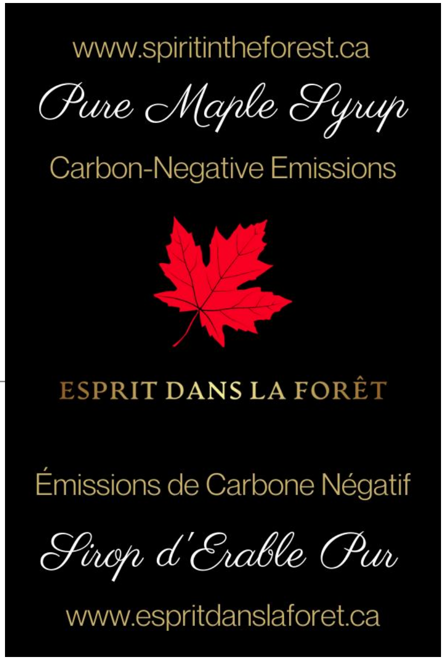
Climate Neutral Backyard Maple Syrup

PAUL RENAUD

THE LANIGAN GROUP



Impact of Climate Change on Maple Syrup

- The Climate Change Committee of the Ontario Maple Syrup Association examined all available research on the impact of climate change on maple syrup published in both Canada & the USA
- Since science always evolves, we were careful to include only the findings where every research scientist agreed
  - By excluding “research in progress”, we excluded findings which might possibly be validated in future by other researchers
  - However, we also eliminated any speculation or theories which might not turn out to be validated due to regional or methodological differences
  - Our findings can be viewed as “baseline” information upon which decisions can be made with confidence because we did this work to support Ontario’s strategic planning process

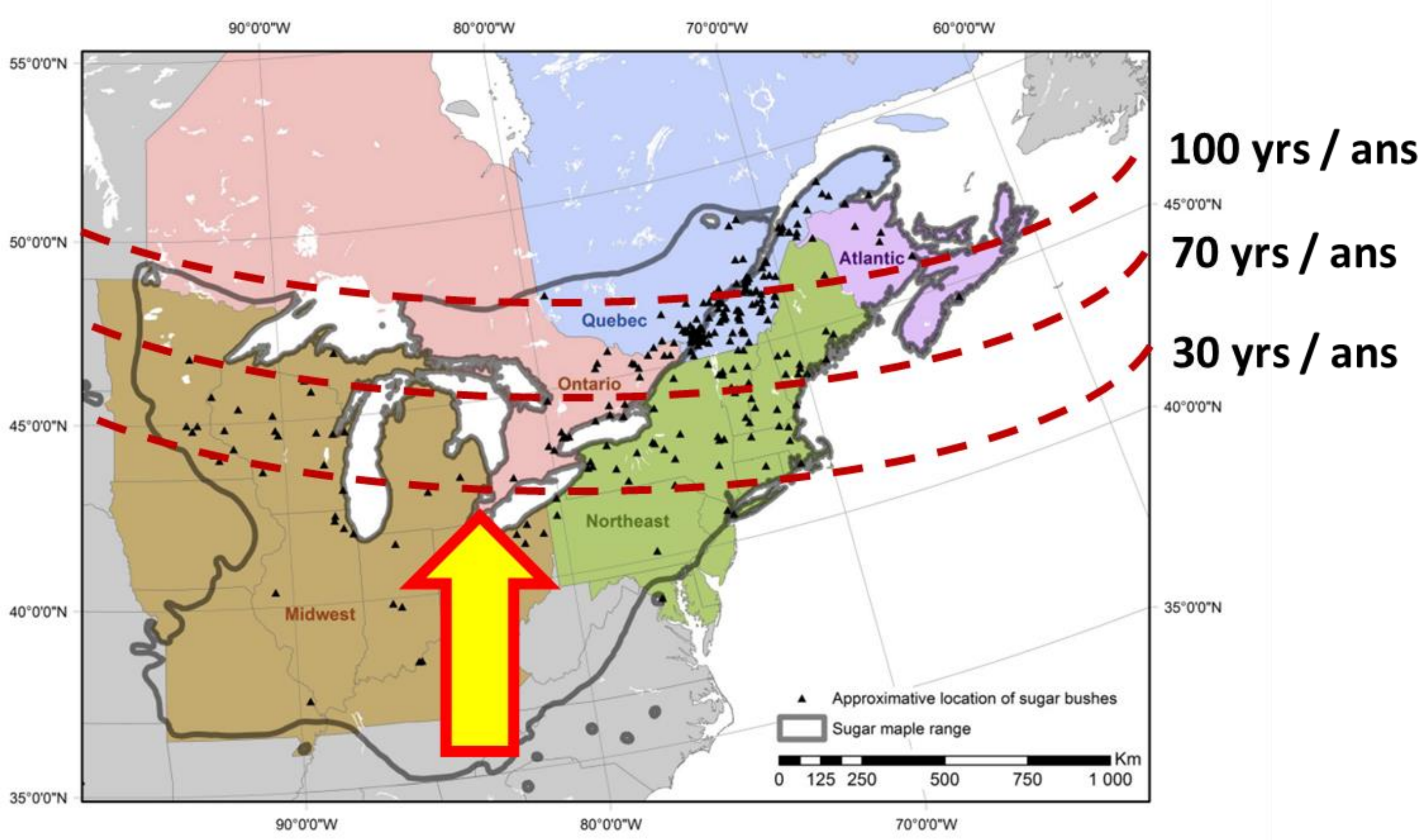
The Obvious Problem: Maple Season Timing & Length

1. Spring sap flows occur earlier each year and more unpredictably
   - Autumn sap flows are later and eventually may merge with spring flows
2. Unpredictability increases risk of the season starting before the sugarbush is tapped
   - Most large producers are already tapping during winter to avoid missing the start of the season
3. Timing of end is affected more than the timing of start
   - Buddy sap will appear earlier & more unpredictably
   - Overall season length will get shorter & shorter

