

PROS AND CONS OF TORREFACTION OF WOODY BIOMASS

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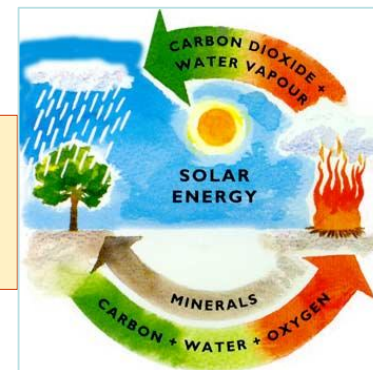
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BACKGROUND

Depleting fossil fuel resources and GHG/Global Warming

Renewable energy, sustainable fuels

Biomass → Carbon-neutral,
local fuel; energy security



Technology barriers to their utilization as
energy source

Torrefaction

- Low energy density/heating value (low fixed carbon content ~45%)
- High moisture content (~50%)
- High volatile matter content (~70%)
- Low ash content; high alkali metal content (Na, K) (low Cl content compared to herbaceous biomass)
- More oxygen content (needs less air for stoichiometric combustion)
- Hygroscopic (absorbs moisture)
- Non-uniform (wide range of shapes, sizes and types)

- Low calorific value, high moisture content
- Low energy density
 - ➔ too bulky, not economical to transport over long distances
- Non-homogeneous
 - ➔ Wide variations in combustion properties (Fixed C, VC, inorganic constituents, moisture, calorific value)
 - ➔ Wide variations in sizes, shapes and types (handling and storage difficulties)
- Low combustion efficiency, smoking during combustion

- Difficult to pulverize like coal (poor grindability)
- Hygroscopic (absorbs moisture during storage)
- Significant inorganic matter content (mainly Ca, Si and K)
 - ➔ ash-related problems (sintering, fusion, agglomeration)
 - ➔ coal generally has a much higher ash content, but biomass ash is more prone to slagging & fouling

Torrefaction can address most of these issues to a reasonable extent.

