CivicAI How to read the *Blueprints*

Dark Matter Labs
Lucidminds
Nesta
September 2020
civic-ai.org

CivicAI is a project exploring how AI can enhance collective intelligence to help communities respond to the climate crisis through three near-future use cases.
Read more at civic-ai.org

Start at (A) for a visual summary
See (B) for schematic representations of the processes involved
See (C) for challenges that ACI can help address
See (D) for opportunities for people and machines to collaborate
Follow (E) for technical requirements and readiness across the full proposal
Follow (F) for details within each stage of proposal

Section overview

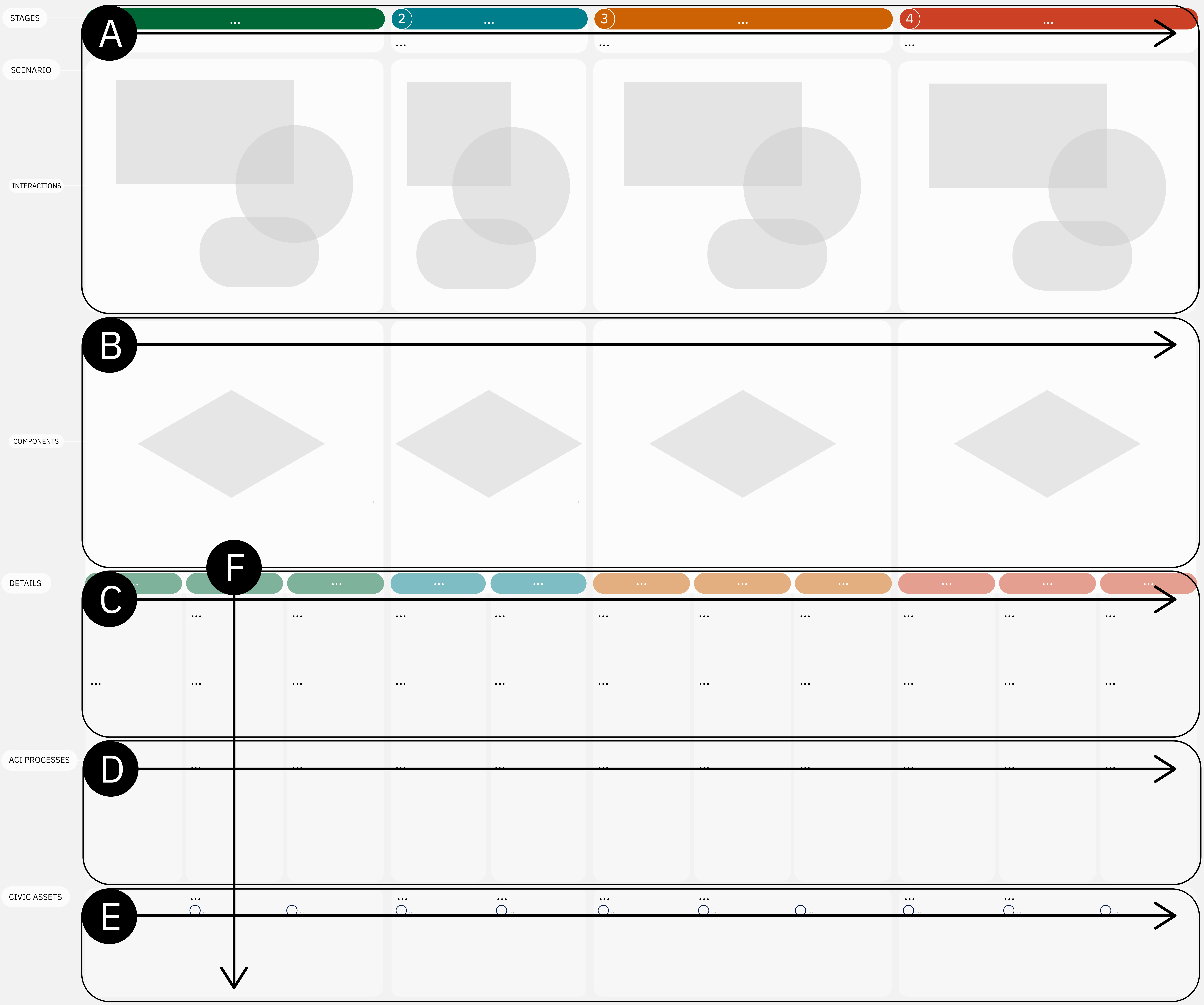
(A) provides a visual summary of the key stages and example interactions within each scenario.

(B) gives a schematic overview of the processes conducted by people and machines in each of the scenarios.

(C) details the key challenges experienced by organisations working in these areas and a proposal for how they may be overcome.

(D) provides details of how people (HI) and machines (AI) collaborate and the specific tasks carried out during each stage of the proposal.

(E) summarises the civic assets which make up the proposal. These are separated in *Tangible* (physical) and *Intangible* (non-physical). Each component has an indicative *Technology Readiness Level* reflecting level of development of related technologies/projects. Components to focus on to achieve a *Minimum Viable Product* for the use case have also been highlighted.



CivicAI

BLUEPRINT #1/3

Connected urban forest

CivicAI is a project exploring how AI can enhance collective intelligence to help communities respond to the climate crisis through three near-future use cases. **Read more at civic-ai.org**

Connected urban forest combines automated and participatory processes for mapping, monitoring, caring for, and measuring the holistic benefits of urban trees.

The *Blueprint* outlines how people and machines could collaborate in this area. It provides an overview of opportunities for implementing community-led AI systems, as well as a framework for connecting organisations who share common challenges or are developing potential solutions.

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STAGES

1 MAPPING — People and machines work together to identify the location and species of urban trees, uploading data to an open Tree Registry.

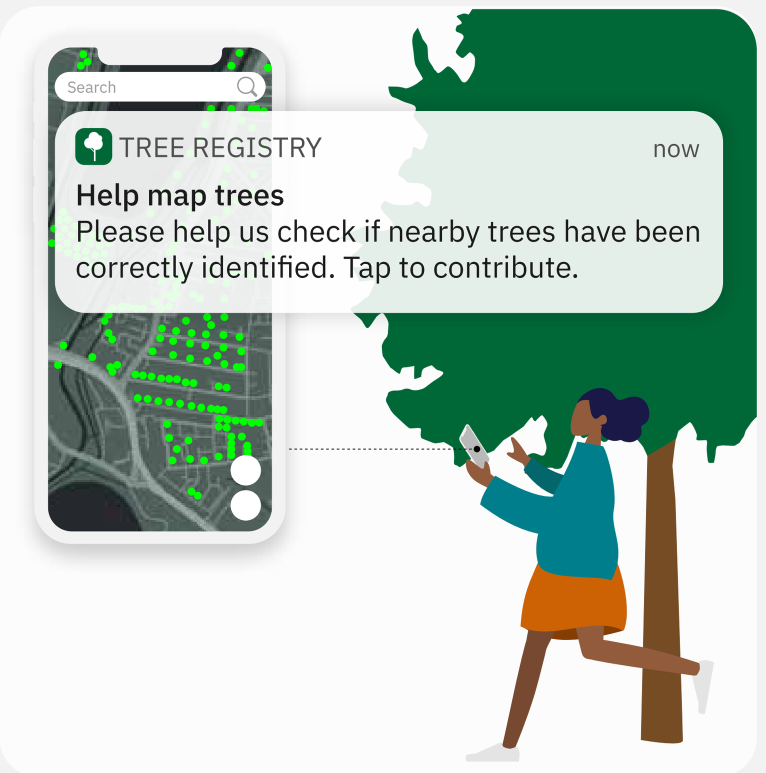
2 MONITORING — Data is collected to monitor tree characteristics and health, as well as environmental and social impacts, using satellite imagery, IoT sensors and participatory data collection processes.

3 MAINTAINING & CARING — A maintenance and caring platform prompts people to help care for urban trees. Autonomous agents monitor tree data from sensors and notify local authorities and citizens when trees need care.

4 IMPACT MEASUREMENT — Analytical models and simulations measure the environmental and social impacts of existing urban forest and future plans.

SCENARIO

INTERACTIONS



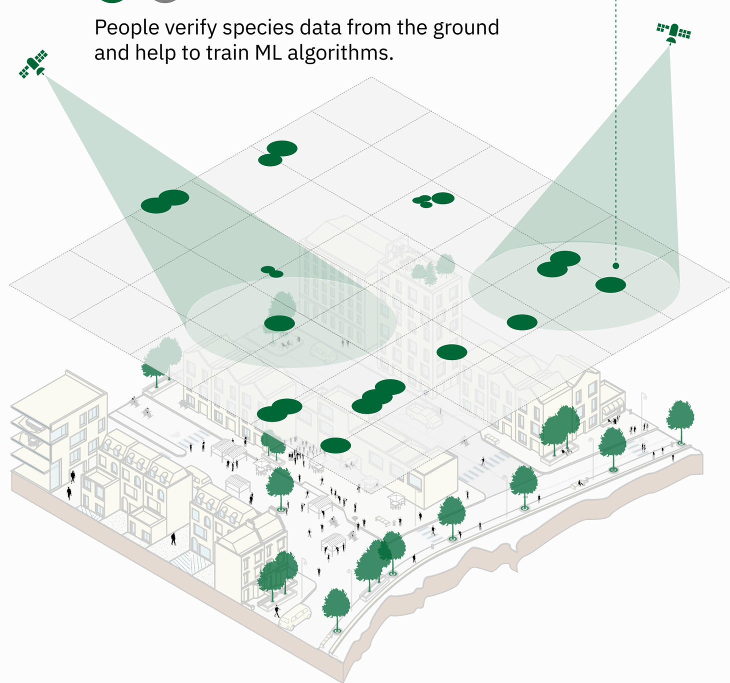
COMPONENTS

People doing tasks
Machines doing tasks

1 Mapping

A Satellite imagery and ML algorithms used to automatically map tree locations.
People verify location data from the ground and help to train ML algorithms.

