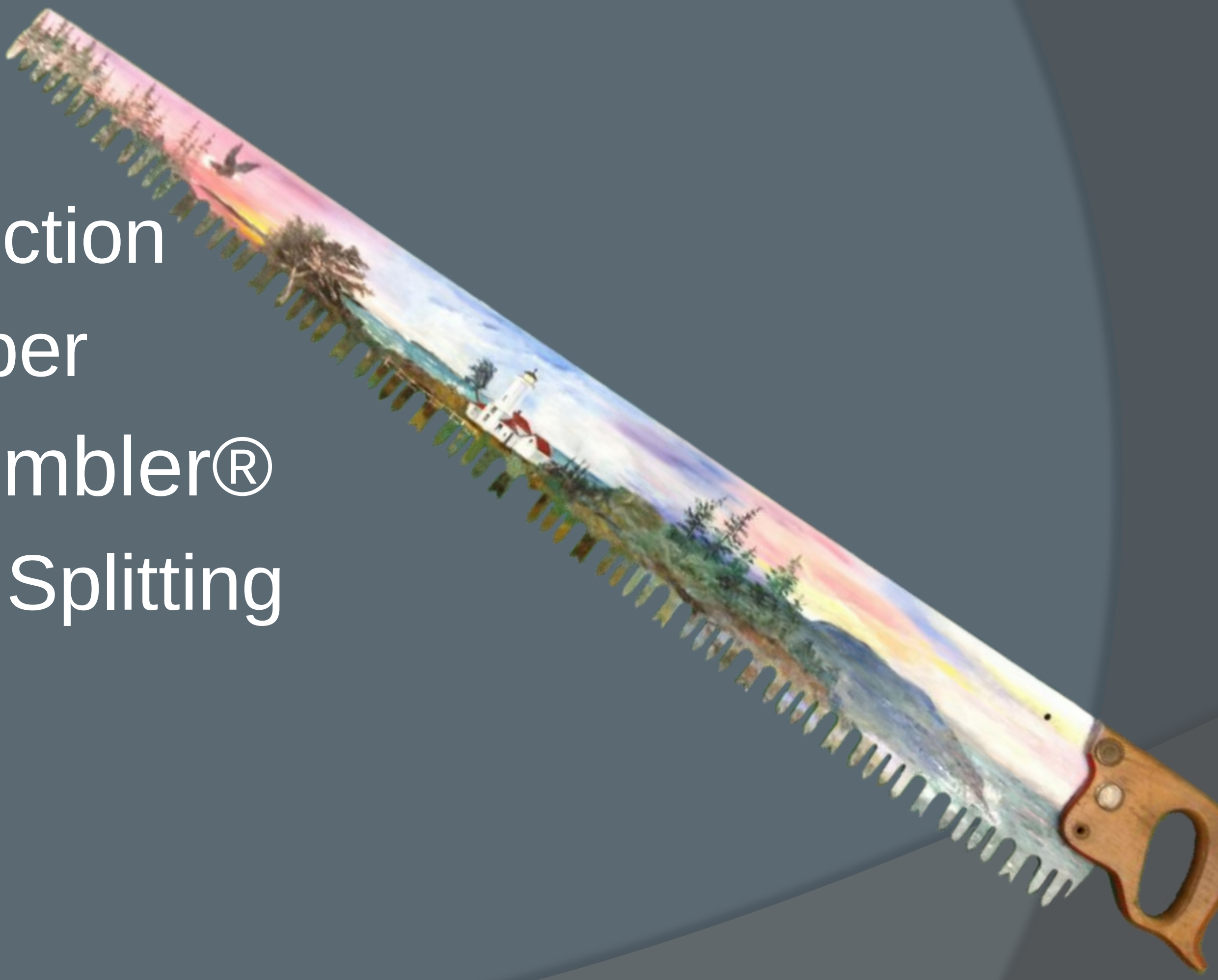
# System Efficiency –Sized & Dry Biomass