The Hidden Problem – Slowly declining Productivity

- Warmer & longer growing seasons can benefit tree growth if properly managed
- Increased drought frequency & severity can cause seedling mortality, hinder root performance, and impact growth
- Higher & more frequent risk of native pest outbreaks and invasive insects
- More frequent spring frosts can coincide with budbreak, causing leaf dieback and delay canopy development
- Reduced winter snowpack with more winter precipitation falling as rain can cause fine root damage

If we do not mitigate climate change



Viable Zone For Sugar Maple is Changing

THE VIABLE REGION FOR SUGAR MAPLE IS MOVING NORTHWARD AT THE RATE OF 25 KM / YEAR

The Imminent Problem : Wind & Ice Storms

- Wind storms are already increasing in both severity & frequency
- Ice storms are occurring more often at both the start & end of winter
- Loss of a tapped maple tree during a wind or ice storm results in > 40 years of lost production
- In 2022:
  - Nova Scotia producers lost their entire season when an ice storm hit them at the start of their season, damaging both trees and infrastructure
  - 3 – 5% of producing maple trees were lost in Ontario due to the derecho windstorm in May
  - Many producers also sustained significant infrastructure damage to pipelines, pumps, etc.
- If 3% of trees are lost each year, 60% of existing commercial production of maple syrup will be lost in 20 years and may not exist by 2050

What You can Do – 1 : Reduce Risk of Tree Loss In Your Sugarbush

1. Promote at least 20% biodiversity in your sugarbush
   - ✓Slows the spread of invasive species and disease
   - ✓Conifers act as wind-breaks to protect maples from wind
2. Change thinning practices
   - ✓Preserve and nurture replacement trees that are not yet large enough to be tapped
   - ✓Allow crowns on maple trees to support each other during windstorms
3. Look for opportunities to improve productivity to compensate for shorter harvesting seasons
4. Plant red maple to replace any lost sugar maple because it is more tolerant to a warming climate

What You Can Do – 2 : Maximize Sequestration & Reduce Emissions in Managing your Sugarbush

1. Maximise sequestration of CO_2 via photosynthesis in your existing trees
   - ✓ A tree large enough to be tapped (> 10” diameter) has already sequestered a metric ton of carbon to grow to that size and sequesters carbon at the rate of 32 kg CO_2 each year.
   - ✓ Non-maple trees this size also sequester this much carbon (some variation by species)
   - ✓ So, harvest only dead, diseased, or fallen trees
   - ✓ Allow all healthy trees to continue to sequester carbon – all species
2. Reduce all unnecessary use of fossil fuel in chainsaws, UTVs, generators, etc used in the sugarbush
   - ✓ Many electric chainsaws have the same chain speed as pro-style saws from Husqvarna or Stihl
   - ✓ And use batteries that last as long as a tank of gas
   - ✓ Battery-operated mobile generators are increasingly available if you need electricity in your sugar shack
   - ✓ Electric skidoos, ATV/UTVs are becoming increasingly available

What You Can Do – 3 : Reduce the amount Sap you need to boil

1. If you have < 50 taps:
   - ✓ Throw out the ice that may form in your pails instead of boiling it
     - ✓ Ice is nearly 100% water, with virtually no sugar in it
   - ✓ Discarding ice can raise the Brix level (i.e. sugar %) in your sap from < 2 to over 3 Brix
     - ✓ This reduces the amount of sap to boil by 33%, saving you time as well as fuel

2. If you have > 50 taps:
   - ✓ Consider buying a mini-Reverse Osmosis machine to increase sugar in your sap to > 6 Brix
     - ✓ This reduces the amount of sap to boil by 50% if the output concentrate produced by the RO is 6 Brix (concentrating to 8 Brix reduces sap by 75%)
   - ✓ Mini-RO are available from maple syrup equipment retailers for about $1,000
     - ✓ You are already saving > $20 per L by making your own syrup so your cost for the RO is recovered after 50 L of syrup made
   - ✓ Mini-RO use low amperage and can be powered using a battery & inverter if your sugar shack has no power

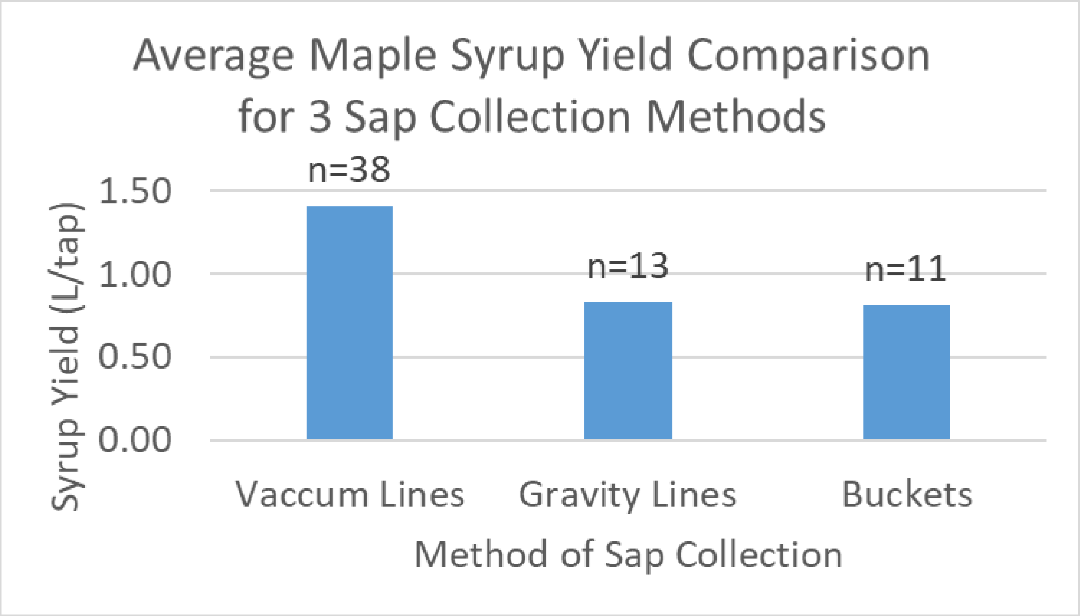
What You Can Do 4 – Become More Efficient

