Emerging
COOKING
SOLUTIONS

Replacing Charcoal with Pellets for Cooking

– With Massive Climate Impact

The Problem of Unclean Cooking

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- Global climate foot print is greater than that of entire airline industry.
- 2.5M premature death from Indoor Air Pollution (more than TB, Malaria and HIV/Aids combined).
- Women and girls spend 1-3 excessive hours per day.
- Tens of millions of households in peri-urban Africa spend 5-10% of total income on cooking fuel.
- Social and environmental cost is in the trillions of dollars annually.
- Spend on charcoal in SSA is 5-10% of household income (about 40 billion per year)

The Solution

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1. Introduce aspirational, high-quality, gasifying stoves.

2. Sell the stoves on highly attractive terms.

3. Replace charcoal with biomass pellets, sold *substantially* below price of charcoal.

4. Leverage appropriate technology such as mobile money, Pay-As-You-Go (stove shutting off if not paid for) and remote monitoring of usage.

Climate Impact

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- 3-5 tonnes CO_2 mitigated, per household, per year, based on *actual* usage, i.e. kg pellets sold (integrity and predictability).
- Total mitigation potential for clean cooking is > 1 gigaton per year.
- This is 2% of total world emissions and on par with entire airline industry.

From Charcoal (virgin forest) to Pellets (waste biomass) and from 6 tonnes raw material per household per year to 500 kg…

Which is the "Best Value for Money" Fuel?

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Fuel Comparisons – Typical Efficiencies [29]

Fuel	LPG	Charcoal (in efficient stove)	Charcoal (in traditional stove)	Firewood (in efficient stove; 15% moisture)	Firewood (in traditional stove; 15% moisture)
Energy Content (Megajoules (MJ) per kg)	45.5	30.0	30.0	16.0	16.0
Conversion Efficiency (%)	60	30	20	25	15
Useful Energy at Final Consumption Stage of Cooking (MJ per kg)	27.3	9.0	6.0	4.0	2.4
Quantity Necessary to Provide 5 Gigajoules of Useful Energy for Cooking Estimate (kg)	180	550	830	1250	2000

Fuel	Kg/year	Price/kg (USD)	Total (USD)
Pellets	590	0.27	$160
Charcoal	830	0.3	$240
LPG	180	1.7	$306
Ethanol	400	1.15/kg (0.9/lit)	$460

Note that 100s of millions of value in carbon credits every year are based on similar thermal energy calculations. There are other factors not taken into account (such as wastage of fuel during start/stop) but the above table clearly suggests that pellets is *by far* the best value of *modern* (Tier 4-5 on the World Bank/ESMAP scale) cooking fuels. A USAid Controlled Cooking test survey in Zambia came to similar conclusions.

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Competitive Advantage of Pellets 4th gen

- Time and price is what matters most to our target groups (#1 and #2)
- #3 (wide heat range from low-low to high-high) is key for fuel efficiency
- Pellets stand out with: lowest cost, revenue potential, best climate solution

	Pellets (4th Gen)	Pellets (3rd Gen)	LPG	Ethanol	Electricity	Charcoal
Monthly cost of fuel (USD)	7	10	15-25	15-20	15-25	20
1. Fast to start	✓	✓	✓	✓	✓	✗
2. Fast boiling of water	✓	✓	✓	✗	✓	✗
3. Able to keep water boiling at right power level	✓	✗	✓	✓	✓	✗
Renewable origin?	✓	✓	✗	✓	✓	✓
High sustainability potential?	✓	✓	✗	✗	✓	✗
Low emissions?	✓	✓	✓	✓	✓	✗

Table: Comparison of the four (4) clean fuels and charcoal

1^{st}-4^{th} Generation Biomass Stoves

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- **First generation:**

Basic improved stove from simple materials such as clay.

