Crowdsourcing Village Energy Modeling:

Starting a Broader Conversation

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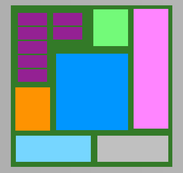
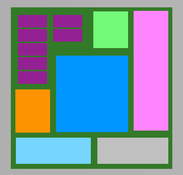
We want to change people’s lives

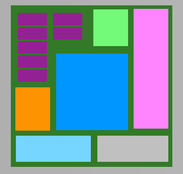


- We need to design, build, and deploy the right stove(s)

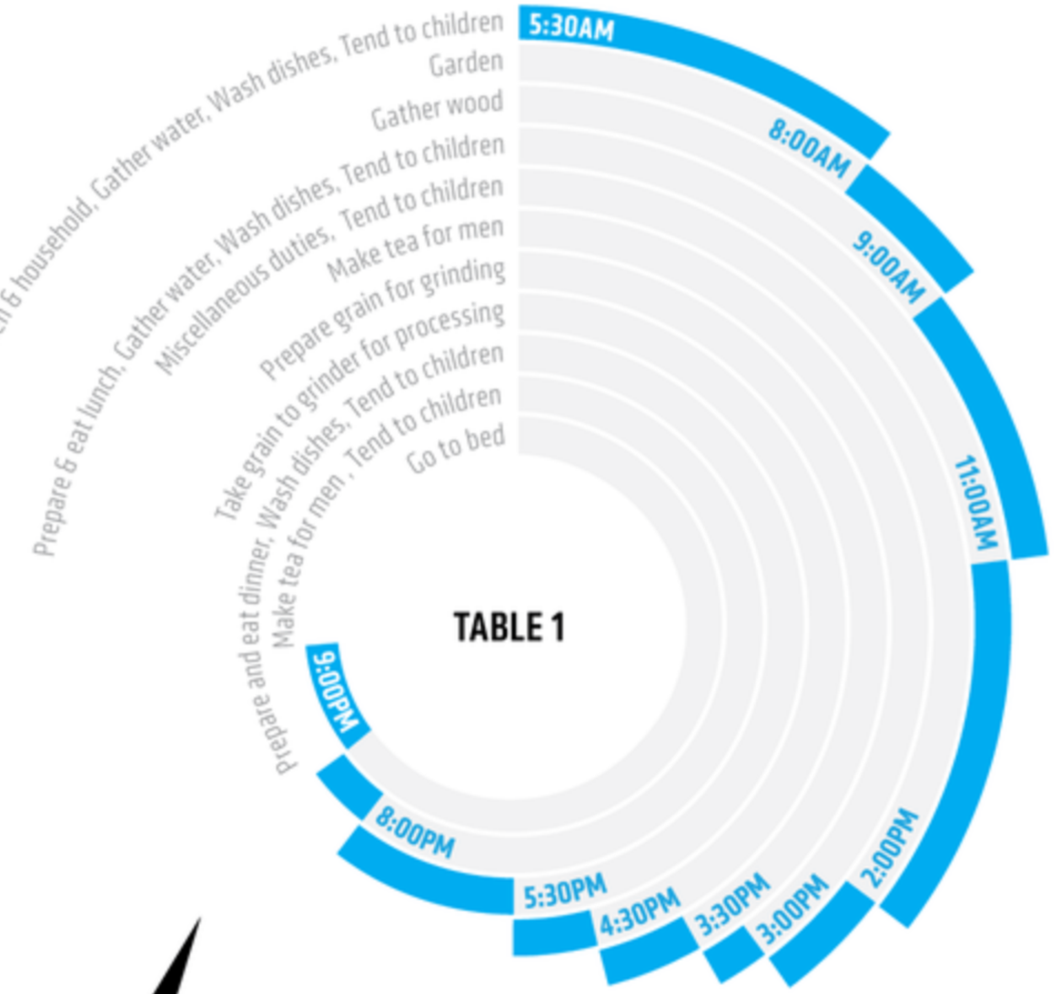


My thoughts ~20 years ago

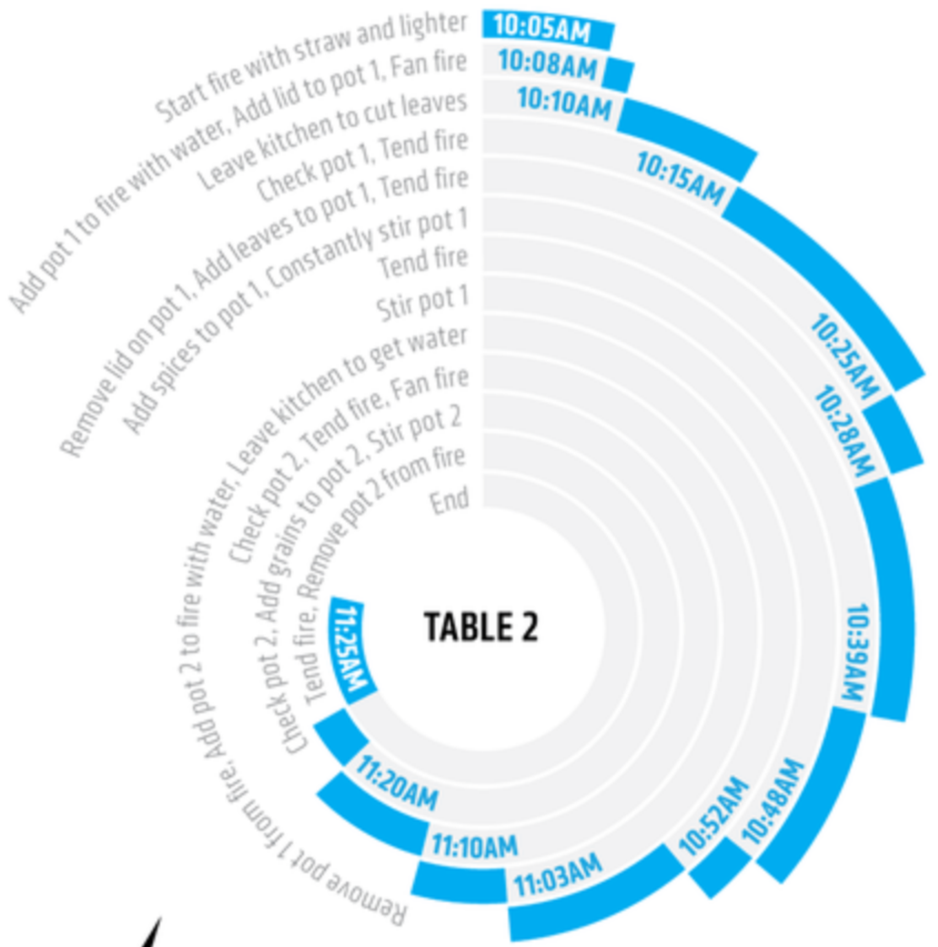
- Failure to engage the community
- Failure to understand the cultural constraints of the community
- Lack of training
- Failure to revisit the project
- Technical errors



It’s harder than it looks!