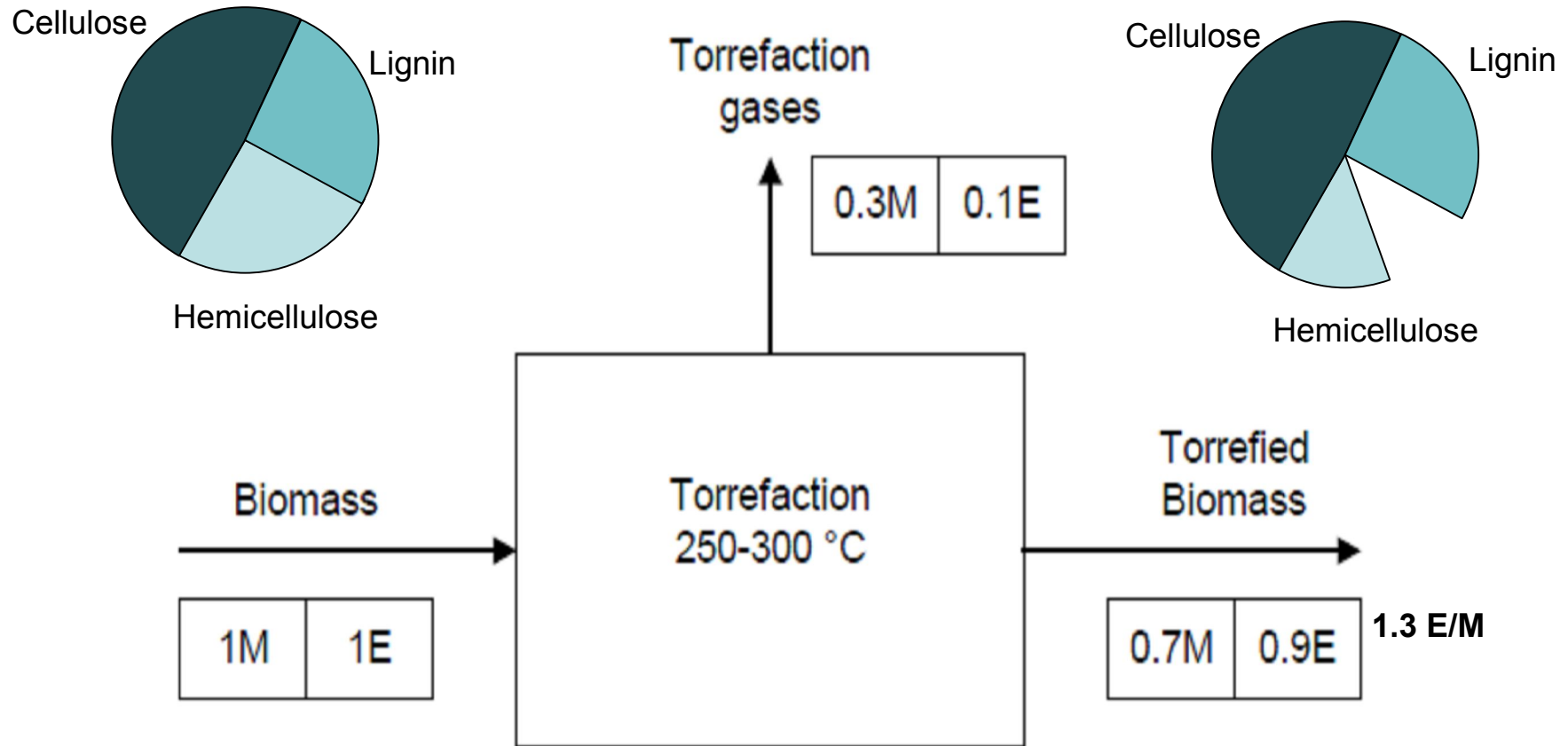
TORREFACTION



- A thermochemical treatment process, similar to roasting or mild pyrolysis
- To separate water, some VOCs & hemicellulose in woody biomass, leaving only cellulose & lignin to produce a charcoal-like carbonaceous residue ➔ **Torrefied wood.**
- VOCs and hemicellulose are combusted to generate process heat ➔ required to sustain the process.
- Warm lignin acts as a binder if TW is pelletized.
- Depending on the process time, the TW yield varies between 66% and 75%.

TORREFACTION

- Energy density increases as ~70% biomass remains with 90% of its original energy content



