

Welcome to the D3A Alpha Simulation

Simulation stopped

Example Simulations

Case One Before
Device Prioritization with Sufficient Generation



Device prioritization concept demonstrated by an islanded microgrid containing two homes and one cell tower

[RUN THIS CONFIGURATION](#)

Case One After
Device Prioritization with Sufficient Generation



Device prioritization concept demonstrated by an islanded microgrid containing two homes and one cell tower

[RUN THIS CONFIGURATION](#)

Case Two Before
Device Prioritization with Insufficient Generation



Device prioritization concept demonstrated by an islanded microgrid containing two homes and one cell tower

[RUN THIS CONFIGURATION](#)

Case Two After
Device Prioritization with Insufficient Generation



Device prioritization concept demonstrated by an islanded microgrid containing two homes and one cell tower

[RUN THIS CONFIGURATION](#)

Small Microgrid Configuration
Five Homes and One Cell Tower



Model of a rural islanded microgrid consisting of five homes and one cell tower

[RUN THIS CONFIGURATION](#)

Deep Dive: The D3A

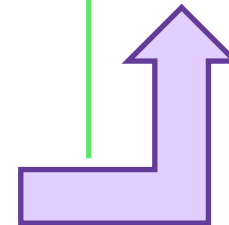
18 April 2018
Event Horizon | Berlin, Germany

Sarah Hambridge, PhD

Outline



1. Background
2. What is the D3A?
3. D3A Market Model Design
4. D3A Roadmap
- 5. The D3A Alpha Simulation and Results**
6. Future Work

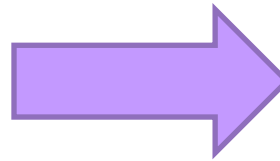


The Modern Grid



Problems and Inefficiencies

- Coordination of an increasing number of electrical devices (IOT)
- Massive power outages from “natural” events
- Parts of the world would like to be electrified
- Slow acceptance of renewable energy due to economical, technical and regulatory hurdles
- Increasing complexity of electricity markets



Yield

New Values

- **Decentralization:** Powered by distributed resources of all types
- **Decarbonization:** Capable of achieving high penetrations of renewable resources
- **Democratization:** Provides the greatest degree of freedom for consumers by increasing choice, improving access, and enabling participation
- **Resiliency:** Resistant to and rapidly able to recover from both physical and cyber disruption.

Specific Problems

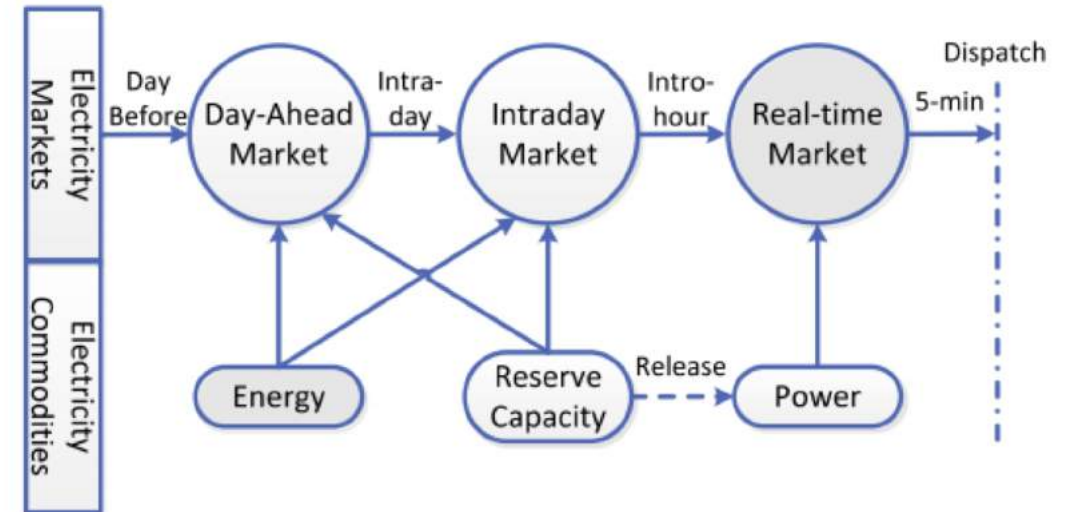


1. Inefficiencies in the Balancing Market: It currently takes several weeks to publish the imbalance price in Germany

2. Blockchain scaling for Peer to Peer Trading: Peer to Peer projects must use smart contracts economically and require a blockchain platform with much higher transaction speed (ex: CryptoKitties)

3. Development of Rural Electrification Projects: Specific loads should be prioritized in grids with limited supply, while avoiding frequent blackouts

4. Prosumers cannot know the true value of their Distributed Energy Resources (DERs) without liberalized markets. A sharing economy is needed for rapid uptake of renewables and energy storage



Solution: What does the D3A Solve?



- The D3A provides a free-to-use modular simulation environment for users to simulate a variety of grid configurations and market models
- The D3A allows anyone to experiment with a decentralized market model, eliminating the barrier of costly simulation tools, and enabling unrestricted transactive energy research
- The D3A will replace the core technical processes of the grid from centralized to decentralized
- Settlement of transactions and balancing in real-time



First Feature: Prioritization of Devices

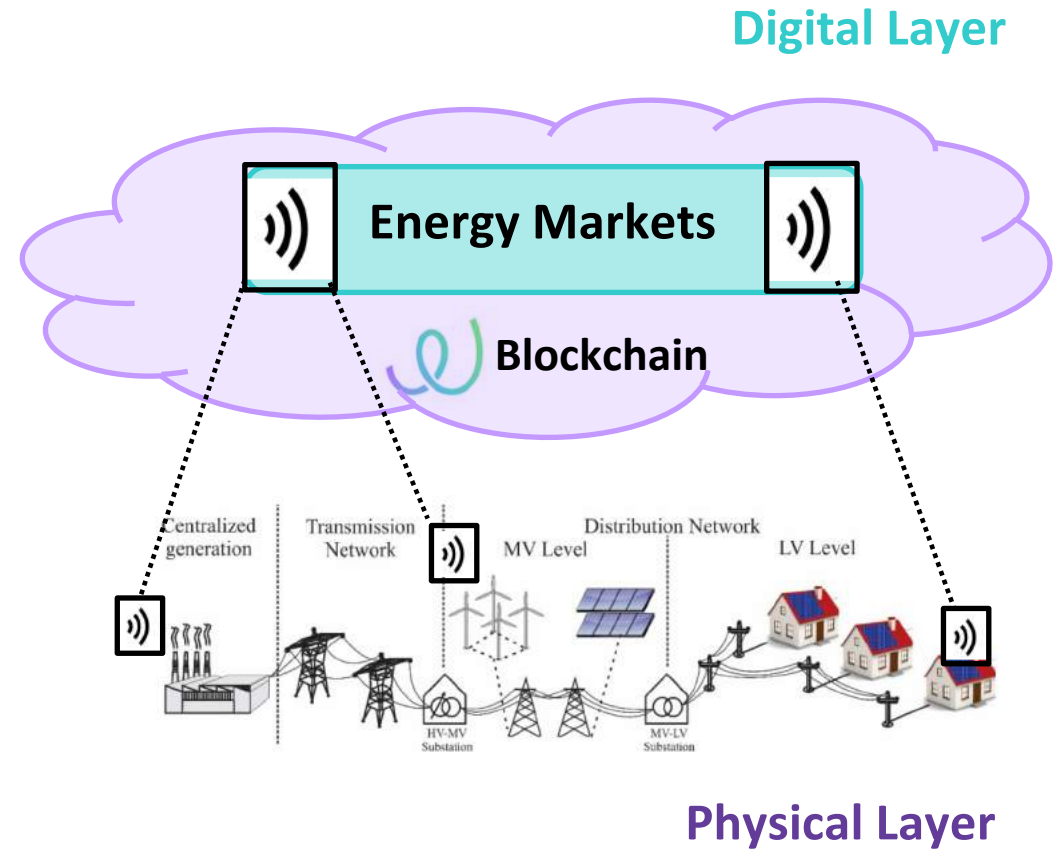
Homeowners can choose which devices continue to consume and which devices go offline in emergency situations or rural grid configurations instead of suffering a complete blackout