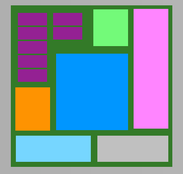


Typical daily activities for an adult woman

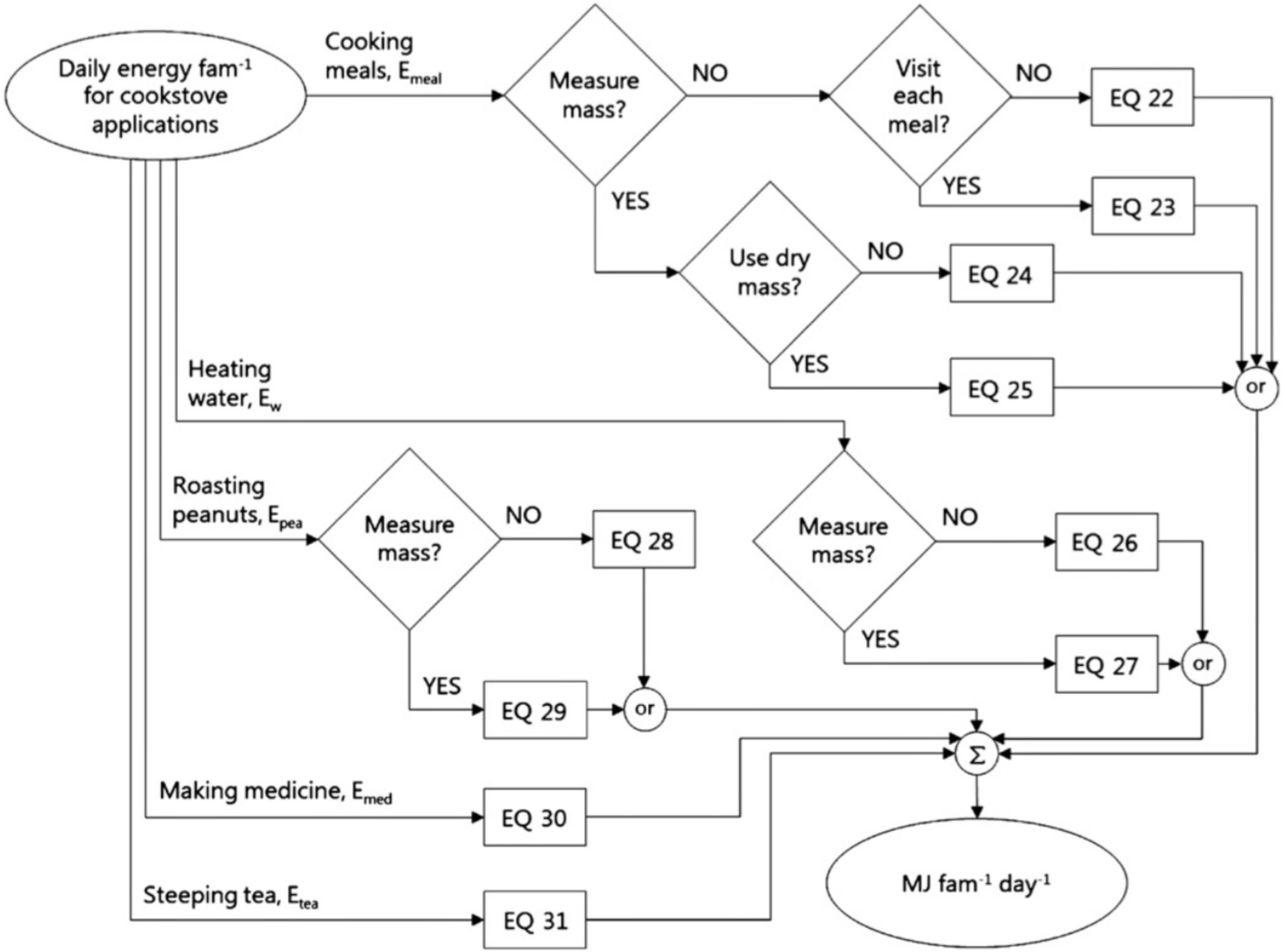


Example time-series data for cooking lunch

N G Johnson and K M Bryden, DEM+ND: ASME Global Development Review, 1:8-13 (2013)



Understanding the user

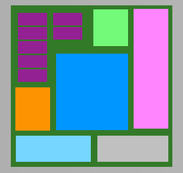


N G Johnson and K M Bryden, Energy, 46:310-321 (2012)

Daily household energy use for cookstoves

- Cookstove type may not impact energy consumption
- Using burning embers as a fire starter significantly reduces energy consumption
- Cooking on two fires increases the amount of energy use per meal by ~26%
- There is strong evidence of stove stacking
- Cooking meals (65%) and heating water (27%) account for nearly all fuel usage
- Wood species, wood moisture content, cookstove operator, and season did not impact energy use

N G Johnson and K M Bryden, Energy, 46:310-321 (2012)