- **Second generation:**

Natural draft gasification (TLUD) and Rocket stoves

- **Third generation:**

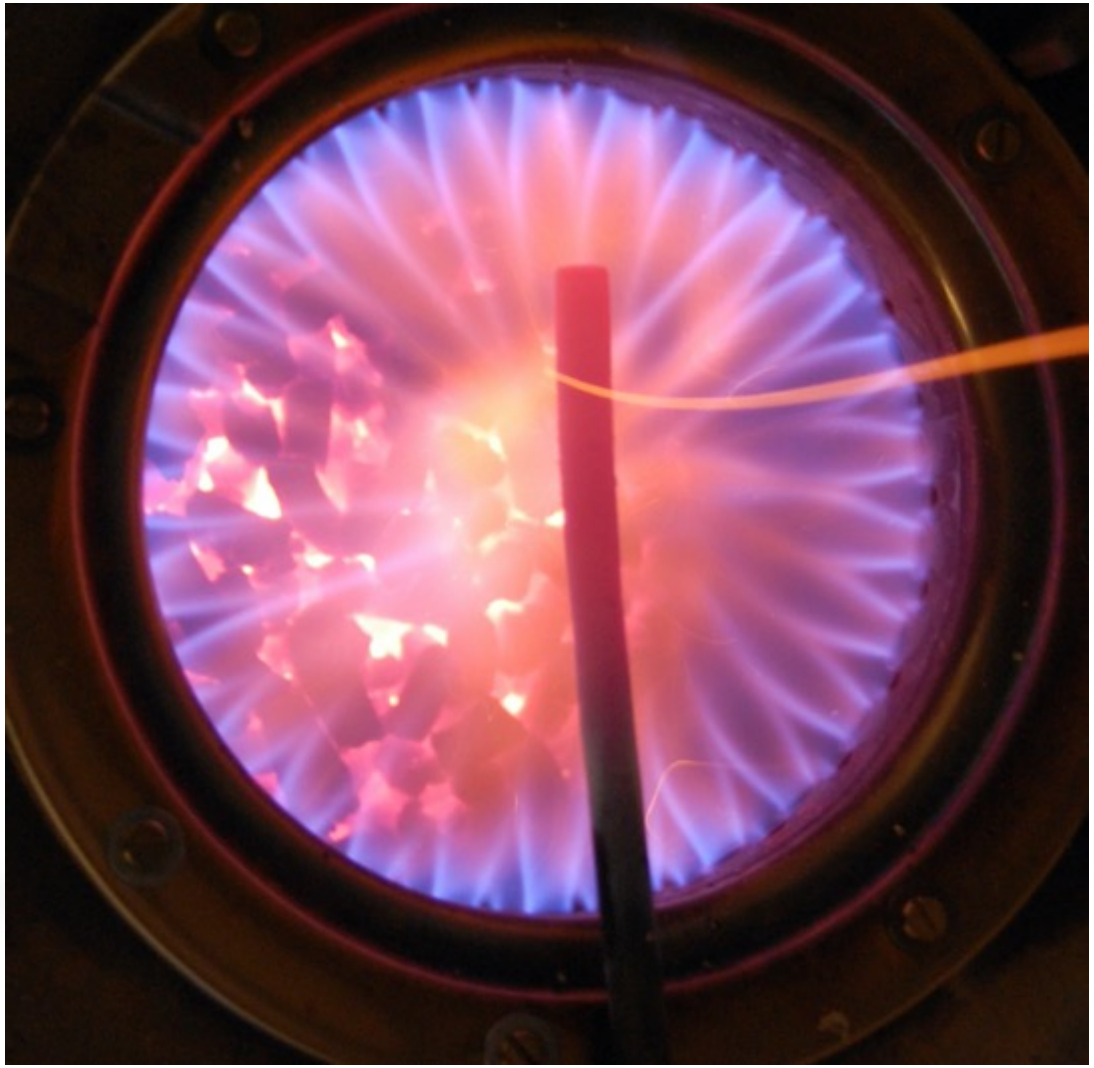
Forced air gasification

- **Fourth generation:**

Advanced airflow:

-Dramatically improved performance (duration, heat-range, emissions

-Connected (PAYGO and usage data)



4th generation biomass stove

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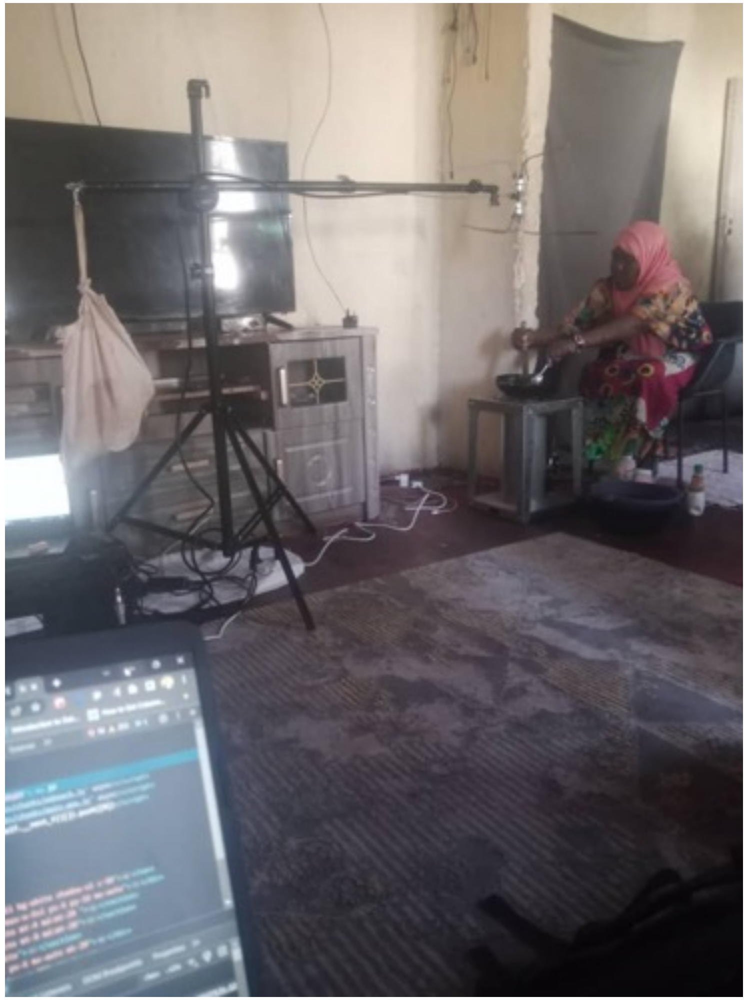
Key performance improvements:

- Drastically improved turn-down ratio
  - Fuel savings
  - Extended time range
  - Extended range of cooking tasks
- Low PM 2.5 emissions across ranges (time and power)

"I never thought that we would see a biomass stove come so close to meeting the aspirational PM 2.5 WHO Emission Rate Target."
-Aprovechio

Biomass gasification stove (all tests @Aprovechio)	Efficiency (%)	PM/HP (mg/MJ-d)	PM/LP (mg/min/l)	CO/HP (mg/MJ-d)	CO/LP (g/min/l)
SupaMoto stove	54	7,9	0,07	0,28	0,00
Market leader	50	9,58	0,22	0,9	0,02
Typical rocket stove	40	100	1,5	2,0	0,20