CONDITIONS FOR TORREFACTION

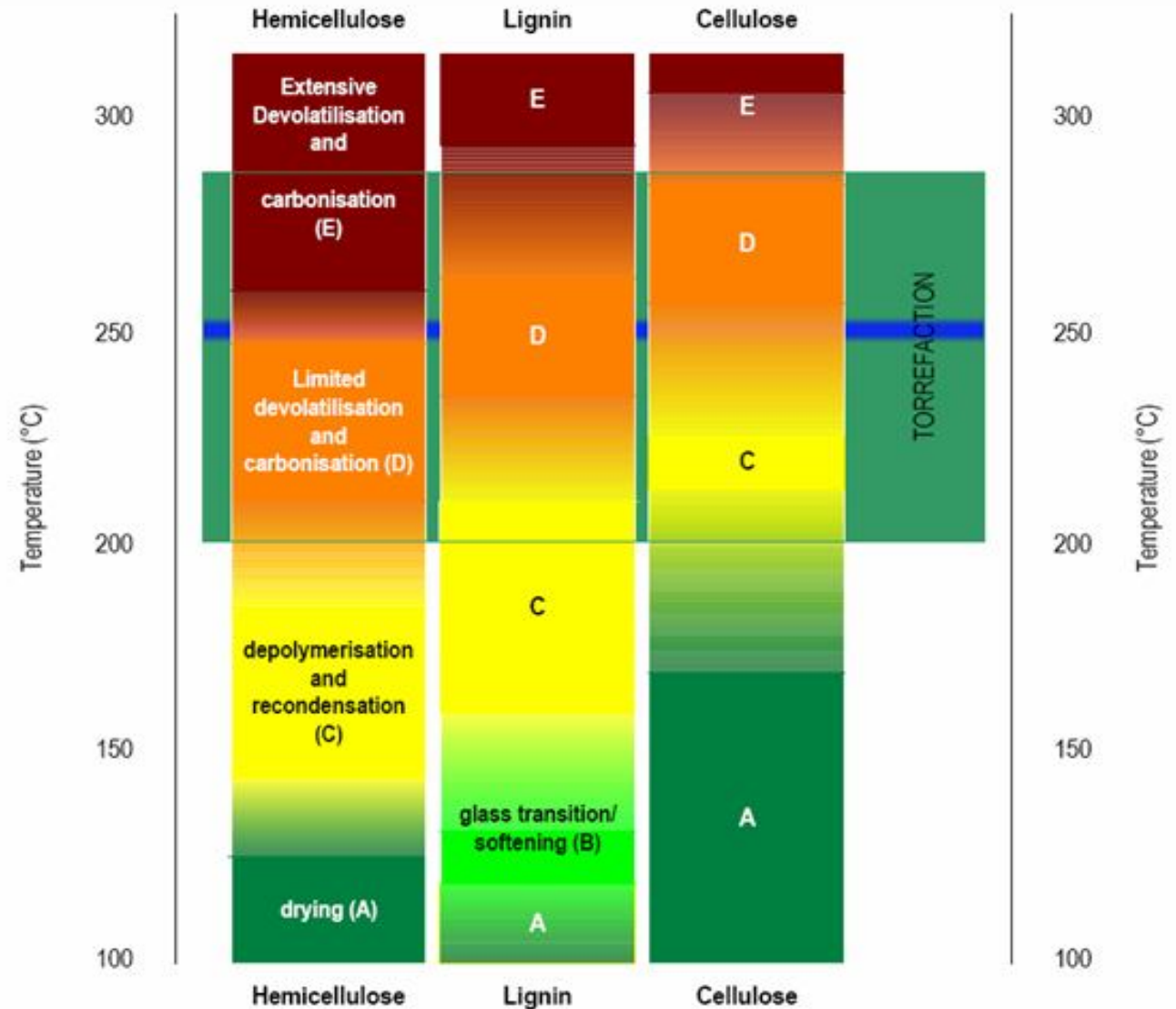
- Temperature of 200-300° C
- Near atmospheric pressure
- Absence of oxygen/air
- Low heating rate (residence time of 30 min – 2 hrs)