Observations

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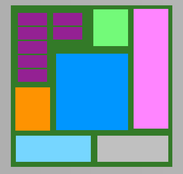
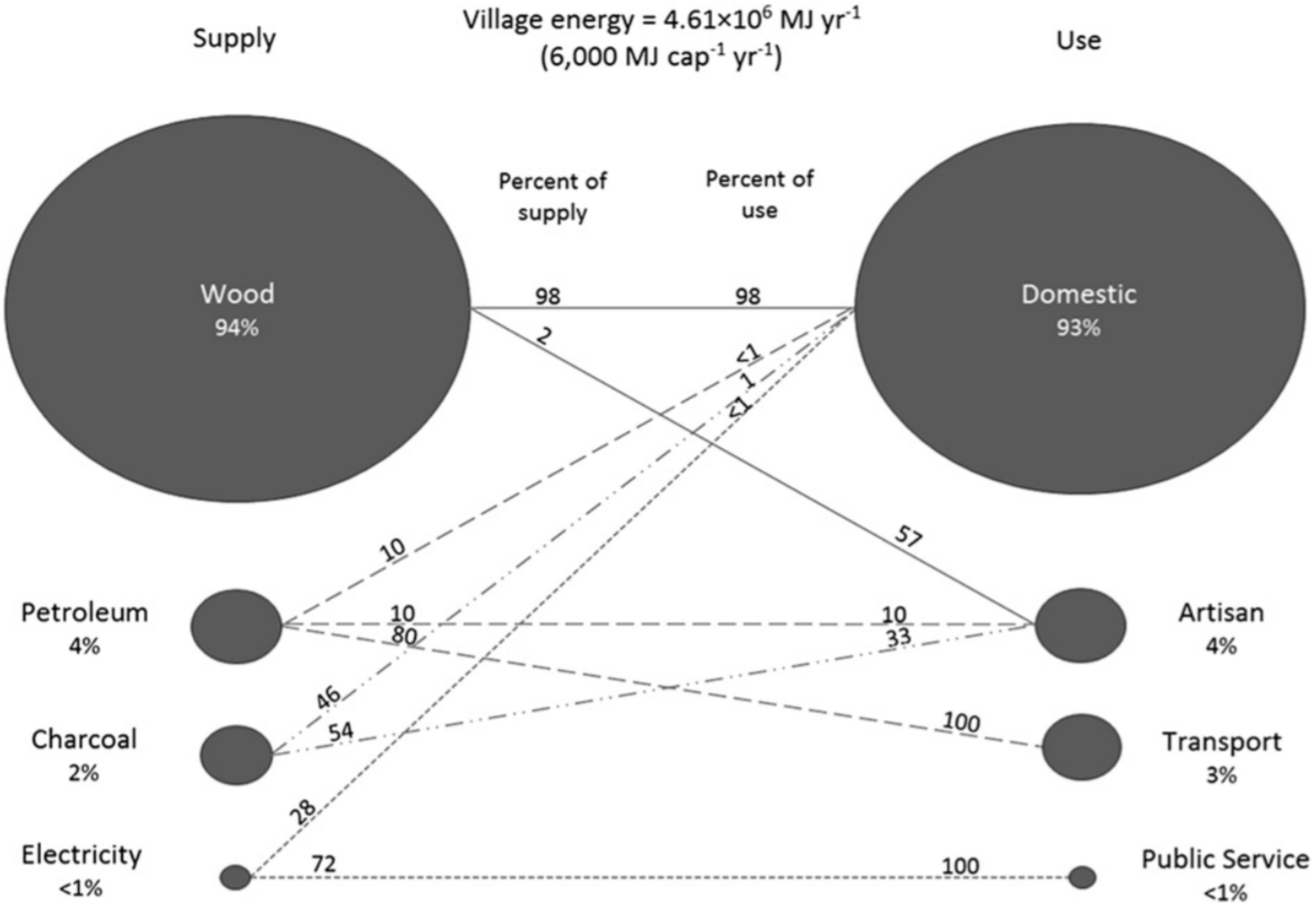
Maybe the solution isn't an improved stove!

N G Johnson and K M Bryden, Energy, 46:310-321 (2012)



Observations

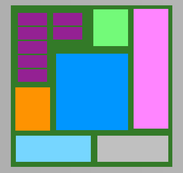


N G Johnson and K M Bryden, Energy, 43:283-292 (2012)

Village energy supply and use

- Disposable batteries (primarily for lighting) account for <1% of energy use and ~65% of cash expenditure for energy (~$2/family/week)
- Using thermal solar to heat water results in the same reduction in fuel use as 100% adoption of the best available improved stoves
- Space heating accounts for 18% of village energy use

N G Johnson and K M Bryden, Energy, 43:283-292 (2012)



Observations

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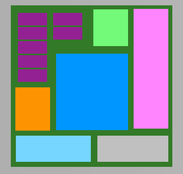
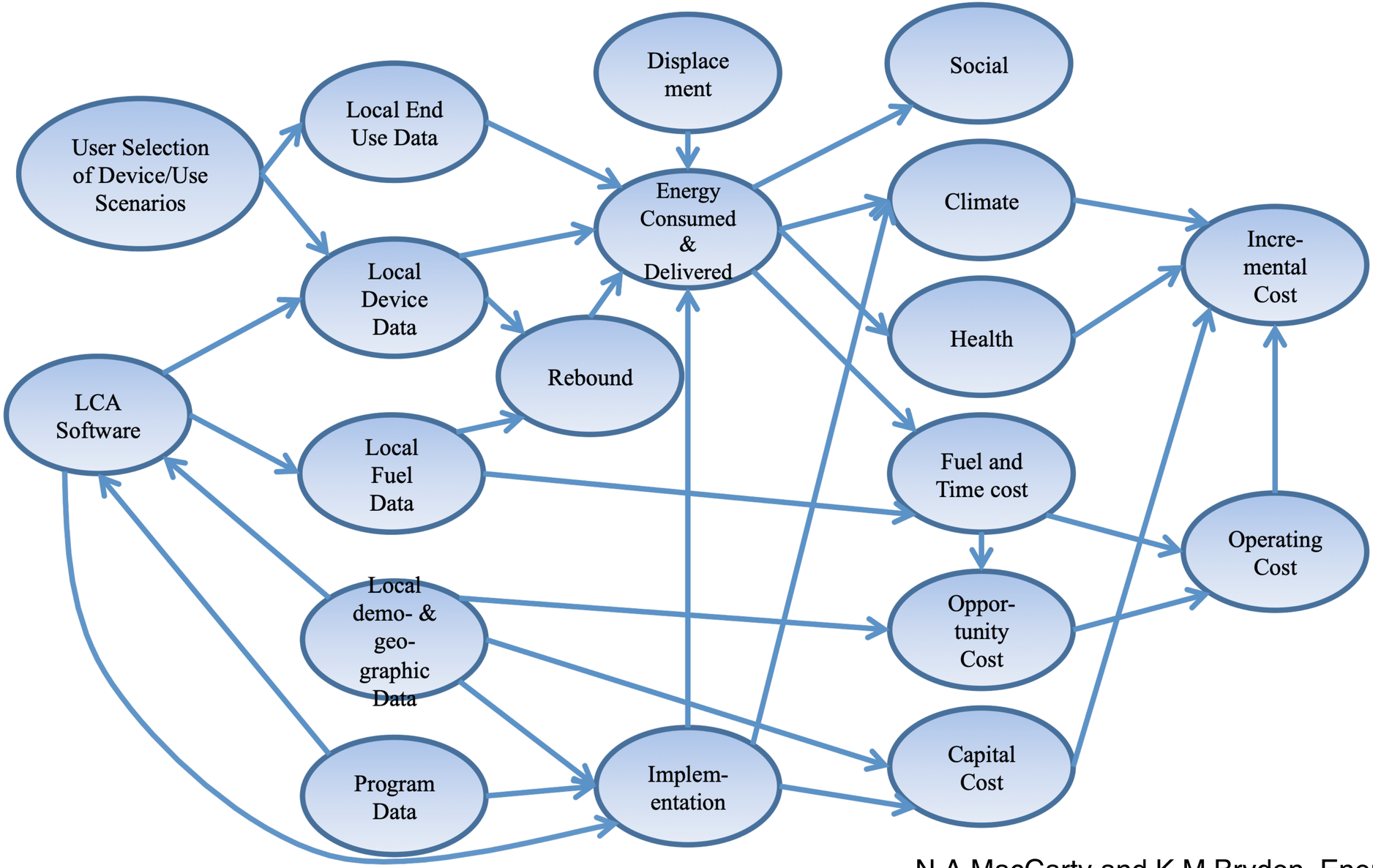
- Using thermal solar to heat … same reduction in fuel use as 100% adoptio… ble improved stoves
- Space heati… % of village energy use

The solution is more than an improved stove.
We need a systems approach!