- 3+ Fold increase over improved charcoal system efficiency
- 8+ fold increase over traditional charcoal system efficiency

# Size Reduction



- Pellet Production
- Screw Chipper
- Lathe & Crumbler®
- Chopping & Splitting

# Size Reduction

- Densification / Pelletization
  - Mech. Energy (kW-hr/t)
    - 125 - 225
  - Benefits
    - High Density
    - Low Moisture
    - Very Uniform Size & Shape
    - Material handling
      - Good flowability
  - Limitations
    - Requires consistent feedstock
    - High Grit intolerance
    - Dust & Fire Hazards

# Size Reduction

- Auger Chipper
  - Mech. Energy (kW-hr/t)
    - 25-140
  - Benefits
    - Simple Design
    - Efficient
    - Moisture tolerance
      - Effective over wide moisture range
  - Limitations
    - Material handling
      - Low flowability
    - Grit intolerance
    - Product size range
      - Larger particles
    - Wide piece size distribution

# Size Reduction

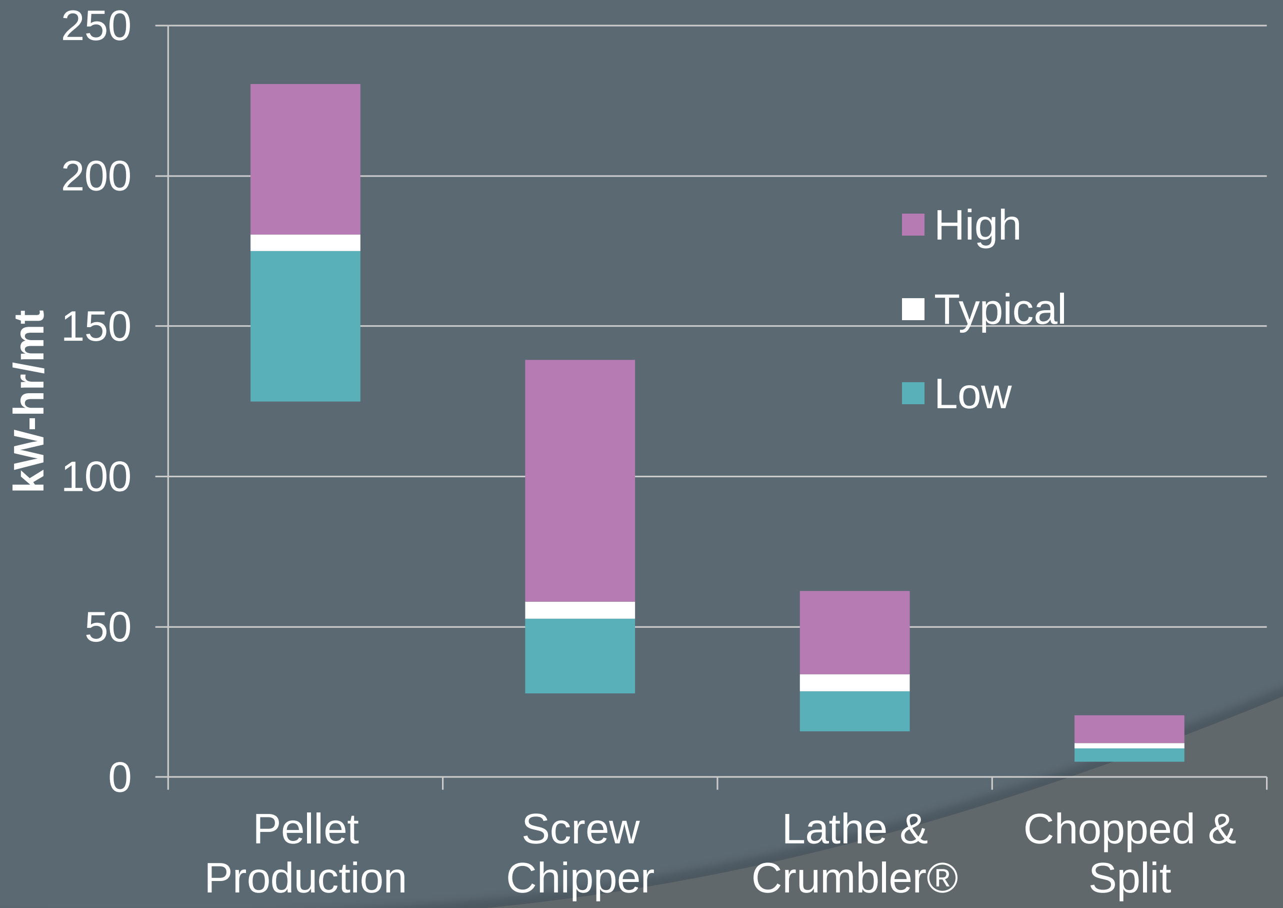
- Lathe & Crumbler®
  - Mech. Energy (kW-hr/t)
    - 15 - 60
  - Benefit
    - Very Efficient
    - Uniform product
    - Transportable & Flowable
    - Narrow size distribution
  - Limitations
    - Size range
      - 16 mm maximum in 1 dimension
    - Grit intolerance
      - Grit wears blades
    - Lathe - Out of round material
      - Lost yield, can be difficult to start