CONDITIONS FOR TORREFACTION

Temperature regime

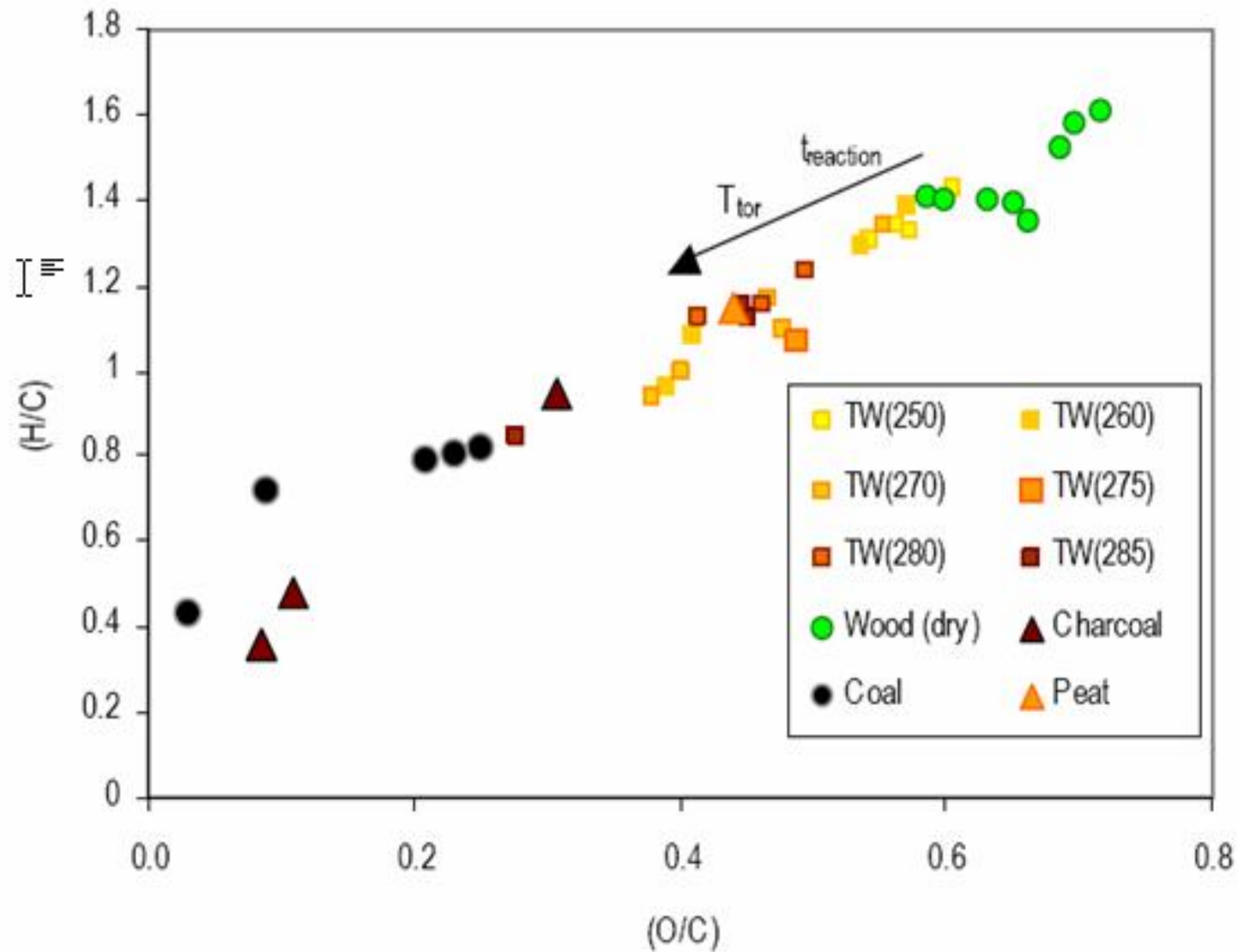
At lower temp.,
limited
devolatilisation &
carbonization of
hemicellulose.

At higher temp.,
vigorous
decomposition of
hemicellulose into
volatiles, leaving a
char-like residue.
Lignin and cellulose
show limited
devolatilization and
carbonization.