N G Johnson and K M Bryden, Energy, 43:283-292 (2012)



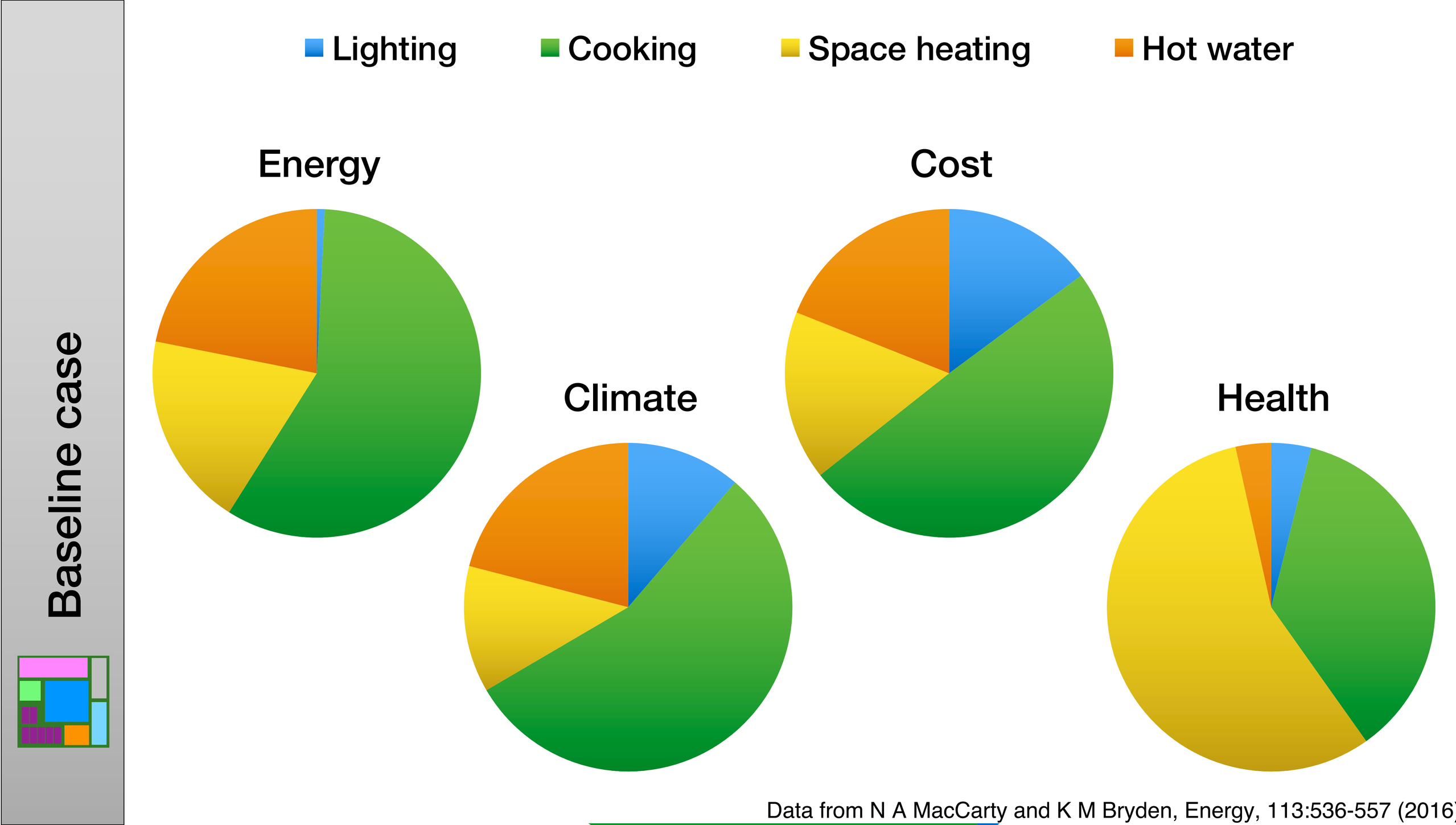
Observations



N A MacCarty and K M Bryden, Energy, 113:536-557 (2016)

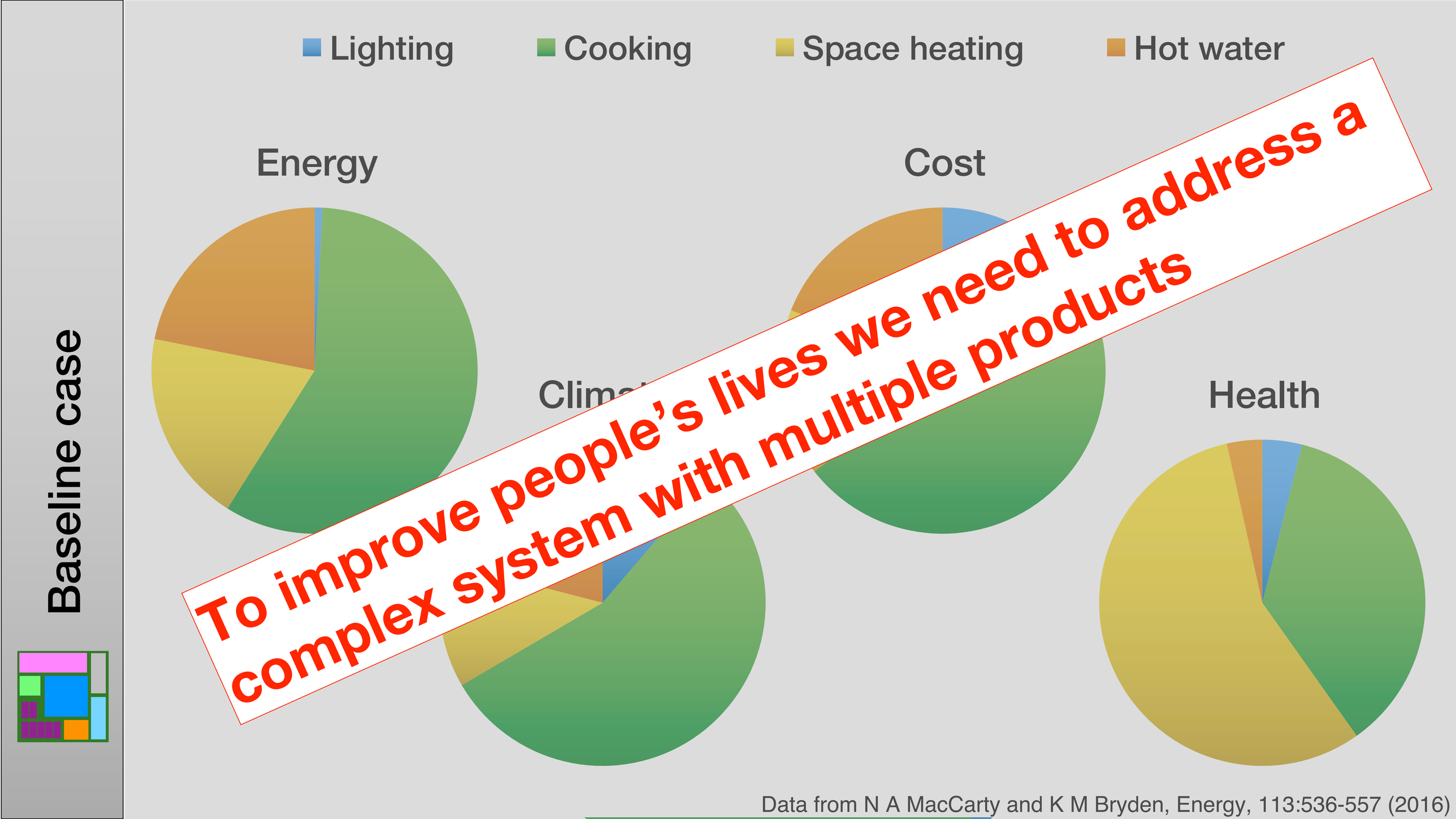
Village energy system model

Baseline case



Data from N A MacCarty and K M Bryden, Energy, 113:536-557 (2016)