# Size Reduction – cont.

- Choping & splitting
  - Mechanical Energy (kw-hr/t)
    - 5 – 20
  - Benefits
    - Low capital
    - Existing technology
    - Efficient
    - Uniform size
    - High grit tollerance
  - Limitations
    - Very labor intensive
    - Limited size distribution
    - Variable size

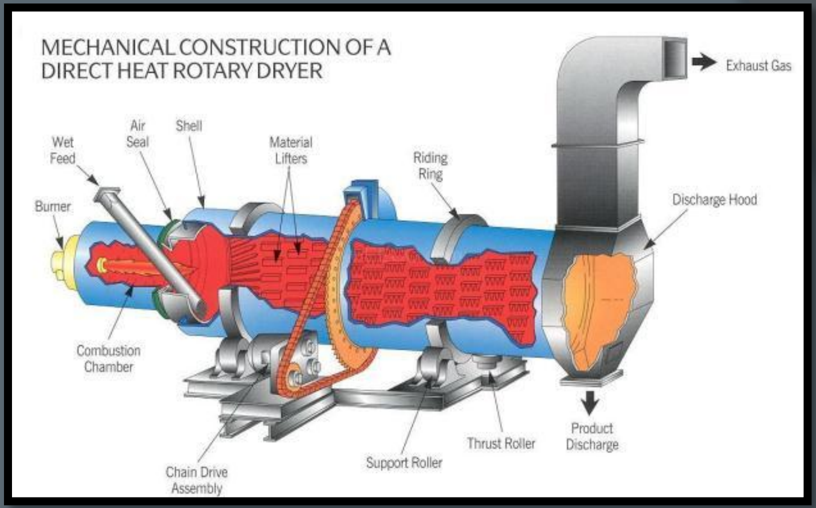
# Size Reduction

- Mechanical Energy Requirements



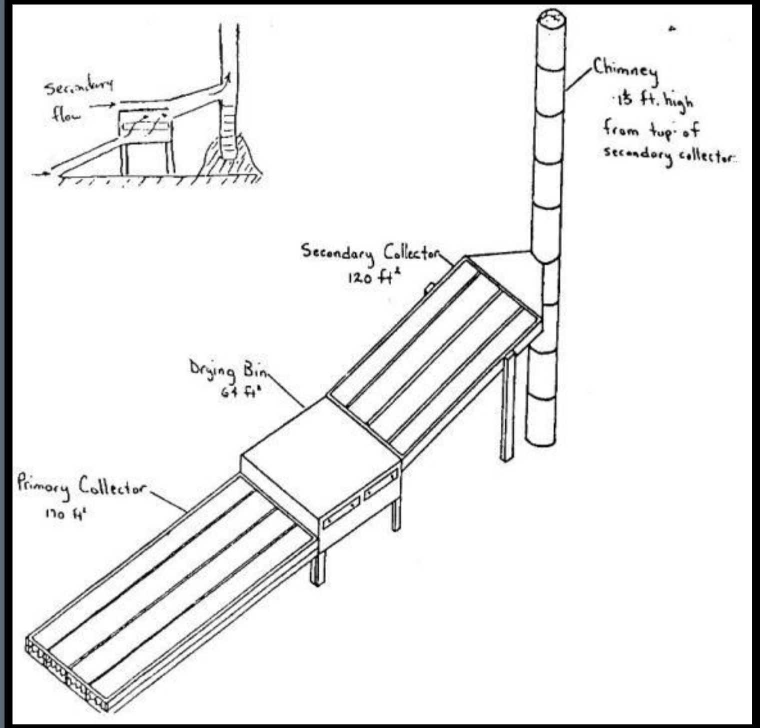
# Drying

- Types
  - Rotary drum
  - Fluidized bed
  - Belt
  - Deep bed (grain)
  - Tarp
- Fuels
  - Fossil fuel
  - Electric (very limited)
  - Wood / biomass
  - Sun



