ENERGY FROM WASTE

WEBINAR

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LAFARGE

WISE
WATERLOO INSTITUTE
FOR SUSTAINABLE ENERGY

SHAPING THE FUTURE
CPIA
Canadian Plastics
Industry Association

UNIVERSITY OF
WATERLOO

Opening Remarks

Fergal McDonough

President, Envise Consulting

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Cement Kiln Fuel Opportunities
February 8, 2016

Agenda

- About the Cement Industry
- What types of waste are suitable fuels
- Typical Specifications
- The Language of Fuels
  - Calculating Carbon emissions and carbon price effects
  - Comparing fuels
- Evolution of fuel use
- O.Reg 79/15 Alt. Low Carbon Fuel Regulation
- Questions and Wrap up

About the Cement Industry

About Lafarge Canada Inc.
- A Member of Lafarge Holcim

- Lafarge Canada Inc. consists of two separate business units: Western Canada and Eastern Canada. Separated by the Manitoba border
- We provide building materials solutions for the construction sector using cement, ready mix concrete, asphalt, concrete products, and aggregates.
- Lafarge is not just a material supplier
  - buildings and bridges,
  - brownfield soil remediation,
  - energy,
  - mining and
  - pavement infrastructures.
- R&D network of more than 1,000 experts, the world's largest building materials research center in Lyon, France.

Cement Manufacturing in Ontario

- **Cement manufacturing operations at 6 locations across the Province:**
  - **Essroc Italcementi Group** – Picton
  - **Federal White Cement Ltd.** – Woodstock
  - **CRH (formerly Holcim, St. Lawrence)** – Mississauga
  - **Lafarge Canada Inc***. – Bath
  - **St Marys Cement Group** – Bowmanville and St Marys
- **Sector makes important direct contributions to the Ontario economy (jobs, taxes, community donations)**
  - **Produced**: 7.3 MT of cement in 2007 -- **45% of national production**
  - **Exported**: 3.1 MT of cement to USA in 2007 -- **over 42% of provincial production**
- **Cement makes an important contribution to the Provincial and regional economy (direct $1 billion and 1,000 jobs; indirect $5 billion/15,000 jobs), allowing the province to be fully self-sufficient in meeting demand:**
  - Infrastructure renewal and expansion
  - Cement and concrete products play an important role in making Ontario's infrastructure more sustainable and energy efficient

*** In 2015, Lafarge and Holcim completed a merger. Due to competition board requirements, the former Canadian Holcim assets were sold to CRH. Lafarge Canada Inc is a member of Lafarge Holcim.**

C-(S-A-F)-H

CaO (Lime)

SiO_2 (Silica)

Al_2O_3 (Alumina)

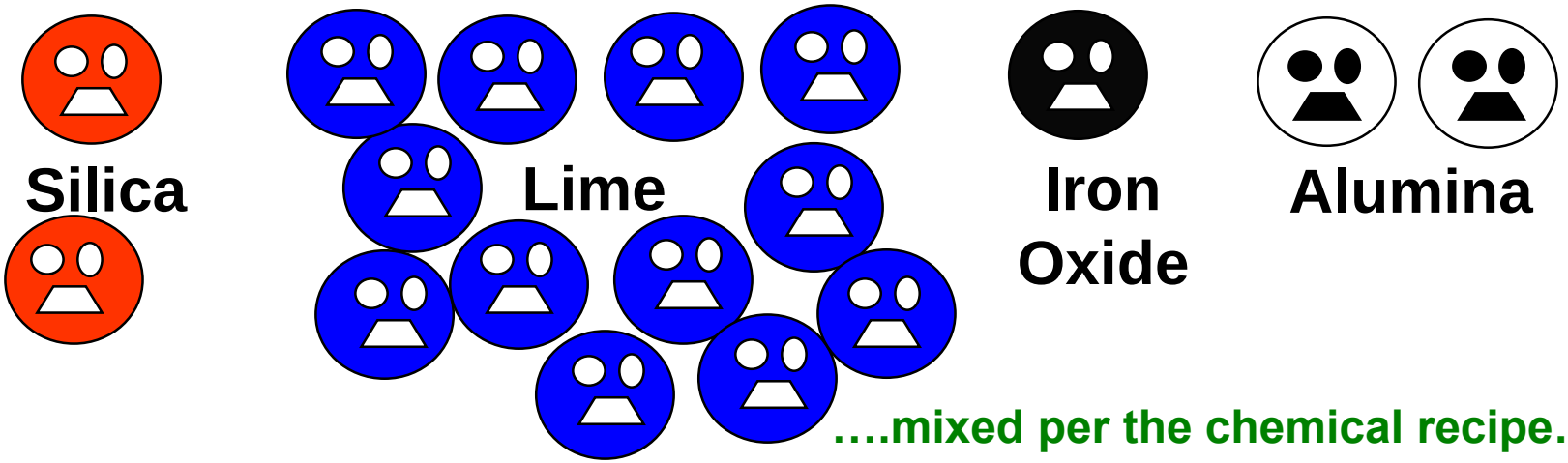
Fe_2O_3 (Iron Ox.)

H_2O (Water)

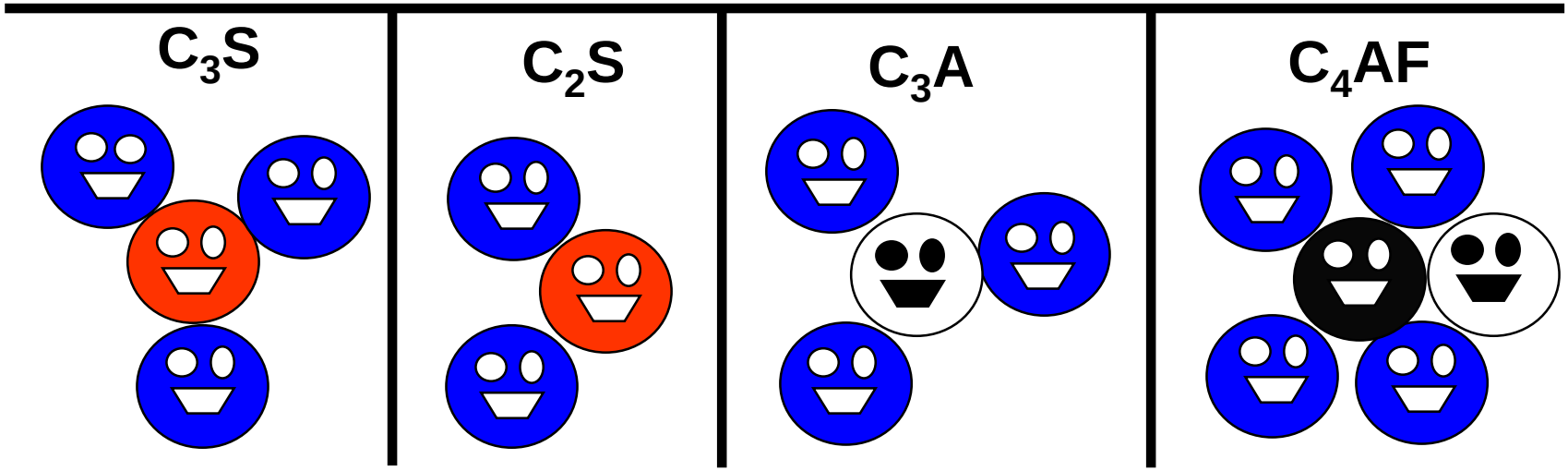
PRESENT IN CLINKER

Chemistry Made Easy

Any raw materials having the right chemical components, …..