CHARACTERISTICS OF TORREFIED BIOMASS

Van Krevelen diagram for torrefied wood



Torrefaction

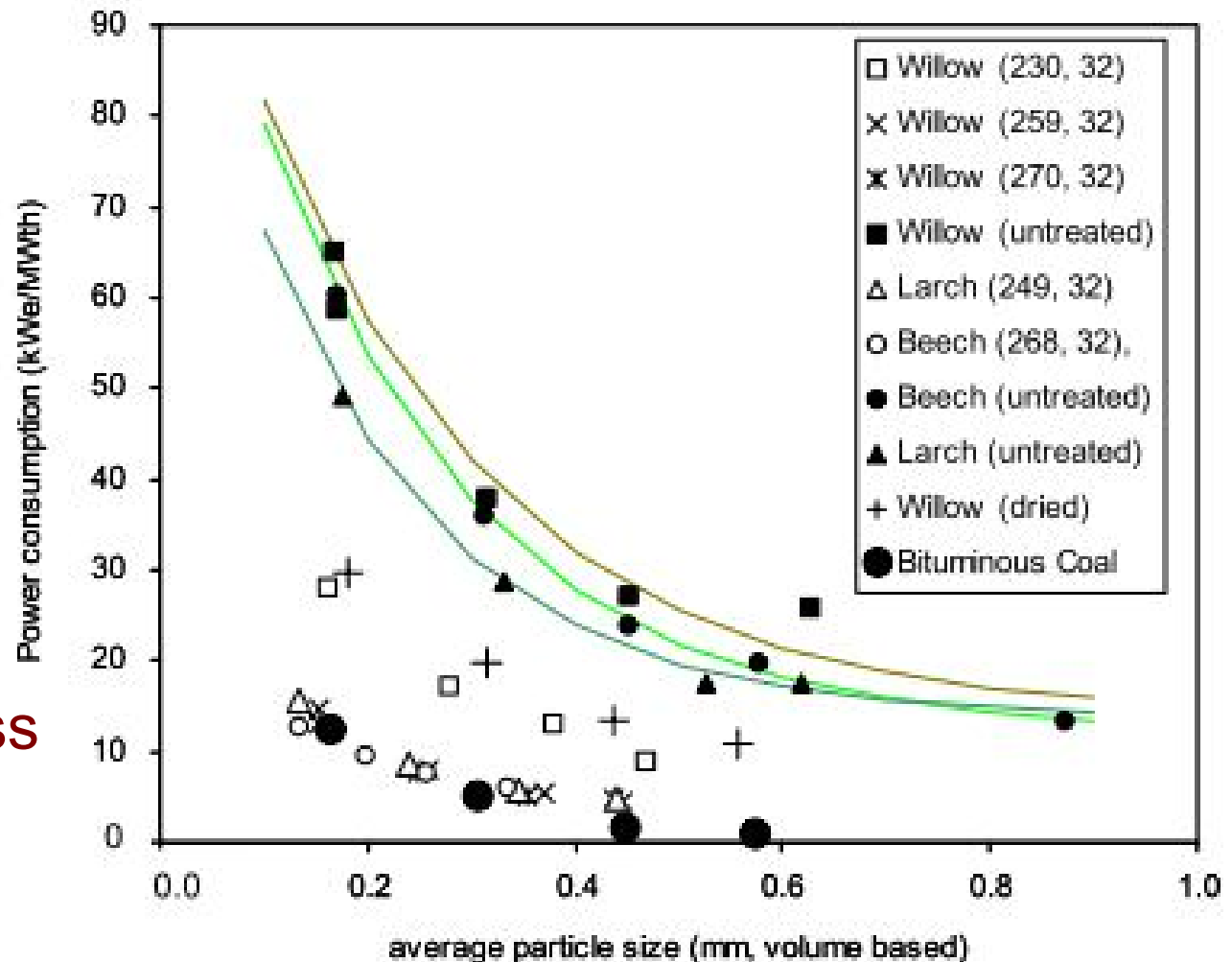
- ➔ improves the physical characteristics of biomass, and thus the overall economics of the biomass utilization process for energy production.

Torrefied product is a homogeneous solid fuel with:

- Higher energy content (per unit volume) and
- Lower moisture content

BENEFITS OF TORREFACTION

- **Makes biomass friable**
 - ✓ 80-90% less energy consumption for grinding



Specific power consumption (milling/grinding)

- **Makes biomass hydrophobic**
 - ✓ Transport and material handling is less expensive & easier
 - ✓ Outdoor storage possible ➔ Less expensive storage option
 - ✓ Significant loss of energy due to re-absorption of moisture in biomass (pellets) is saved
- **Negligible biological activities (decomposition, mould)**
 - ✓ Longer storage life without fuel degradation
- **Low O/C ratio ➔ higher yield during gasification**
- **Smoke producing compounds removed**