What is the D3A?



D3A: Decentralized Autonomous Area Agent

- A Hierarchical Market Model
- For the Transactive Grid
- A Platform on top of the Energy Web Blockchain
- Enables Rapid Uptake and Management of Renewable Energy Resources
- One Agent on Every Energy Producing or Consuming Device
- Energy Transactions Secured by Smart Contracts and Private Transparency





How is it Designed?

The D3A will cover 3 dimensions:

- A **hierarchical market model** for the transactive grid
- A **communications protocol** for devices in the network
- **Hardware** implementation and grid balancing



What Do The Agents Do?

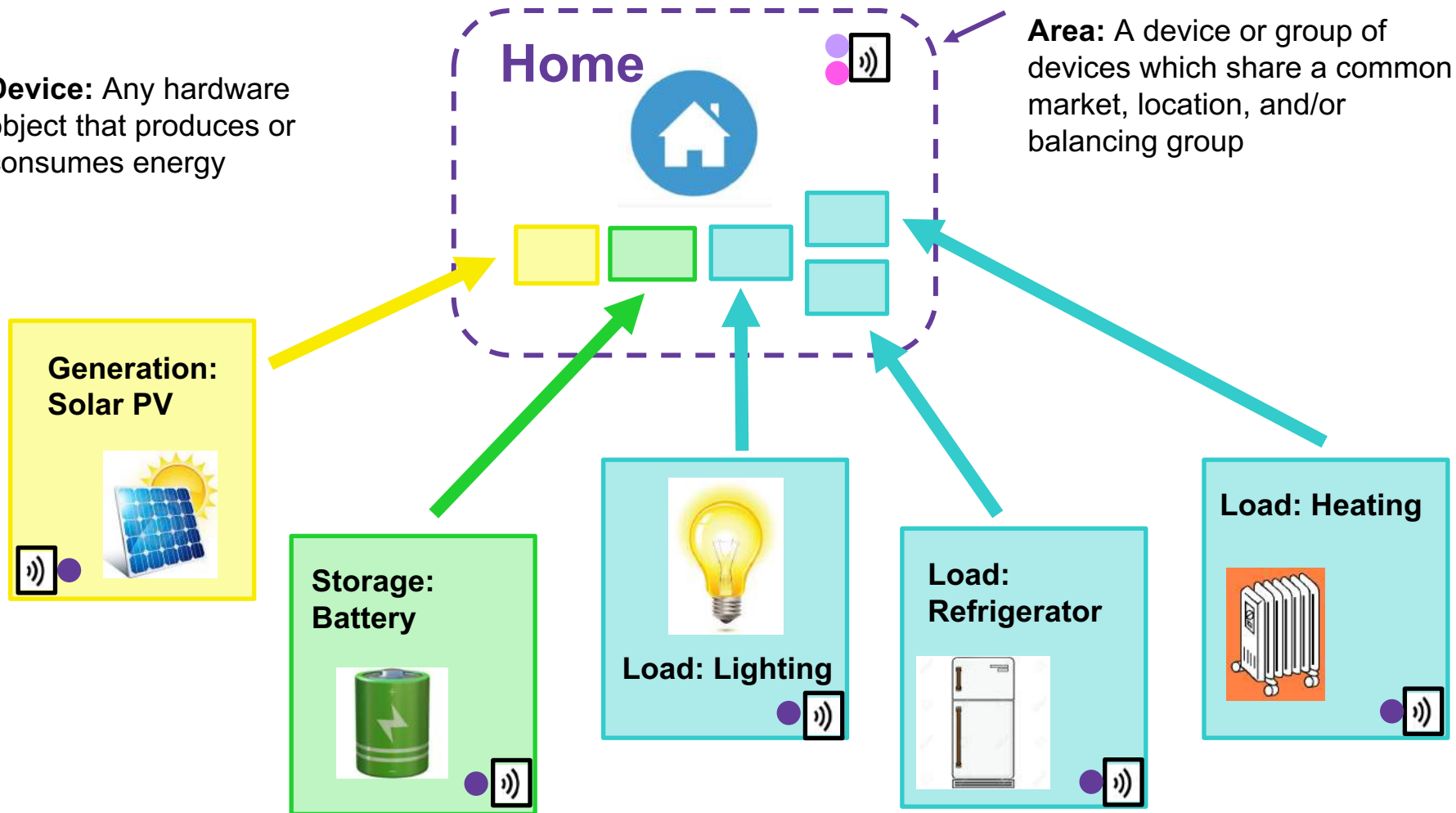
There are three agents currently defined:


1. **Device Agent (DA):** Represents a device in it's parent area market ●
2. **Inter-Area Agent (IAA):** Moves offers from one area market to it's higher and lower hierarchy market ●
3. **Balancing Market Maker Agent (BMMA):** An agent responsible for buying capacity in the balancing market to balance it's area in real-time ●