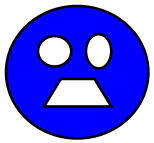


….mixed per the chemical recipe….



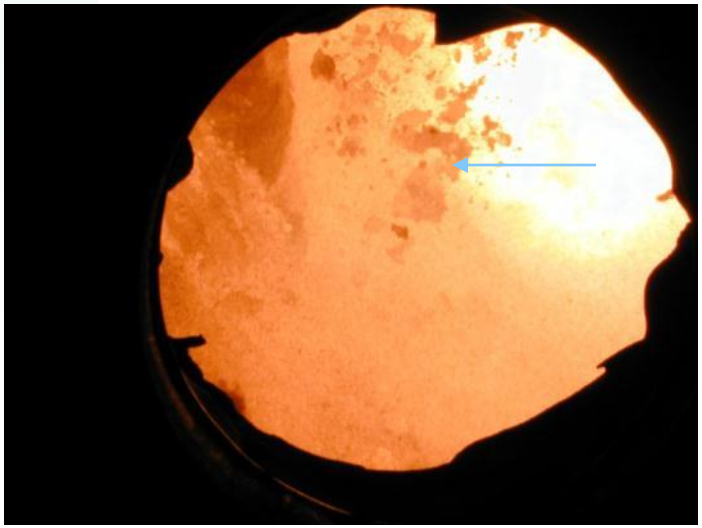
…. can be used for making clinker.

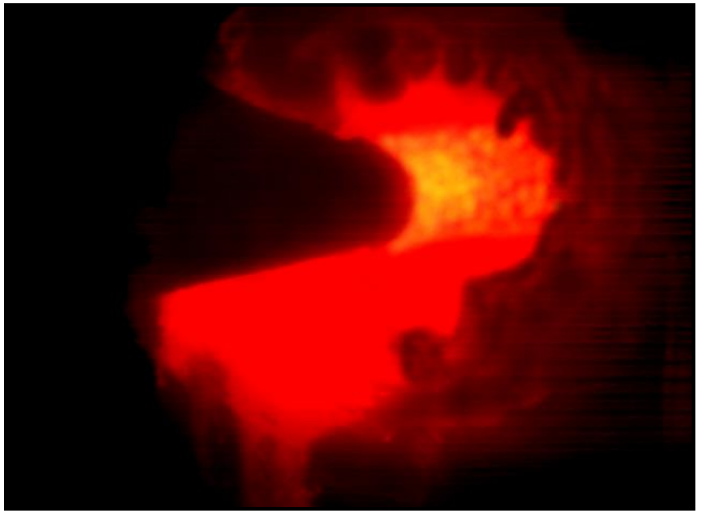
Which Raw Materials Work ?

				
NATURAL	**Limestone Marl Chalk Coral Oyster Shells**	**Sand Sandstone Conglomerate Diatomite Flint Clay**	**Shale Bauxite Kaolinite Clay**	**Iron Ore Hematite Clay Taconite**
SOME ALTERNATIVES	**Lime Kiln Dust Lime Sludge . . .**	**Glass Bottles Foundry Sand . . .**	**Fly Ash Spent Pot Liners . .**	**Mill Scale Slag . . .**

Cement Kiln Operation

The rotary kiln is on an slight incline and raw materials are added at the high end and work their way down the kiln. Fuel is injected at the downhill end. Average temperature of 1450 C is reached. Flame and product are in the same vicinity. Fuels can be injected in main burner, mid-kiln, or in Pre-Heater sections.

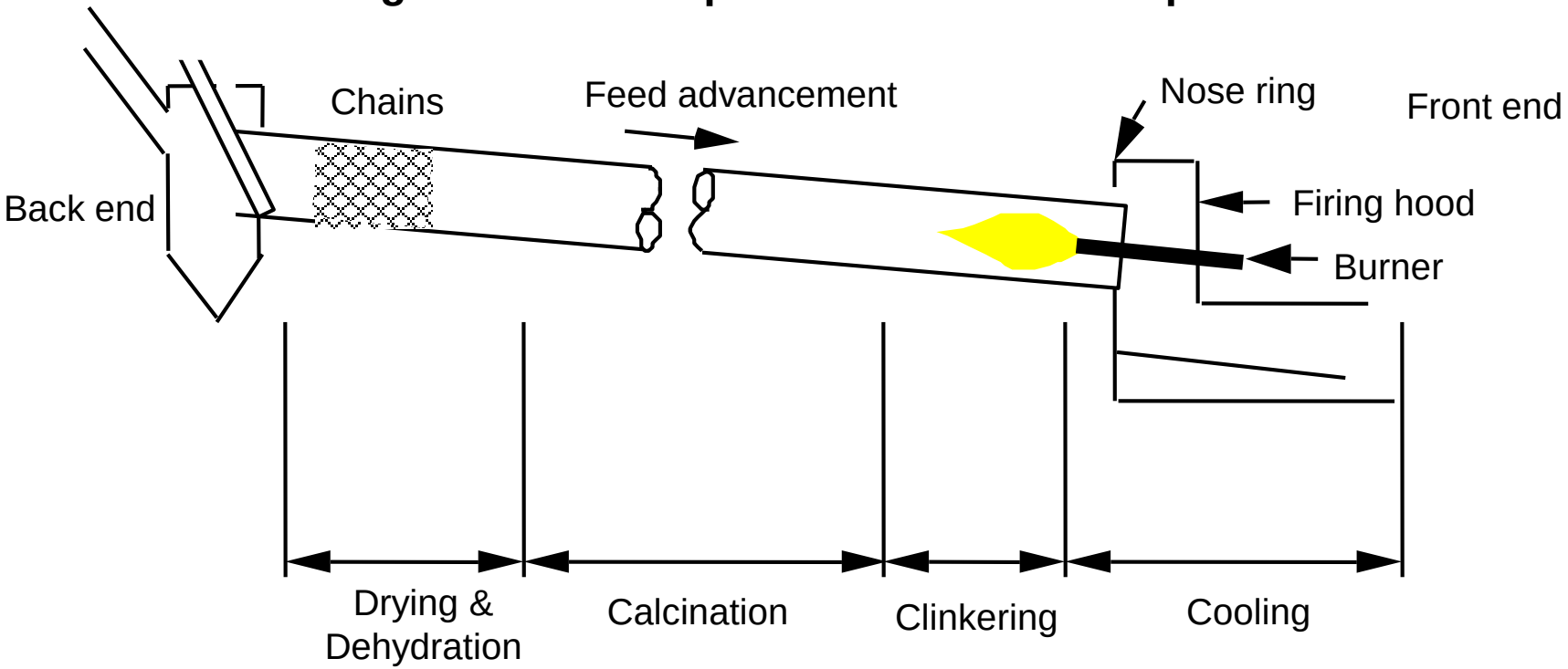




Types of Kiln Systems…Long Kilns

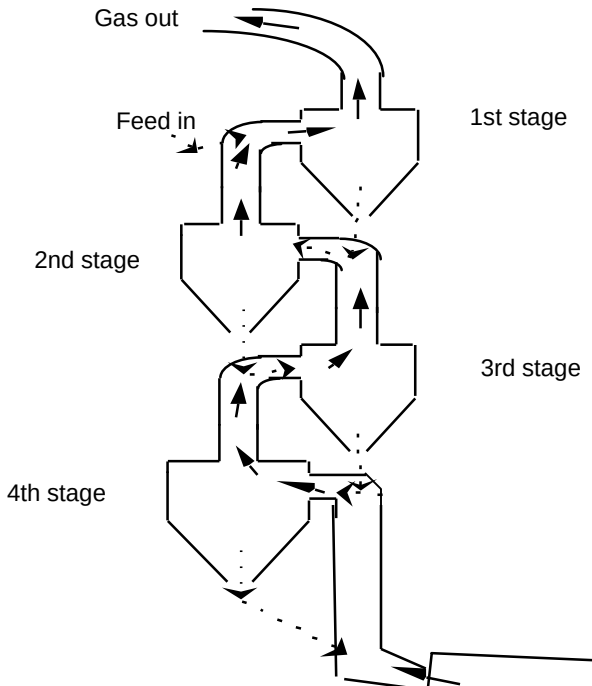
- **have chains to help transfer heat from gas to load**
- **2 sub-types: wet or dry**