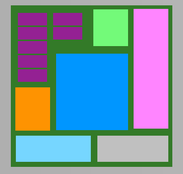
Baseline case



To improve people's lives we need to address a complex system with multiple products

Data from N A MacCarty and K M Bryden, Energy, 113:536-557 (2016)

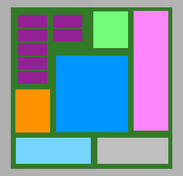
- What is the tradeoff between cost, acceptance, and impact for a particular geometry change to a cookstoves?
- How does the design of one energy system (e.g., solar thermal water heating) impact the design of another (e.g., a cookstove)?
- How do I maximize the impact of my village energy system?
- If I change materials what will be impact of the stove on the local environment or user’s health?



Design questions we can’t easily answer today

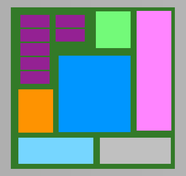
We want to change people's lives

- Real change relies on many interconnected factors
- To effectively intervene we need to be able to understand (model) the complex systems representing village energy/life.

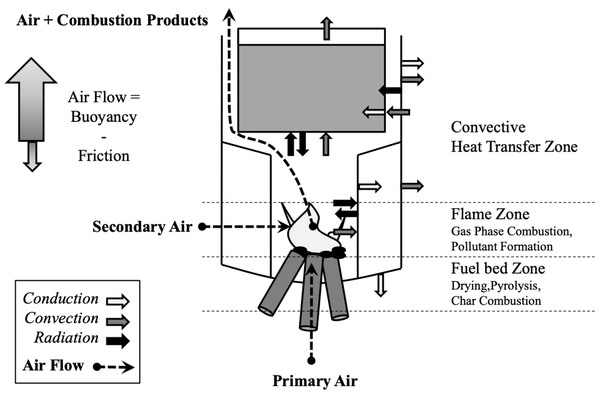


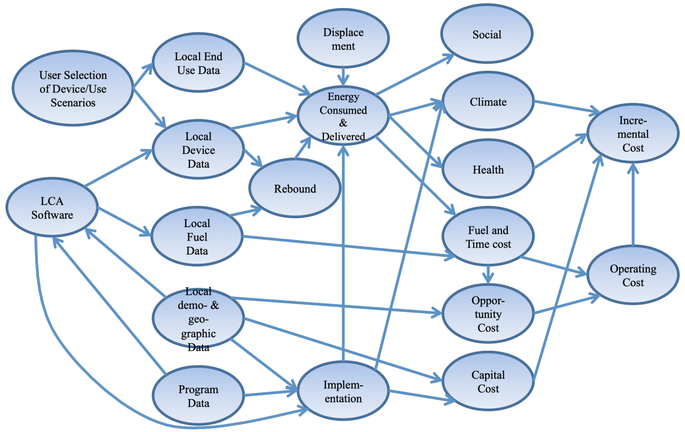
We need to develop new types of large scale engineering tools that enable holistic engineering design processes.

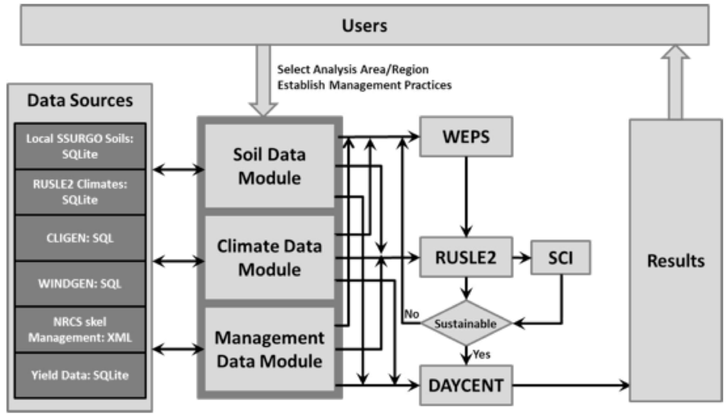
- These tools need to enable easy and rapid construction of realistic system models of complex systems that work across scale and components
- These tools must maintain the fidelity and complexity of the environment around us and enable us to real engineering



My thoughts today







Components

- Cookstoves
- Solar hot water
- Lights

+

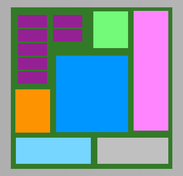
Village Energy Model

- Rebound
- Climate impacts
- User acceptance

+

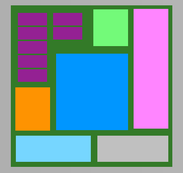
Agronomic Model

- Erosion
- Fertility
- Crop yield



Systems level design

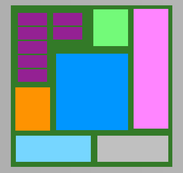
- The problem is big, hairy, and hard,
- The current model is a great start but is complicated and hard to modify or comment,
- No community agreement/support/input, and
- It’s important.



Observations

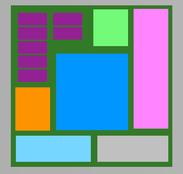
Crowdsourced modeling

- Independent thinking
- Independent model development
- Access to more models and data
- Implicit agreement with the outcomes of the models



Need

- Open modeling environment
- Easy, straight forward to understand systems models that are linked to the narrative
- The ability to query, modify, and change the model (think - wikipedia of models)
- Collaborative development community