BENEFITS OF TORREFACTION

- Homogeneous output from mixed biomass



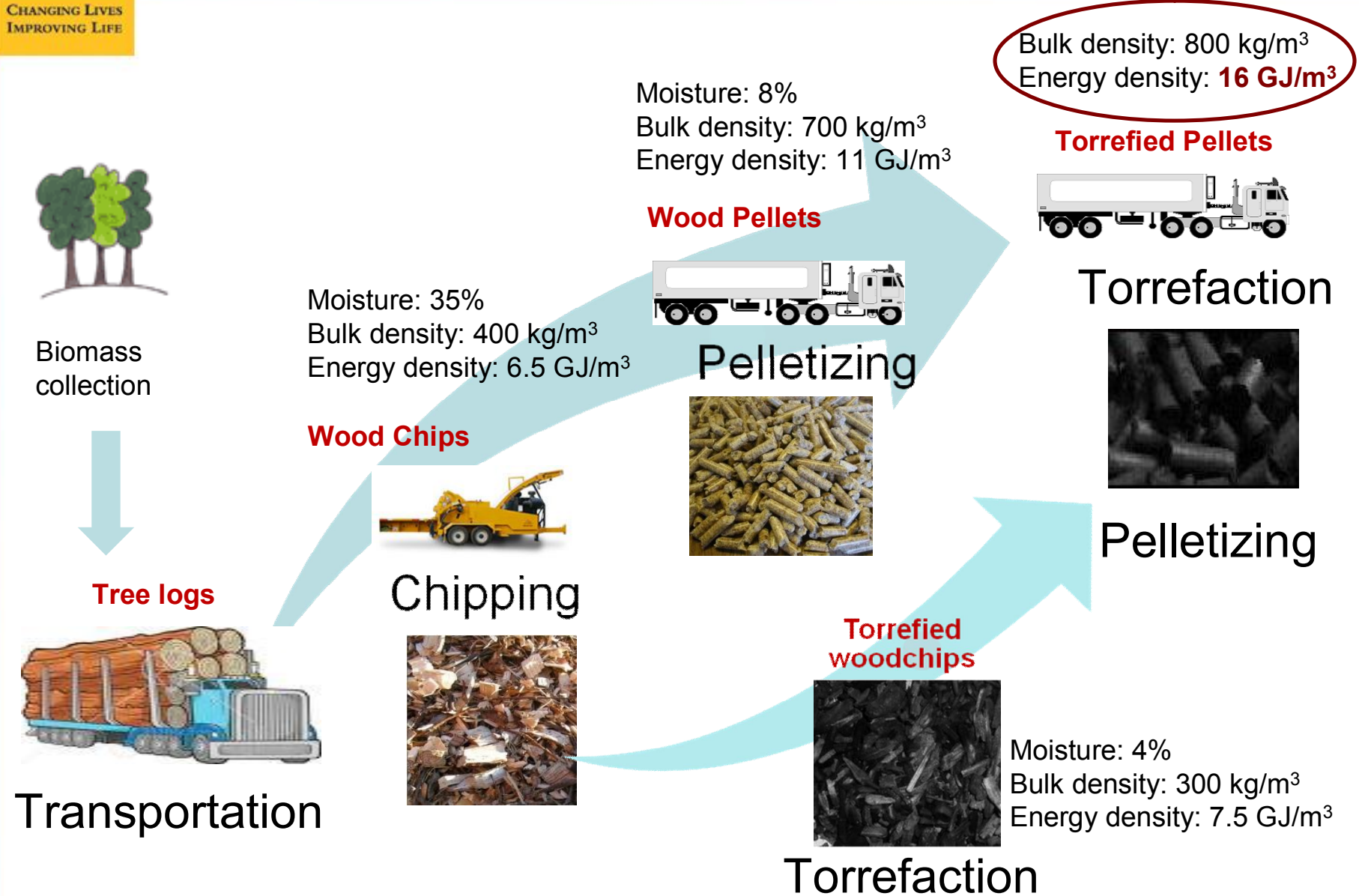
Homogeneous Fuel

- Torrefied biomass: More homogeneous physical & chemical properties
- Allows sourcing of different types of woody biomass for pelletizing in a single device ➔ **improves economics of pelletization**
- Possibility of utilizing different types of local woody biomass for energy use in a single combustion equipment ➔ **improves fuel availability, supply reliability; reduces fuel cost**