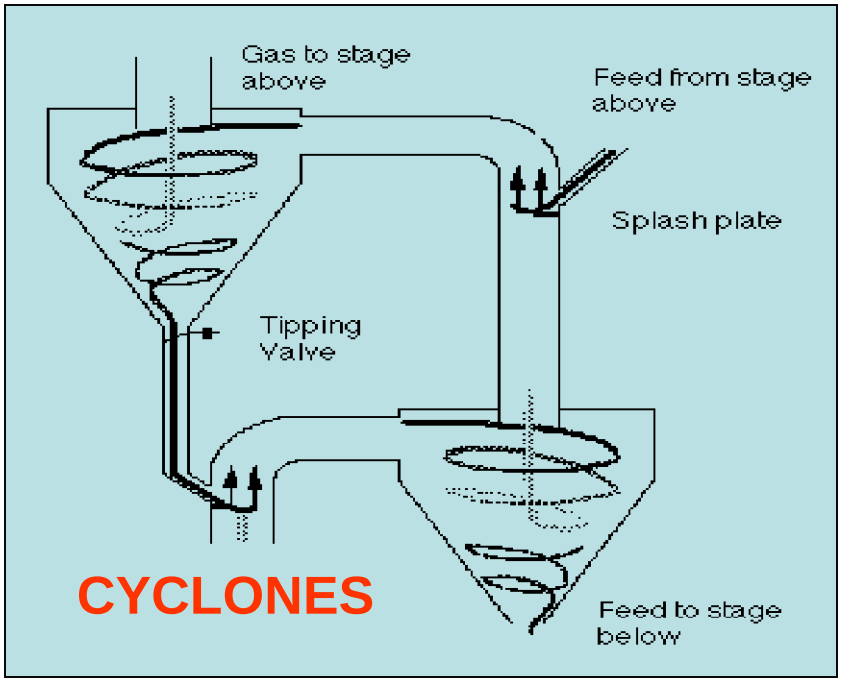
- **Wet Kilns have feed suspended in slurry**
  - **easier to obtain good feed blend**
  - **easier to transport feed**
  - **high fuel consumption due to water evaporation**

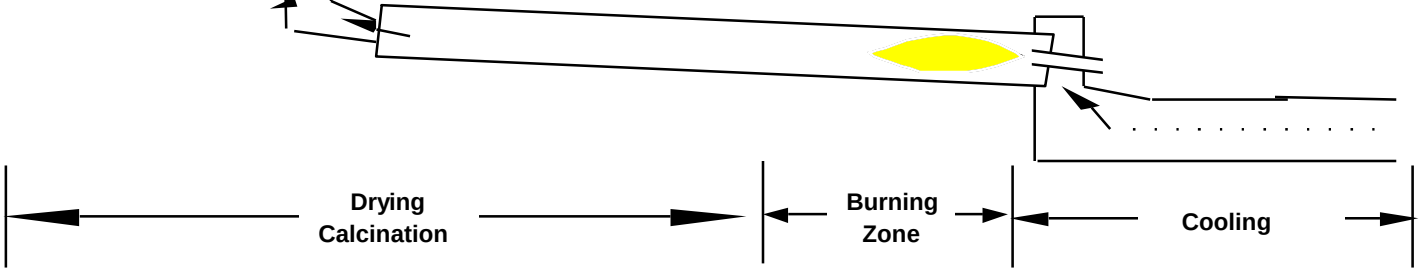


Types of Kiln Systems...Preheater Kilns

- **uses cyclones to preheat feed by suspending in hot gas stream**
- **short kiln…. eliminates preheat zone**
- **low fuel consumption**