B Satellite imagery and ML algorithms used to identify tree species.
People verify species data from the ground and help to train ML algorithms.



2 Monitoring

A People and machines monitor characteristics to track trees as they grow - size, stability, canopy cover.

B Distributed sensors and citizen collected data used to monitor tree health and identify specific caring needs.

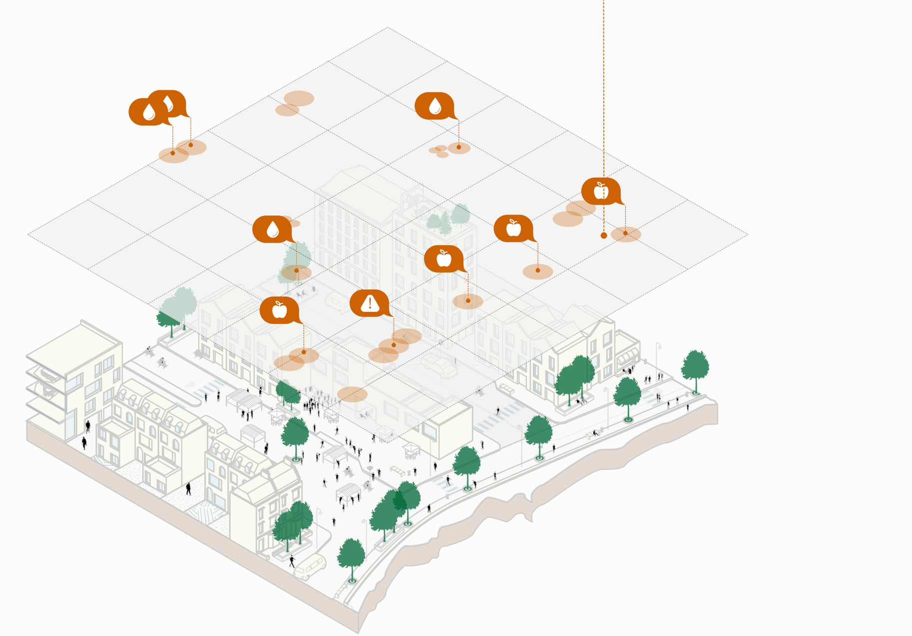
C Remote sensing and ground sensors measure multiple impacts (surface temp., air quality, water run-off, biodiversity) forming a digital twin of the urban forest.

3 Maintaining & caring

A Machines notify people if nearby trees need water or nutrients via a public interface (e.g. audio, digital board, app, augmented reality etc)

B Machines analyse tree condition data and notify tree officers & citizens if trees are at risk of falling or are damaged.

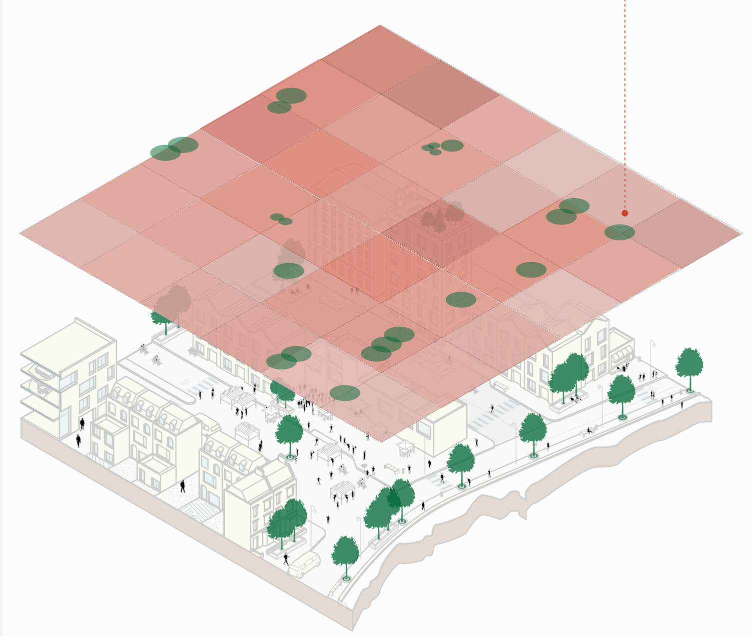
C AI agents analyse data to identify which trees are about to produce fruit or need pruning, and alert nearby citizens.



4 Impact measurement

A Impact analysis used to provide evidence for outcomes-based investment.

B Agent based models used to simulate outcomes of alternative planting strategies.



DETAILS

KEY CHALLENGE(S) — *for organisations working in this field, which ACI can help to address*

DESCRIPTION — *of ACI proposal*

ACI PROCESSES — *Overview of activities performed by machines (AI) and people (HI)*

1 Mapping

	A) Tree location	B) Species identification
KEY CHALLENGE(S)	Cost and resource required for manual data collection. Verification of data from satellite images.	Difficult to obtain data from private gardens. Coordinating data collection. Uncertainty in accuracy of remote species detection.
DESCRIPTION	People and machines identify tree locations from satellite imagery and on the ground verification. This data is uploaded to a Tree Registry. By contributing data, people can receive personalised feedback on the state of the urban forest in their area.	An automated process for identifying tree species using satellite images and other airborne sensors, which is verified by citizens through a mobile app. The data is uploaded to a public Tree Registry.
ACI PROCESSES	**HI** People verify data on the ground via a mobile app, helping to train a ML algorithm to improve it's reliability and regularly update the registry with newly planted trees. This process could be gamified. **AI** ML algorithm used to automatically distinguish between buildings; paved areas; grass or vegetation; tree canopy; water etc. to locate trees.	**HI** ML and domain experts design and train species identification algorithm. People provide data to verify and improve species identification. **AI** ML algorithm used to identify tree species from spectral variability of satellite images, cross-referenced with 3D imagery from LiDAR sensing (a remote method of measuring ranges using laser light).

2 Monitoring

	A) Tree characteristics	B) Tree health	C) Impacts
KEY CHALLENGE(S)	Resource intensive and repetitive tasks. Requires regular updating.	Resource intensive and repetitive tasks. Requires regular updating.	Limited accuracy of remote sensing. Granularity of on the ground sensors. Isolating entangled impacts.
DESCRIPTION	Regular data collection to monitor urban tree characteristics and contribute to an open Tree Registry using open data standards. Data collection could be gamified to create competitions between different neighbourhoods.	Regular data collection to track urban tree health from a combination of citizen recorded data and on the ground sensors. Data uploaded to Tree Registry.	Monitoring a range of impacts e.g. local cooling; flood alleviation; air quality improvement; biodiversity increase; carbon sequestration; health/wellbeing from both sensors and citizen collected data (e.g. wellbeing or fitness apps).
ACI PROCESSES	**HI** People provide data on tree height, trunk diameter and species through a mobile app. **AI** ML algorithm used to regularly track canopy cover, grass cover and shrub development from satellite imagery. Distributed sensors monitor tree stability. Edge AI could enable local computation with data fed intermittently to a digital twin of the urban tree network.	**HI** People verify and contribute data e.g. uploading photos of diseases. **AI** Distributed sensors monitor rainfall, ground water levels, soil salinity and nutrient levels to infer tree health. Deep learning from street view images to track tree health. Machine vision used to identify diseases from photos uploaded by citizens.	**HI** People help train ML algorithms, upload readings from private sensors and share qualitative data e.g. wellbeing. **AI** Remote sensing & ML algorithms measure surface temperature, soil moisture, air quality and plant and animal species. Ground sensors track air quality, air temperature and water run off rates. This feeds a digital twin of urban forest to model its impacts.

3 Maintaining & caring

	A) Watering & nutrients	B) Health & safety	C) Pruning & harvesting
KEY CHALLENGE(S)	Different ages or species of tree need different amounts of water and nutrients. Access to nearby water supplies.	Minimising resource and cost to local authorities to maintain increasing number of trees across a borough.	Local authorities are resource limited and so seek to minimise maintenance. Safely involving citizens in pruning and maintenance.
DESCRIPTION	A citizen supported caring platform analyses water and nutrient level data from the tree registry and alerts citizens when trees need additional care. Engagement programs - e.g. competitions between different districts - could incentivise participation.	Data on a tree's condition is analysed to help local authorities identify more precisely where maintenance is required to ensure public safety.	The caring platform monitors and estimates when trees are likely to bear fruit or require pruning and alerts citizens.
ACI PROCESSES	**HI** People subscribe to care for a tree and are notified which trees need watering or additional nutrients. They log the amount of water or nutrients they add through an open tree care platform. **AI** AI agents prompt people if a nearby tree requires water or nutrients, directing people to nearby public taps.	**HI** People identify trees that are damaged or at risk of falling. **AI** Remote sensing using satellite images and LiDAR data to determine which trees may be at risk of falling. This is combined with data from distributed stability sensors on large trees. AI agents notify tree officers and nearby citizens if trees are at risk of falling.	**HI** People tag trees that require pruning or that have fruit. **AI** AI agents analyse data from citizens on available fruit or maintenance needs and notify people nearby or those who have subscribed. ML used to estimate when fruit is ripe from citizen data, tree characteristics and environmental conditions.

