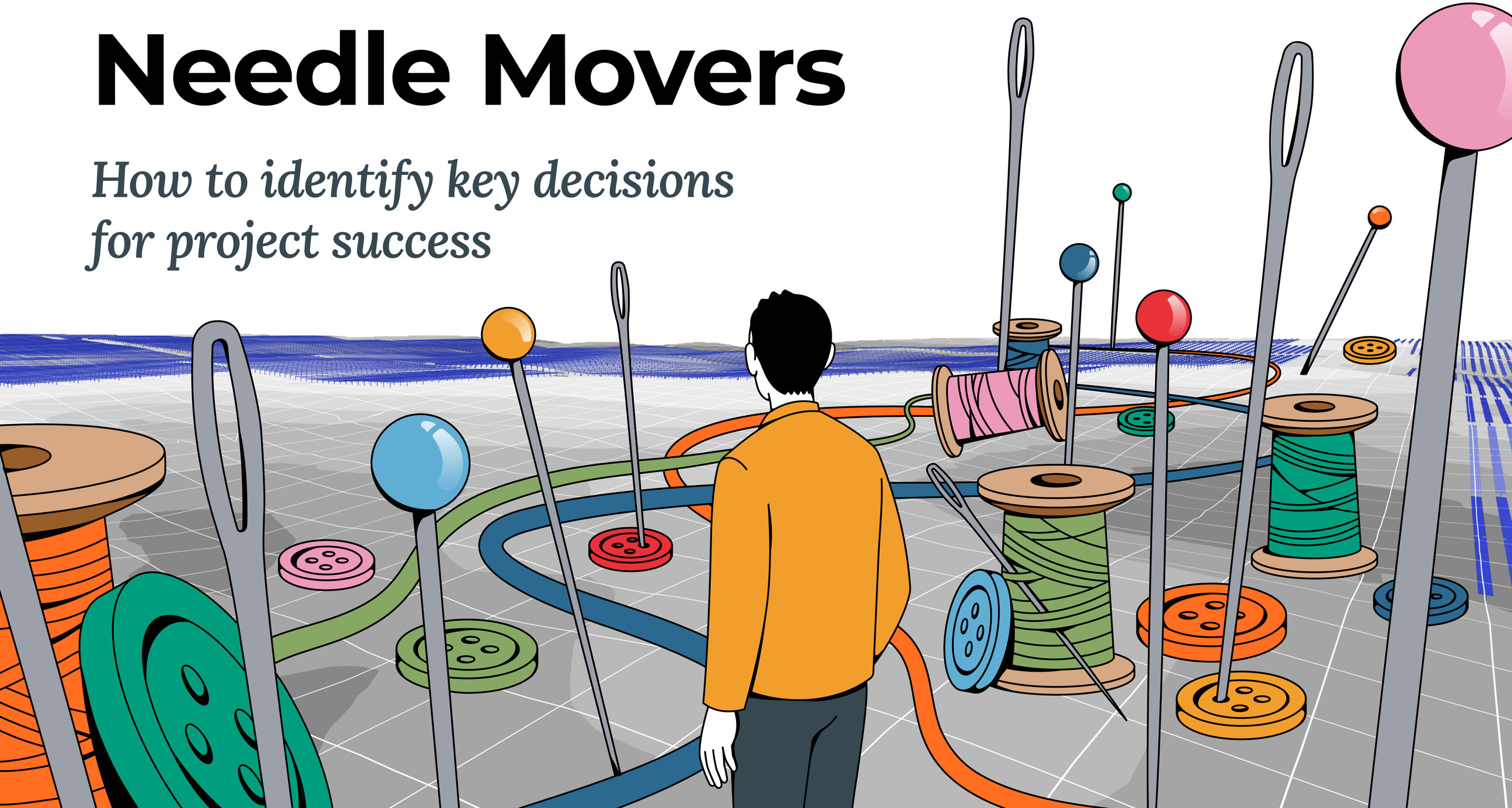
Needle Movers

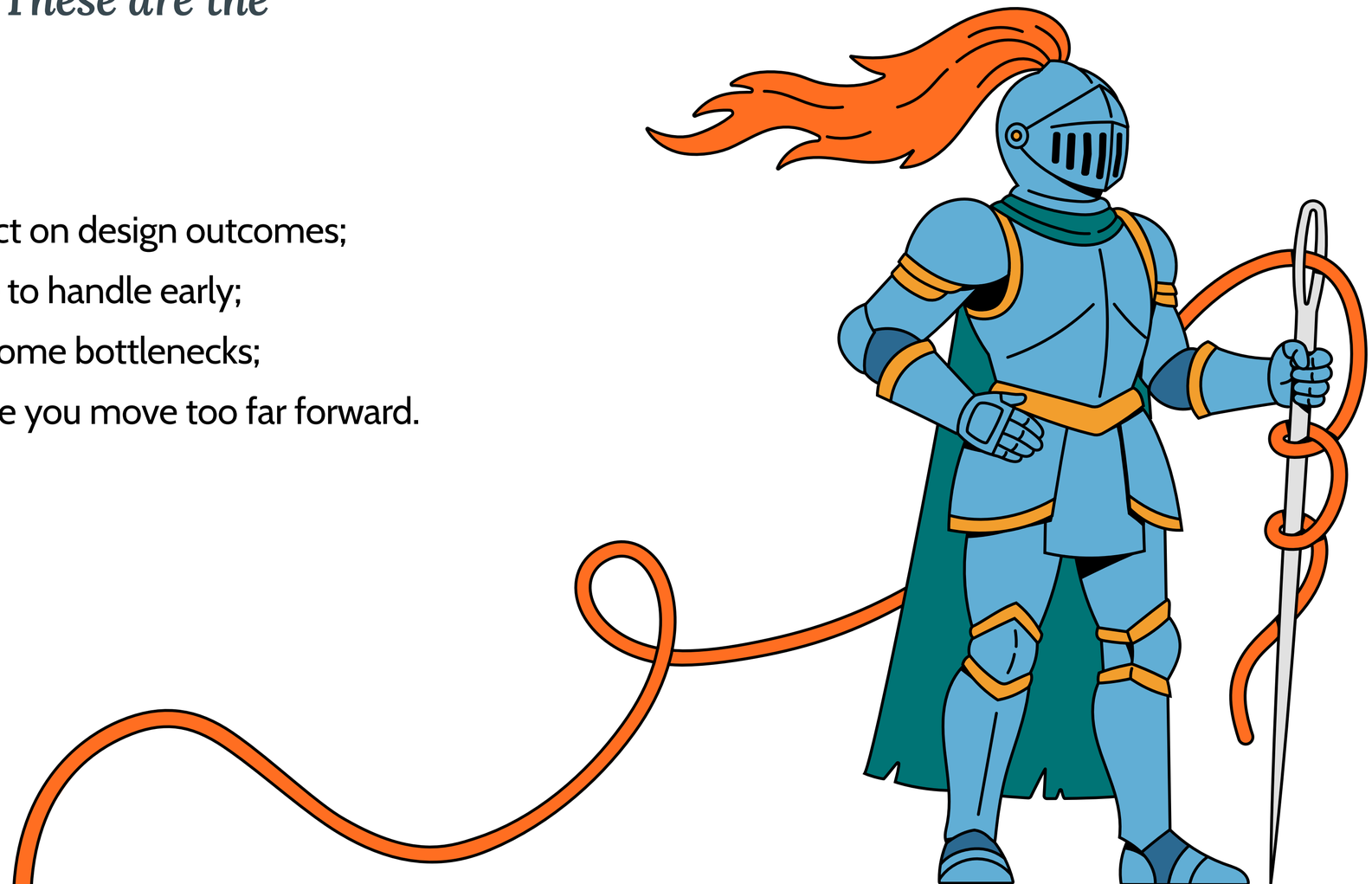
How to identify key decisions for project success