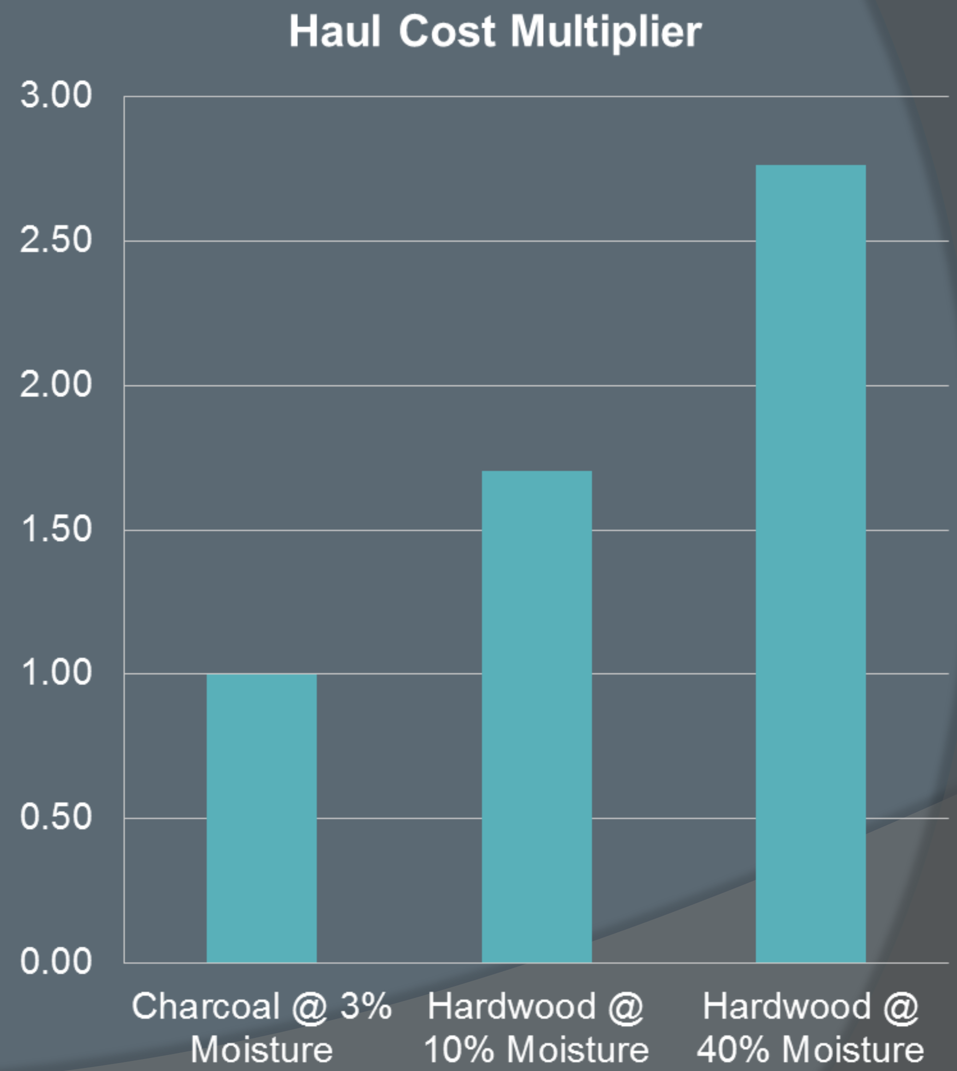

# Air / Solar Drying

- Types
  - Rotary drum
  - Fluidized bed
  - Belt
  - Deep bed (grain)
  - Tarp
- Fuels
  - Fossil fuel
  - Electric (very limited)
  - Wood / biomass
  - Sun




# Transport Considerations

- Hauling Cost Impact due to lower net heating value for raw biomass.