4 Impact measurement

	A) Analysing impact	B) Simulating outcomes
KEY CHALLENGE(S)	Difficult to isolate impacts and link to contributor. Different metrics or measurements may be required for different funding mechanisms.	Accuracy of simulated outcomes.
DESCRIPTION	Outcomes and impact data is used to support investment e.g. heat island effect reduction; storm water alleviation; air quality improvement; biodiversity increase; carbon sequestration; improved health and wellbeing.	Simulations help evaluate outcomes of alternative tree planting strategies using agent-based models.
ACI PROCESSES	**HI** Community members work with funding institutions to develop proposals and allocate future funding based on an analysis of measured impacts. **AI** ML algorithms are used to help identify links from measurements to impacts. Data analysis using ML and regression, correlation and clustering analysis of direct and indirect outcomes.	**HI** Community members are involved in making project and funding decisions based on simulated outcomes. **AI** ABMs are used to simulate alternative strategies comparing baseline scenarios to counter-factual scenarios, measuring multi-dimensional and multi-scale outputs over different time horizons.

CIVIC ASSETS

Open ecosystem of components

Technology Readiness Levels of components
- Deployment (TRL 7-9)
- Development (TRL 4-6)
- Research (TRL 1-3)
- Focus for MVP

1 Mapping

TANGIBLE
- Trees

INTANGIBLE

DATA
- Satellite image data - canopy
- LiDAR data - verification
- Citizen verification/photos

AI
- ML canopy algorithm
- ML species ID algorithm

SOFTWARE
- Citizen verification app
- Open Tree Registry

FRAMEWORKS
- Open data standards

2 Monitoring

TANGIBLE
- Trees

SENSORS
- Tree stability
- Soil moisture
- Temp., humidity, rainfall
- Air quality
- Water run off

INTANGIBLE

DATA
- Satellite image data - canopy
- Satellite radar - tree stress
- Citizen data - tree size/health
- Weather data

AI
- ML canopy algorithm
- ML tree stress algorithm
- MV disease detection
- ML surface temp. algorithm

SOFTWARE
- Citizen monitoring app
- Open Tree Registry

FRAMEWORKS
- Valuation metrics/index

3 Maintaining & caring

TANGIBLE
- Trees
- Fruit and timber
- Public taps
- Nutrients/compost bank
- Maintenance tools

INTANGIBLE

DATA
- Citizen data - care given

AI
- AI tree care agent

SOFTWARE
- Tree caring app/dashboard
- Open Tree Registry

FRAMEWORKS
- Participatory care guides

4 Impact measurement

TANGIBLE
- Trees

INTANGIBLE

DATA
- Satellite image data - canopy
- LiDAR data - verification
- Citizen verification/photos

AI
- ABM - planting/felling

SOFTWARE
- Measured impact dashboard
- ABM dashboard

FRAMEWORKS
- Decision framework
- Open data standards

ACRONYMS

ACI	Augmented collective intelligence
AI	Artificial intelligence
HI	Human intelligence
MV	Machine vision
ML	Machine learning
ABM	Agent-based modelling
TRL	Technology Readiness Level
MVP	Minimum Viable Product
LiDAR	Light Detection and Ranging

CivicAI Collective climate action

BLUEPRINT #2/3

CivicAI is a project exploring how AI can enhance collective intelligence to help communities respond to the climate crisis through three near-future use cases. **Read more at civic-ai.org**

Collective climate action imagines a new form of collective deliberation to support ecocentric decision-making. Utilising both feedforward and feedback mechanisms to facilitate climate-positive commitments and sustained behaviour.

The *Blueprint* explores how people and machines could collaborate to respond to the climate crisis. The intention is for it to provide an overview of opportunities for using AI, as well as a framework for connecting organisations who share common challenges or are developing potential solutions.

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STAGES

1 SENSE-MAKING & IDENTIFYING

Building more-than-human shared understanding and a wide range of potential interventions.

2 SIMULATING POTENTIAL IMPACT

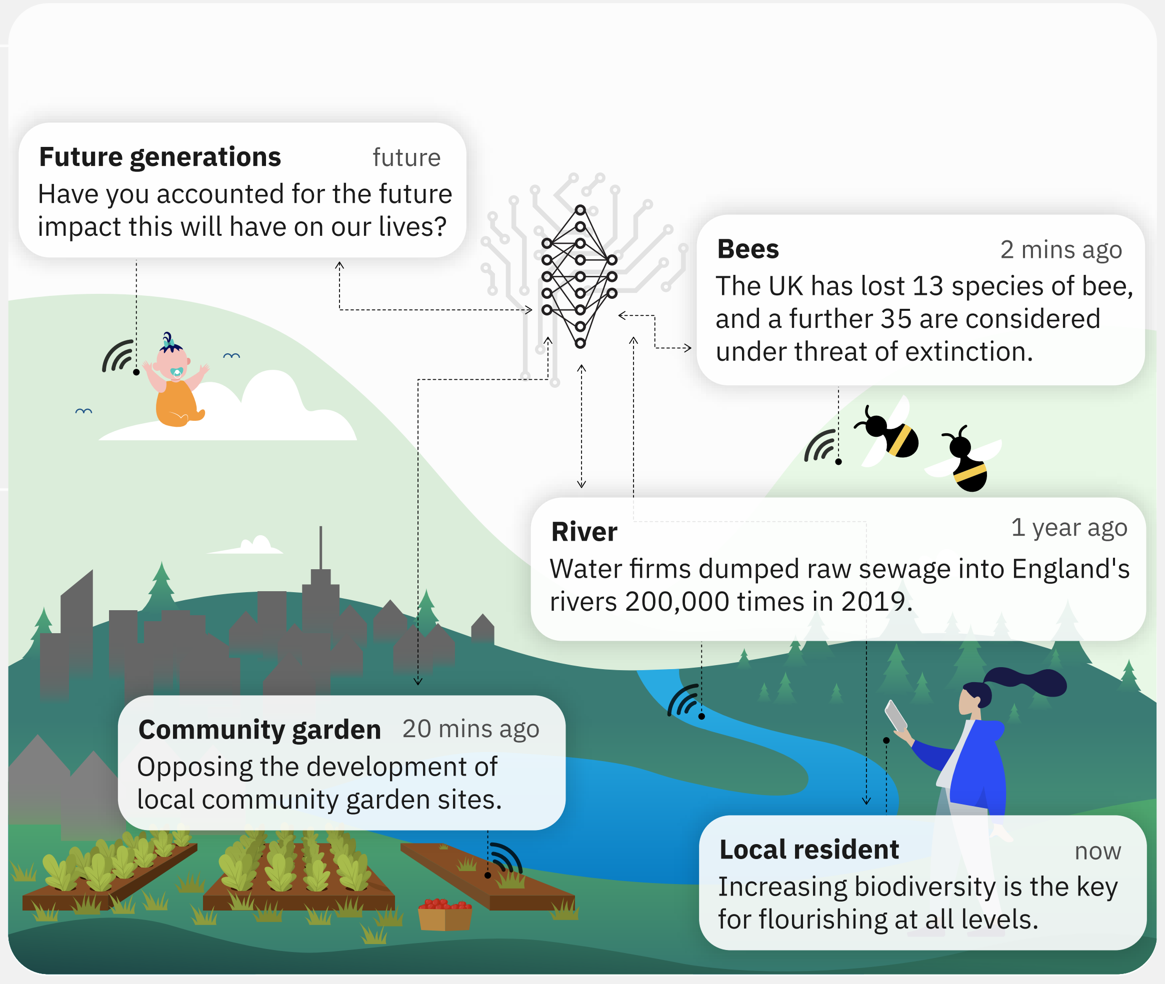
Calculating potential impact of choices to encourage behavioural change.