- ✓ If you are using buckets to gather your sap, consider using gravity lines instead

- ✓ Field data from Ontario Maple Syrup producers in 2023 shows that gravity lines are slightly higher yield than using buckets
  - ✓ Approx. 0.8 L syrup produced per tap vs 0.7 L syrup per tap via buckets (the amount will vary depending on the height that the gravity line drops from start to end)
  - ✓ Larger producers using vacuum lines attain 1.4 L/tap

- ✓ Using gravity lines results in significantly better quality of sap and less risk of contamination from rainwater, squirrels, mice, etc.
  - ✓ Reduces risk of having to discard spoiled sap

- ✓ Use of gravity lines reduces the time needed to gather sap since you collect only at the end of the line instead from every tap along it.
  - ✓ 10 taps per line means 1/10th of the effort to collect sap!



What You Can Do – 5(a) : Ways to Reduce Propane Emissions

1. Switch from propane to an induction-electric burner that is more efficient
   - ✓ Outside propane burners are rarely enclosed due to risk of carbon monoxide poisoning and lose a lot of heat and consume more fuel than necessary due to wind
   - ✓ Inside gas stoves emit CO_2 when propane is burned
   - ✓ An electric induction burner avoids these problems at a cost of $50 - $150 and can be faster than using propane if you are boiling outside
   - ✓ All you need is an induction-compatible pot and an electric outlet
     - ✓ If a magnet sticks to the bottom of the pot, it is compatible for induction

2. If you don't have electricity in your sugarshack, you can power the induction burner with a deep cycle battery and inverter.
   - ✓ Consider recharging your battery with a solar panel in-between boils.
3. At minimum, if you decide to use propane to boil outside, at least protect the flame from wind via a half-wall, or other suitable partial enclosure.
   - ✓ This will significantly reduce your propane consumption & emissions as well as speeding up your boil

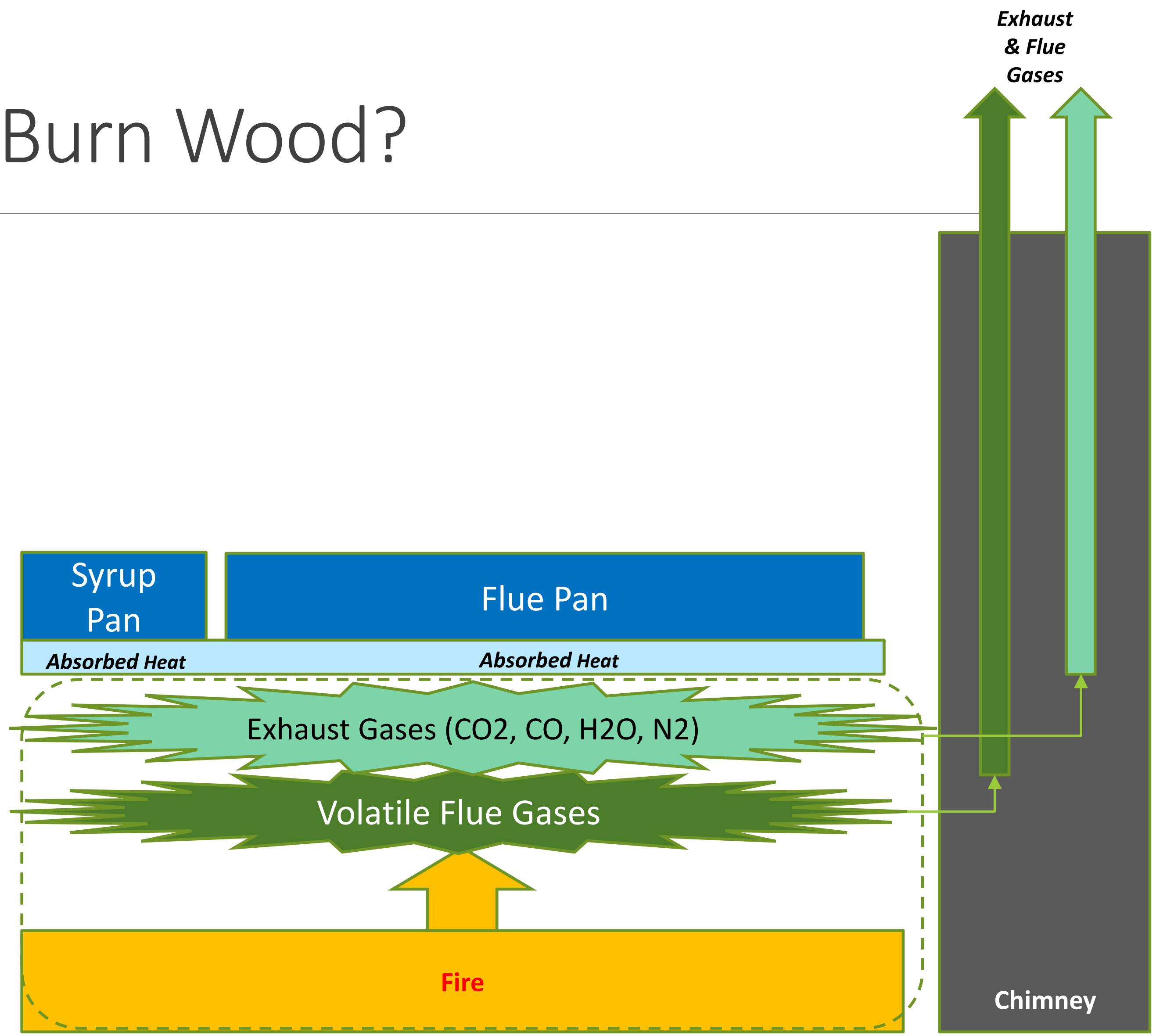
What You Can Do – 5(b) : Ways to Reduce Wood Fire Emissions