- Reduced handling and storage cost

BENEFITS OF TORREFACTION

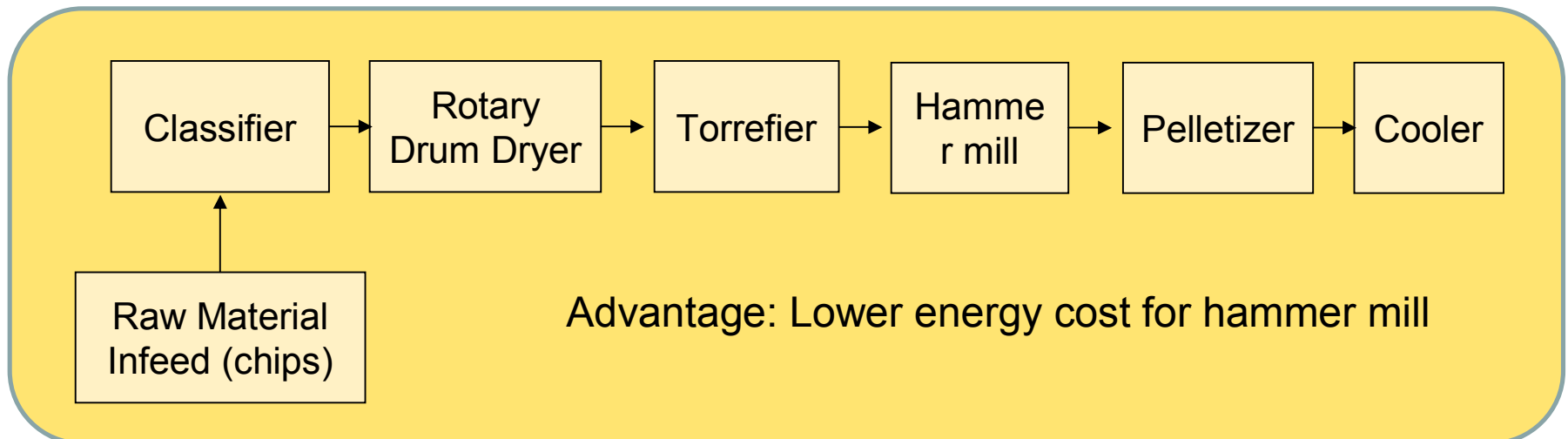
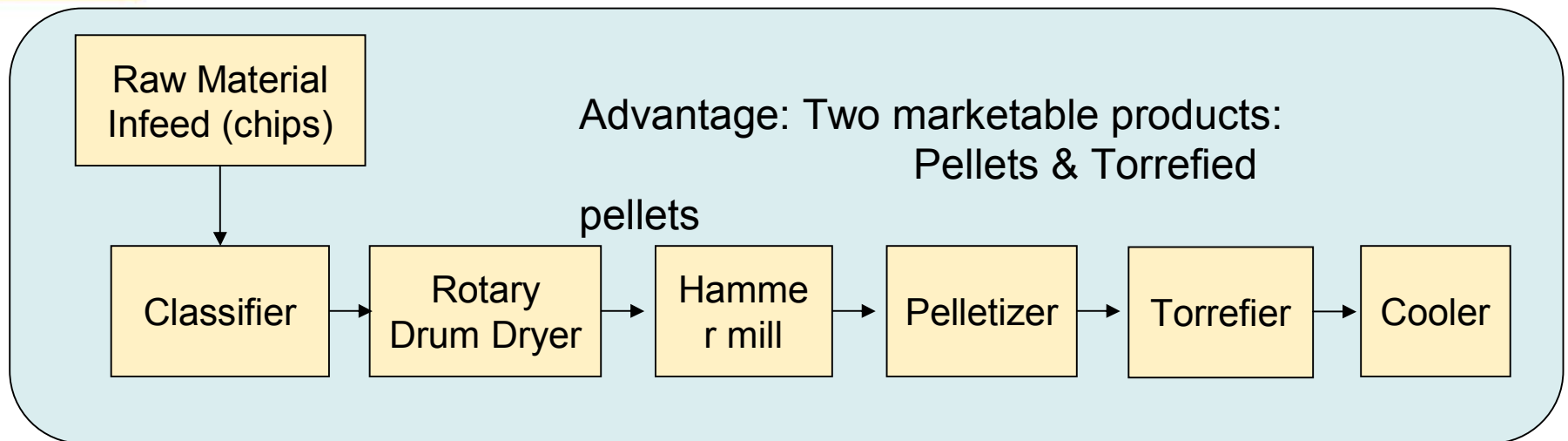
- **Makes *pelletization* easier**
 - Lignin fraction increases (by 10-15%)
 - More fatty structures developed, helps in binding
- **Torrefied pellets have more strength**
 - 1.5 to 2 times impact load
 - Does not disintegrate easily during handling & storage
- **Economics are in favour**