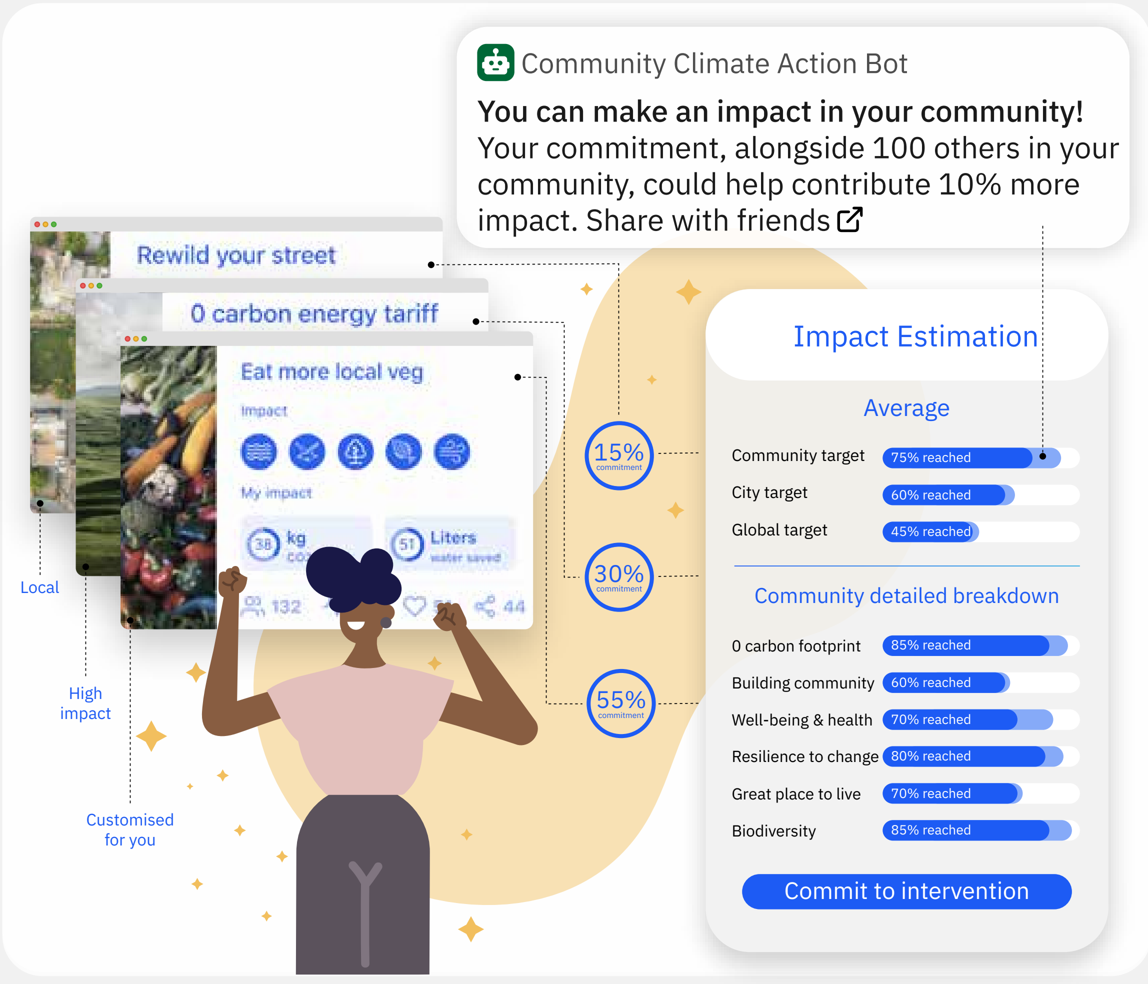
3 FEEDFORWARD & FEEDBACK

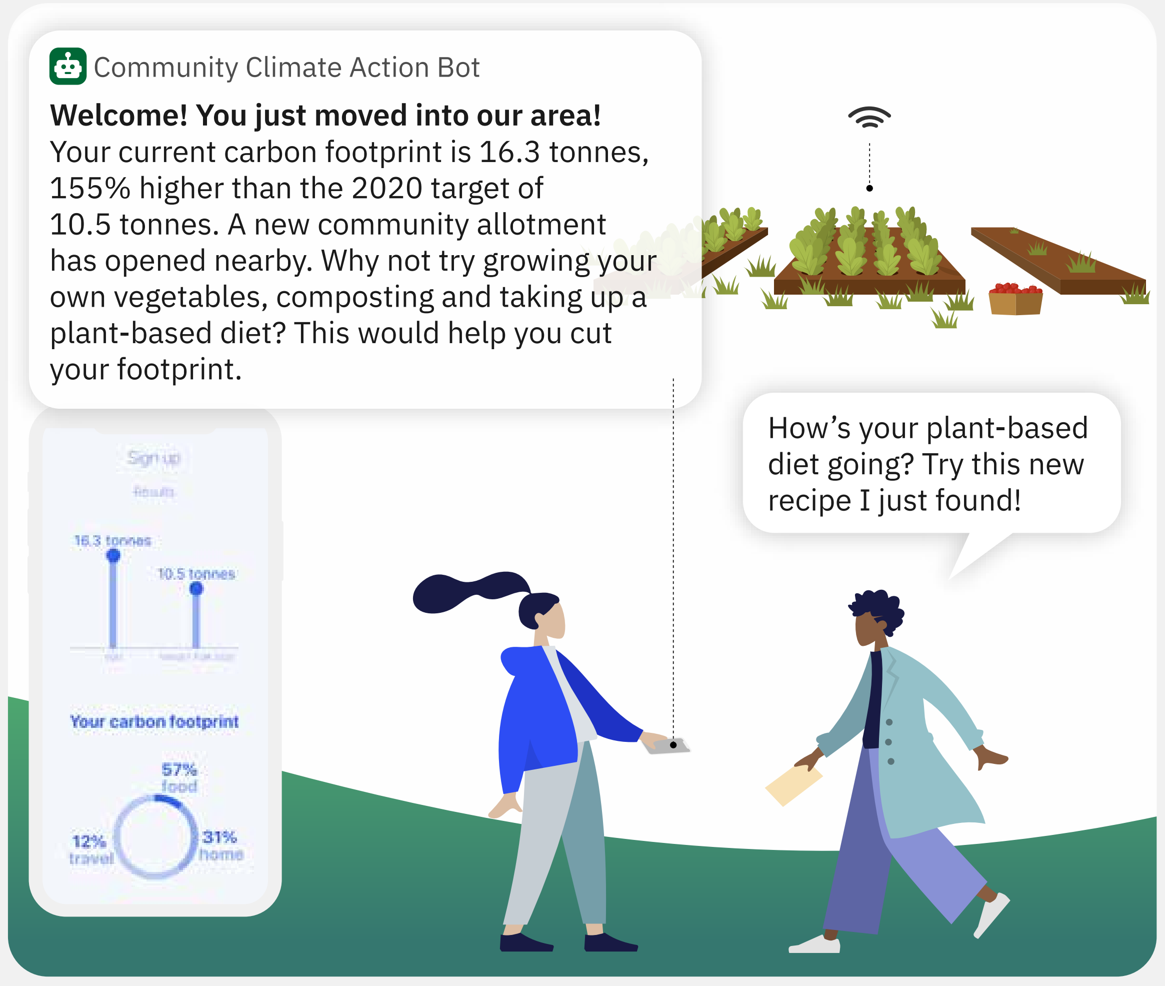
Providing feedback to sustain behavioural change.