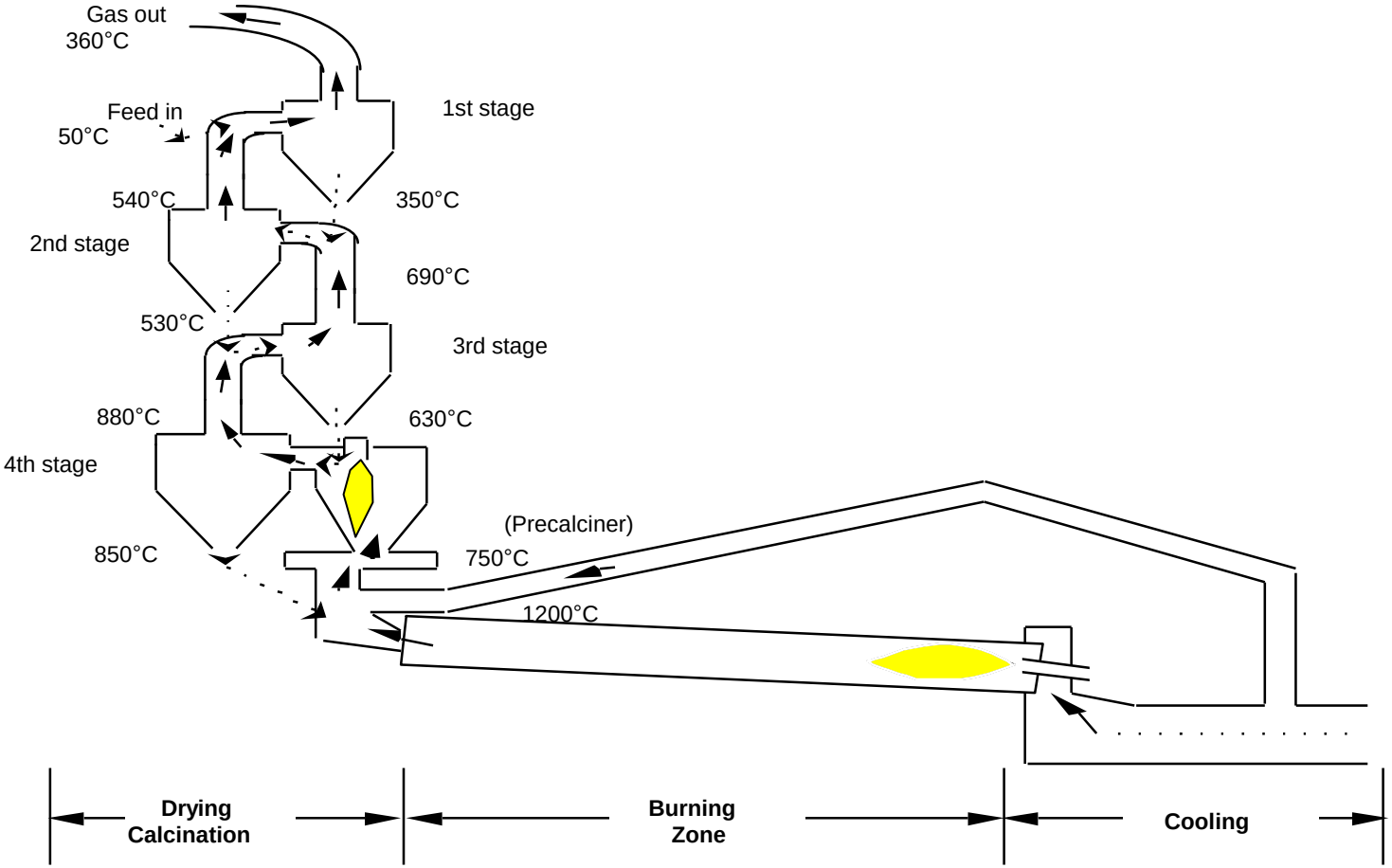




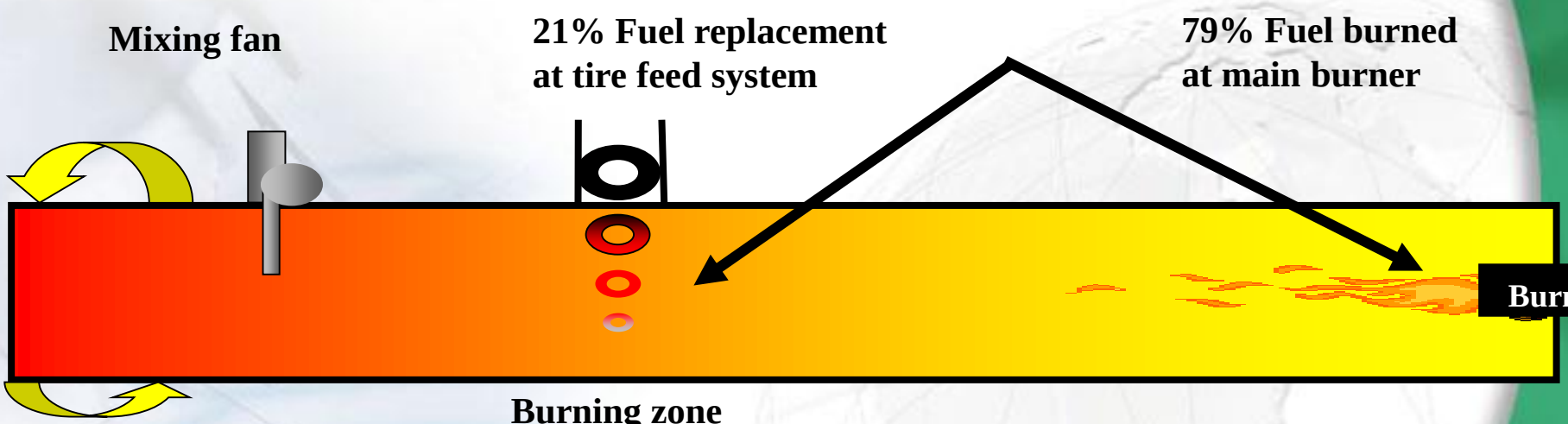


Types of Kiln Systems...Precalciner Kilns

- **burns most fuel in a precalciner reactor at the back end**
- **feed is more prepared… less work for kiln**
- **high clinker production for small kiln size**



St-Constant :Tire Derived Fuel - How It Works



Brookfield SSW system

~10,000 Mt / year of mix plastic and shingles flakes

LHV ~20 Gj TSR ~ 18%

Lafarge & Geocycle

Partners in Fuel and Raw Material Supply

- **Two different business, two different types of expertise**
  - Cement Companies make cement using fuel
  - Waste Recovery Companies collect and process waste into fuel
- **Prior to the merger of Lafarge and Holcim in 2015**
  - Lafarge & Systech
  - Holcim & Geocycle
  - Agreed to merge Geocycle and Systech (Systech remains for Haz Waste)
- **Fuel Suppliers will typically engage with Geocycle**

SYSTECH®

Systech Environmental Corporation

Byproducts into Resources

For more information visit www.go2systech.com

geocycle

Because tomorrow matters

For more information visit www.geocycle.us

What types of waste are suitable fuels?

Current Fuel Use

Across Canadian Cement Plants

- **British Columbia**
  - Treated wood chips, K-Cups, non-recyclable rubber, non-recyclable plastics, C&D, railway ties, wood fines, tire fluff, carpet
- **Alberta**
  - Studies underway
- **Ontario**
  - Lafarge (Bath) – (Phase 1) woodwaste, virgin biomasss (complete); railway ties, C&D, asphalt shingles (Phase 2); non-recyclable packaging, manufacturing composites, K-Cups, carpets/textiles; (Phase 3) non-recyclable plastics & rubber (incl. tire fluff)
  - CRH (Clarkson) – Used oil, solvents
  - Essroc (Picton) – No current use
  - St. Mary's (Bowmanville) – Woodwaste (approved), plastics (planned)
  - St. Mary's (St. Mary's) – No current use
  - Federal White – No current Use
- **Quebec**
  - Used tires, C&D, shingles, etc
- **Nova Scotia**
  - Asphalt shingles, non-recyclable plastics

✓ - OK

paper, OCC, cardboard

rags & textiles

rubber

plastics
Types 1-7 & mixed

wood

We're here to help your company go green.

Being smart about managing waste byproducts is important for every company.

If your company can do its part and sort smart when throwing things away, our company can do its part and use many of these materials as fuel in our cement partner's process.

Energy made from waste.
Byproducts into resources.

Help Us Help You
- Sort Smart -

Not Acceptable

metal

glass or free liquids

food

bricks & rocks

bio-waste or haz waste

dusty/fine material

Alternate Solid Fuel (ASF)

Nonhazardous byproduct streams are produced by almost every industry.

The ASF managing facilities are interested in nonhazardous, dry materials with at least 5,000 Btu/lb. Some additional limitations may apply at various facilities as to types of ASF accepted. This graphic shows key types that are acceptable and not acceptable.

Systech Environmental Corporation

The Process of Becoming a Fuel Supplier

Getting Started

Generator fills out & signs Profile Form and pulls a representative sample (approx. a gallon sized baggie.)

Testing

Managing Facility Assessment

Profile and sample sent to managing site for visual assessment of material and review of profile.

Lab Testing

If the managing site approves the sample and profile, both are sent to a Systech lab (or Systech approved lab) for analysis.

Trial Loads

Upon approval, Systech sends a letter to customer and trial loads can be scheduled.

Trial loads will take place to determine if there are any contaminant issues that need to be addressed.

Approval

After trial loads are approved, final pricing will be determined and ongoing loads can be scheduled.