PROCESS FLOW BEFORE TORREFACTION



TYPICAL TORREFACTION PROCESS FLOW

CHANGING LIVES
IMPROVING LIFE



	Coal	Torrefied Pellets
Heating Value	25 GJ/T	22 GJ/T
Ash	10%	3%
Sulphur	3%	0.1%
Nitrogen	1.5%	0.2%
Chlorine	0.05%	0.01%

Indicative values: can change depending upon the type of biomass and coal

Grindability comparable to coal; combustion reactivity comparable to wood.

- Low vol. density enhancement
 - Volume of torrefied biomass is reduced only slightly, ~ 10-20% lower than the dried feedstock
- Despite higher calorific values, energy density is not improved significantly (~5 GJ/m³)
- Although small, some of the energy content in original biomass is lost (~10%)
- Torrefaction does not reduce corrosive deposits on boiler tubes (all ash components of biomass are still present in TB)
- Limited knowledge on process performance, properties of torrefied product and composition of volatiles
- No commercial torrefaction unit in operation yet

Residential and commercial heating

Power generation

- Biomass Co-firing in large scale coal-fired power plants
- Competes with coal in terms of price as well as performance
- Higher co-firing rates possible (compared to biomass)
- Most practical option to meet provincial mandate to phase out coal by 2014

Steel production

- TB with LHV in the range of 25 MJ/kg required

Biomass-to-liquid fuel

- Transportation fuels (Fischer–Tropsch process)

Export

- Large markets exist in US & Europe

SUMMARY

- Issues with wood as fuel: Low LHV, high moisture, low energy density, non-homogeneous, hygroscopic, poor grindability
- Torrefaction addresses most of these issues, delivering a fuel comparable to coal
- Torrefaction: thermochemical treatment process at 200-300°C to separate water, VOCs & hemicellulose in woody biomass
- Torrefied biomass:
 - ✓ Higher energy, lower moisture content; better grindability
 - ✓ Transport, handling & storage advantages due to higher bulk & energy density, homogeneity, hydrophobic property
 - ✓ Drawbacks: low vol. & energy density enhancement; no commercial unit in operation yet.
- A competitive fuel when co-firing with coal in power plants.

Thank you.