1. Use heat-efficient wood:
   - ✓Heating with wet wood produces steam that never gets hotter than 212"F
     - ✓This is not hot enough to boil your sap and occupies valuable space under your pans that could be hotter. Less humid wood results in more space for hotter exhaust gasses
   - ✓Age your wood for 2 years , this will decrease the amount you need by 15 – 20%
     - ✓Even drying wood for a full year results in a 10% reduction in wood required
     - ✓Dry hardwood is 20% more efficient than dry softwood
2. If you boil over an open wood flame, switch to propane as it is more efficient or switch to a small evaporator with a chimney that will better contain the heat. You will boil significantly faster.
3. Improve heat use in your evaporator – keep the heat under the arch and NOT in your chimney
   - ✓Install draft control on chimney to reduce speed of air leaving your evaporator by 30 - 50%
   - ✓Install a damper at the base of your chimney to allow you to reduce the volume of air going up it
   - ✓Install a thermometer so that you can measure the heat escaping in your chimney
     - ✓Stack temp should be less than 500' F in a small evaporator (smaller than a 2x6)

What Happens When You Burn Wood?

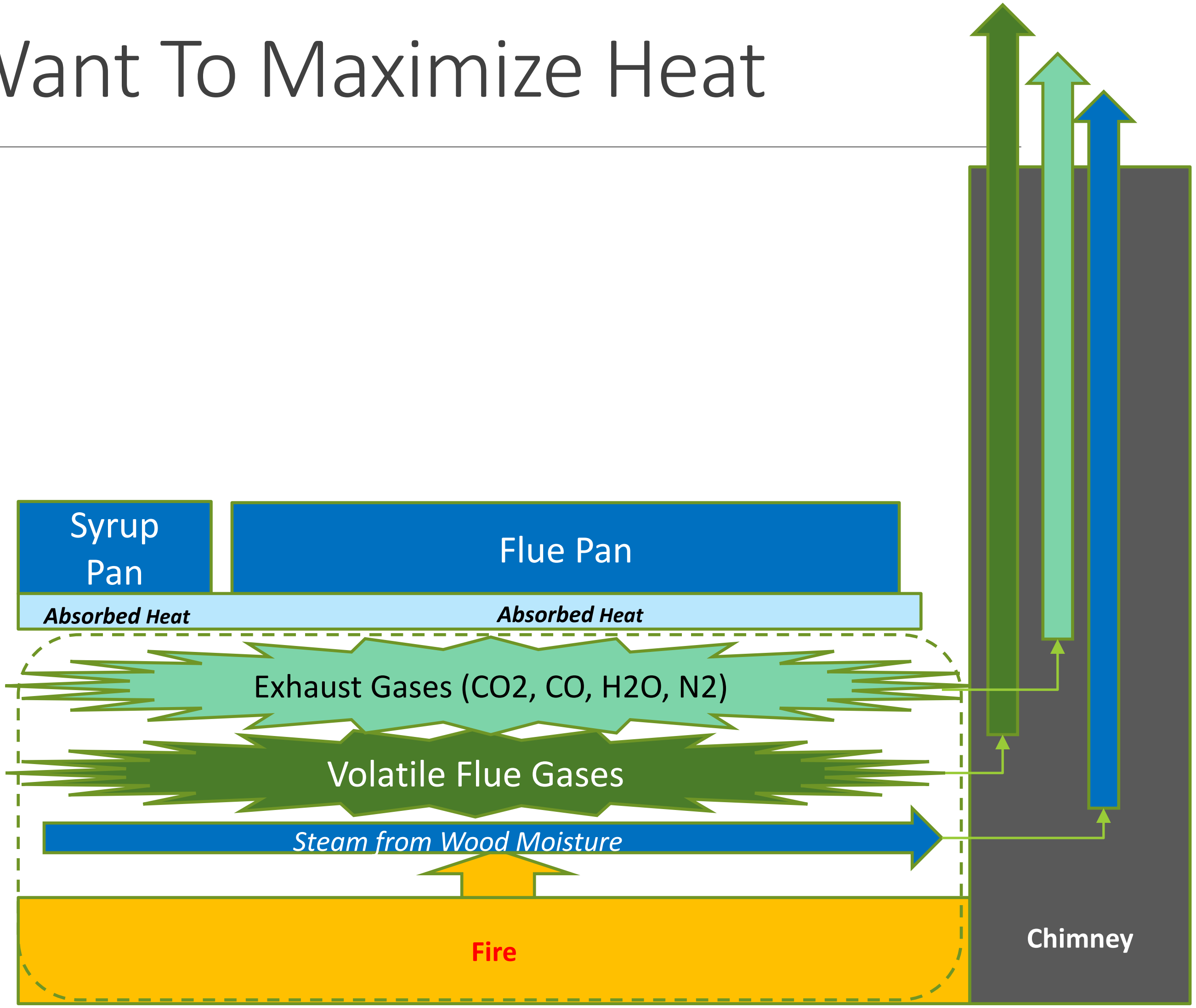
1. **Primary** combustion from burning wood releases 550 – 700’ F (depending on how dry the wood is)
   - Fire gives off:
     - inert gases (CO, CO2, N2O) plus,
     - volatile flue gases that can be burned again
   - Exhaust Gasses go up your chimney unchanged
   - Flue gasses will also escape up your chimney if they are not burned
     - Cannot be burned unless they are enclosed by the arch or chimney
     - Dangerous if they burn in your chimney

2. **Secondary** combustion (aka “gasification”) from burning the volatile flue gasses releases another 1000 – 1400’ F
   - i.e. 2x the amount of heat released from primary combustion