All delivered loads are visually inspected and subject to random quality checks

Systech Environmental Corporation

Low Carbon Fuel Specifications

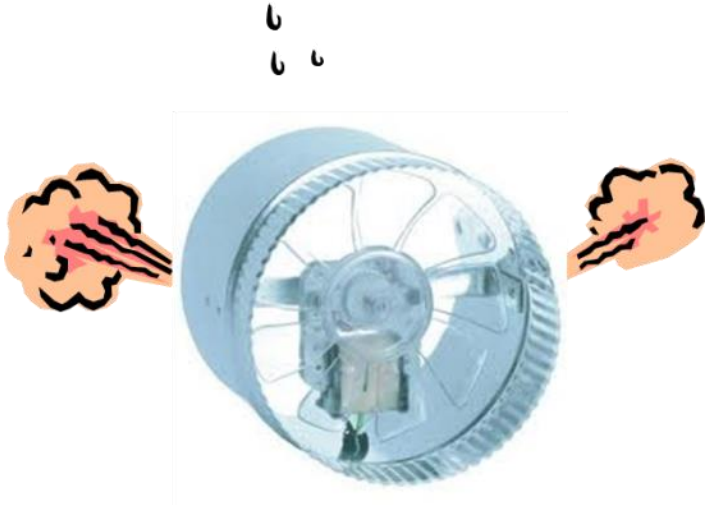
- Heating value
  - > 14 GJ/tne (Lower HV)
- Size
  - 90% passing 10 mm (3D)
  - 90% passing 25 mm (2D)
- Water content
  - < 15%
- Other
  - Homogeneous
  - Low carbon (net)
  - Low heavy metals
  - Low or good ash
  - Low chlorine (< 1500 ppm)
  - Tramp non-combustibles removed

Heating Value / Btu Value

- In order for a cement plant to make quality cement, it must have a fuel supply with consistent heat value.
- For each stream being considered as alternate solid fuel (ASF), customers are asked to supply a representative sample of the waste during the initial qualification phase.
- It is critical that the sample be representative since final approval is based lab work conducted off-site. Lab results are used to verify that fuel value and certain permit and health and safety criteria are met.
- Once approval has been given, the plant expects that the Btu value (and other specifications) will only vary slightly from the original and plans around that value to work up a strategy of what streams can be mixed together to come up with a homogenous/consistent fuel blend to use in the kilns.
- Major deviations from that original analysis cause production issues. Therefore we request that the site be notified if there are any significant changes to the stream.

Water Content

- **Moisture is a problem because**
  - Lowers fuel value
  - Kiln Induced Draft (ID) fans must run harder to move tramp water vapour
  - Fuels are typically sold on a $ per tonne basis (avoid paying for water)
  - Will require more truck loads to get the same energy (more cost)
  - Can lead to odour issues and handling problems
  - Freezing issues in the winter
  - If too high can cause spontaneous combustion in hotter months
    - Spontaneous combustion requires long storage, warmth, and biological action
- **Commercial terms will evolve over time**
  - Moisture testing (each load or random)
  - Visual observations (not just for moisture)
  - Testing prior to shipment with random checks
  - Research into hand held moisture devices



Chlorine's Effects on Cement Product - Quality Control

- Chlorine can affect the chemical reaction that forms clinker by:
  - lowering melting point of raw mix so it forms a sticky mass rather than clinker granules.
  - promoting sulfur loss thus affecting the end product's setting time.

- Additional chlorine related problems:
  - ✓ The plant has to waste cement kiln dust rather than reincorporate it back into the cement process.
  - ✓ Chlorine promotes kiln ring formation which causes kiln downtime while the ring is removed.
  - ✓ Chlorine makes the dust sticky and it clings to the Air Pollution Control Devices (APCD). More downtime is added while the APCD is cleaned.

Systech Environmental Corporation

Ash Content

- Since ash drops into the kiln during clinker production it is incorporated into the raw material mix.
- A high ash content in the ASF can change the clinker chemistry since it can contain high levels of either alumina or silica, for example.
- Depending on the level and types of constituents in the ASF ash, there may need to be adjustments to the raw mix blend on the front end to compensate for the additional components within the ASF's ash.
- It is paramount that the clinker quality not be put at risk, so if the initial tests on the ASF sample show high ash content, extra analyses may be performed on the representative sample to determine its constituents.

Low Carbon Fuels: General Safety Instructions

Equipment, use, storage, and handling

- **LCF is combustible (obviously)**
  - Be aware of potential combustion sources such as lights, equipment, etc that may generate heat
  - Non-sparking tools where necessary
  - Clean areas prior to hot work
  - Minimize long term storage (spontaneous combustion)

- **Physical characteristics**
  - Sharp edges, nails, glass
  - Dust, odour, mold
  - May be explosive, risk increases with dusty characteristics

- **Good Housekeeping**
  - Clean up after each load
  - Contain and clean up any spilled materials
  - Avoid excessive dust accumulation, remove prior to maintenance

- **Fire Protection and Dust Collection**
  - Important engineering controls (explosion panels etc)
  - Class A Fire Extinguishers

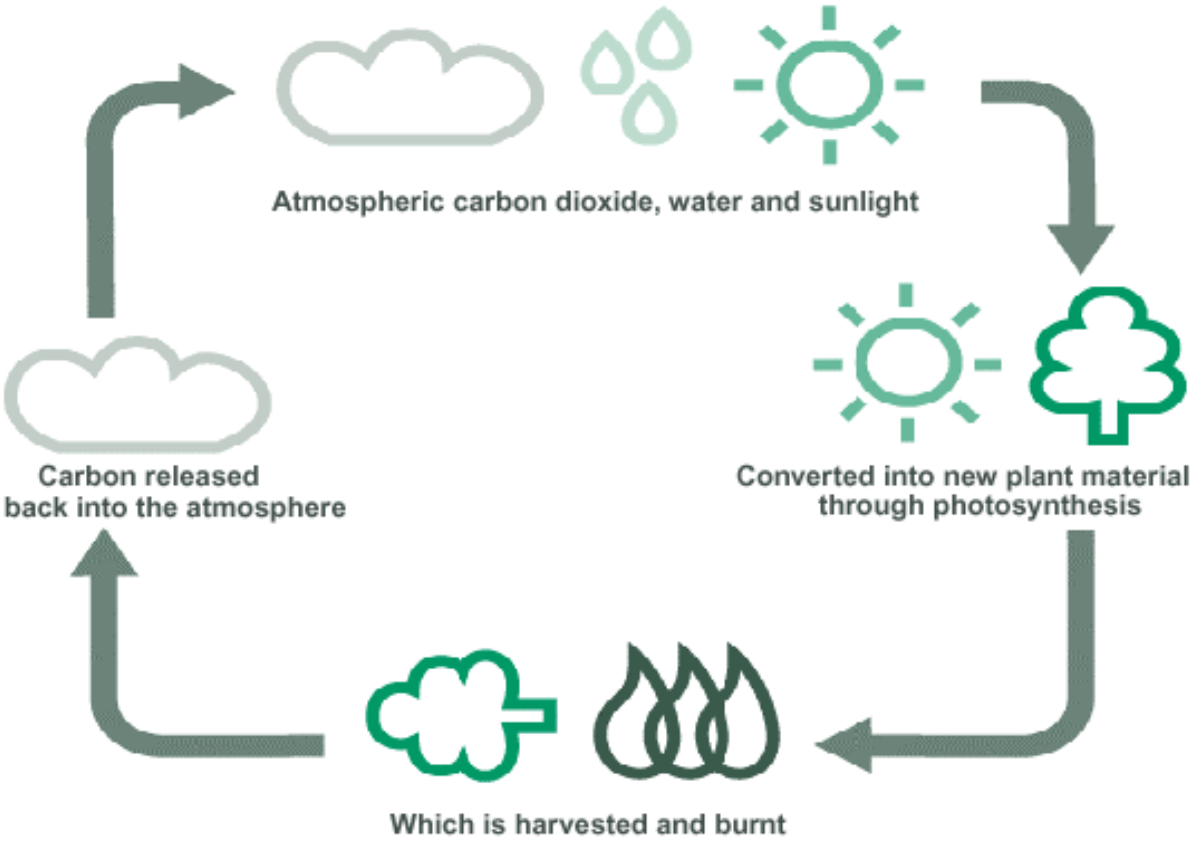
The Language of Fuels

The language of fuels

- **Typically waste management companies talk about**
  - Truck loads
  - Tonnes or m3
  - “T&D”
  - $/tonne
  - $/load
- **Fuel purchasing companies talk about**
  - Gigajoules or BTUs
  - Fuel cost FOB the plant
  - $/GJ
- **Carbon Pricing**
  - Influence of biogenic carbon
  - Comparing fuels “apples” to “apples”

Note: “tonne” is used in common practice to represent 1000 kg of fuel. Under official SI (metric) rules, we should use Mg but we’ll use the common parlance here. Don’t confuse with ton which is 2000 lb.