What are Needle Movers?

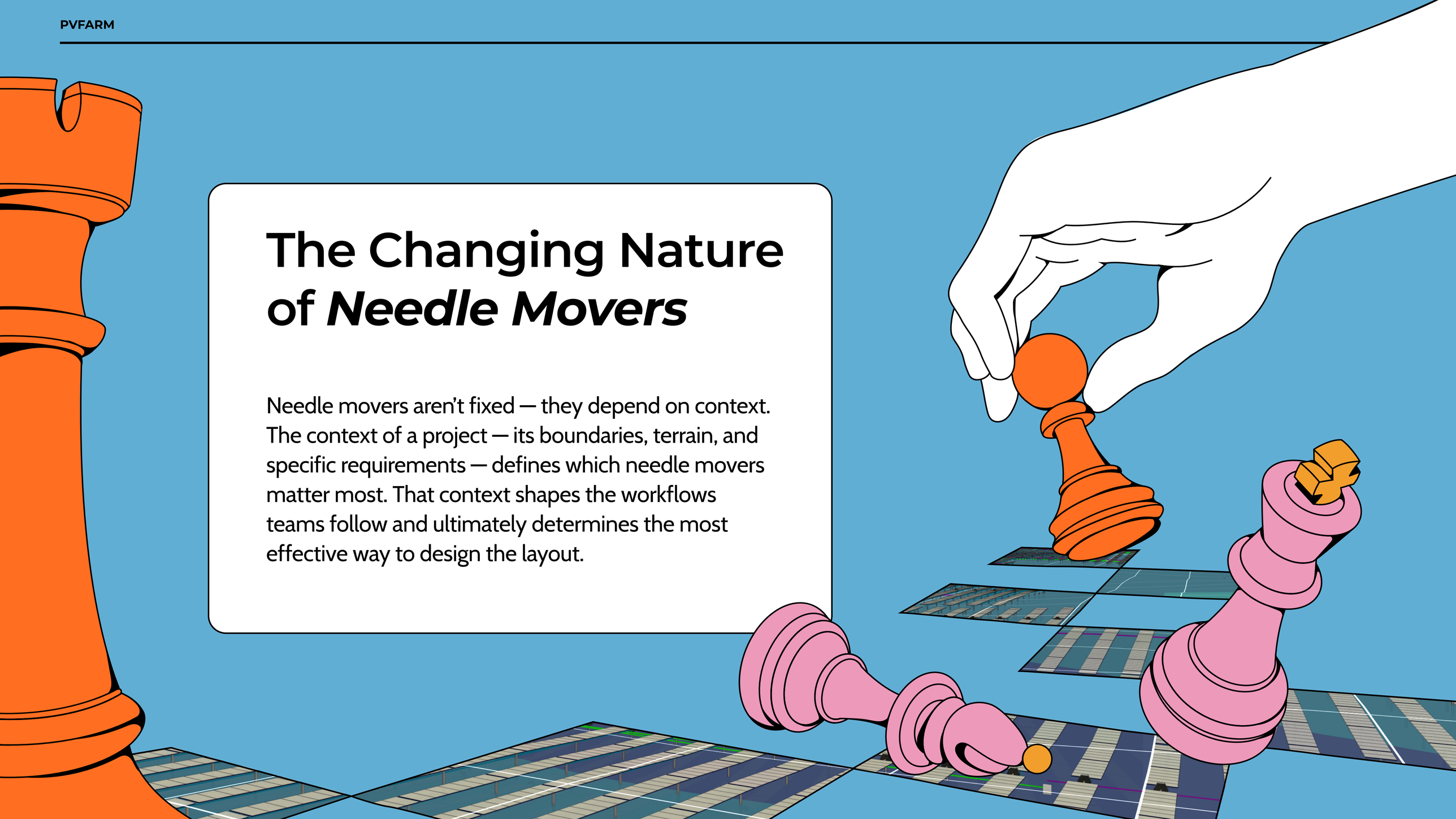
Every solar project has a handful of decisions that make or break success. These are the needle movers:

- the factors with the biggest impact on design outcomes;
- the risks and challenges you have to handle early;
- the handover points that can become bottlenecks;
- the strategies worth testing before you move too far forward.



The Changing Nature of *Needle Movers*

Needle movers aren't fixed — they depend on context. The context of a project — its boundaries, terrain, and specific requirements — defines which needle movers matter most. That context shapes the workflows teams follow and ultimately determines the most effective way to design the layout.