The D3A Builds Market Models From the Bottom Up

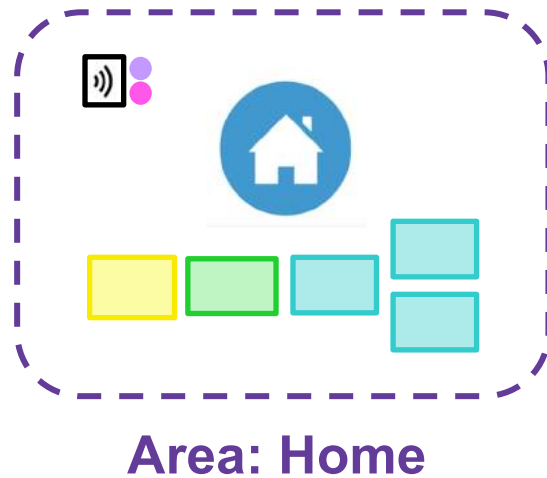


Device: Any hardware object that produces or consumes energy



 **Agent:** An energy trading node which acts in the interest of one or more devices or areas

Spot Markets in Each Area



Default: Four spot markets each of 15 minutes length

Market Participants for this Area:

- IAA Home 1
- Generation: Solar PV
- Storage: Battery
- Load: Lighting
- Load: Refrigerator
- Load: Heating

Spot Energy Market Exchange

[● IAA House -> ● Load: Lighting] 0.012 kWh @ 0.20 euros/kWh

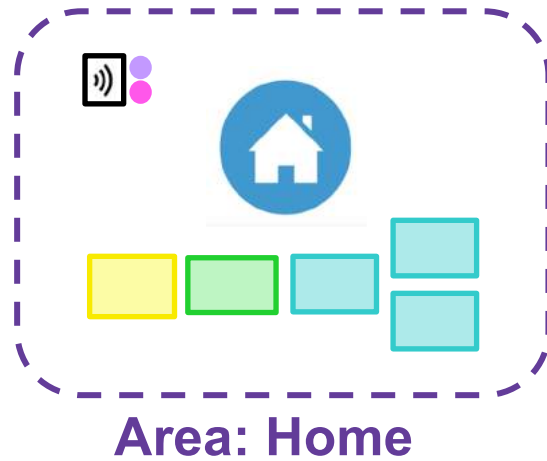
[● Generation: ● Solar PV -> Storage: Battery] 0.250 kWh @ 0.15 euros/kWh

[● Storage: Battery -> ● Load: Refrigerator] 0.021 @ 0.23 euros/kWh

[● Generation: Solar PV -> ● IAA House] 0.051 kWh @ 0.19 euros/kWh

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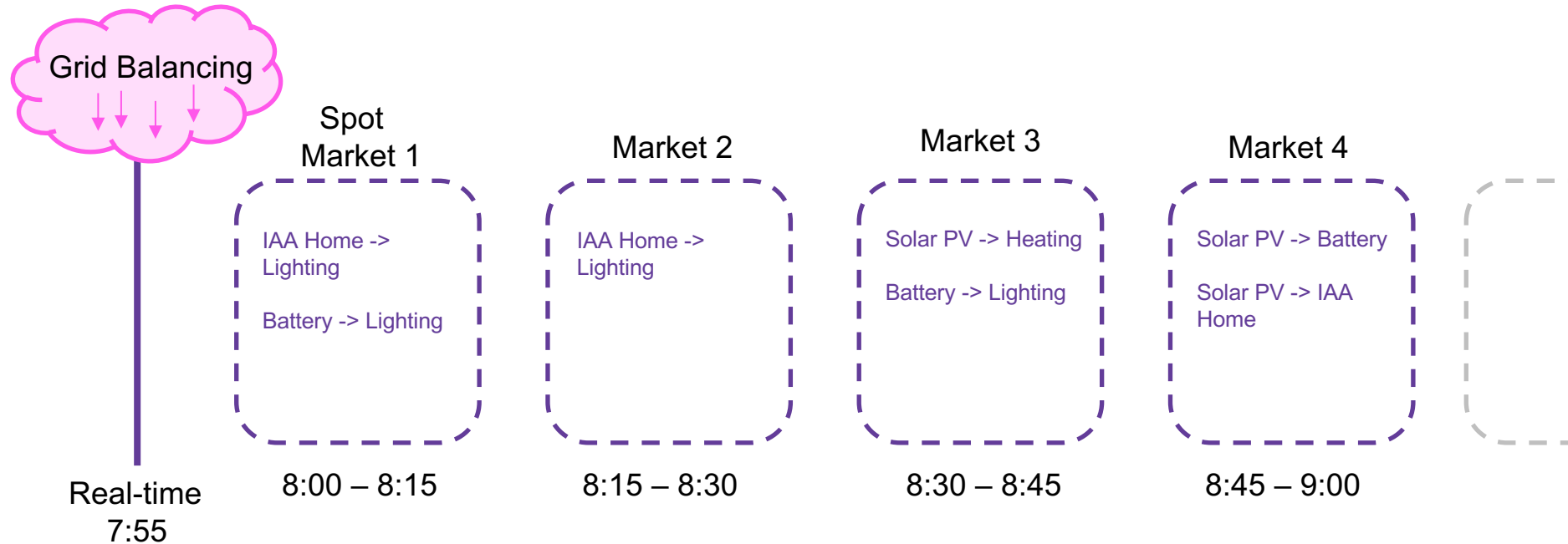
Spot Markets in Each Area