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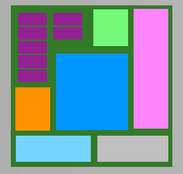
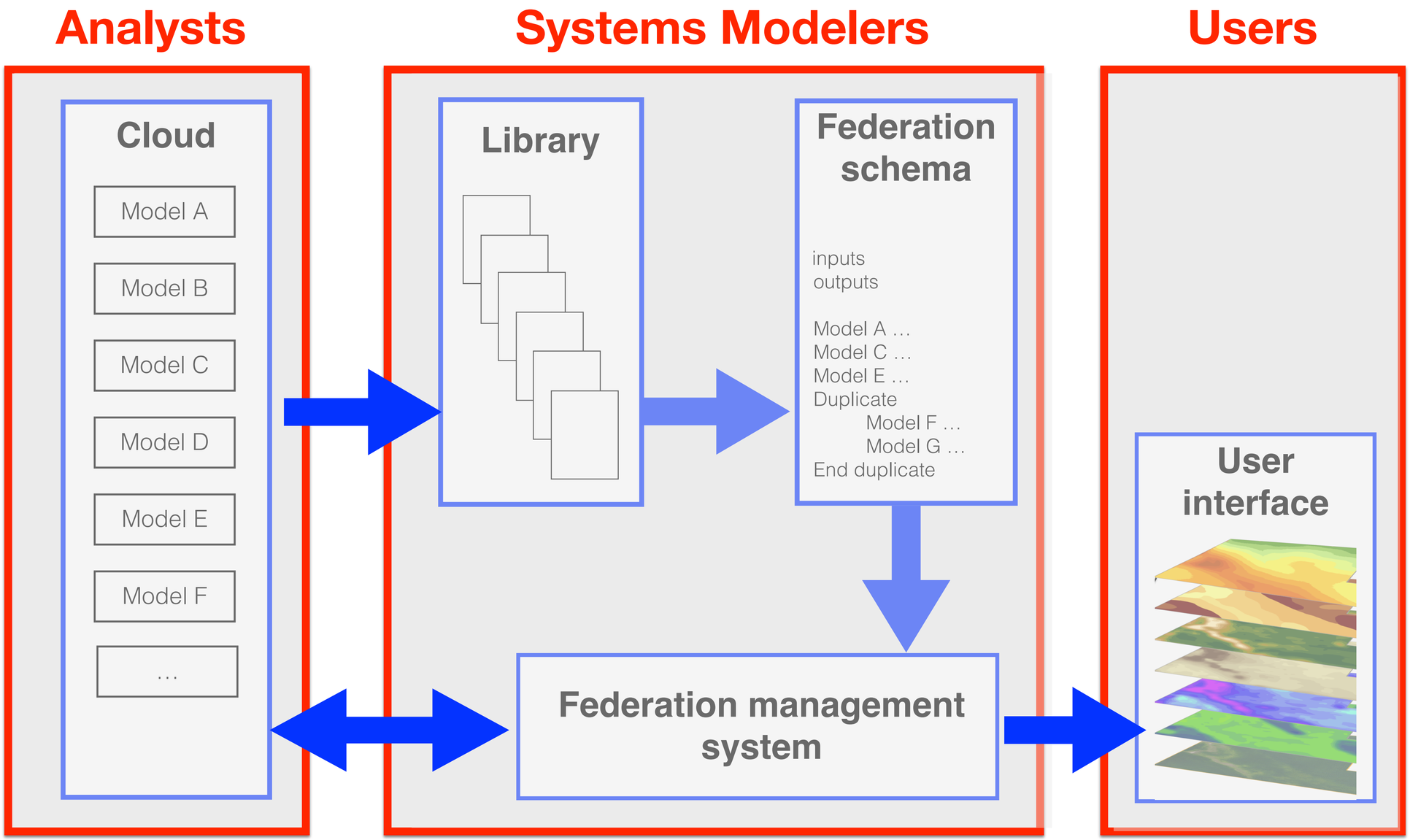
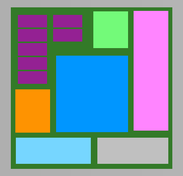
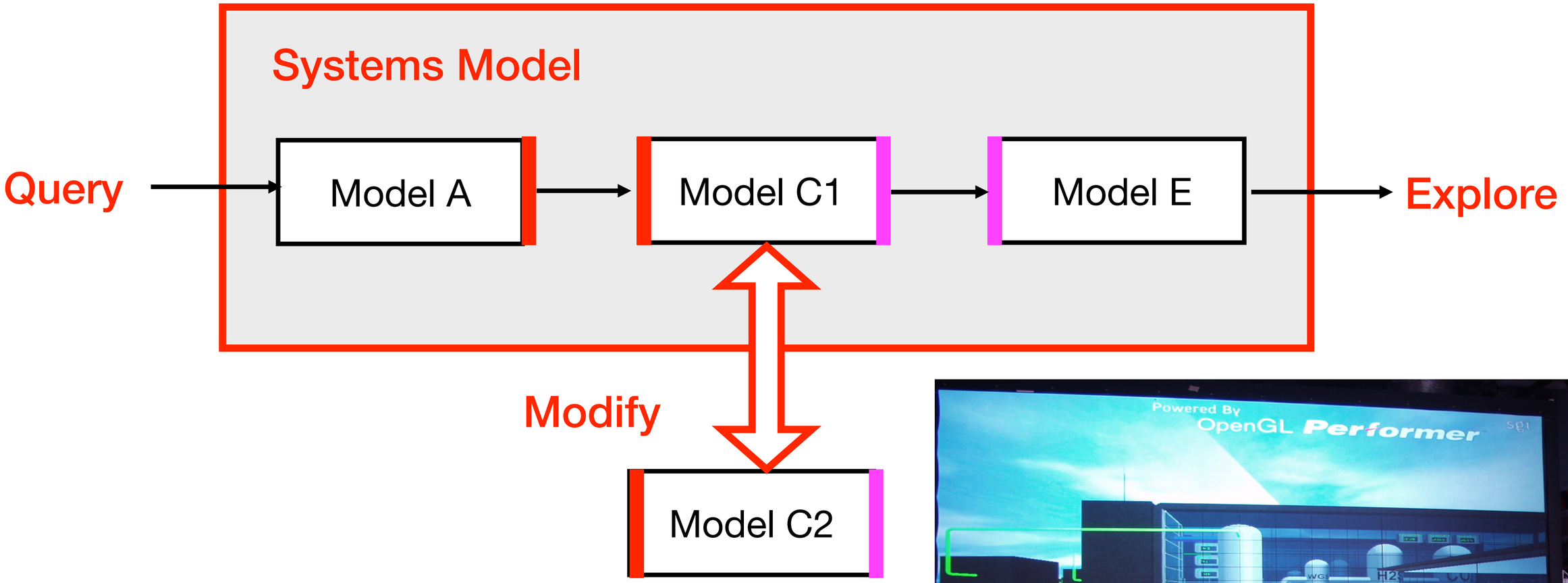
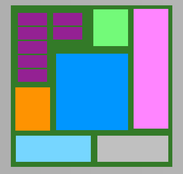



Analysts
Systems Modelers
Users
Cloud
Model A
Model B
Model C
Model D
Model E
Model F
…
Library
Federation schema
inputs
outputs
Model A …
Model C …
Model E …
Duplicate
Model F …
Model G …
End duplicate
Federation management system
User interface