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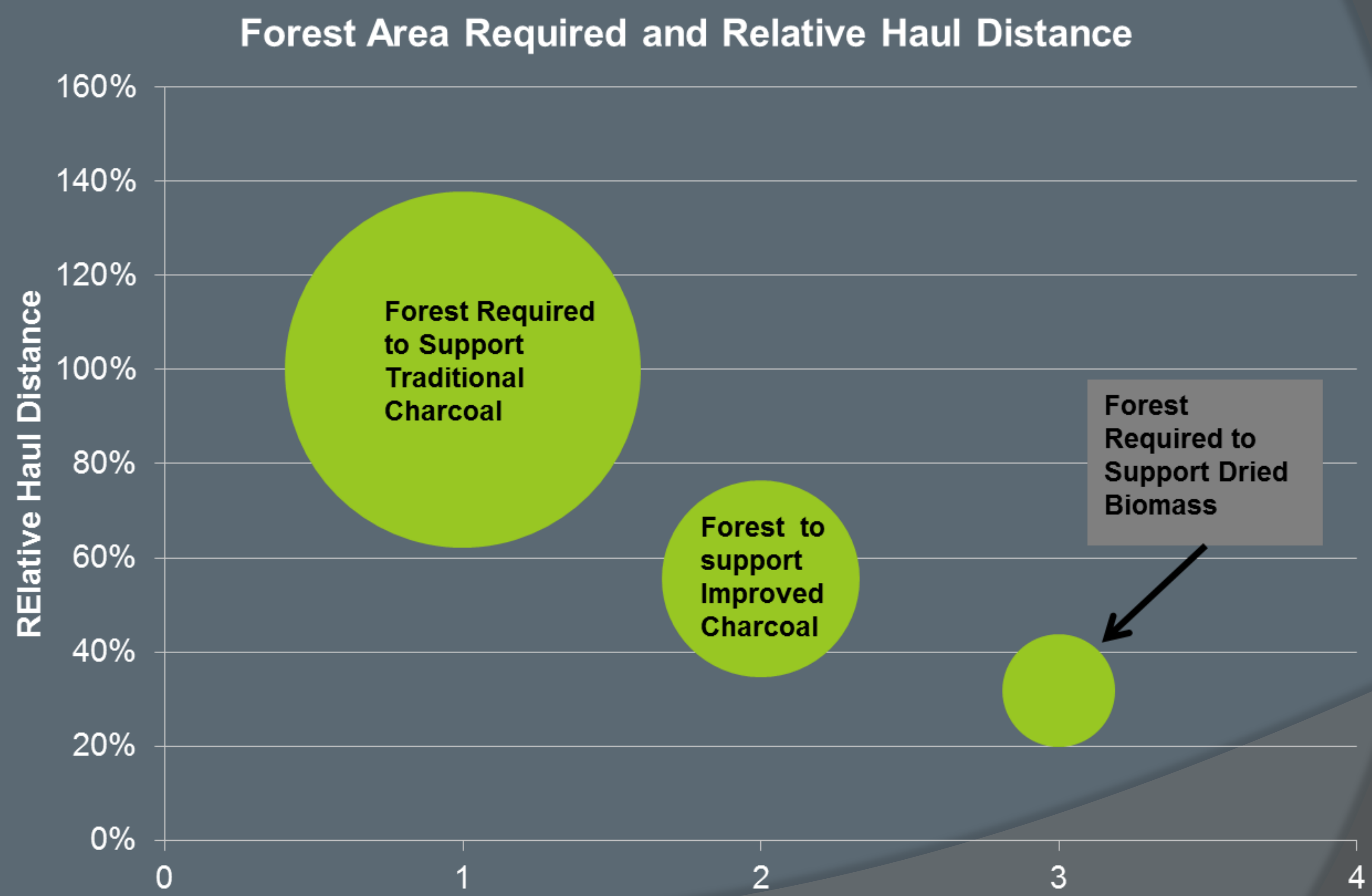
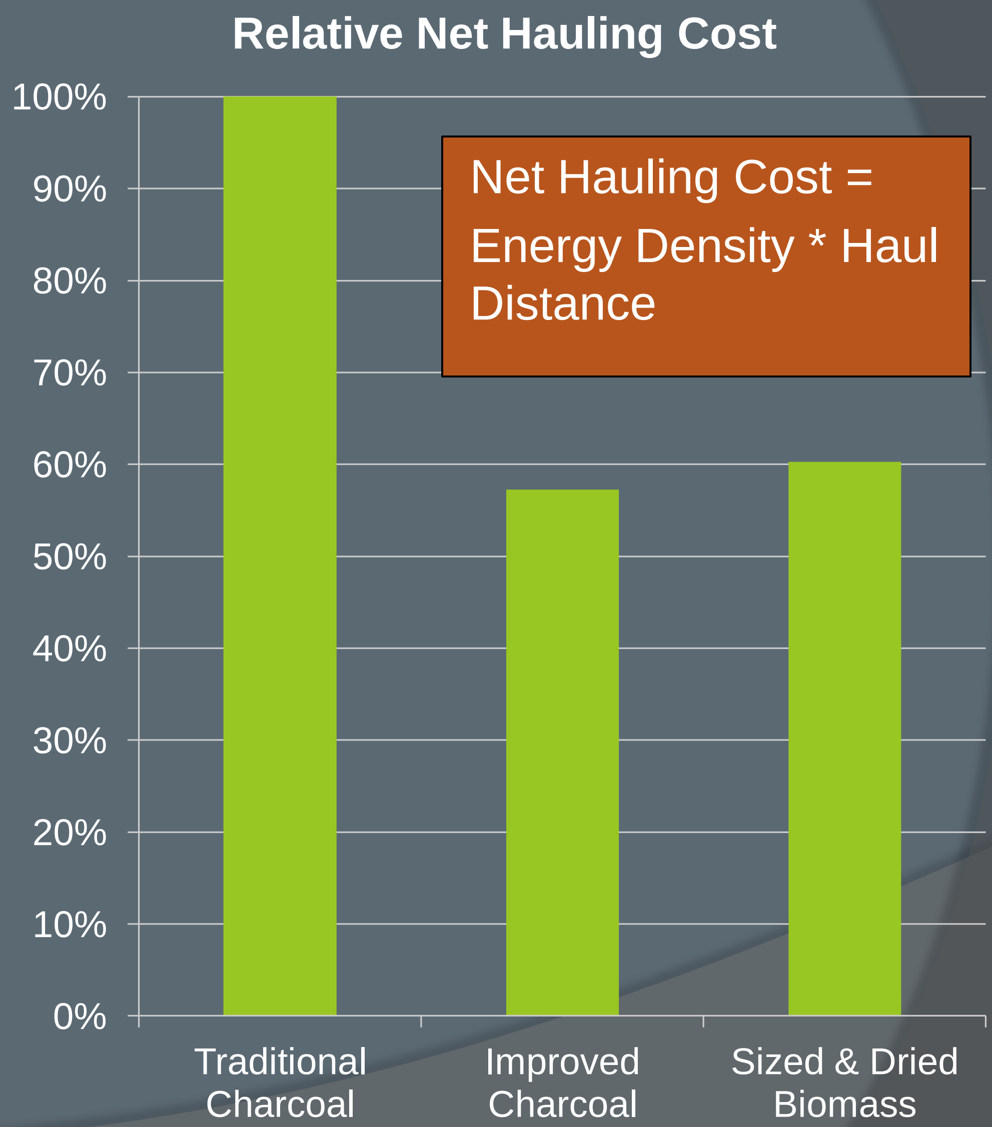