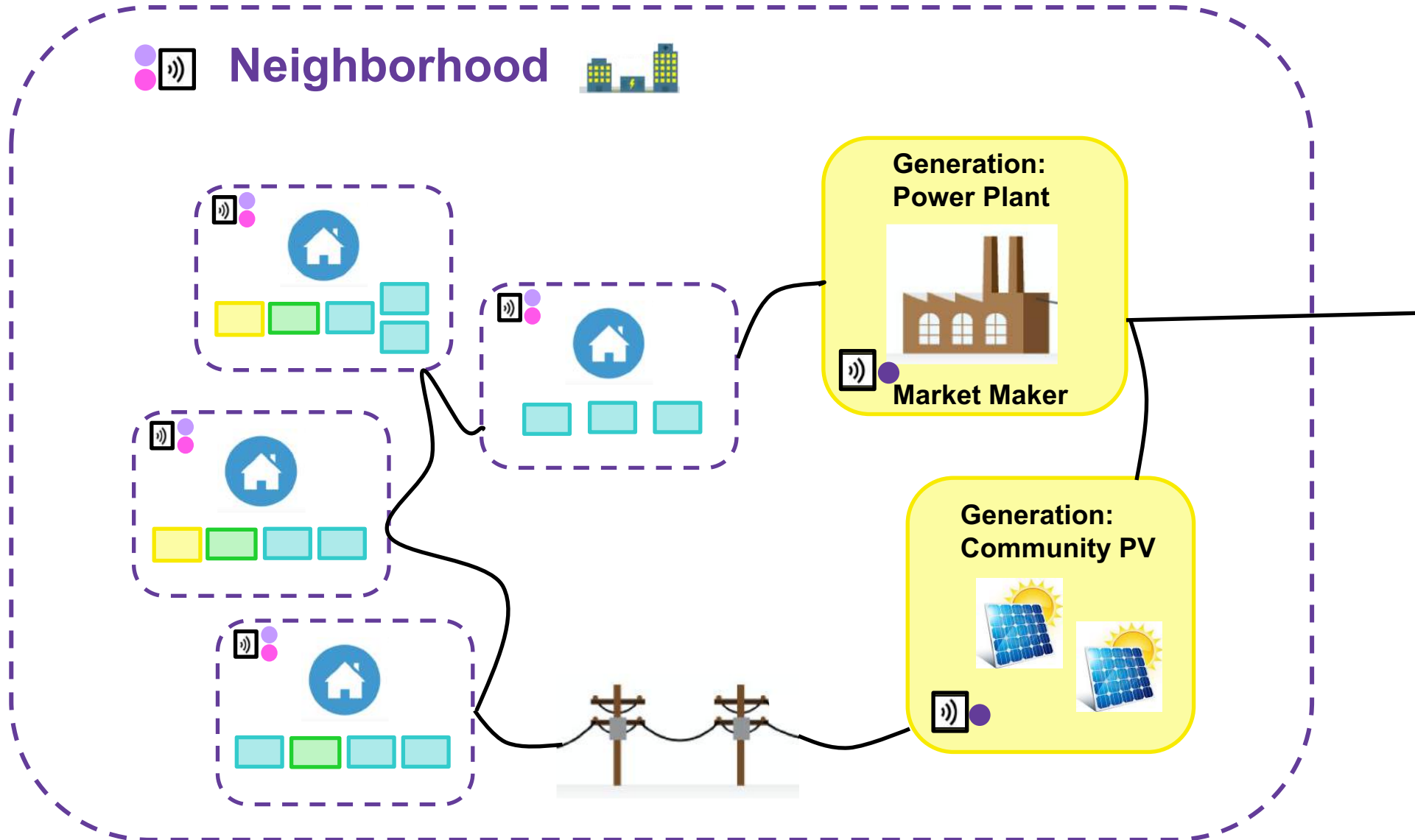
Default: Four spot markets each of 15 minutes length

Market Participants for this Area:

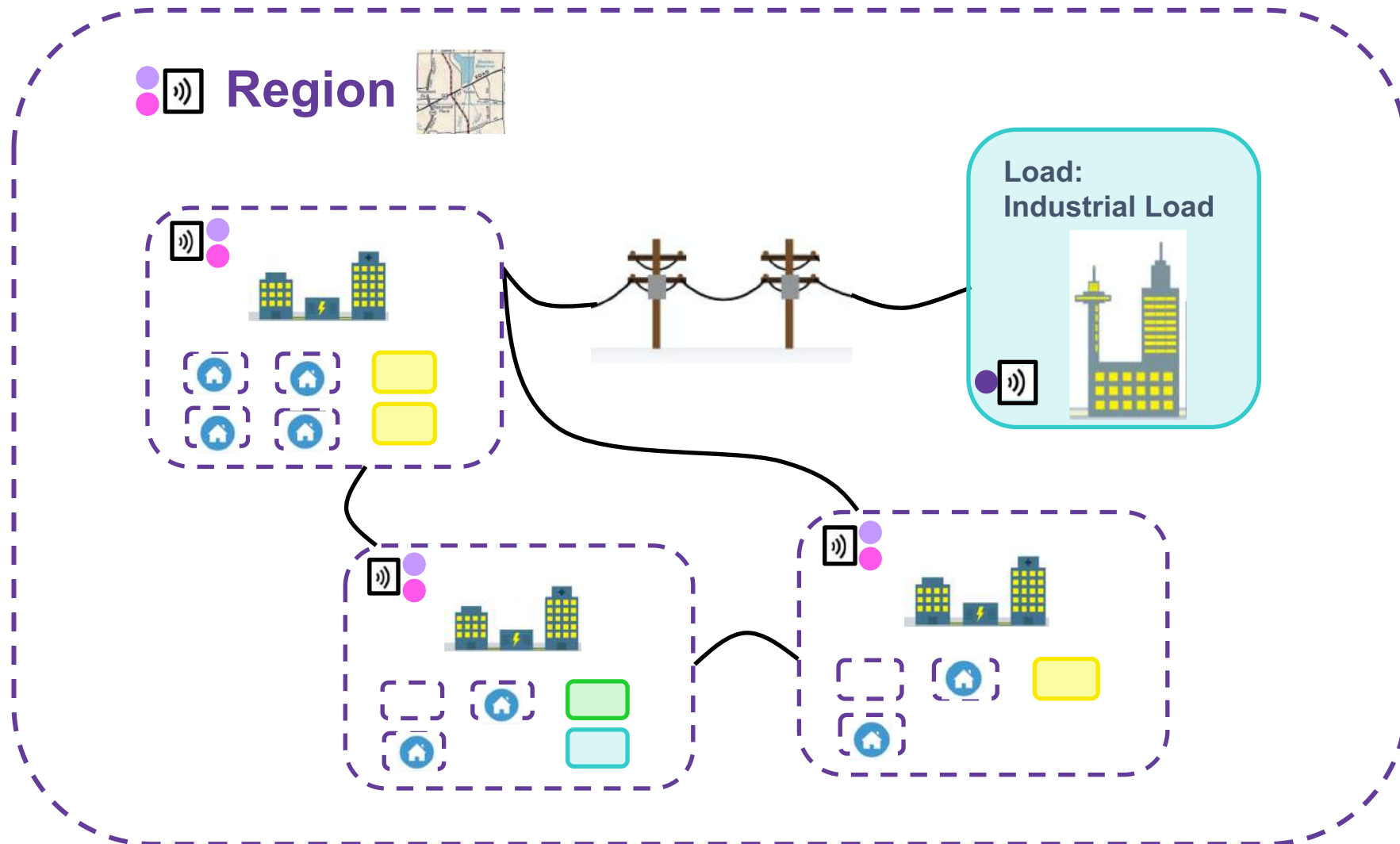
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- Generation: Solar PV
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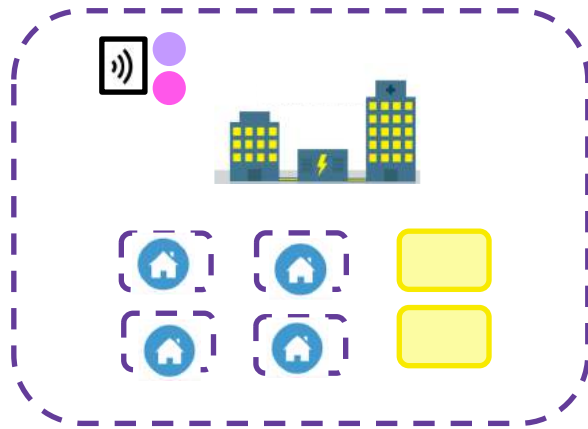
The D3A Builds Market Models From the Bottom Up