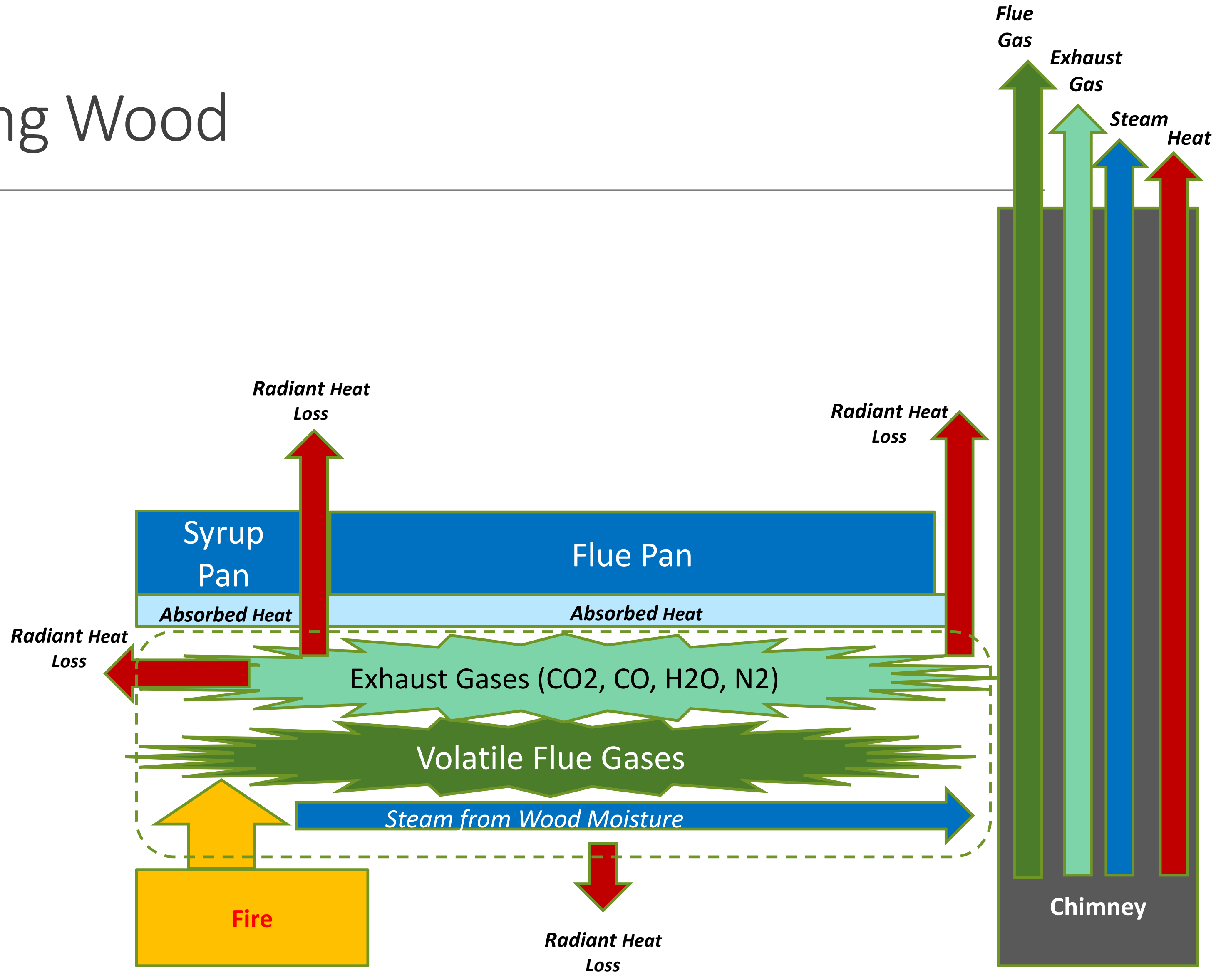
Dry Wood Matters If You Want To Maximize Heat

1. Any **moisture** in the wood is converted to **steam** when the wood is burned
   - Since the evaporator is unpressurized, the steam does not get much hotter than 212’ F (boiling point of water)
   - But you need 220’F to boil your sap!
2. Producing steam **absorbs valuable heat** that would otherwise be used to boil sap
3. Steam also occupies space in the arch of the evaporator that **displaces** hotter exhaust and flue gasses
   - Resulting in less total heat than what could otherwise be attained
4. Creosote often forms when moisture is present during burning (because the wet wood cannot be fully burned)
   - Creosote is both dangerous (flammable & toxic) and will also insulate your pans from heat
   - I.E. less heat can be absorbed into your pans



Maximizing Heat from Burning Wood

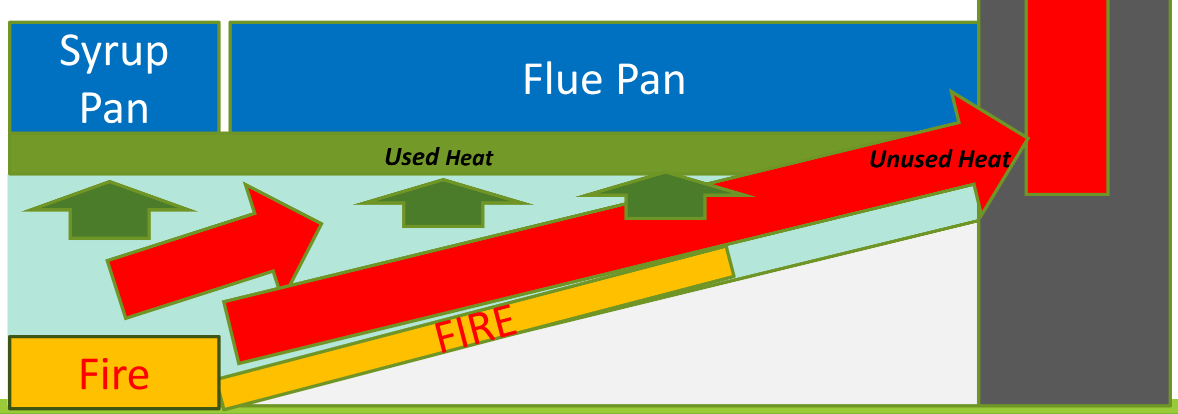
1. To maximize Primary combustion (wood):
   - Use 2-year dry wood so you don't waste heat creating steam from wet wood
   - It's hard to get super dry wood, but 2-year dry has 20% less moisture than same year dried wood
   - Burn more hardwood than softwood
2. To maximize Secondary combustion (flue gases)
   - Fire of any kind needs both fuel & air
   - You have already burned the wood to generate flue gas, so, you need to a
     1. Assure enough **air** flow to enable it to burn completely
     2. Allow enough **time** & **space** for it to burn before it goes up your chimney
   - Be careful not to supply too much air which will blow the heat up your chimney (adds to natural chimney draft)
   - Slowing down the air flow in the chimney (i.e., draft speed) keeps the burning flue gases under your pans longer