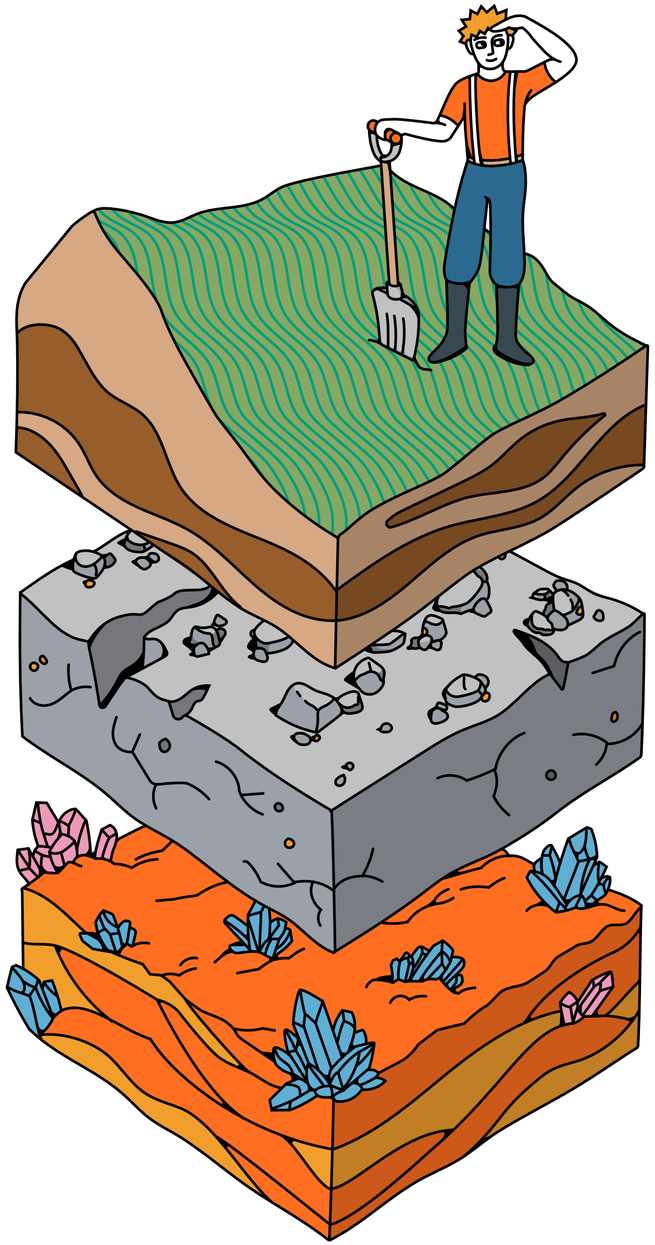
Three levels of analytical depth

When designing solar PV layouts

Level 1: The Obvious

Level 2: Rules of Thumb

Level 3: Strategic Optimisation



1 The Obvious

On the surface, common sense

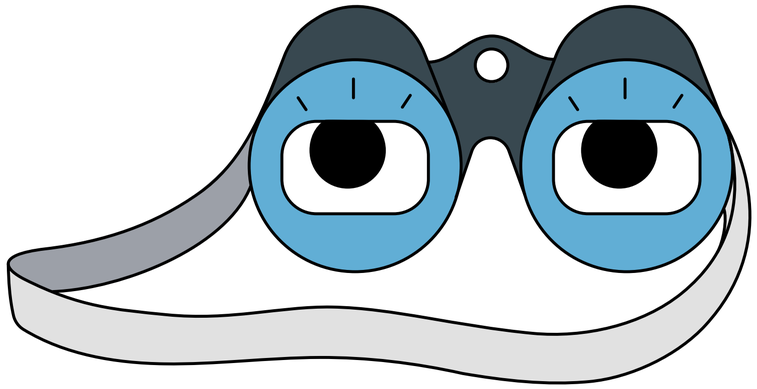
- Well understood by the competition and the market
- Insights that are easy to spot from a high-level view

Examples:

- Steep terrain clearly requires layout to be optimized around grading;
- Tough voltage drop requirements will push the definition of ideal blocks.

Limitation: good as a starting point, but rarely enough for complex or competitive projects





2 Rules of Thumb

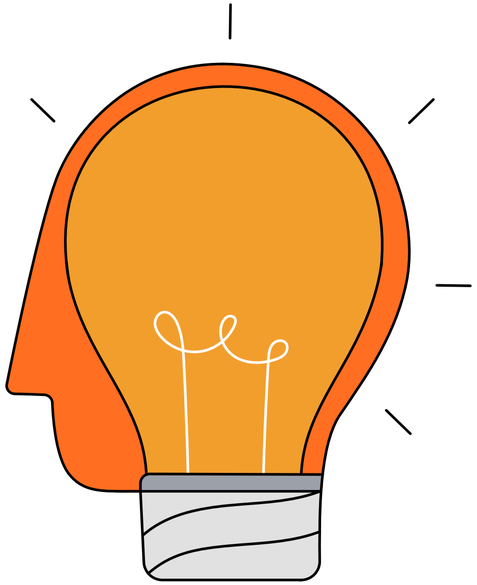
Digging in, industry standards

- Reliance on familiar standards and habits that produce **“acceptable”** results.
- Often used when teams don’t have the time or resources to explore deeper.

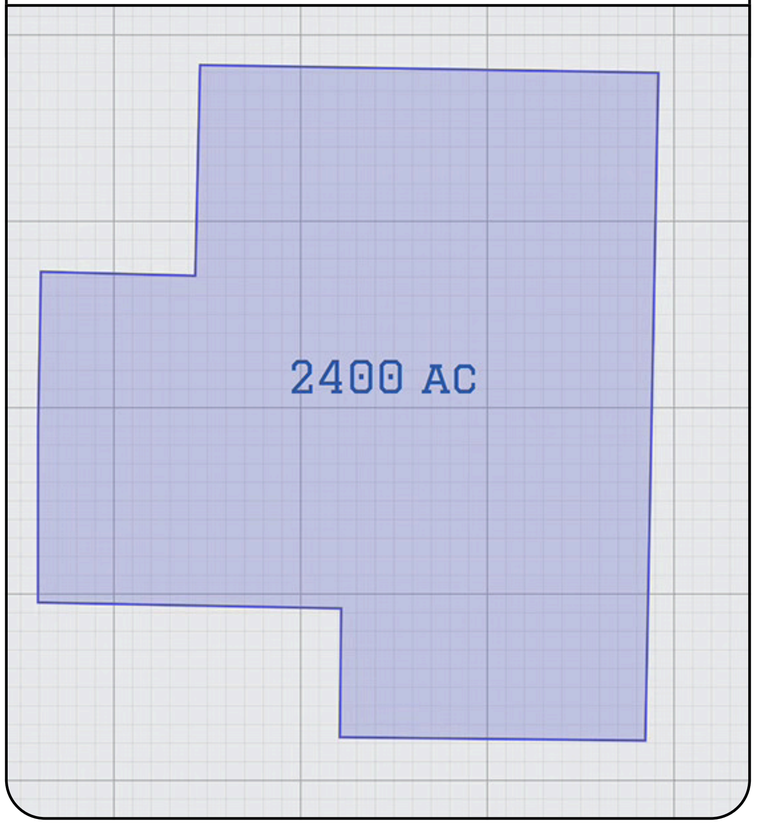
Examples:

- Using central inverters no matter the site context.
- Sticking to the block configuration that worked last time.