One more thing: the Biogenic Factor



Biomass Carbon Cycle

Experimental Biogenic Carbon Results

Results are +/- 3%

Fuel Description	Percent Biogenic Content
Petroleum Coke	0
Coal	0.6
Shredded Railway Tie	73
	76
	74
Shredded Asphalt Shingle	21
	19
	19

- **Observations**
  1. Biomass refers to natural sources of carbon such as wood, grasses, seeds, oat hulls, coffee grounds, biosolids, food waste, energy crops, soil, etc. These are all 100% biogenic carbon containing materials.
  2. Virgin biomass is biomass from non-waste sources (includes woodwaste)
  3. Biogenic testing uses carbon dating techniques

Example: Comparing railway ties to coal

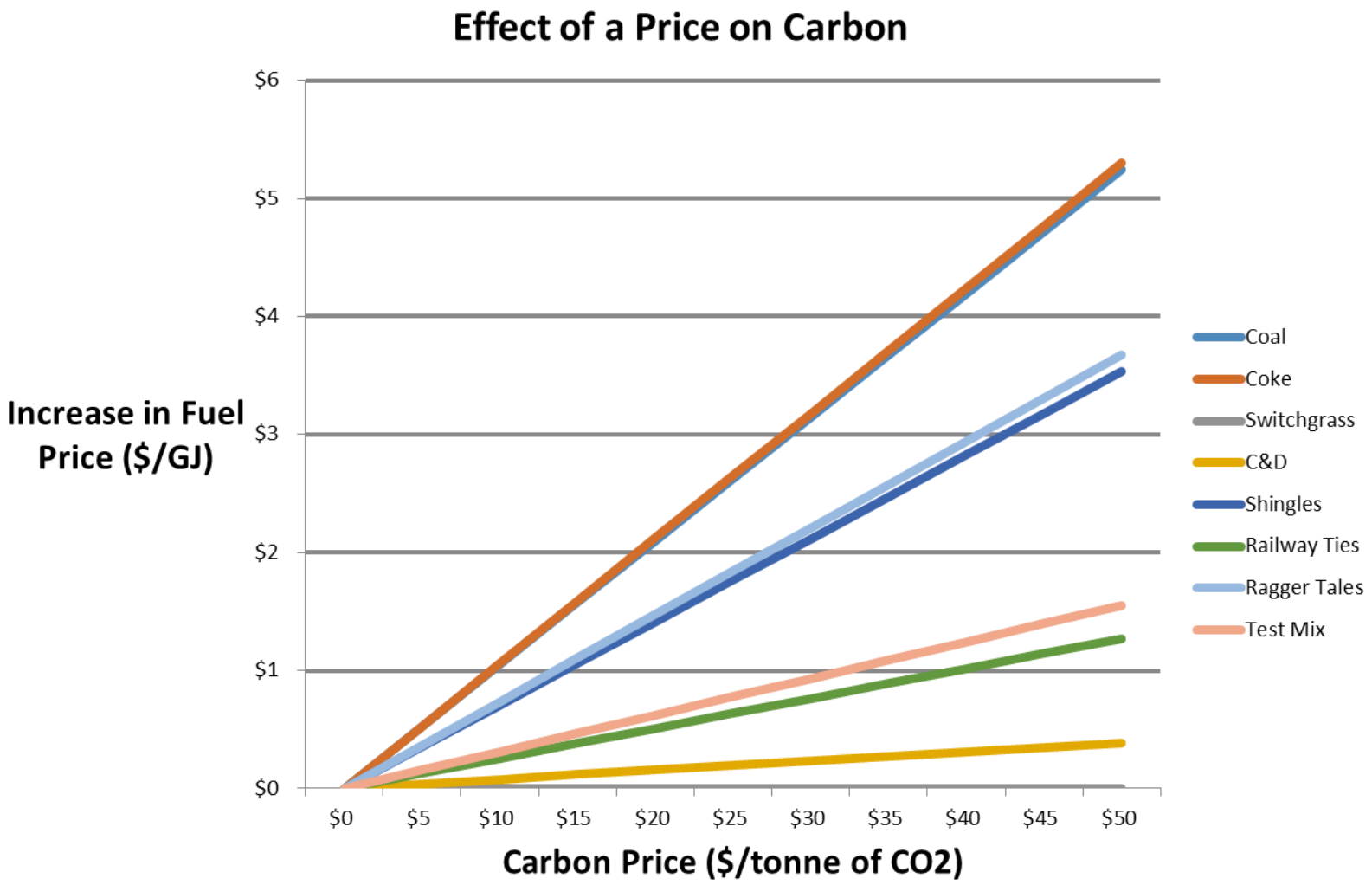
Parameter	Coal	Railway Ties	Percent
Gross tne CO2 per tne of fuel	2.42	0.83	34.3%
% Biomass	0%	75%	-
Net tne CO2 per tne of fuel	2.42	0.21	8.7%
LHV GJ/tne	24.9	10.8	43.4%
Net tne CO2 per GJ	0.097	0.019	19.6%
Cost @ $10/tne CO2 / Tne	$24.2	$2.1	8.7%
Cost @ $10/tne CO2 / GJ	$0.97	$0.19	19.6%

Observations

1. It takes 2.5 tons of railway ties to replace a ton of coal on an energy basis. Ties produce only 34.3% of CO2 compared to coal
2. Net tne CO2 per tne of fuel: this is the amount of CO2 after removing the biogenic CO2
3. Factoring in bulk density means it can take 3-5 truckload of ties to replace a truck load of coal
4. Does not include transportation costs nor associated carbon costs (i.e. at 20 tnes/truck, it will take 3000-5000 trucks of railway ties to replace a 20,000 tonne boat shipment of coal)
5. Railway ties generate 80.4% LESS CO2 than coal, or 19.6% compared to coal - they're 5x lower in carbon intensity than coal)

So what does all of this mean to the cost of fuel purchases with a Price on Carbon added in?

Putting it all together



Comparing Carbon Taxes to Cap & Trade

	Carbon Tax	Cap & Trade
Advantages	-Relative simplicity -Known price	-Lower cost to achieve reductions -Allows offset programs to participate -Allows the use of "free" allowances to simply address EITE and process emissions -Encourages innovation through off-set systems.
Disadvantages	-Unknown level of reduction -Other forms of GHG abatement (eg offsets) are not incented -Difficult to deal with the concerns of EITE industries.	-Complex -Price uncertainty -Only readily applicable to larger entities, not applicable directly to the general public -Perception that the system can be gamed -Perception that off-set credits are not real ("hot air" credits).