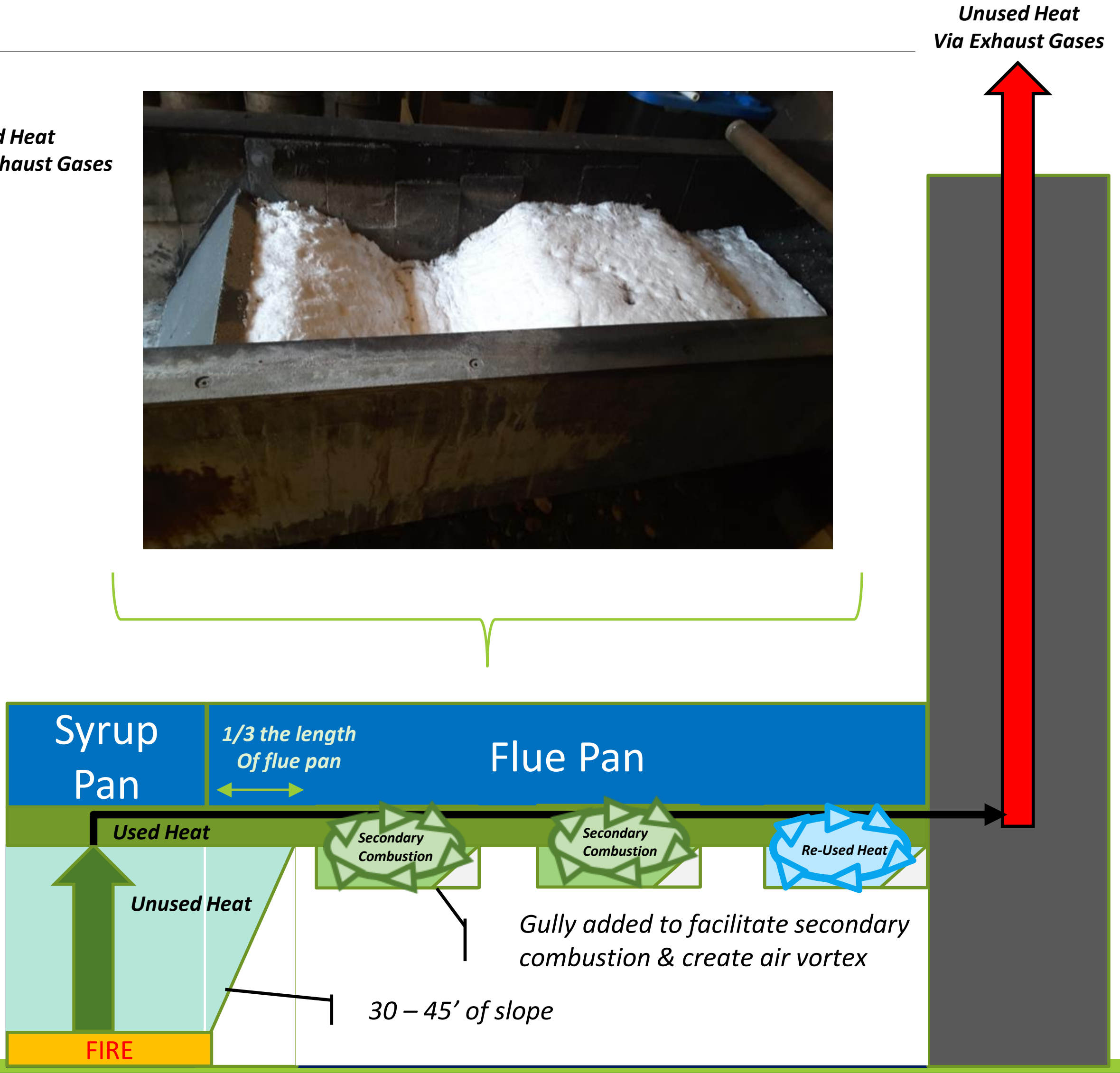


Improving Secondary Combustion

There are 2 places where secondary combustion can happen:

1. **Above** the firebox (illustrated below)
   - This is method used in most air-tight evaporators
   - Relies on fans to ensure combustion and manage air flow so that not too much of the heat escapes
   - Without fans, or with fans too high, is inefficient
2. **Behind** the firebox (illustrated right)
   - Waves are used to create secondary combustion areas
   - Heat is trapped in each gully instead of flowing up chimney
   - May or may not need fans (rarely necessary if arch < 8')