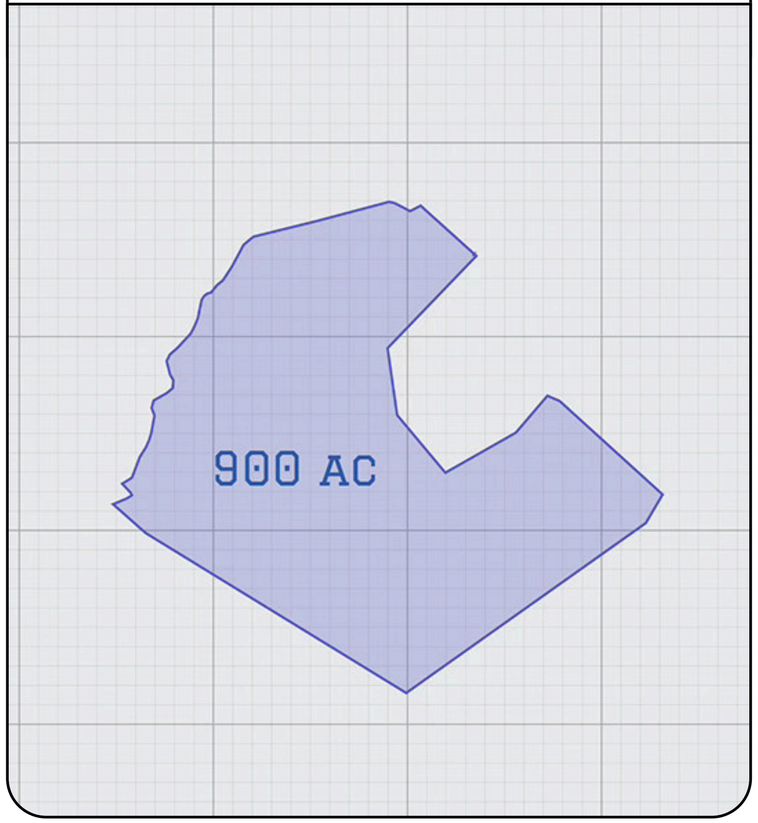
Limitation: can overlook site-specific opportunities and leave value on the table.



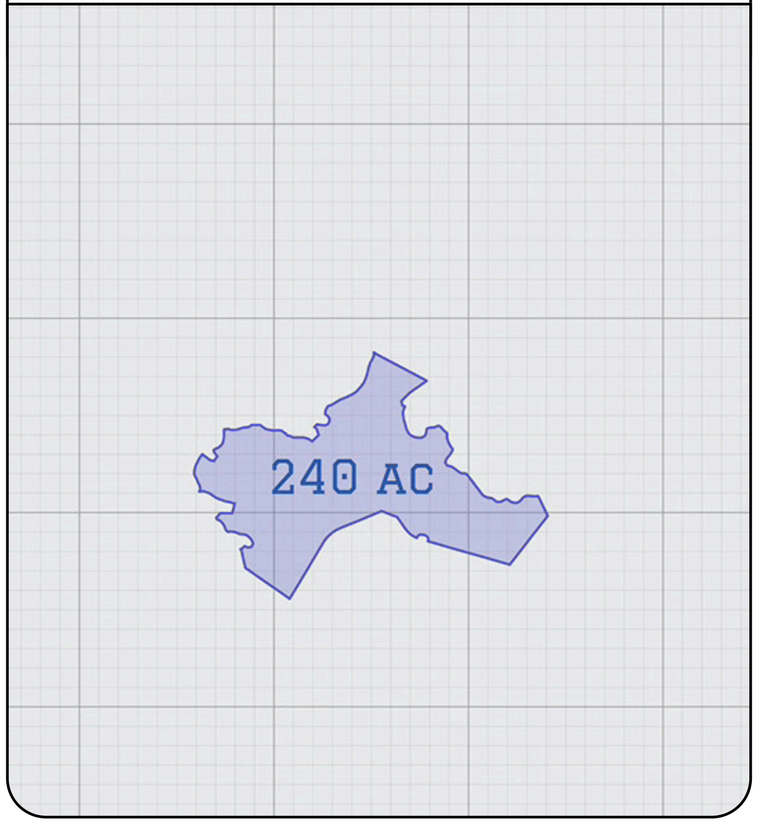
Big Boxy & Easy

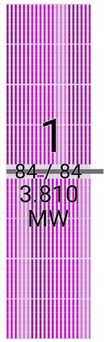
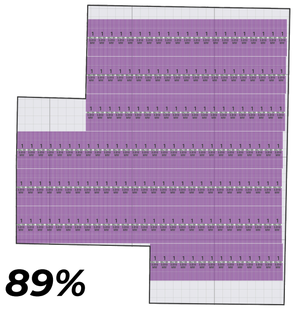
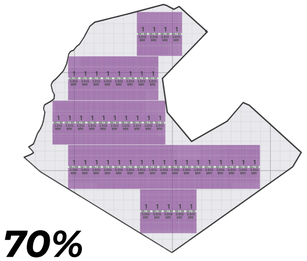
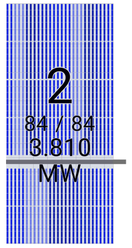
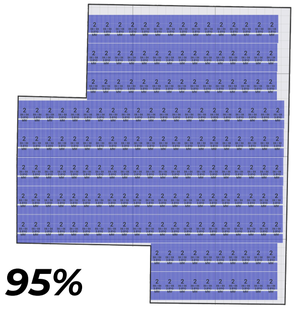
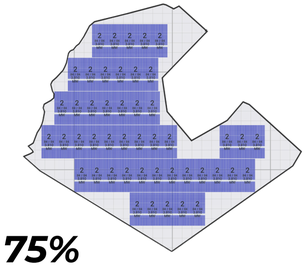
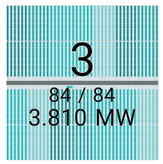
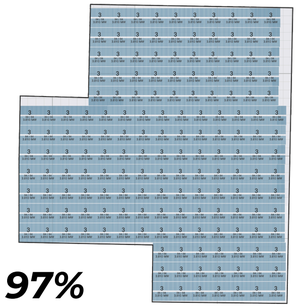
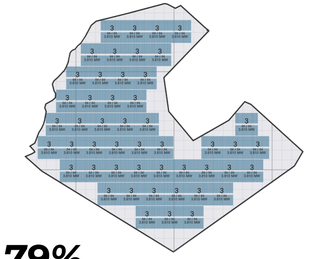