Canadian Cement Industry Particulars

- **British Columbia**
  - Carbon tax applied to fuel purchases ($30/tonne CO2e)
  - Process emissions exempted (so far), poster child for “leakage
  - About 5% returned in form of incentive funds
- **Alberta**
  - Specified Gas Emitters Regulation being replaced with Output Based Allocations
  - A modified, Alberta only Cap & Trade system
  - Recognition of EITE (See next slide)
- **Ontario / Quebec**
  - Cap & Trade system harmonization with California
  - Recognition of EITE through Free Allocations (approx. $18/tne)
- **Maritimes, Manitoba, Saskatchewan**
  - No current carbon pricing system
- **Federal Government**
  - Carbon tax ($10/tne in 2018 to $50/tne in 2023) OR Cap & Trade
  - Provinces must demonstrate that their system will deliver commitments made in Paris to be recognized as equivalent

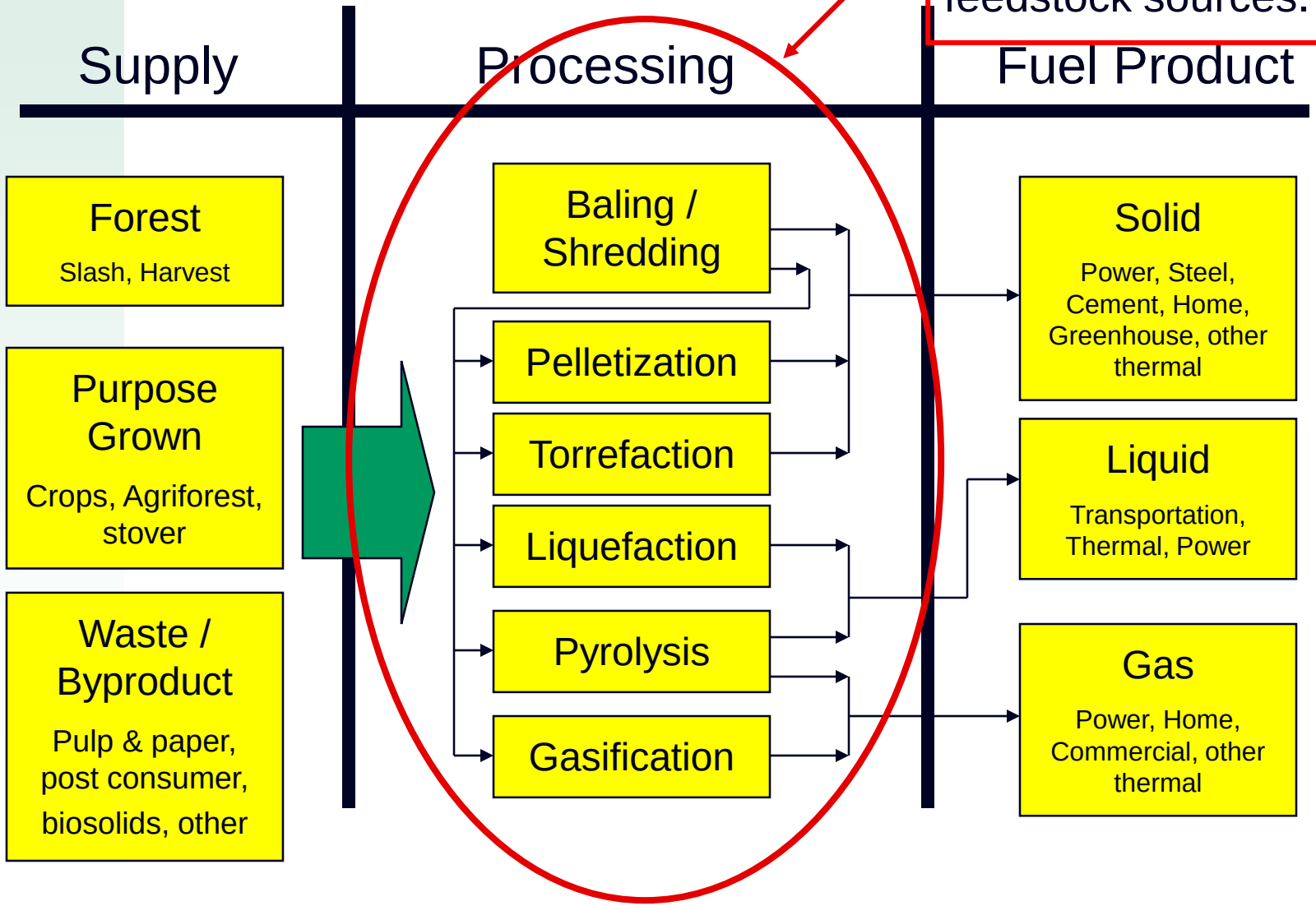
Next Steps in Increasing the use of LCF

Ongoing evolution

- **Obstacles**
  - Supply infrastructure
    - Separation processes
    - Processing
    - Collection and Seasonality
  - Permitting and Social License
  - Investment
  - Fuel quality and cost
- **Ontario Cement industry Capacity**
  - Rough estimate of 600,000 tonnes per year of coal and coke for cement
    - Additional capacity in lime plants, steel plants, and greenhouses
  - Corresponds to 900,000 tonnes of unprocessed LCF
  - BUT typically 30-50% co-fire is the maximum achieved w/out additional processing
  - 400,000 tonnes per year corresponds to 3-4% of Ontario's waste generation rate

Additional Processing Options

These technologies may be applicable to a variety of feedstock sources.

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Hawthorne Green Key Group Inc

Introduction of the Tucker Pyrolator Technology

INTRODUCTION

Hawthorne Green Key Group

- A Canadian corporation licensed to market and manufacture the patented Tucker advanced waste conversion system (Pyrolator)

- **Vision**: to provide environmental and economical solutions that produce results,

  - **Reducing GHG**
  - **Zero waste**
  - **Behind the Meter opportunities**
  - **New value added revenue streams**
  - **Job creation.**

Today's Challenges

Public Sector

- **Economic shortfalls for municipalities**
- **Zero waste mandate at landfills**
- **Reduction of C02 emissions**
- **Rising Hydro and operation costs for municipal facilities**
- **Recycled plastics demand challenges**
- **Closing of Borders/ new duties?**

Today's Challenges

Private Sector (Industry)

- **Rising Hydro rates**
- **Disposal costs**
- **Operating costs**
- **CO2 emissions**
- **Overall Global Competitiveness**
- **Disposal of Industrial and Commercial waste**

Waste as a Resource

Waste Hierarchy

Pyrolator Solution

Solution

The Pyrolator system – What it can process

- **Any Organic feedstock,**
  - **Woody Biomass** ✓
  - **MSW** ✓
  - **All Plastics** ✓
  - **Railroad ties** ✓
  - **Tires** ✓
  - **Coal** ✓
  - **Asphalt Shingles** ✓

Solution

The Pyrolator system - How it works.

- **Pre Process**
  - **Material reduction < 2” optimal size**
  - **Material moisture reduction 5% optimal**

- **Conversion**
  - **Feedstock rapidly heated to 850 ° C in oxygen starved atmosphere (Non-Burn)**
  - **The process of molecular disassociation as it nears the pyrolysis unit chamber**
  - **Control system and fixed carbon sequester noxious elements to produce a clean, product gas, consisting primarily of methane.**
  - **System initially fueled by propane and switched to product gas as tangent burner fuel source. (Closed Loop)**

Solution

Tucker Pyrolator system - How it works.