SCENARIO

INTERACTIONS



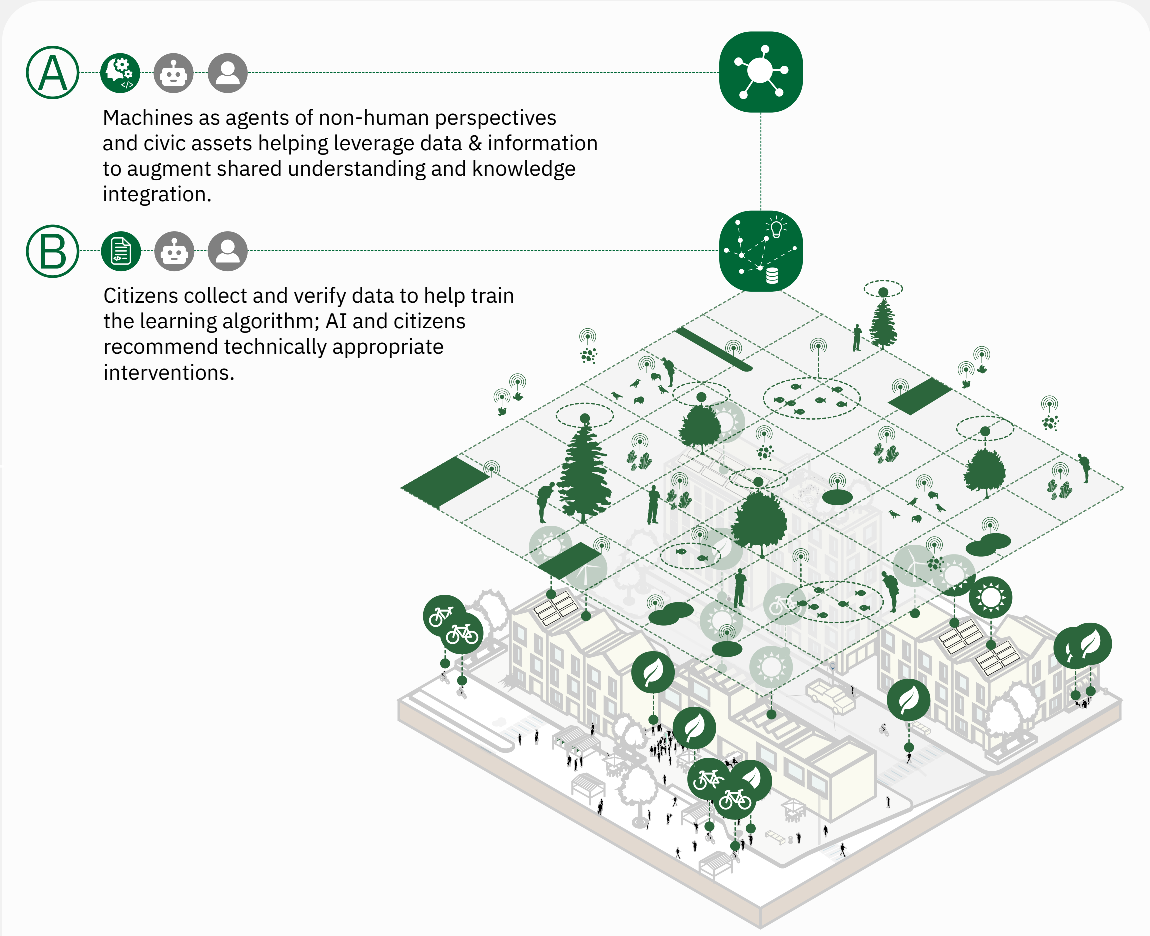


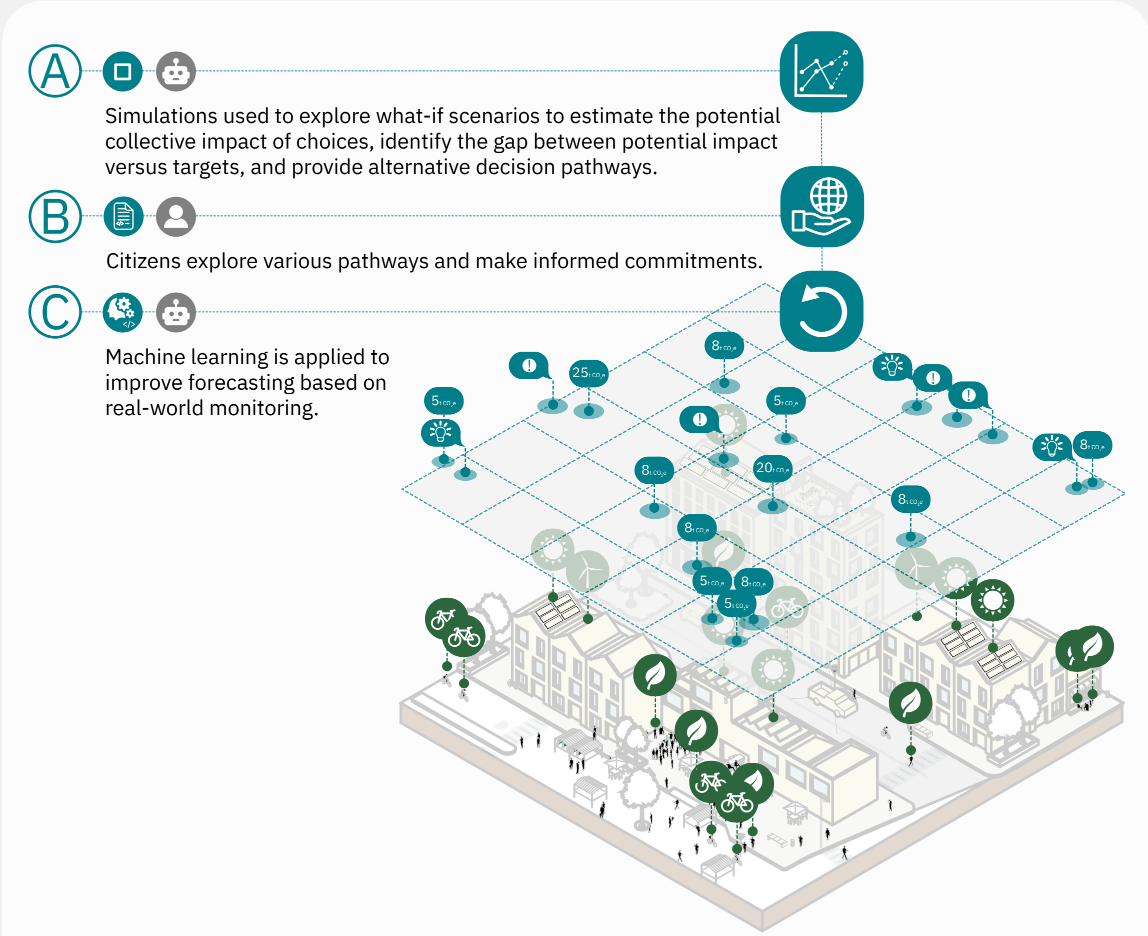


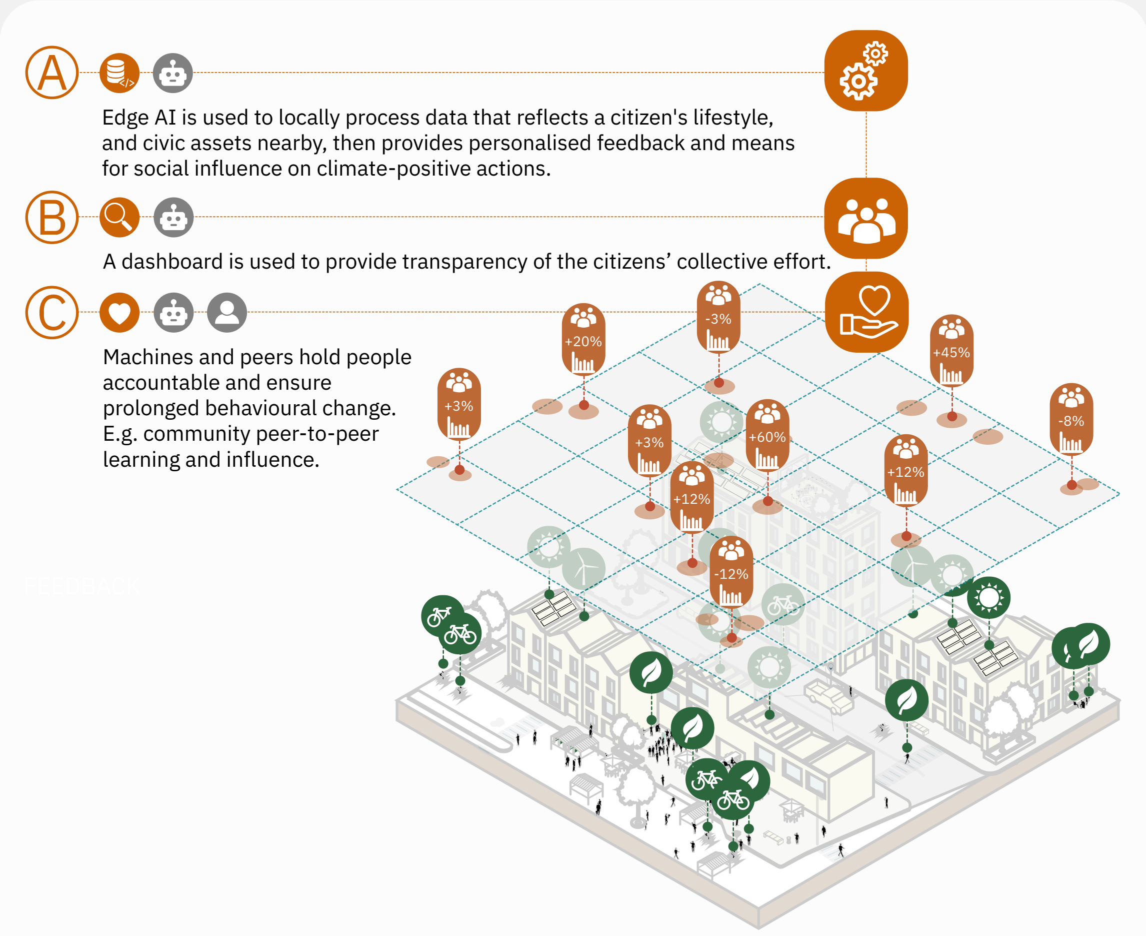
COMPONENTS

People doing tasks

Machines doing tasks







DETAILS

Stage 1: A) Data collection | B) Shared understanding | C) Interventions

KEY CHALLENGE(S) — *for organisations working in this field, which ACI can help to address*

Perspectives - getting stuck in biased and narrow human-centric worldviews, lacking a more ecocentric shared understanding. Overly simplified conceptual frameworks could lead to inaccurate decisions.

Value alignment - incompatible or non-diverse values may impede the attempts of communities to prioritise mitigation and adaption efforts.

A lack of agility in iterating interventions.

DESCRIPTION — *of ACI proposal*

A) Collecting a wide range of data to support relational thinking (understanding systems through relationships) and create the conditions for building holistic shared understanding among humans, non-humans, inanimate things and future generations.

B) Citizens and machines work together to integrate knowledge and democratise deliberation by analysing impacts from an ecocentric perspective.

C) Citizens can propose and contribute to a repository of interventions. Interventions are shown through the lens of customisation, locality, and impact. With the consideration of each agent's boundaries and behaviour, people in the community can come up with appropriate interventions.

ACI PROCESSES — *Overview of activities performed by machines (AI) and people (HI)*

A)
HI
Citizens collect and verify contextual data & quantitative data (e.g. well-being and biodiversity data) to help enrich the database and train the algorithm using citizen sensing kits and a mobile app. Data collection should avoid bias, encourage diverse participation and oversight.

AI
Semantic web technology - machines are capable of analyzing all the data on the Web - the content, links, and transactions between people and machines.

B)
HI
Citizens augment their understanding with emphasis on relational thinking.

Citizens oversee models and algorithms.

AI
Agent-based Modeling - this is employed to model how an actor learn, adopt, interact, and mimic each actor, simulate their interactions with other actors and the environment hence expand our understanding.

Machine Learning - machines update shared understanding based on real-time data input and learning. For example, using machine learning to recognise bees and understand their behaviour.

C)
HI
Citizens explore various pathways and propose potential interventions.

AI
Machine algorithms - synthesising discussions such as finding common view points, highlighting important issues, identifying nuances among similar proposals, summarising discussions.

Agent-based Modeling - simulating civic assets' interactions with others.

New forms of real-time governance through Conviction Voting - continuously sampling preferences can provide instantaneous data that allows people to account for the underrepresented.