Medium Chunky Puzzle



Complex Swiss Cheese



CBX 400A	*Big Boxy & Easy*	*Medium Chunky Puzzle*	*Complex Swiss Cheese*
x14 	161 Blocks 613.5 MWdc *Land Use Ratio* ***89%*** 	44 Blocks 167.7 MWdc *Land Use Ratio* ***70%*** 	5 Blocks 19.1 MWdc *Land Use Ratio* ***53%*** 
x15 	170 Blocks 647.7 MWdc *Land Use Ratio* ***95%*** 	47 Blocks 179.1 MWdc *Land Use Ratio* ***75%*** 	9 Blocks 34.3 MWdc *Land Use Ratio* ***75%*** 
x14 	169 Blocks 643.9 MWdc *Land Use Ratio* ***97%*** 	49 Blocks 186.7 MWdc *Land Use Ratio* ***79%*** 	8 Blocks 30.5 MWdc *Land Use Ratio* ***71%*** 

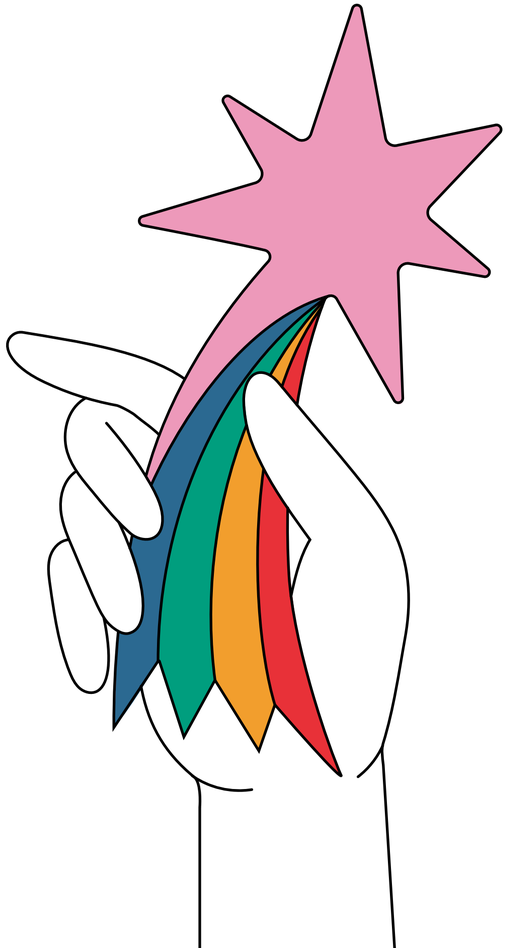
3 Strategic Optimization

Deep trade-offs, biggest opportunities

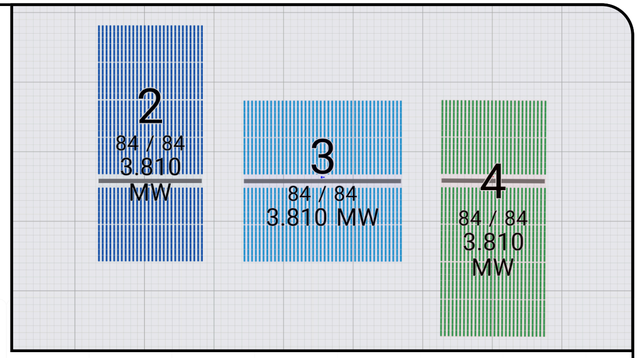
- Going beyond heuristics by testing multiple scenarios across civil, electrical, and layout disciplines;
- Exposes hidden trade-offs that reshape cost, performance, and constructability.

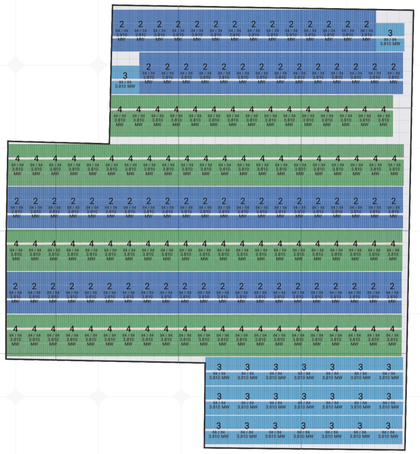
Examples:

- Adjusting block configurations to unlock extra MW;
- Well-thought out cross-discipline optimisation strategy;
- Constant exploration to find the best layout for current context.