The D3A Builds Market Models From the Bottom Up



Spot Markets in Each Area

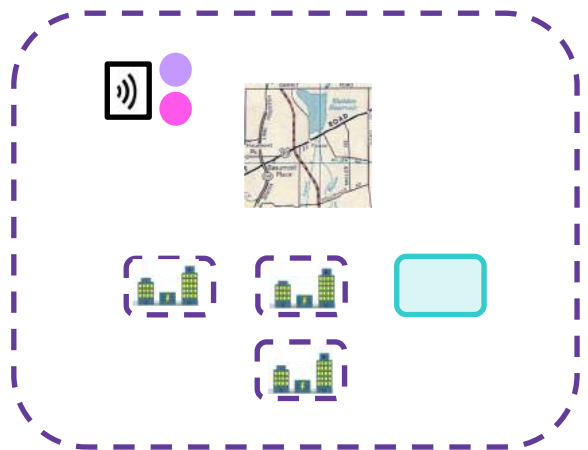


Area: Neighborhood

Default: Four spot markets of 15 minutes

Market Participants for this Area:

- IAA Home 1
- IAA Home 2
- IAA Home 3
- IAA Home 4
- IAA Neighborhood 1
- Generation: Power Plant
- Generation: Community PV



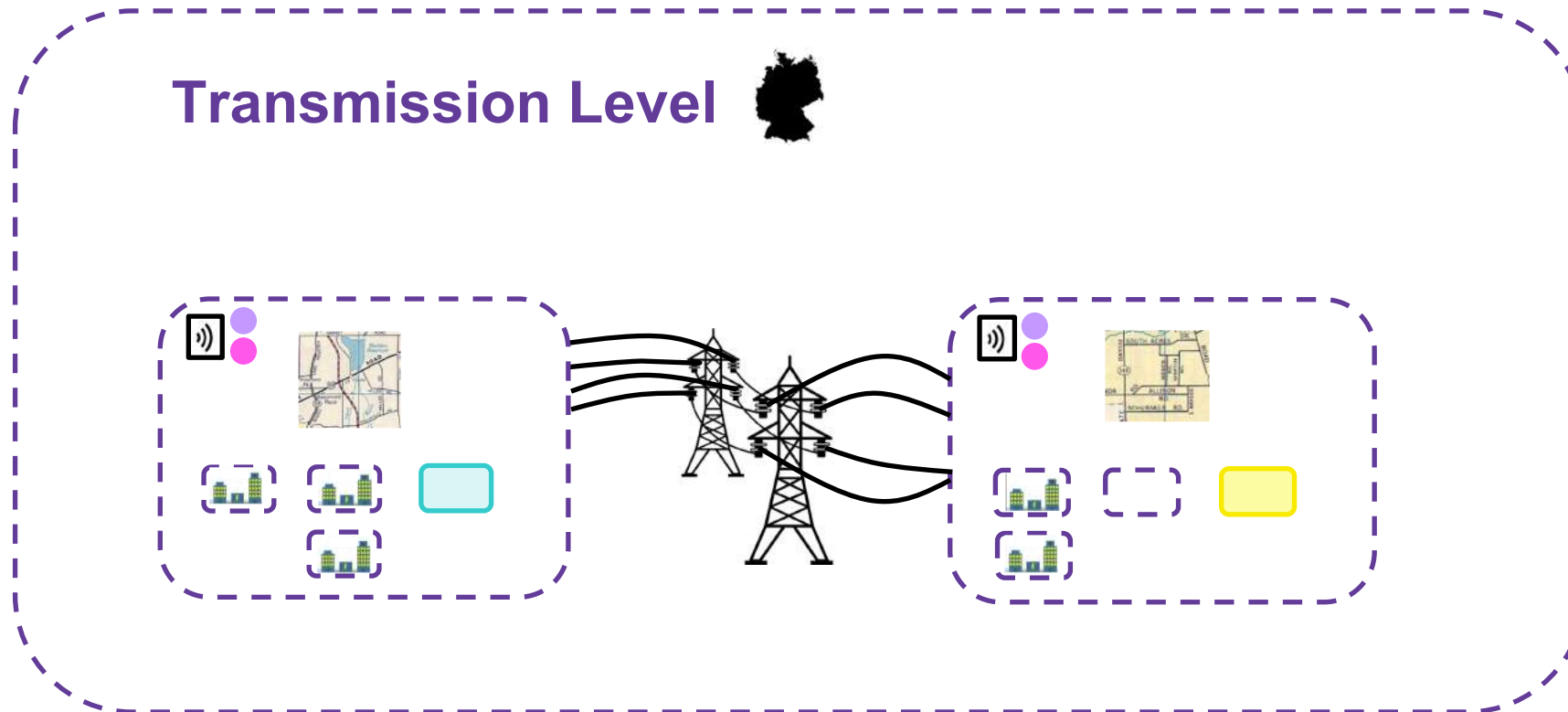
Area: Region

Default: Four spot markets of 15 minutes

Market Participants for this Area:

- IAA Neighborhood 1
- IAA Neighborhood 2
- IAA Neighborhood 3
- IAA Region 1
- Load: Industrial Load