- **Post Conversion**
  - **Product gas is cooled and condensed for removal of any tars and particulates (No Scrubbers required)**
  - **Product Gas can be fed to a generator, boiler, or compressed as fleet fuel**
  - **Fixed carbon is utilized in new products**
  - **Small amounts of inert ash and soil (dependant of feedstocks.)**
  - **While a single version 3.0 is efficient and cost effective, the efficiencies increase when plants are designed for 20MW or more.**

Pyrolator Benefits

- **Cost effective, Compact, and Modular**
- **Closed loop system**
- **Fits today's Waste Management Strategies**
- **Reduction of GHG Emissions**
  - **Reduced CO_2 and cleaner methane creation**
  - **CO_2 avoidance through bio char component**
- **Noxious elements sequestered in bio char.**

Pyrolator Benefits

- **Supports Ontario's mandates**
  - **Behind the meter**
  - **CO_2 Reduction**
  - **Smart grid compatible to balance wind and solar loads**
  - **Zero Waste**

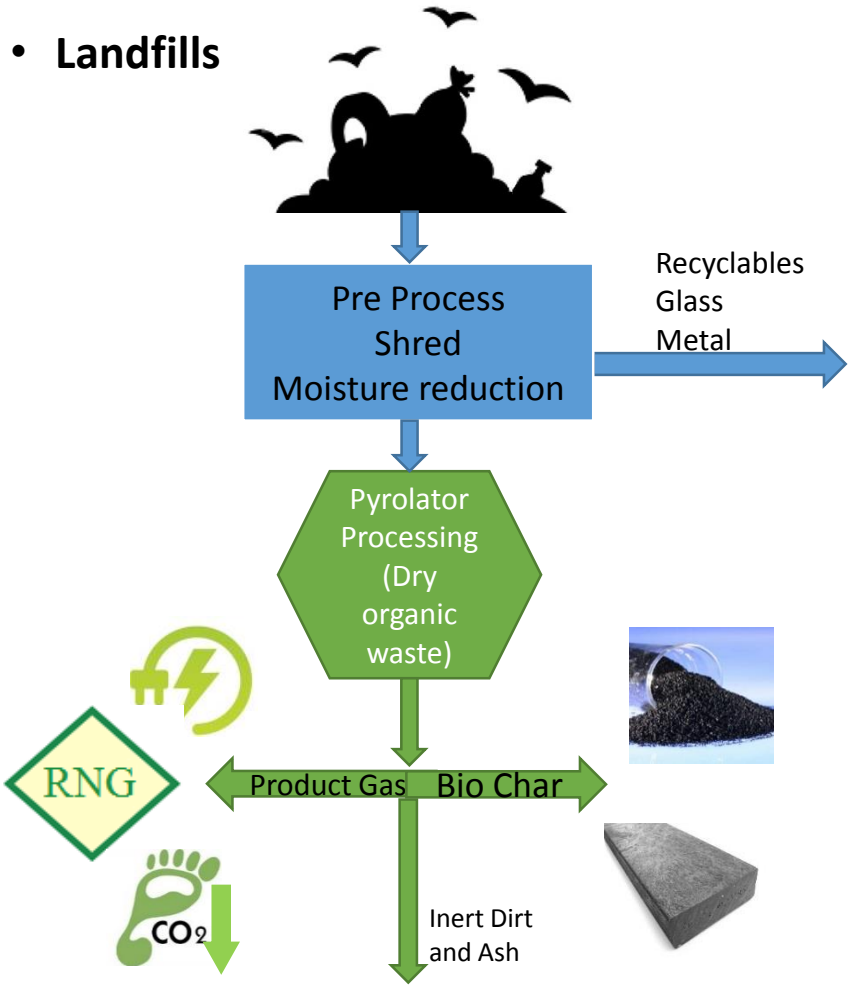
- **Full genset compatibility including full CO_2 capture (carbon negative)**

- **Waste heat capture options for heating, greenhouses, or chillers**

- **Pyrolator can process a multitude of feedstocks**

Pyrolator – Models

- **Landfills**



> 70% Waste Diversion

Pyrolator – Models

- **Forestry**

Pre Process
Shred
Moisture reduction

Pyrolator Processing (Dry organic waste)

Product Gas | Bio Char

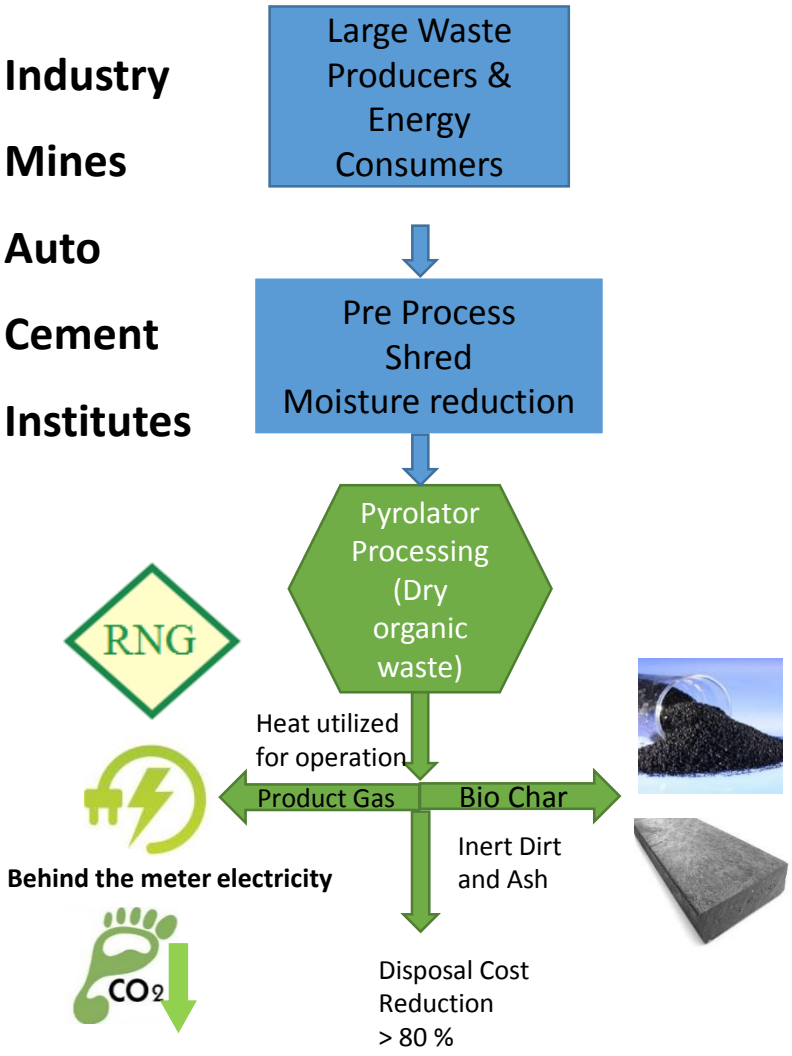
"Gold" Standard Activated Carbon

Behind the meter electricity

Heat utilized for operation

Pyrolator – Models

- **Industry**
- **Mines**
- **Auto**
- **Cement**
- **Institutes**



Waste –Free Ontario and Circular economy

Ontario

- **Pyrolator**
  - **Harnesses the value of the waste**
  - **Enhances waste diversion + resource recovery**
  - **Job creation**
  - **Part of the low-carbon economy**
  - **High growth business**
  - **Reduces GHG**

- **Possible “Cap and Trade” credits**

Closing

- **Today's changing world ,status quo is no longer a viable solution for both private and public sectors.**

- **Hawthorne welcomes all inquiries to discuss a detail site specific solution utilizing customer's waste stream.**

Thank –you !

For your time and input

For further questions or information please contact;

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Thank You
The recording of this webinar will be posted on wise.uwaterloo.ca