Total:
891.6 MWdc





171 Blocks
651.6 MWdc

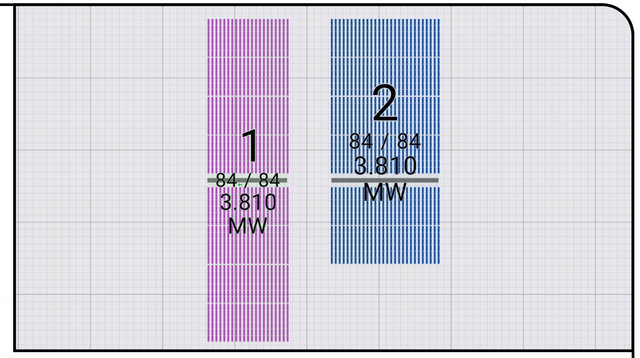


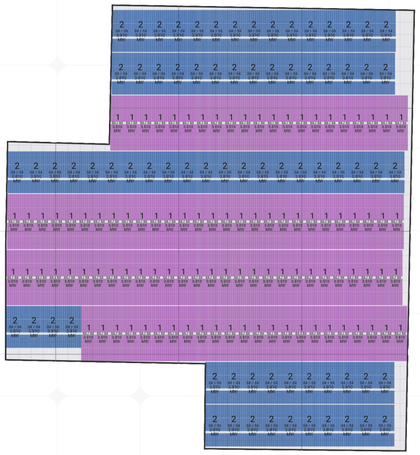
53 Blocks
201.9 MWdc



10 Blocks
38.1 MWdc

Total:
891.6 MWdc





175 Blocks
666.8 MWdc



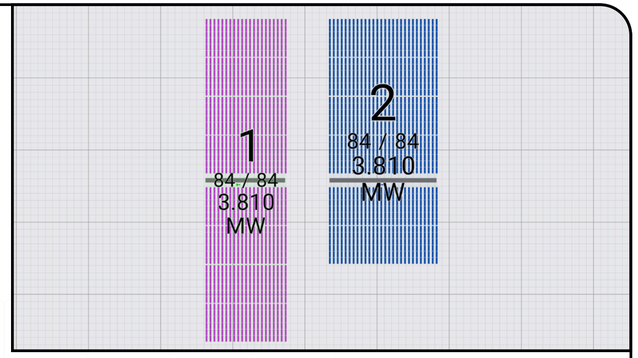
50 Blocks
190.5 MWdc

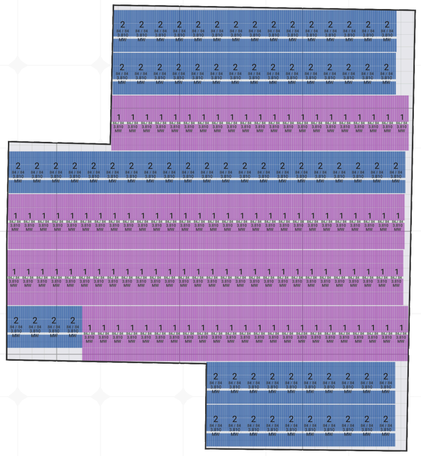


9 Blocks
34.3 MWdc

- Same DC power but different sets of blocks

Total:
891.6 MWdc





175 Blocks
666.8 MWdc

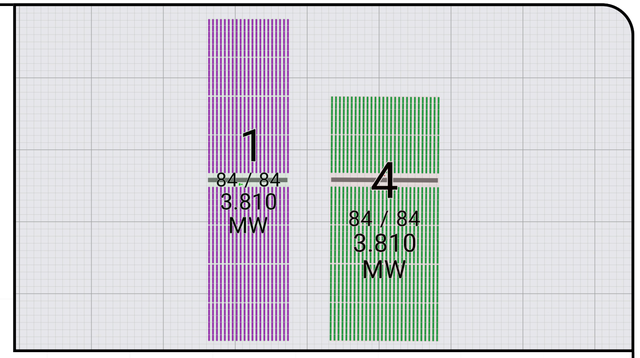


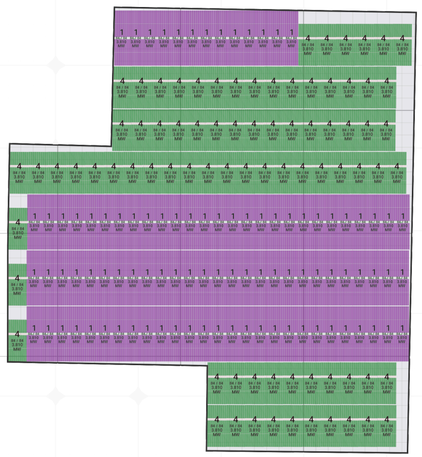
50 Blocks
190.5 MWdc



9 Blocks
34.3 MWdc

Total:
887.8 MWdc





174 Blocks
663.0 MWdc



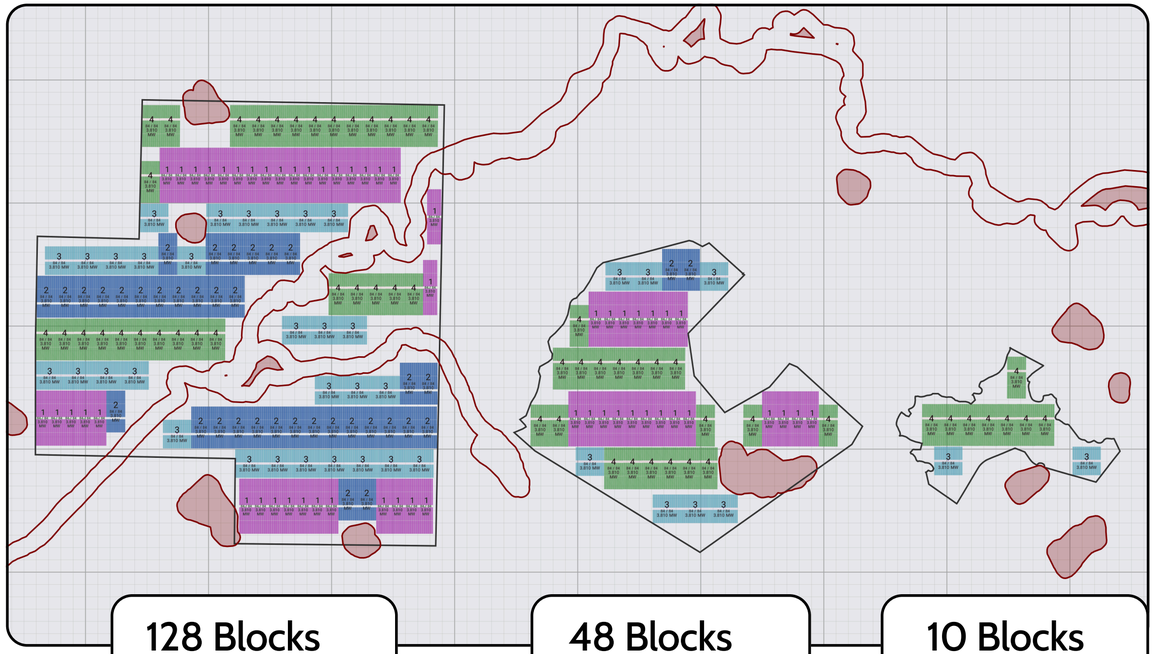
50 Blocks
190.5 MWdc



9 Blocks
34.3 MWdc

- Switching to inverted blocks might unlock several extra megawatts.