The D3A Builds Market Models From the Bottom Up

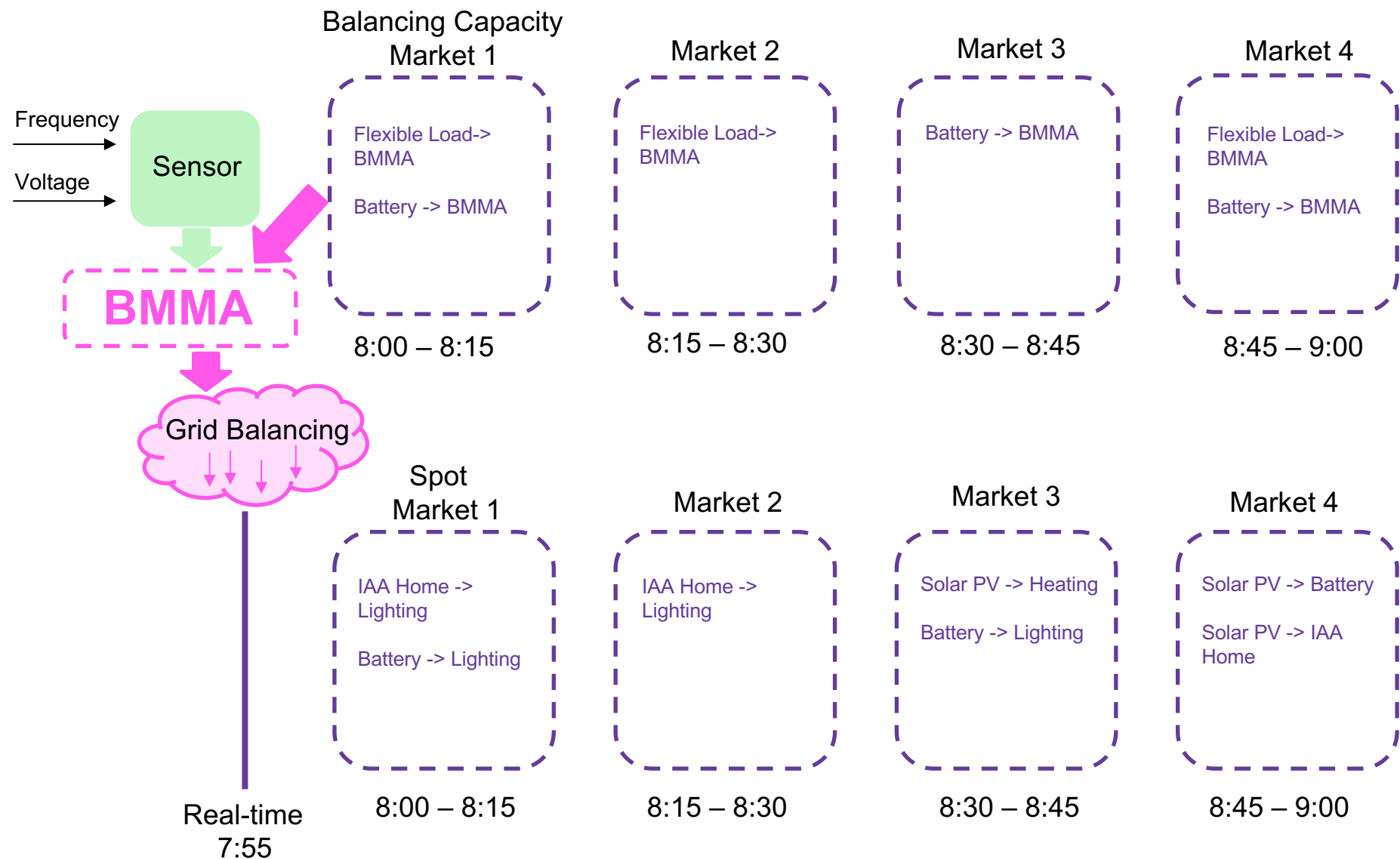


Market Participants for this Area:

- IAA Region 1
- IAA Region 2

Balancing Markets in Each Area

Market Participants: White-list of devices that can provide reliable capacity

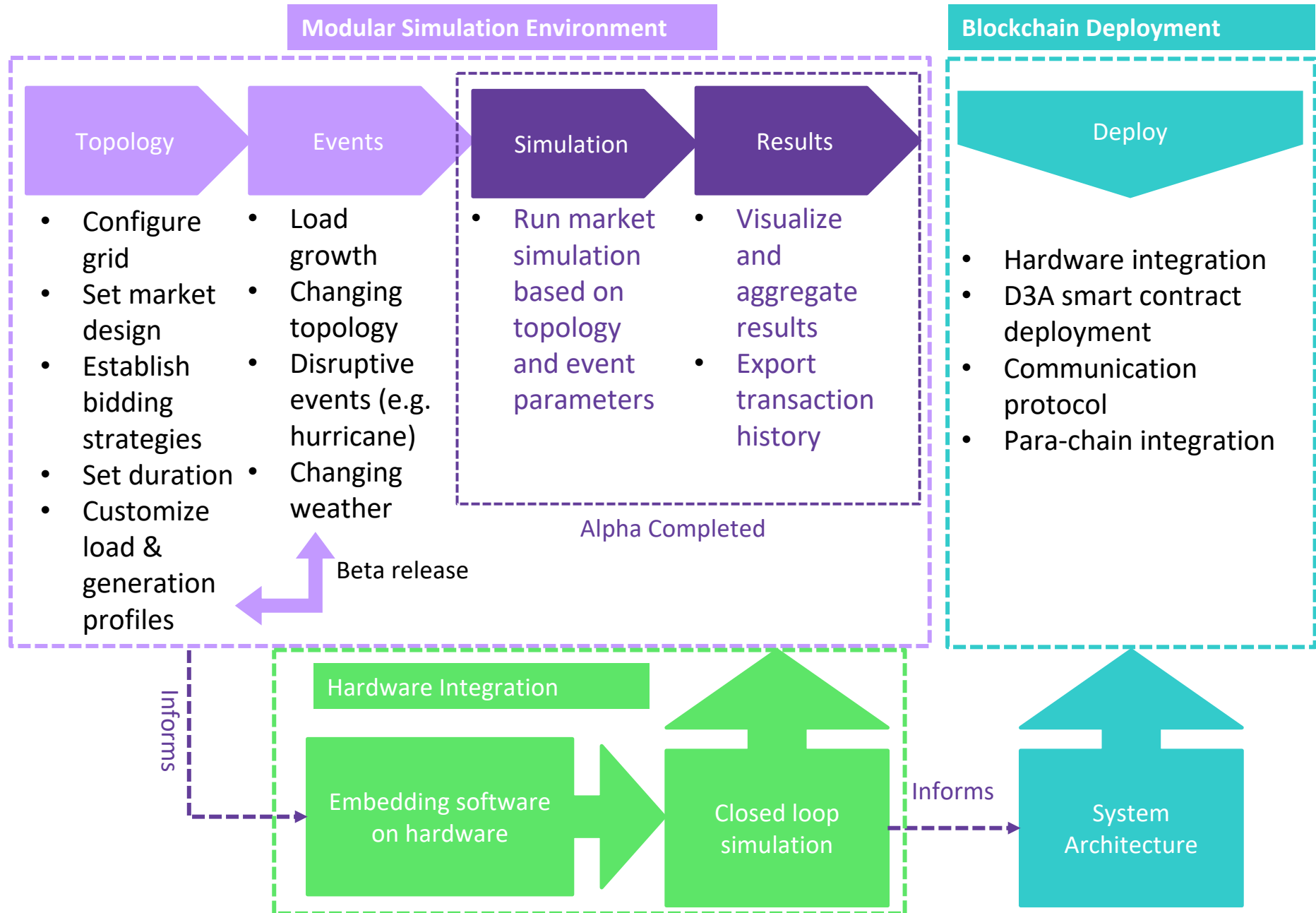


D3A Development Has Been Divided into Five Stages

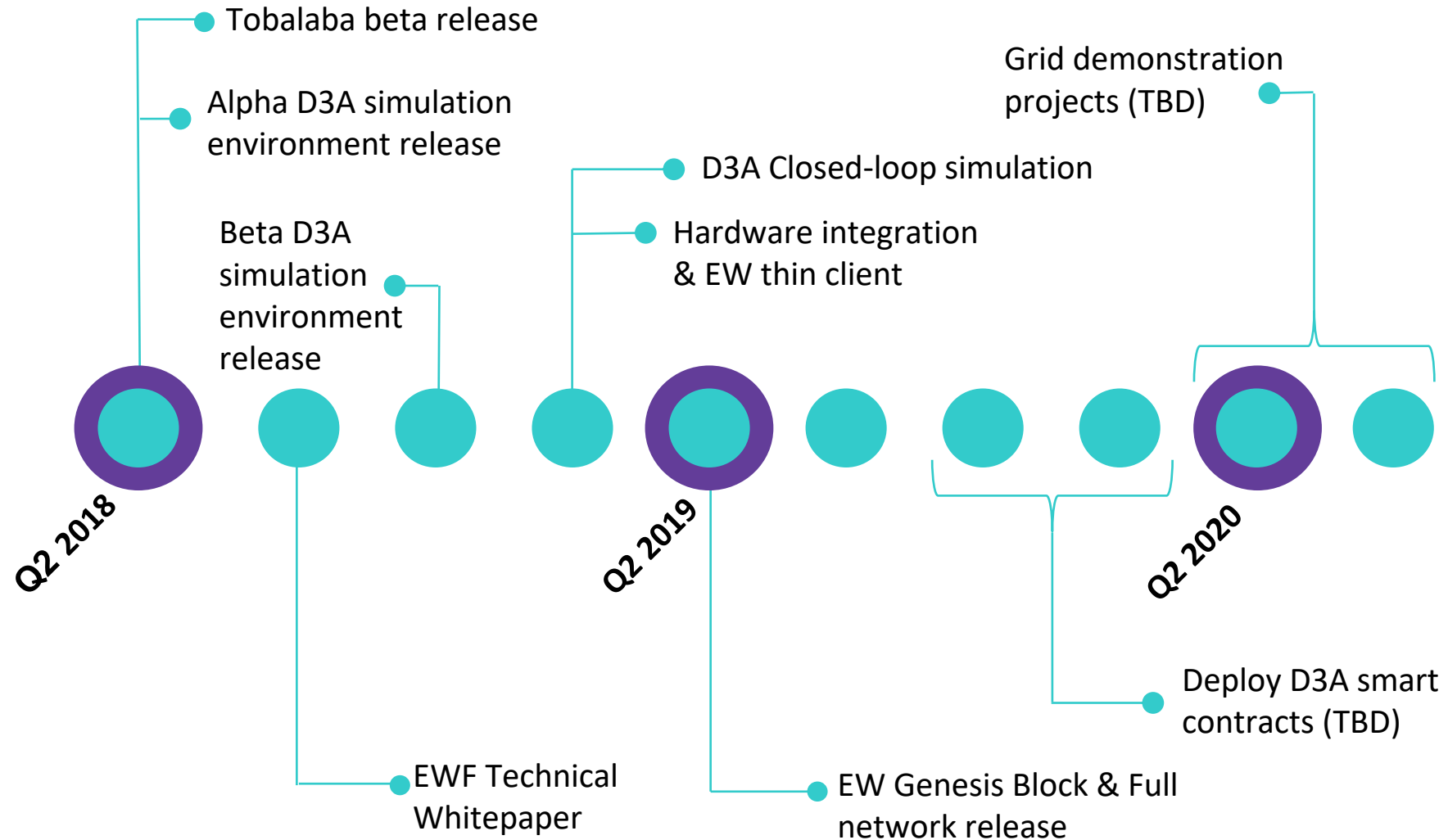


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|-----------------------|-----------------------------|
| 1. Topology: | Grid Configuration |
| 2. Events: | Run-time, changing weather |
| 3. Simulation: | Start Running |
| 4. Results: | Data Analysis and Re-design |
| 5. Deploy: | Print out the code |