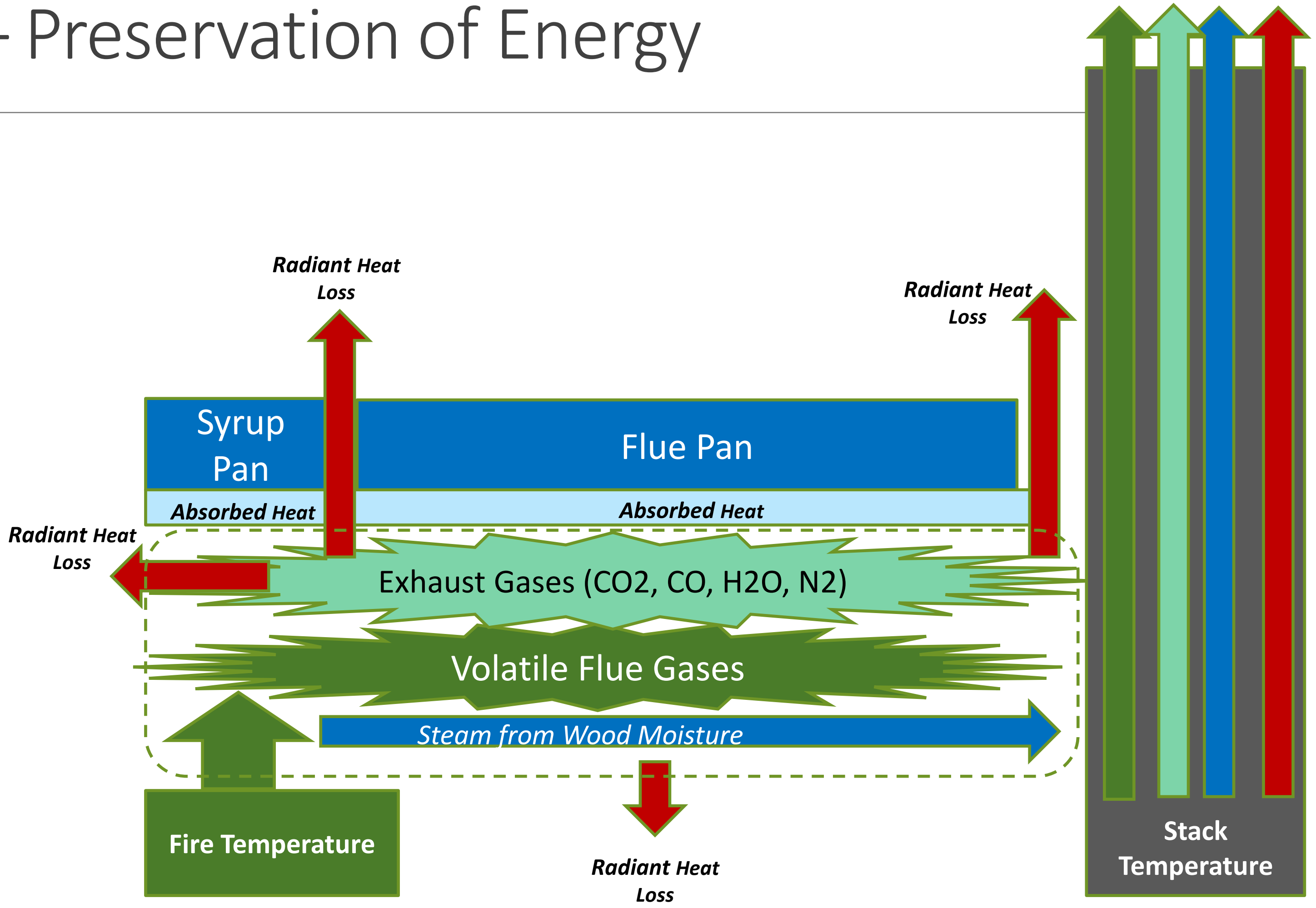




1st Law of Thermodynamics – Preservation of Energy

- The heat produced from burning wood and flue gasses can only be consumed in 3 ways:
  1) **Absorption** into boiling sap @ ~212' – 220' F, never hotter because that is the max temp that can be absorbed at any instant in time

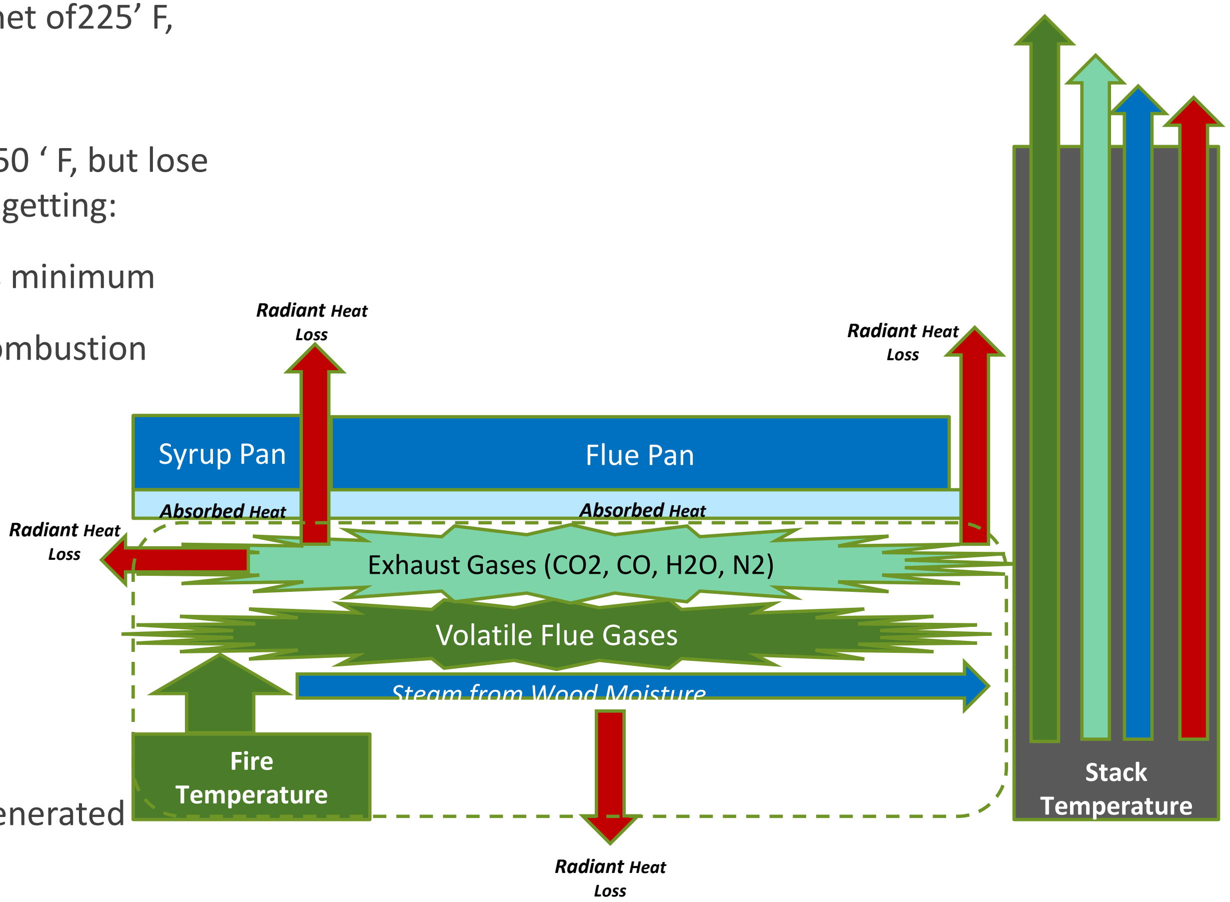
     (supplying more heat speeds up the boil but does not increase the temperature of what is being boiled past the evaporation point)
  2) **Lost** up your chimney
  3) **Radiation** via heat lost from fire doors, arch, pans, gaps
- Good insulation around the arch and between your pans can minimize radiant heat loss to 5 – 10%
  - Depending on how often you open the fire doors
- Your stack temperature tells you how much heat is going up in smoke