Work flow



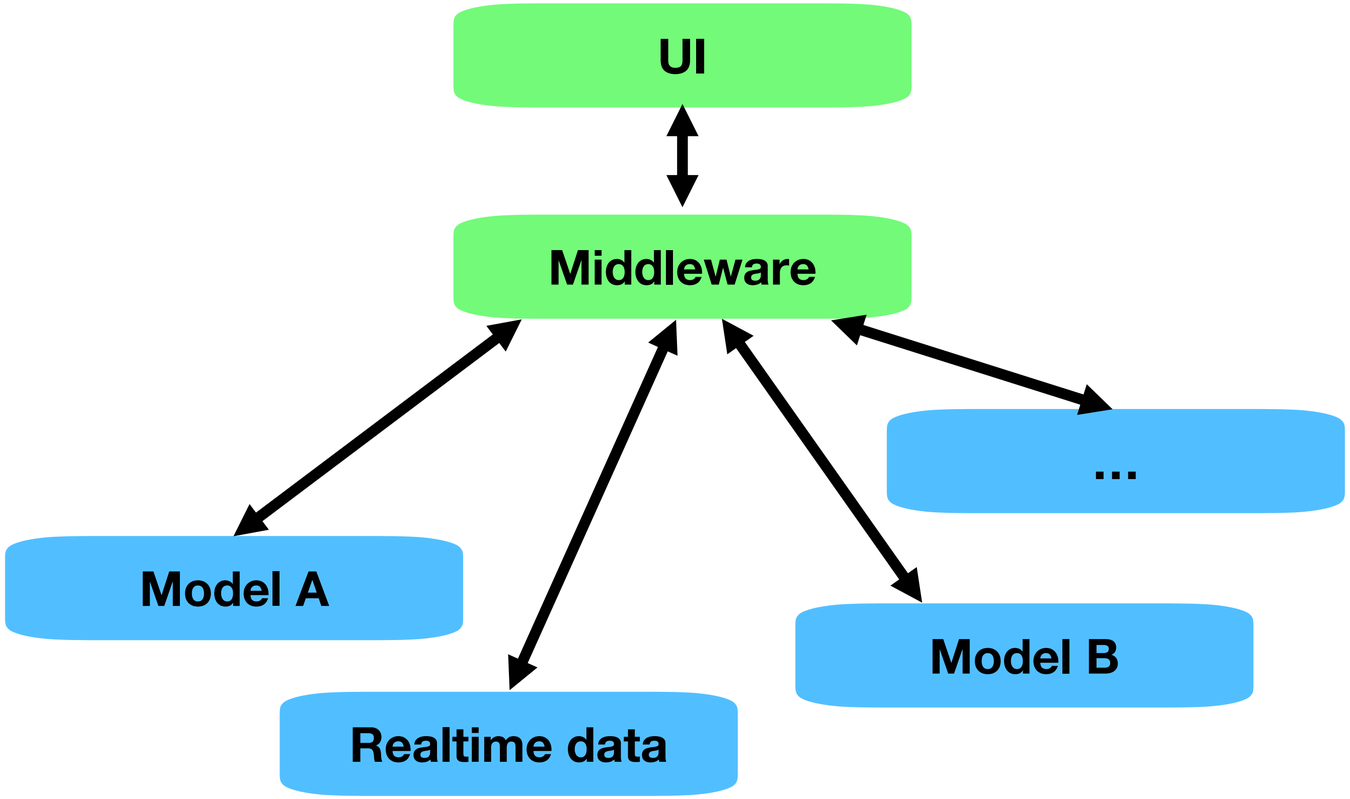


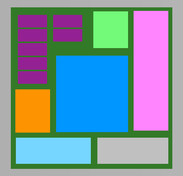
User experience

Monolithic modeling

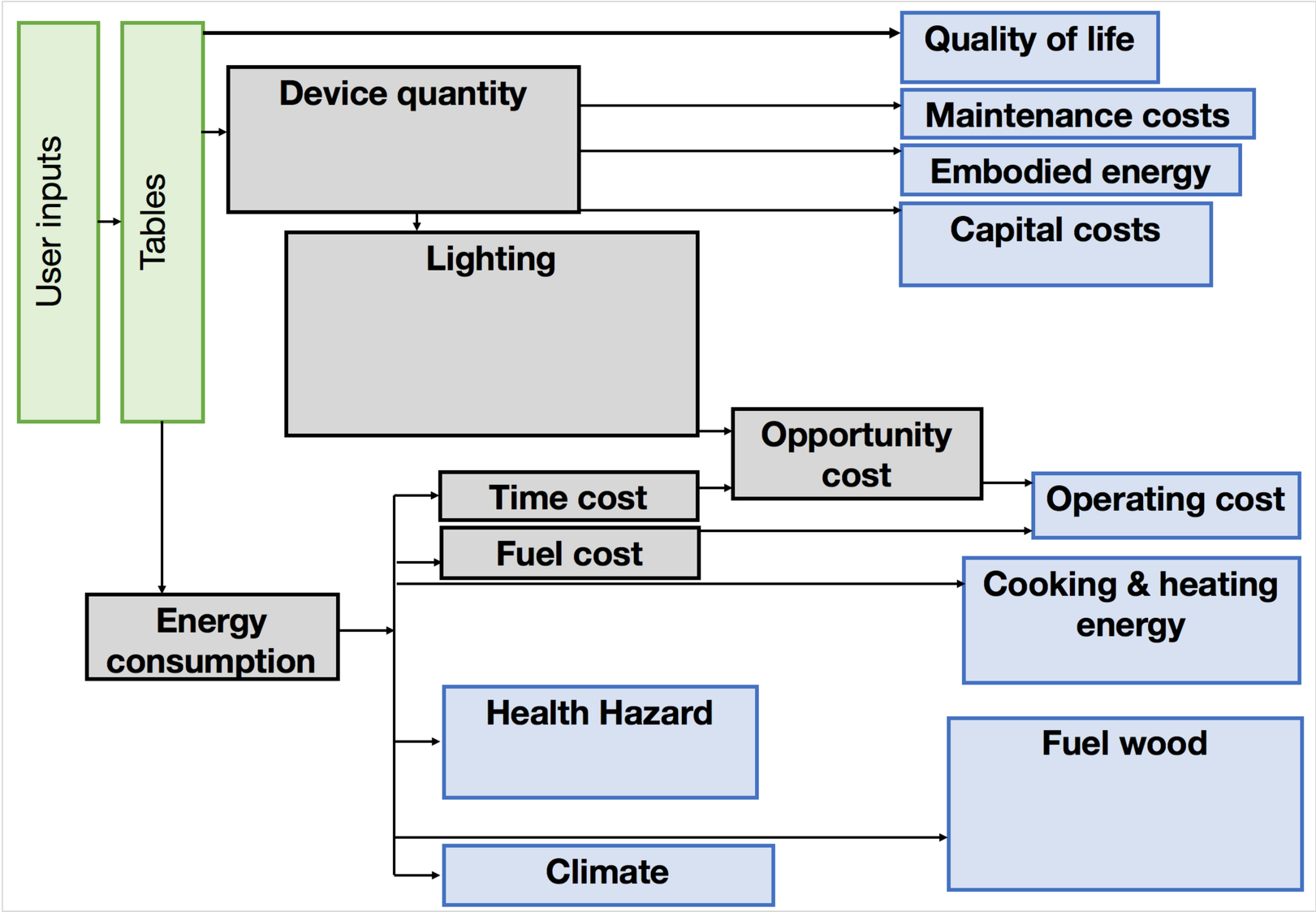
The model

Microservice modeling





The new modeling environment



Village energy system model

Village Energy Model

Model Library — Inputs

- Addition
- Annual Embodied Energy
- Annual Fuel Cost
- Annual Fuelwood
- Annual Mechanical Energy Delivered
- Climate
- Device Quantity
- Energy Consumption
- Energy Delivered Cooking Heating
- Equivalent Annual Capital Cost
- Float Source
- Health Hazard
- Integer Source
- Lighting
- Maintenance Cost
- Operating Cost
- Opportunity Cost
- Quality Of Life
- Fuel Used
- Fuel Price Elasticity
- Annual Energy Use Baseline by Task
- Device Fraction Displacement
- Single Task Energy Consumption
- Time Cost

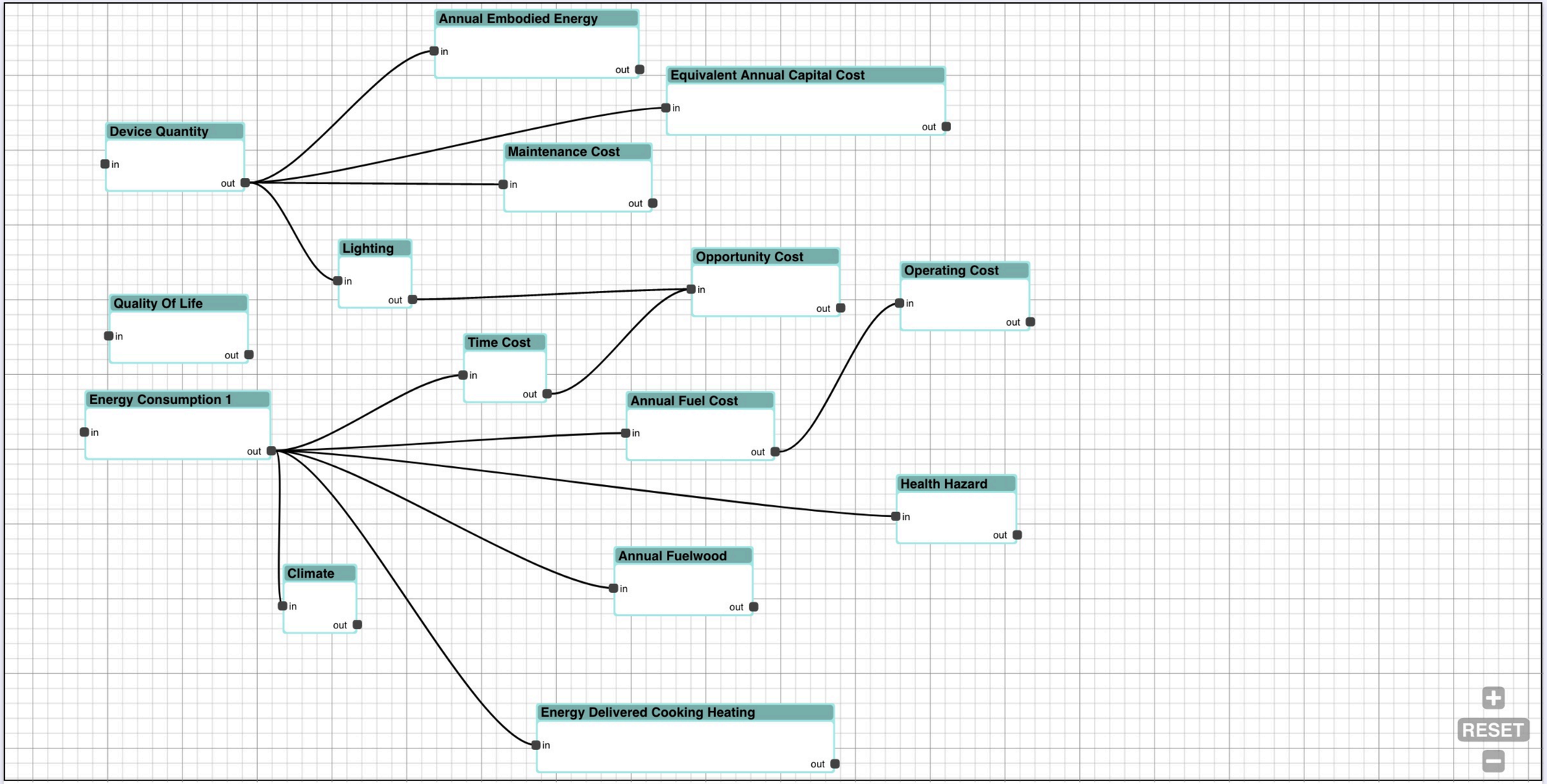
SELECT EXISTING WORKFLOW

CALCULATE AND RUN

RUN

Go to Executio

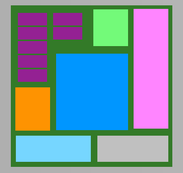
CALCULATE



DELETE LINKS

CLEAR DIAGRAM

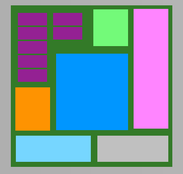
- Energy consumed/delivered
- Climate
- Health
- Costs - user/implementer
- Quality of life



Outcomes we are about

- The more models that are brought to the table results in continuously improving the modeling of a village

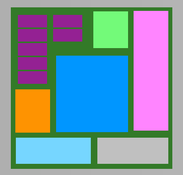
- Enabling better conversations and decisions about the holistic impacts of any proposed interventions



Moving forward

Join the conversation

- submit models
- explore the systems model
- provide data
- comment, critique, and help improve

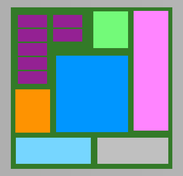


Invitation

We can integrate data, models, user interfaces together to explore complex systems including carbon emissions, energy outcomes, dynamic modeling.

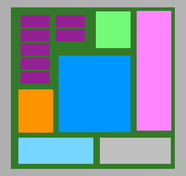
- detailed analysis of complex energy systems,
- design and decision making across scale,
- live data/information integration (digital twinning).

We are eager to work on projects that matter and can change peoples lives.

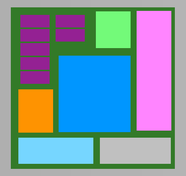


Collaboration and consulting

We should flip the existing trickle down paradigm of engineering tools in which engineering tools for the developed world are then modified/used in the developing world.



A final thought

Yes, but …

- We need to do real engineering
- We need to true transparency and accountability
- An idea is not a design, a design is not a product, a product is not a business, and a business is not a solution
- We need to develop new types of large scale engineering tools that enable holistic engineering design processes.