D3A Stages



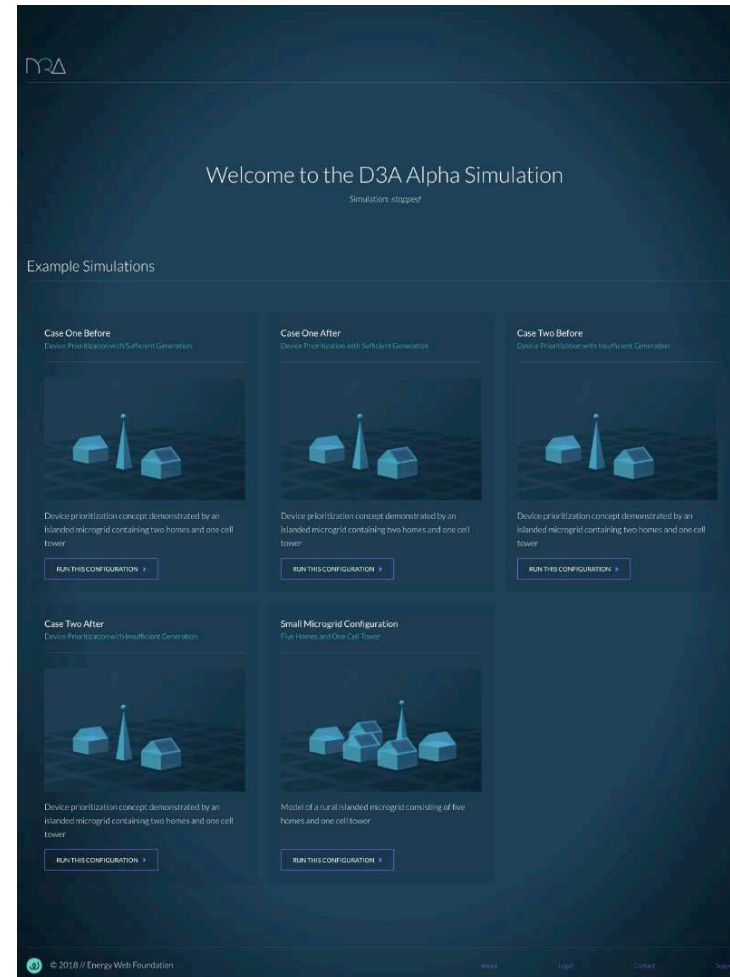
D3A Roadmap



Introducing the D3A: Product and Features



The D3A



Results: Small Microgrid



Rural Microgrid: 5 Homes, 1 Cell Tower

Cell Tower: 100 W @ 24 h

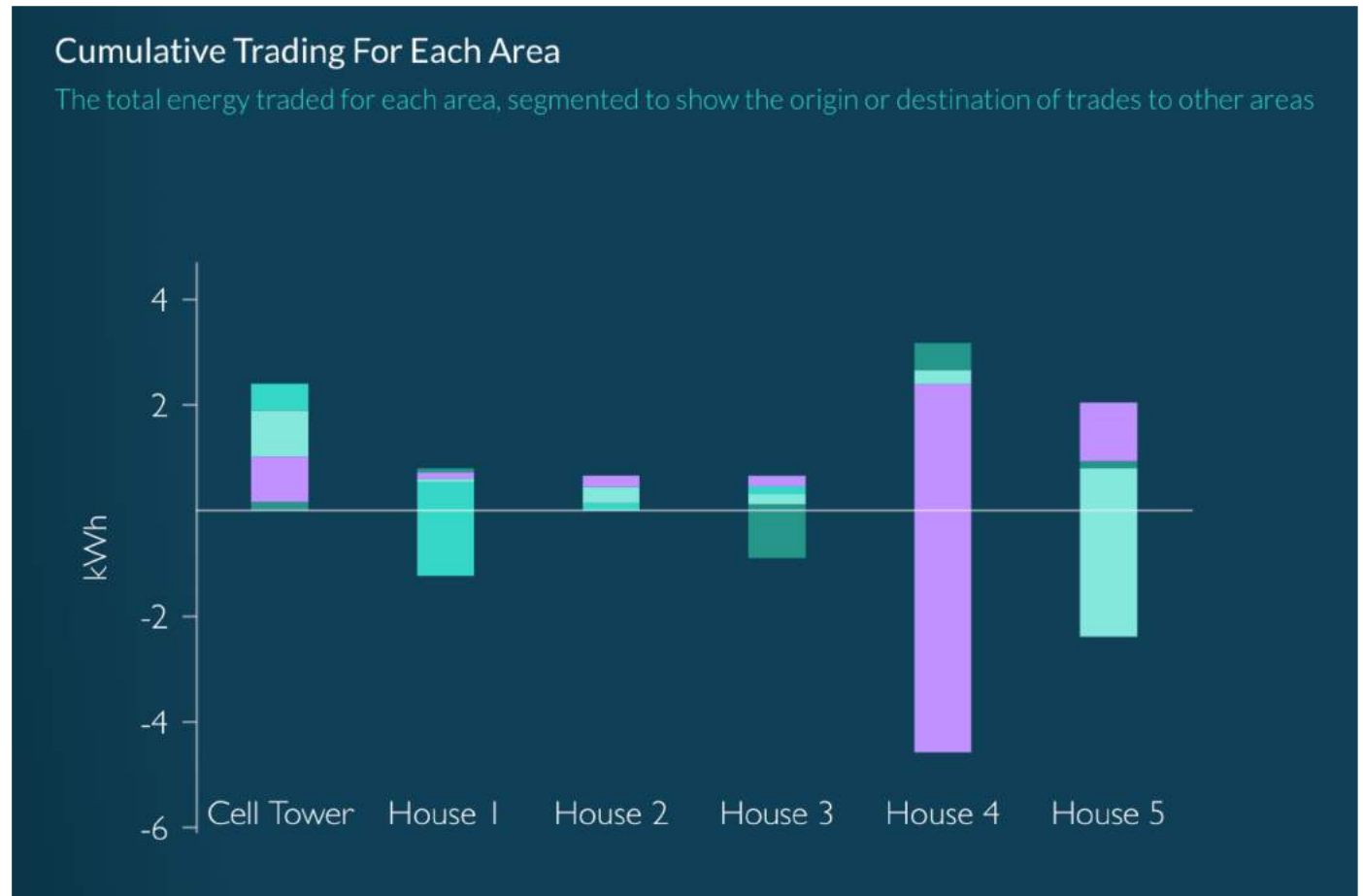
House 1: General Load: 100 W @ 4 h
Low Lighting: 100 W @ 4 h
ESS: 2 devices

House 2: General Load: 100 W @ 3 h
Low Lighting: 100 W @ 4 h

House 3: General Load: 100 W @ 3 h
Low Lighting: 100 W @ 4 h
PV: 1 panel

House 4: General Load: 100 W @ 4 h
Medium Lighting: 200 W @ 4 h
TV: 100 W @ 4 h
PV: 3 panels
ESS: 1 device

House 5: General Load: 100 W @ 1 h
Medium Lighting: 200 W @ 4 h
TV: 100 W @ 4 h
PV: 1 panel
ESS: 2 devices



Results: Device Prioritization

Case 1

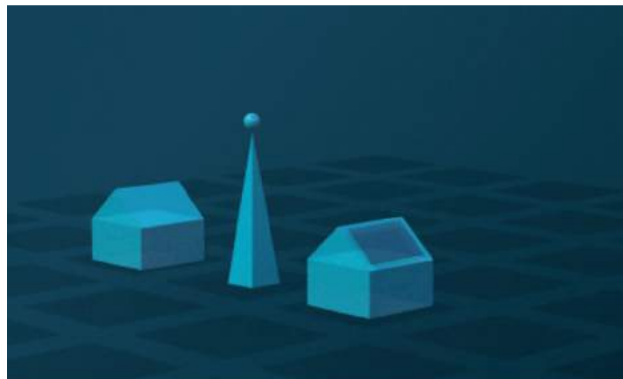


2 Homes, 1 Cell Tower

Cell Tower: 100 W @ 24 h

House 1: General Load: 200 W @ 6 h
ESS: 2 devices

House 2: General Load: 200 W @ 3 h
PV: 4 panels



With sufficient generation, BEFORE



With sufficient generation, AFTER House 1 Load limits its max energy rate



Results: Device Prioritization

Case 2



2 Homes, 1 Cell Tower

Cell Tower: 100 W @ 24 h

House 1: General Load: 200 W @ 6 h
ESS: 2 devices

House 2: General Load: 200 W @ 3 h
PV: 4 panels



With insufficient generation, BEFORE. Cell Tower goes offline

Energy Availability to all Areas

Loads that were not able to consume are marked in purple



With insufficient generation, AFTER. House 1 Load limits its max energy rate and goes offline instead

Energy Availability to all Areas

Loads that were not able to consume are marked in purple



Future Work



Over the course of 2018, EWF will add more features to the D3A that can be tested, including:

- **Advanced grid configurations**, with multiple tiers ranging from individual buildings to the bulk power system
- **Inter-area agent and other types of agents**, which coordinate transactions between disparate components and grid tiers
- **Advanced bidding strategies for devices and area agents**, which may change over time or in response to exogenous factors (e.g., weather, behavior of other participants)
- **Grid events**, including changing load profiles and grid configurations over time as well as disruptive events
- **Custom load and/or generation profiles**, either uploaded by users or fed in from external data sources
- **Different Market Designs** (e.g., one-sided vs. two-sided), exploring outcomes under varied price-setting mechanisms
- **A Balancing Market**

Questions?

Come Visit Us at the D3A Cube!

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D3A Product Owner

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