IoT Platform and (near) real-time carbon credits

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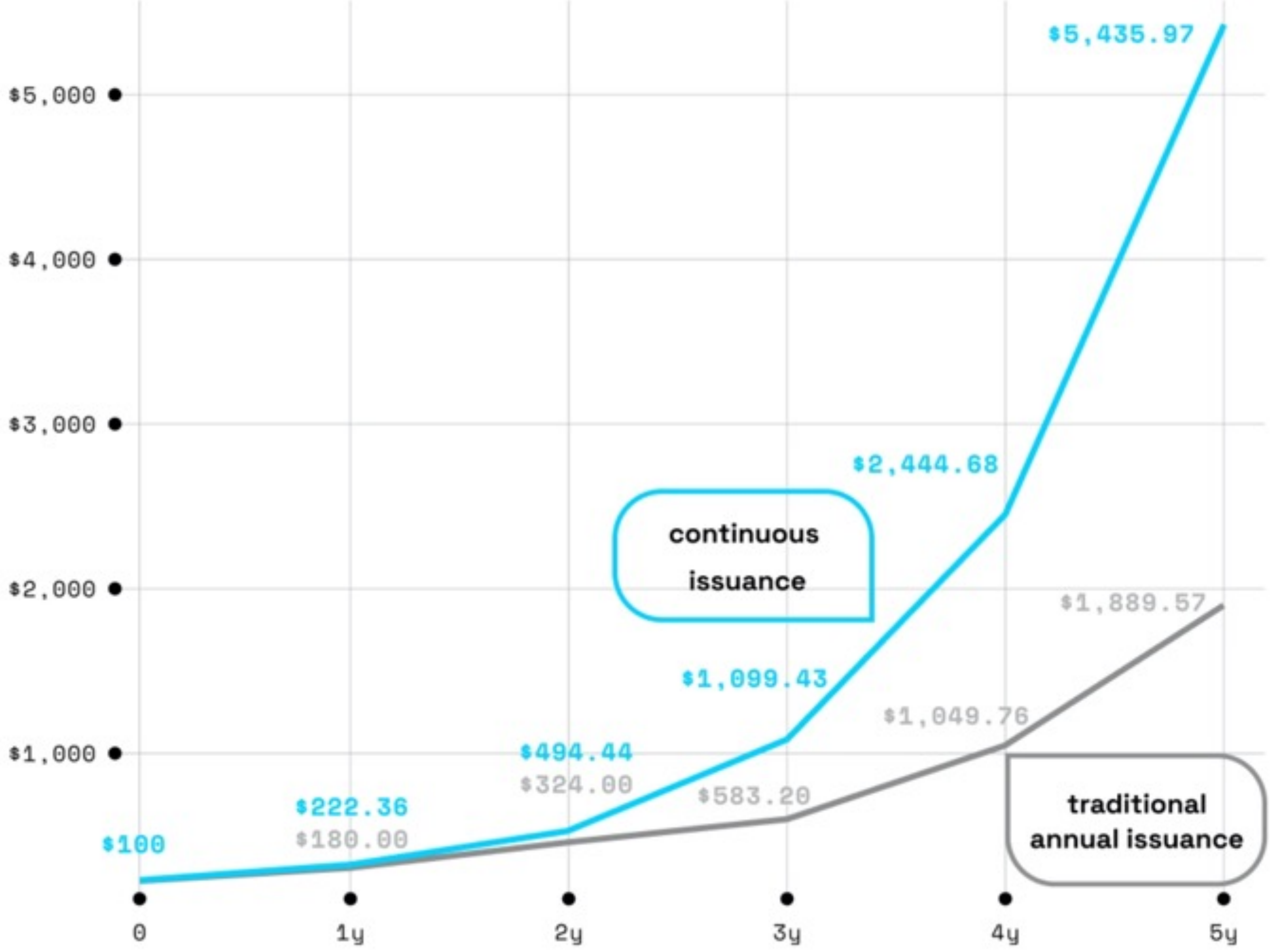
- 3,000+ stoves connected to internet
- Millions of cooking session records collected
- Ability to turn off stove remotely if not buying our fuel (printer-cartwridge model)
- Close Partnership with ixo (ixo.world)
- Blockchain and smart-contract based carbon credits
- Based on GS Measured and Metered Methodology
- Highest quality