CIVIC ASSETS — *Open ecosystem of components*

Tangible
- Community gardens
- Pollinators
- Bacteria

SENSORS
- Air quality
- Biodiversity

Intangible

DATA
- Satellite data - CO2 spread
- Ecology data - biodiversity
- Citizen data - well-being
- Contextual data - stories

AI
- AI agent (e.g. future generations)
- ABM - shared understanding
- ML algorithm
- Digital twin - pollinators

SOFTWARE
- Interventions dashboard
- ABM dashboard

FRAMEWORKS
- System of ontologies
- Simulation / game

Stage 2: A) Impact estimation | B) Social influence | C) Forecasting improvement

KEY CHALLENGE(S)

A) Measuring impact - uncertainty in comparative impacts of alternative actions, leading to a lack of informed commitment and a reluctance to justify upfront investment.

B) A lack of personalised feedback in order to nudge behavioural change.

C) Uncertainty of comparative impacts.

DESCRIPTION

A) Citizens are given an initial forecast of the comparative impact of different actions. Seeing aggregate data of other nearby commitments helps motivate and reassure them to make informed actions and sustain behavioural change.

B) Citizens make different levels of commitments based on social influence and what they can do. Individual impact can be aggregated e.g. 60% of your community is committed to plant-based diet which is contributed to 15% reduction of CO2 emissions.

C) Citizens receive feedback on how accurate the forecasting is.

ACI PROCESSES

A) and B)
HI
Citizens make informed actions and sustain behavioural change such as plant-based diet and rewild streets.

AI
Run simulations to identify the gap between the potential impact of local actions and what is required to meet national climate targets.

Run simulations to estimate impacts of alternative pathways and scenarios via a digital twin. Self-learning algorithms used to provide impact modeling should be fully transparent and traceable.

Federated learning - understand community choices and predict impact.

Create synthetic data whilst running simulations. Train machines using these data.

Conviction Voting - transforming a continuous data stream of individual levels of commitments into discrete acceptance of interventions. When the level of individual commitments are aggregated, rich temporal data stream of collective impact is created.

C)
HI
Citizens provide feedback for machine learning.

AI
Machine learning - this is applied to improve impact estimation based on real-world monitoring.

CIVIC ASSETS

Tangible
- Community gardens
- Local farm shop
- Pollinators
- Bacteria

Intangible

DATA
- Social impact data
- Satellite data - CO2 spread
- Ecology data - biodiversity

AI
- AI agent (e.g. future generations)
- ML forecasting algorithm
- ABM - impact model
- Simulation - gap analysis

SOFTWARE
- Commitment dashboard
- Simulation dashboard
- Impact dashboard (feedforward)

FRAMEWORKS
- Dynamic decisions
- Smart legal contracts
- Simulation / game

Stage 3: A) Lifestyle pattern | B) Reinforcement | C) Aggregated effort

KEY CHALLENGE(S)

A lack of personalised feedback in order to successfully nudge behavioural change.

Sustained commitment - a lack of mechanisms to support sustained long- term collective commitment.

DESCRIPTION

A) Climate positive interventions are suggested based on nearby civic asset and individuals' lifestyle. This acts as a feedforward mechanism, before making commitments.

B) Machines and peers hold each other accountable to ensure prolonged behavioural change.

C) A dashboard is used to provide transparency of the citizens' collective effort.

ACI PROCESSES

A)
HI
Citizens commit to climate positive actions and provide feedback for machine learning.

AI
Edge AI - this is used to locally process data that reflects a citizen's lifestyle and civic assets nearby, then provide personalised feedback and means for social influence on climate-positive actions.

Recommendation system - this could be used to provide suggestions of commitments. Self-learning algorithms used to provide recommended actions should be fully transparent and traceable.

B)
HI
Citizens provide peer-to-peer learning and social influence in order to hold each other accountable and prolong behavioural change.

AI
Machines show how close the citizens are to the trajectory in order to hold citizens accountable and prolong their behavioural change.

C)
HI
Citizens prolong their commitment based on real-time collective impact and gaps towards desired targets.

AI
Machines provide real-time collective effort and the gap between current and desired targets.

CIVIC ASSETS

Tangible
- Community gardens
- Local farm shop
- Pollinators
- Bacteria

Intangible

DATA
- Purchase history
- Lifestyle survey
- Civic assets location

AI
- AI agent (e.g. future generations)
- Edge AI - lifestyle analysis
- ML algorithm - gap analysis

SOFTWARE
- Lifestyle carbon calculator
- Collective effort dashboard
- Impact dashboard (feedback)

FRAMEWORKS
- Machine & human influence
- Simulation / game

Technology Readiness Levels of components
- Deployment (TRL 7-9)
- Development (TRL 4-6)
- Research (TRL 1-3)
- Focus for MVP

ACRONYMS

ACI	Augmented collective intelligence	MV	Machine vision
AI	Artificial intelligence	ML	Machine learning
HI	Human intelligence	ABM	Agent based modelling

CivicAI

BLUEPRINT #3/3

Participatory energy

CivicAI is a project exploring how AI can enhance collective intelligence to help communities respond to the climate crisis through three near-future use cases. **Read more at civic-ai.org**

Participatory energy explores how communities could adopt Augmented Collective Intelligence to help set-up, operate, maintain and model the financial and social outcomes of community energy projects.

The *Blueprint* outlines how people and machines could collaborate in this area. It provides an overview of opportunities for implementing community-led AI systems, as well as a framework for connecting organisations who share common challenges or are developing potential solutions.

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STAGES

1 PLANNING
The process of planning and setting up a community energy project can be made less resource intensive and less risky by integrating ACI.

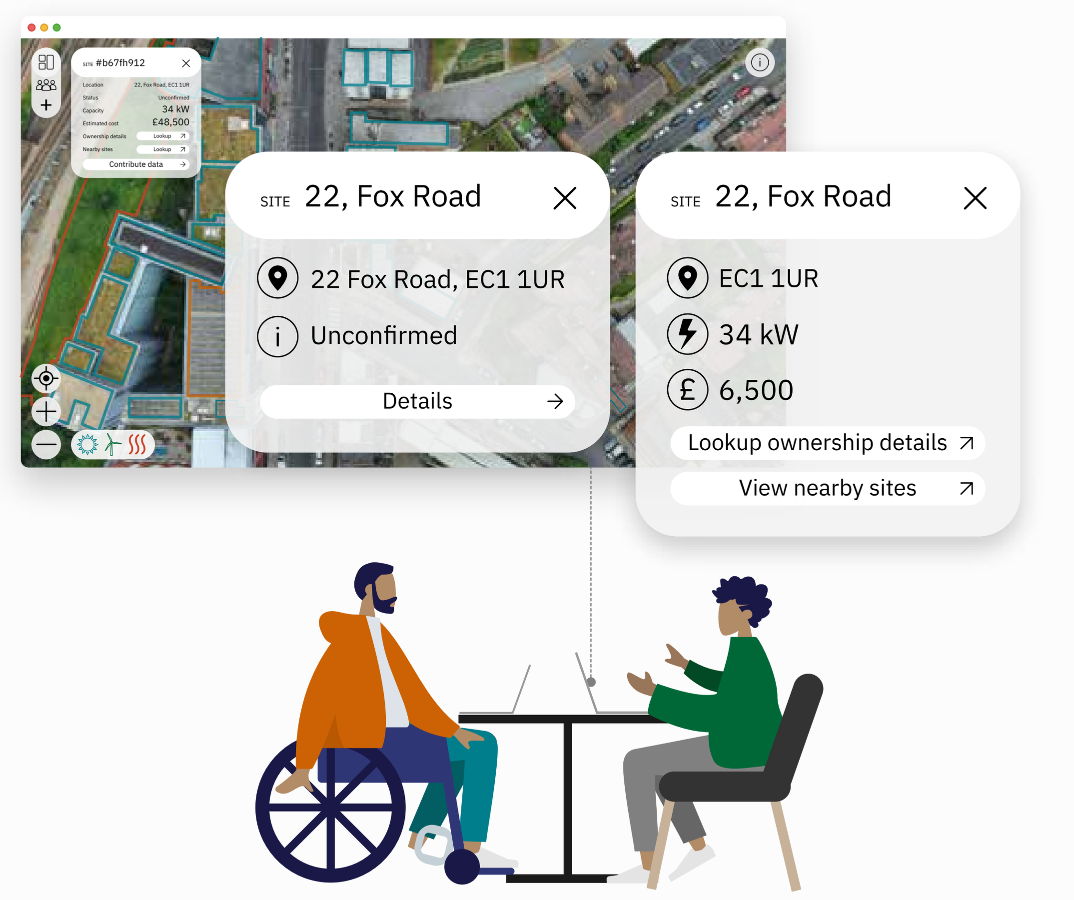
2 FINANCING
ACI can help to streamline project financing by forecasting revenue and social impact and linking investments to smart contracts.