# Transportation Considerations – cont.



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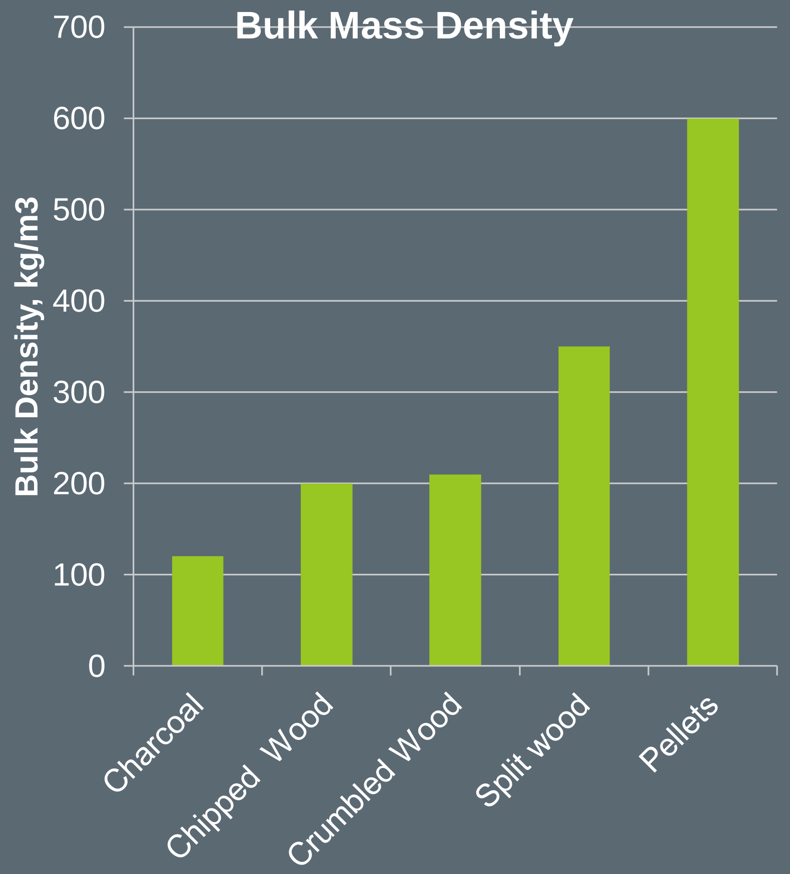