Absorbed Heat = Total Heat – Stack Temp – Radiant Heat Loss

Your stack temp tells you how much heat is going up in smoke

- Your boil never gets hotter than 220’ F, so, over an open fire the max heat possible is 550 ‘ F (the combustion temperature of wood) less at least 50% in radiant loss for a net of225’ F,
  - At best, you are boiling 225 / 220 = 1x or the minimum rate possible
- In an evaporator where secondary combustion is possible, if you generate 1450 ‘ F, but lose 10% via radiant heat loss (140’), if your stack temp is 860’ F then your boil is getting:
  - 1450 – 140 – 860 = 450’ F total heat which boils your sap at 2x as fast as minimum
- To get that 1450’, you are likely obtaining approximately 700’ from primary combustion and 750’ from secondary combustion
  - I.E. losing ½ of the flue gasses before they can be burned
- But if you maximize both primary & secondary combustion 700’ + 1400’ F = 2100’ and achieve a lower stack temp of 650’, you are generating 2750’F but losing 10% (210’) from radiation so, your boil gets:
  - 700 + 1400 – 210 – 650 = 1,240’ F which boils at > 5x as minimum, and
  - Consumes 1240 / 450 = 2.75x less wood for the same amount of heat generated compared to a stack temperature of 860’ F



Summary: Improving Heat Use in Your Wood-Fuel Evaporator

- Note that all the info about primary & secondary evaporator also applies to evaporators using wood pellets or chips as fuel
  - Wood pellets are often much drier than even 2-year dried wood because they are kiln dried
  - Wood pellets and chips are usually hardwood which has higher heating value than softwood
  - The smaller the size of wood fuel, the more completely it will burn (this applies to firewood too)
- Almost all commercial wood evaporators are less than 50% efficient, older ones less than 20%
  - Don't believe manufacturer claims of >80% efficiency, they are measuring ***combustion efficiency*** (how well it burns wood) not ***sap evaporation efficiency*** *(how well it boils sap)*
- Improving evaporator efficiency <u>dramatically</u> reduces fuel consumption as well as CO_2 emissions
  - Rule 1: **Don't boil more than you need to** – use an RO with output brix of 5 (or more) to reduce sap volume by 50% (or more)
  - Rule 2: **Maximize heat produced** by the wood that you burn by creating heat from both primary & secondary combustion
  - Rule 3: **Keep the heat** generated inside your arch for as long as possible before losing it
  - Improving evaporation efficiency from 25% to 50% will also reduce cords of wood consumed by 50%

What is The Carbon Breakeven Point for Evaporator Emissions?

Assuming 0.7 L of syrup / tap and 1 tap / tree in a sugarbush not using vacuum lines		
Propane	Each tap is a tree that sequesters 32.4 kg CO2e	If you produce > 2 L of syrup per BBQ Tank of propane: • Each tank emits 33 Kg of CO2e (41 Kg per RV size tank) • 2 L of syrup needs 2 / 0.7 L = 3 taps @ 3 / 1 tap/tree = 3 trees • 3 trees sequester 3 x 32.4 Kg CO2e = 97 kg CO2e per year • If you consume a tank of propane for each litre of maple syrup produced, you will be better than carbon neutral (leaving headroom room for your other, smaller, emissions)
Wood	If you produce > 25 L syrup per face cord of wood • 25 L / 0.7 = 36 trees	Emissions vary depending on type & age of wood, but an average of 930 kg CO2e / face cord is reasonable for wood dried 1 year • E.G. If you use ½ face cord, emissions are ½ x 930 kg 36 trees x 32.4 kg/tree = 1,166 kg of CO2e sequestered per year

These are rules of thumb, you can work out how much syrup per tap you produce and how much wood you actually use.
If you produce less than 5 L of syrup in total, consider switching to using an induction-based evaporation method.

What You Can Do – 6 : Maximise use of electric power to minimise emissions to Minimise total carbon footprint

Why Bother?

“I’m just a small producer, how does becoming net-zero even matter against global emissions?”

- Collectively, our actions add up

If every maple tap in Canada were as climate neutral as the climate friendly producers in our case studies:

- The amount of sequestration would be equivalent to all the transportation emissions in any of the largest regions in greater Toronto or Montreal

If, with some encouragement, we could do better (e.g. with government incentives):

- The sequestration opportunity would offset the entire emissions of a city of over 500,000 people

Top 3 Reasons for Becoming Provably Carbon Neutral

1. **Good for the environment – the moral reason**
    - Ethically responsible
    - Enables immediate action on fighting climate change instead of waiting for others
2. **Increases efficiency – the lazy reason**
    - Don't like cutting wood, buying so much fuel, …
    - Lowers costs
3. **Financial benefits – the greedy reason**
    - Potential for downstream tax breaks or incentives

Questions?

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See also the Net-Zero page at www.spiritintheforest.ca