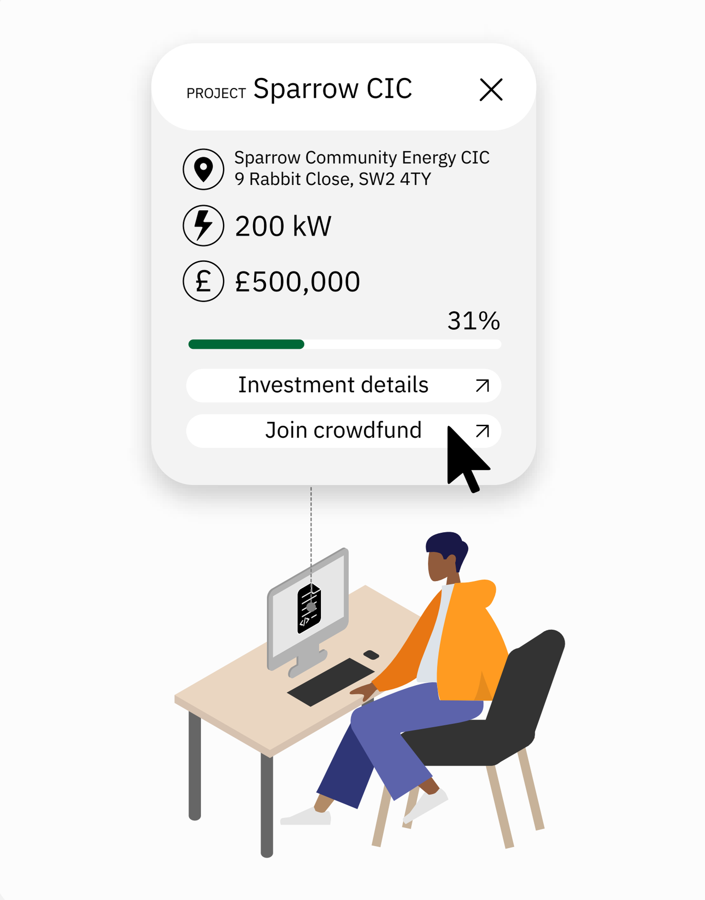
3 OPERATING
During the operating phase of a project, AI agents can help people to balance local production and use of energy, as well as guiding participatory maintenance based on data from distributed sensors.

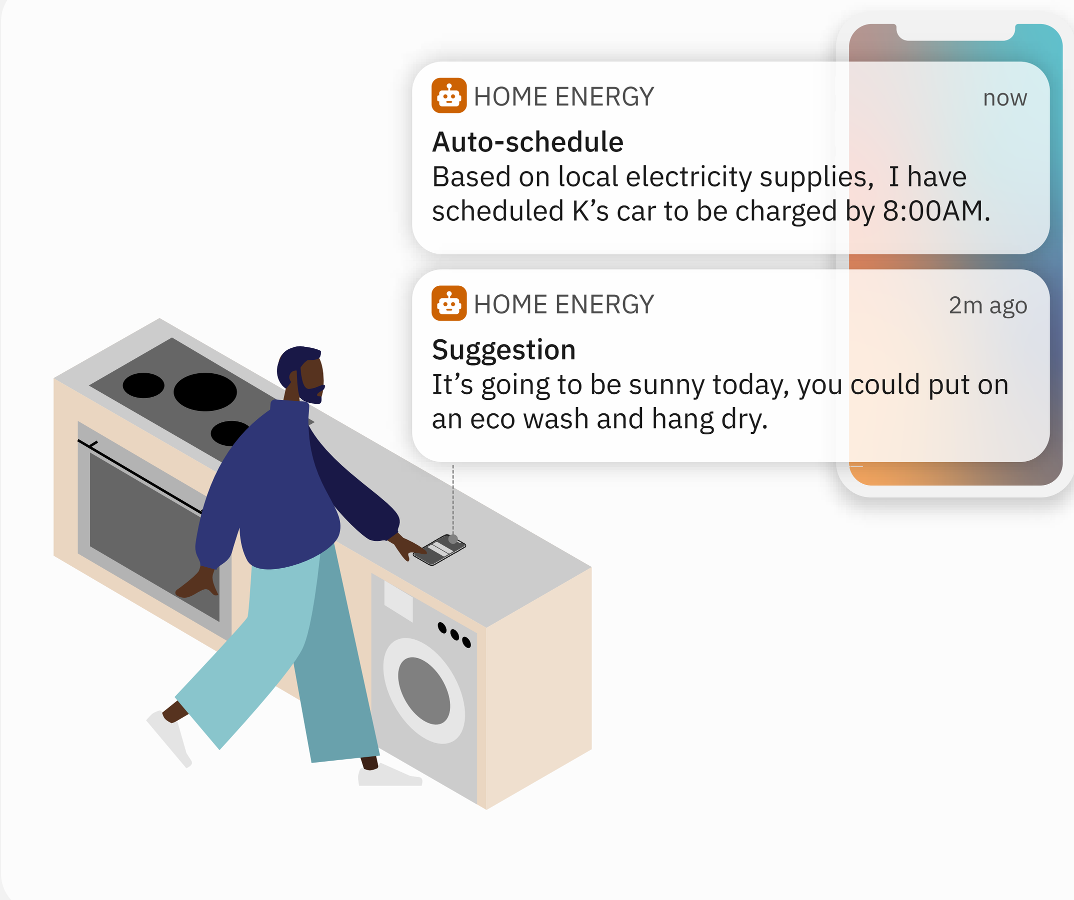
4 MODELLING
Lifetime revenue and social impact of individual community energy projects can be modelled to measure and evidence aggregated impacts across multiple projects.

SCENARIO

INTERACTIONS







COMPONENTS

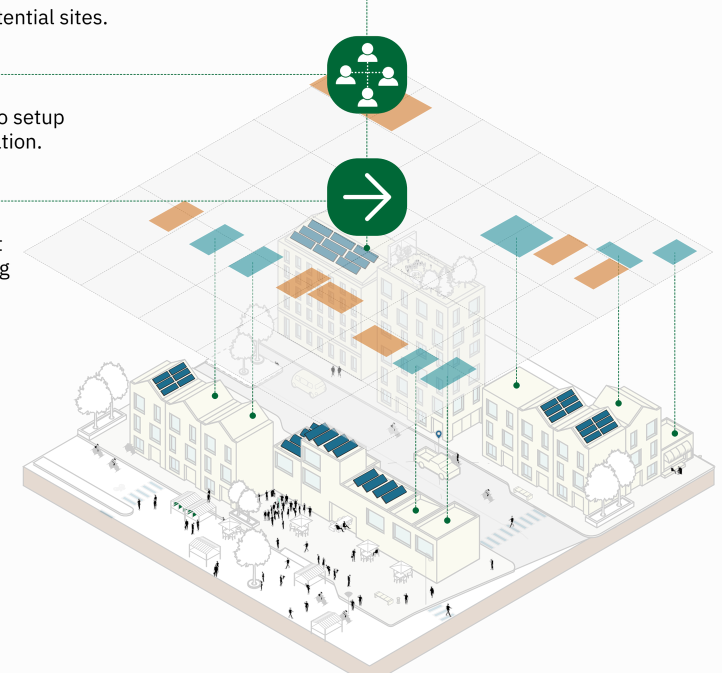
- People doing tasks
- Machines doing tasks

1 Planning

(A) Satellite imagery and ML algorithms used to automate the mapping of sites.
Citizens verify data or tag potential sites.

(B) An AI agent guides citizens to setup suitable community organisation.

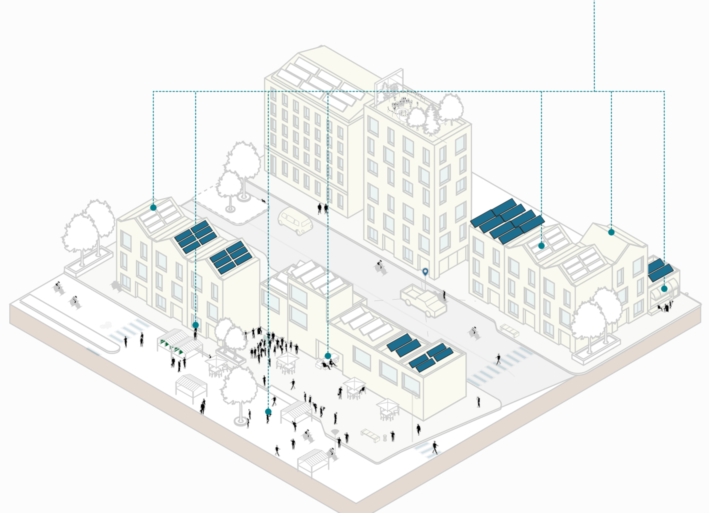
(C) Citizens co-develop a project plan using financial modelling from historic projects.



2 Financing

(A) Share offer integrated with existing investment platforms.

(B) Digital investment contracts automatically transfer initial investment & future revenue distribution.

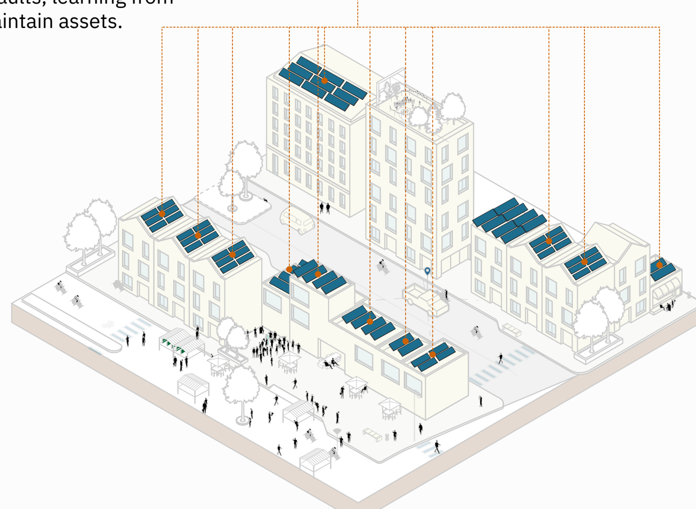


3 Operating

(A) Smart meters automatically collect energy use and supply data, feeding a digital twin of the local grid.