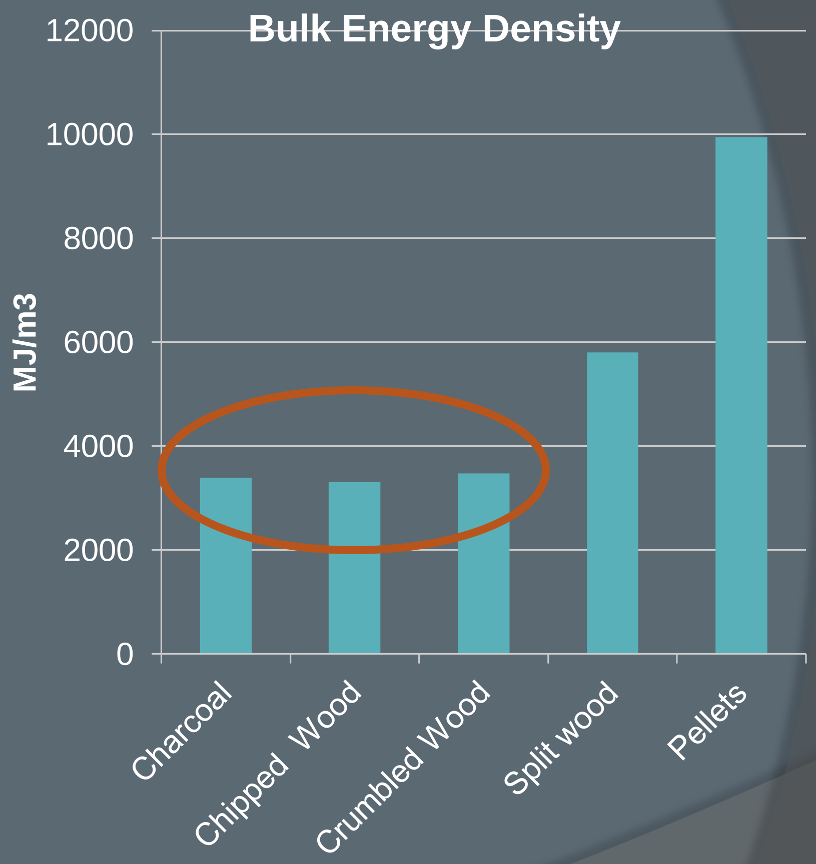


- The bulk energy density of sized and dried woody biomass is equal to or better than that of charcoal.

# Fuel Utilization

- Micro-Gasifiers get their day in the sun..
  - Efficiency = 40+%
  - Low CO and Low PM2.5 emissions
  - Well suited for standard sized dry woody biomass fuel.
- Suited for commercial & industrial energy systems

# Kenya Stove Pilot Project

- Conducting proof-of-concept in Kenya.
- Sustainable fuel supply chain of invasive mesquite wood chips, quality controlled and optimized for use in the stove.
- Novel micro-gasifier design with adjustable grate height.

# Prerequisites – or Where do these approaches fit?

- Woody biomass supply available – ideally wood lot crop.
- Urban markets with ability to pay (currently using charcoal)
- Partners prepared for:
  - market development costs
  - technology development costs
  - mitigating the social impact of the technology change.

# Conclusions

- Size reduction & drying of woody biomass, combined with micro-gasification can displace charcoal as a fuel for urban dwellers.
- These new value chains, if developed, Have the potential to
  - Reduce forest usage up to 87%
  - Substantially Reduce indoor air pollution.

# Next Steps – Gaps to Fill

- Comparative Economic Analysis of Value Chains
- Selection / Development of right sized equipment for size reduction.
- Evaluation of alternative drying technologies. Selection considerations similar to size reduction equip.,
- Micro-Gasifier Stove performance vs. fuel size & distribution, shape, density, etc.
- Transportation, Storage, & Handling vs. Fuel Properties
- Pilot Operations
- Optimization of the fuel System Wide for:
  - Low capital cost
  - Low purchased energy costs
  - Storage, handling, & combustion characteristics
- Bracket Core Technology Assessment with:
  - Social Compatibility Assessment.
  - Operational Assessment

# Thank You!

# Questions?


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