Compounding Climate Impacts

Traditional vs. Digital Carbon Credits

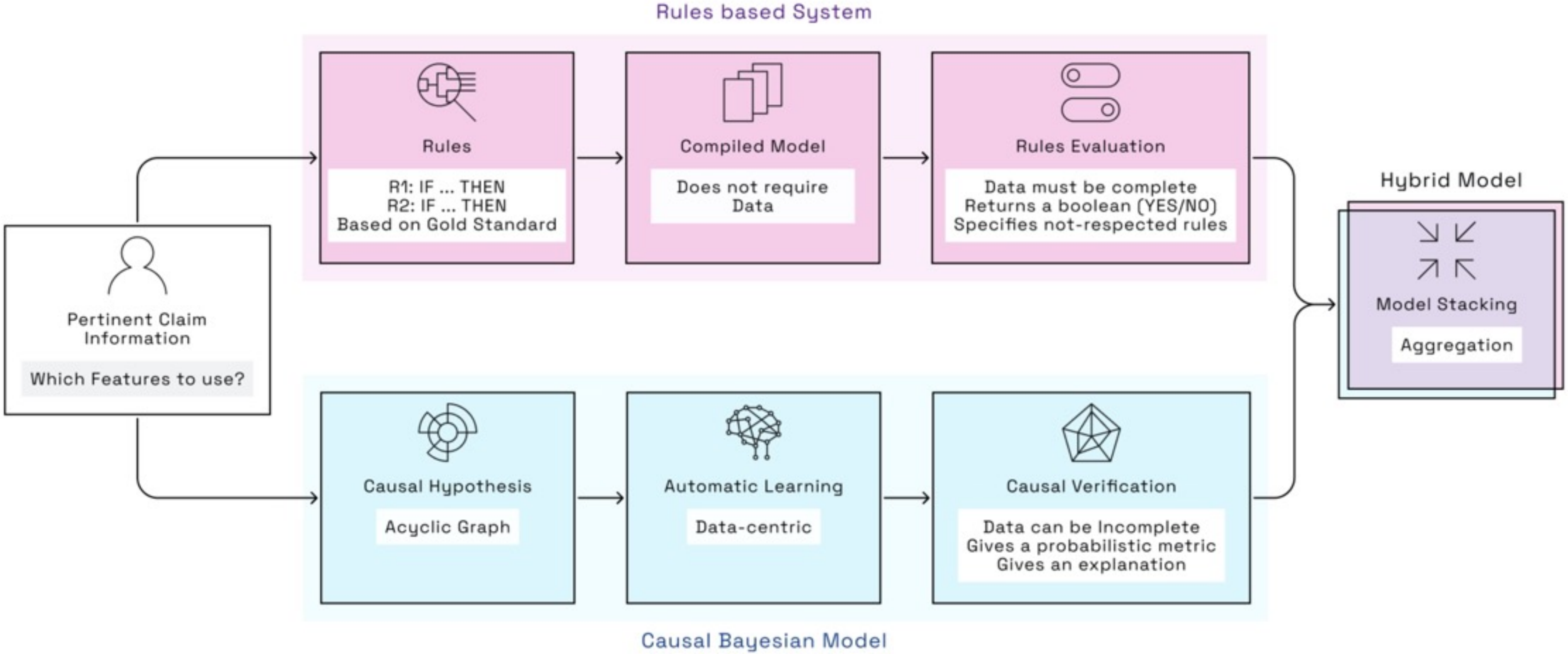
We often overlook the implications of compounding.
If we reinvest the produced impact value of a cookstove, after **3 years**, the total value of compounding daily issued carbon credits is already twice the amount of traditional credits, that take 12 months to verify. The gap widens exponentially after that.

device	smart cookstove
price	$100
est. impact	$4tCO_2/y$
est. carbon price	$20/tCO2
annual return	80%
issuance	yearly vs daily



Verify State-Changes

Evaluating Claims with Explainable Causal AI



Problems we are solving with ixo for carbon markets

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- Time
  - Savings of at least 1 order of magnitude both for onboarding and verification/issuance
- Cost
  - SaaS solution
- Opaqueness
  - All transactions on public blockchain
- Lack of detail
  - All calculations and claims connected to each credit
- Analogue
  - Digital-MRV

Demo of platform: https://app.impacts.exchange/

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