(B) Autonomous agents help balance local energy demand and supply, citizens adapt consumption patterns.

(C) Distributed sensors monitor faults, learning from historic data, citizens help maintain assets.

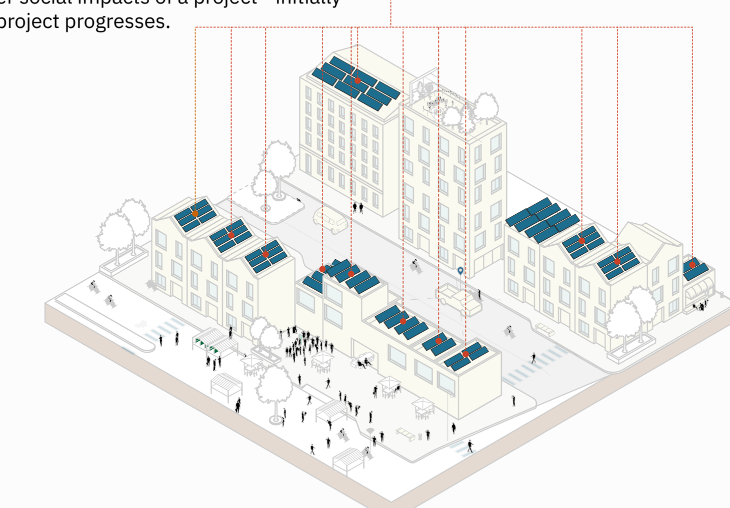


4 Modelling

(A) Machines are used to analyse historic demand & supply patterns to forecast mismatches & balance usage.

(B) Machines help model lifetime revenue for a project - initially as a projection which is updated if a project progresses.

(C) Machines help model wider social impacts of a project - initially a projection, updated if a project progresses.



DETAILS

KEY CHALLENGE(S) — *for organisations working in this field, which ACI can help to address*

DESCRIPTION — *of ACI proposal*

ACI PROCESSES — *Overview of activities performed by machines (AI) and people (HI)*

1 Planning

	A) Mapping sites	B) Organisational setup	C) Developing plan
KEY CHALLENGE(S)	Time consuming and resource intensive to do manually. Creating consistent datasets that are easy to verify.	Process is time consuming, paper based and not easily replicated. Currently requires specialist and context specific legal advice which is expensive.	Reducing admin costs and dependence on volunteers. Funding the pre-financing work.
DESCRIPTION	AI helps to automate mapping potential sites for community energy projects - identifying rooftops suitable for PV panels; land suitable for wind turbines or ground source heat pumps etc. Land ownership data is retrieved from the Land Registry.	A replicable process for setting up a community energy organisation using easily replicable and adaptable legal templates, appropriate for a range of contexts. Integrating smart contracts and linked datasets to automate data collection.	Machines help develop a local energy plan identifying: potential capacity; site ownership or lease details; required investment; technical feasibility; financing strategy and social impact.
ACI PROCESSES	**HI** People tag potential sites, verify automatically identified sites and map existing energy infrastructure. **AI** MV and ML algorithms used to automatically process satellite images and calculate site production capacity. An AI agent proposes energy generation potential to land owners or potential investors.	**HI** People provide context specific information such as organisational rules, members and their positions and bank account details etc. **AI** An autonomous agent guides people through the community organisation setup process. ML used to learn most appropriate organisational structure for given contexts.	**HI** People provide context specific information such as historic energy use, existing available funding and building details etc. **AI** AI agents analyse contextual data - no. of houses, total historic energy demand, location etc. to help specify technical requirements.

2 Financing

	A) Share offer	B) Investment contract
KEY CHALLENGE(S)	Attracting local investment. Minimising admin costs. Collecting relevant data to link to investment contracts.	Minimising admin costs and paperwork required. Adaptable for different types of financing - crowdfund, bond, grant etc.
DESCRIPTION	An investment dashboard shows potential returns and impact for each project, using open APIs to integrate with crowdfunding platforms. If funded, smart investment contracts are automatically created.	Smart investment contracts identify: an individual's investment and corresponding ownership; future purchasing agreements; revenue distribution details. They are linked to a site and transferable with lease or ownership transfer.
ACI PROCESSES	**HI** People coordinate marketing of project and opportunity for local investment. **AI** Simulations used to model scenarios that consider both financial returns, environmental and social impact.	**HI** People sign investment contracts. **AI** The platform features automated identity verification and management of participants. All automated processes are transparently implemented so they can be audited and interrogated if necessary.

3 Operating

	A) Data collection	B) Load balancing	C) Remote maintenance
KEY CHALLENGE(S)	User engagement. Management of data. Data privacy and security considerations.	Increased complexity from managing demand and supply at a local level. Coordinating behaviours of multiple stakeholders to manage energy demand.	Additional investment in sensors and meters. Data privacy and security considerations.
DESCRIPTION	Automated data collection of local energy demand and supply, using open data standards. Automated billing, accounting for community use vs export to grid.	Autonomous agents help enable demand-side response, balancing supply and demand through auto-scheduling electricity usage or prompting behaviour change.	Distributed sensors help to monitor electricity patterns to remotely and diagnose faults. Data is fed to a digital twin of the energy system which enables predictive maintenance schedules to minimise downtime. Citizens conduct simple maintenance.
ACI PROCESSES	**HI** People see their consumption patterns compared to available supply so they can alter consumption accordingly. **AI** Smart meter data feeds a digital twin of local demand and supply, with automated billing.	**HI** People adapt energy consumption patterns with help from automated feedback and task scheduling to meet personalised targets that are pooled at the community level. **AI** AI agents help to automatically balance demand e.g. when an electric vehicle is charged or used as battery; or prompt behaviour adaptations to match fluctuating supply.	**HI** People participate in maintenance practices - cleaning PV panels, replacing components etc. Technicians conduct skilled maintenance and repairs. **AI** ML algorithms learn from production and consumption patterns to help identify faults. AI agents prompt citizens to maintain energy assets, with collectively set rewards for those conducting maintenance.

4 Modelling

	A) Forecasting	B) Revenue	C) Social impact
KEY CHALLENGE(S)	Open data standards. Computationally resource intensive.	Unpredictability of lifetime costs and revenues; fluctuating energy prices.	Difficult to measure aggregated impact across multiple community energy projects. Currently no incentives for community projects to supply social impact data.
DESCRIPTION	Data modelling to forecast energy demand and supply by analysing historic supply and usage patterns and weather forecast data. Live data fed from digital twin.	Modelling lifetime costs and revenue; and simulating alternative investment and financing strategies, both before a project is implemented, as well as throughout a project.	Modelling wider social impacts both before a project is implemented, as well as throughout a project. Calculating emission reductions; support of local economy; social impacts etc. to provide evidence to attract social impact funding.
ACI PROCESSES	**HI** People can see forecasts and can adapt consumption patterns accordingly. **AI** ML used to analyse historic demand and supply patterns. Resulting forecasts of short and long term energy balance help to identify and prevent potential blackouts. MV used to identify solar panel locations and track cloud movements for short-term forecasting.	**HI** People use simulations to help make investment decisions. **AI** Simulations are run to model a project's lifetime revenues based on analysing the outcomes of similar existing projects, helping to create synthetic data for alternative implementation approaches.	**HI** People use simulation to help make investment decisions and provide evidence for social impact oriented funding. **AI** Simulations are run to model social impacts based on analysing the outcomes of similar existing projects, helping to create synthetic data for alternative implementation approaches.

CIVIC ASSETS

Open ecosystem of components

Technology Readiness Levels of components
- Deployment (TRL 7-9)
- Development (TRL 4-6)
- Research (TRL 1-3)
- Focus for MVP

1 Planning

TANGIBLE
- Energy generation sites

INTANGIBLE

DATA
- Satellite image data - sites
- Site boundary data
- Citizen data - energy use
- Weather data
- Solar exposure data

AI
- ML site algorithm
- AI agent

SOFTWARE
- Citizen dashboard
- Open Site Registry

FRAMEWORKS
- Org. setup templates
- Smart legal contracts
- Open data standards

2 Financing

INTANGIBLE

DATA
- Financial model
- Social impact model

AI
- Impact simulation

SOFTWARE
- Investment dashboard

FRAMEWORKS
- Smart investment contracts
- Open data standards

3 Operating

TANGIBLE
- PV panels
- Batteries/energy storage
- Heat pumps
- Smart meters
- In-home interfaces
- Computing network

INTANGIBLE

DATA
- Energy consumption data
- Energy production data
- Fault data

AI
- ML fault detection algo.
- AI DSR & maintenance agent
- Digital twin - energy system

SOFTWARE
- Energy usage dashboard
- Maintenance dashboard
- DSR app

FRAMEWORKS
- Maintenance guides
- Open data standards

4 Modelling

INTANGIBLE

DATA
- Financial data
- Social impact data
- Weather data

AI
- ML forecasting algorithm
- MV- cloud tracking
- ABM - production & usage
- ABM - impact model

SOFTWARE
- Impact dashboard
- Simulation dashboard

FRAMEWORKS
- Decision-making framework
- Open data standards

ACRONYMS

ACI	Augmented collective intelligence
AI	Artificial intelligence
HI	Human intelligence
MV	Machine vision
ML	Machine learning
ABM	Agent-based modelling
TRL	Technology Readiness Level
MVP	Minimum Viable Product
DSR	Demand Side Response