Total: ***708.7 MWdc***

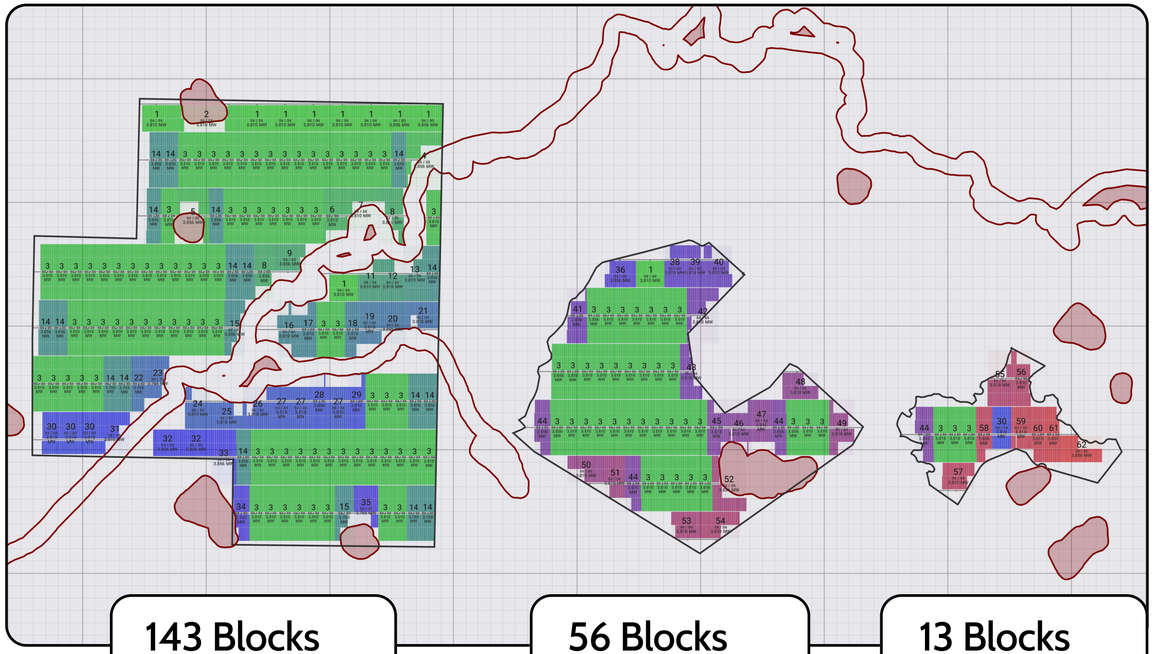


128 Blocks
487.7 MWdc

48 Blocks
182.9 MWdc

10 Blocks
38.1 MWdc

Total: ***809.1 MWdc***

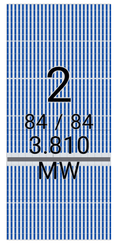


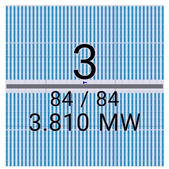
143 Blocks
545.6 MWdc

56 Blocks
213.9 MWdc

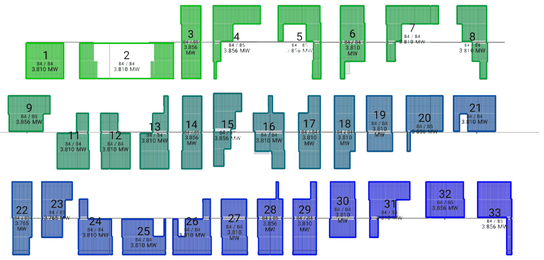
13 Blocks
49.6 MWdc

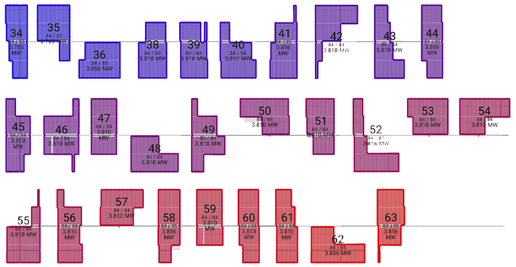




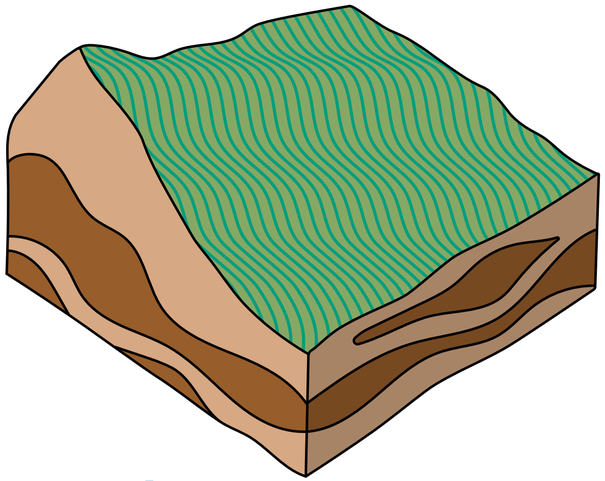






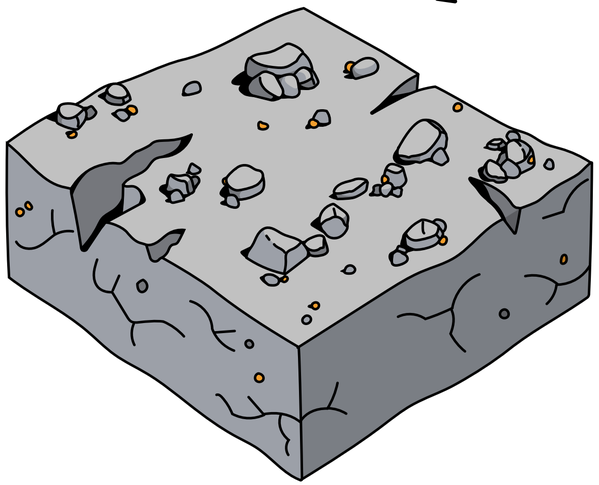


Permanent checking

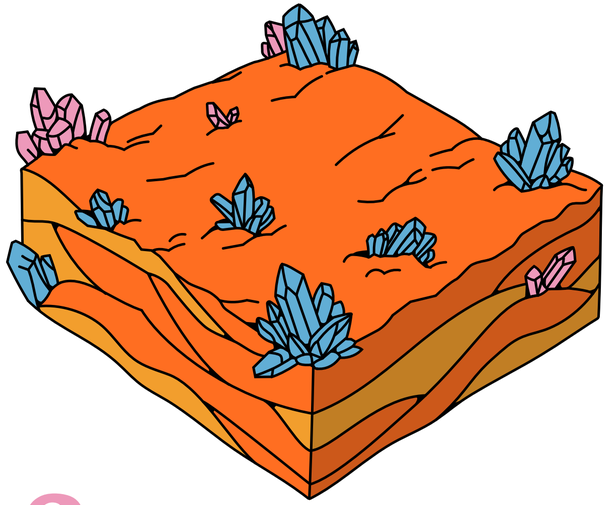


1 *The Obvious*

Enrichment



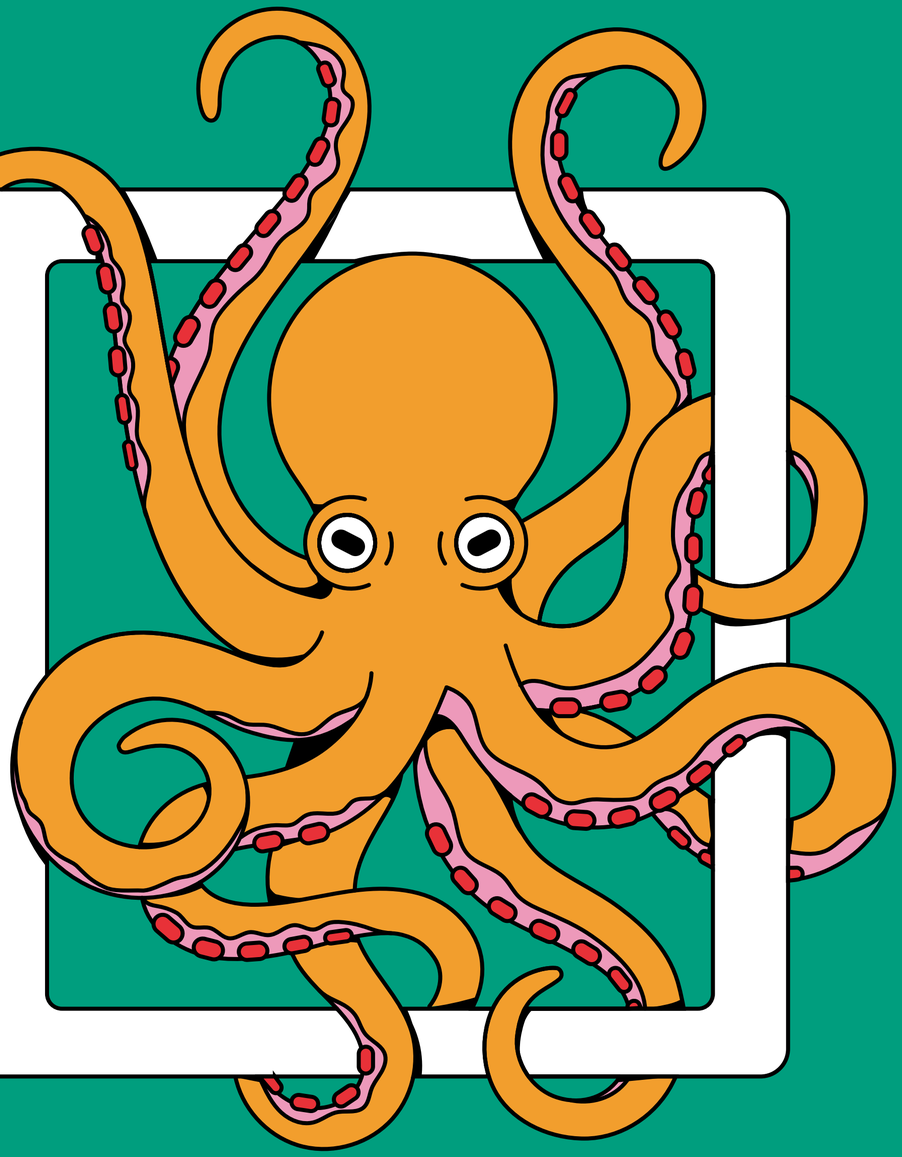
2 *Rules of Thumb*



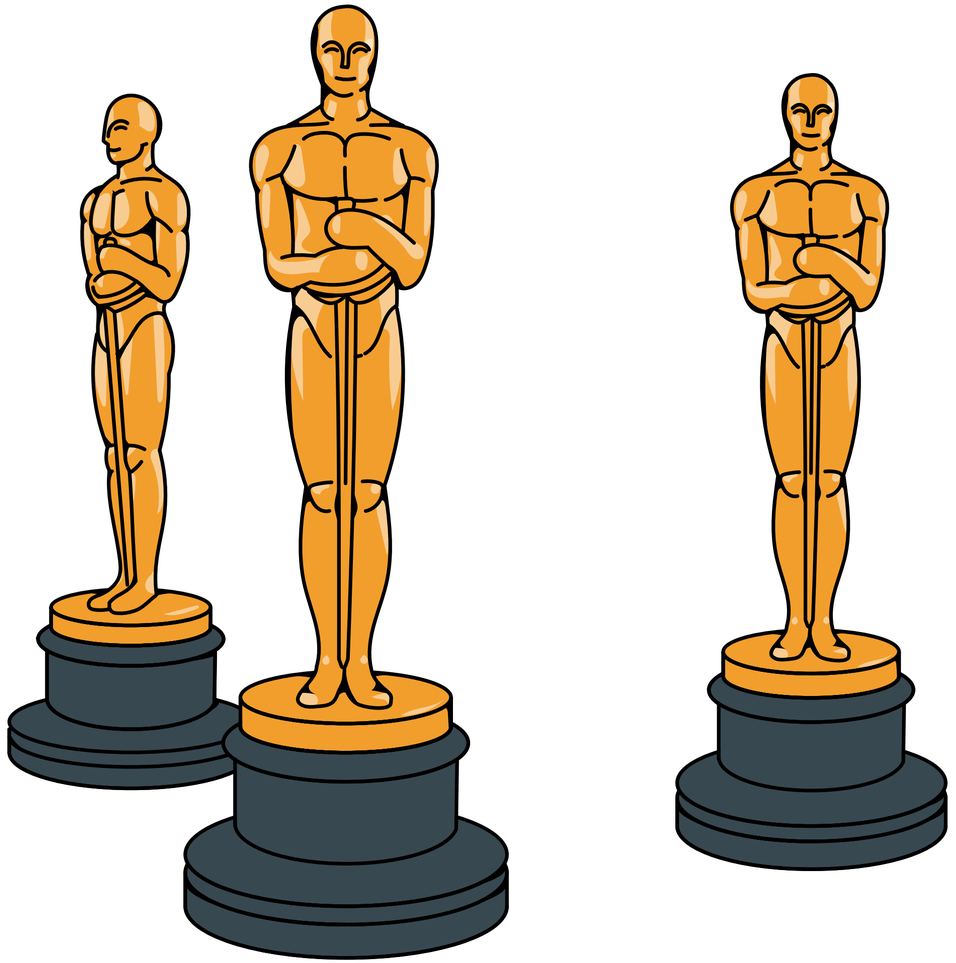
3 *Strategic Optimisation*

Needle Movers **Framework**

The framework helps identify and prioritize the design decisions that have the biggest impact on project success. Needle movers are not fixed - they depend on project context (boundaries, land availability, terrain). Recognizing them early sets the right workflow order and avoids wasted effort.



Dimension	*Definition*
Cost Impact	How much this parameter influences total system cost
Design Lock-In Risk	How hard it is to change this decision later in the design/ construction
System Interaction	How many other design elements this parameter affects or constrains



Discipline-Specific Parameters

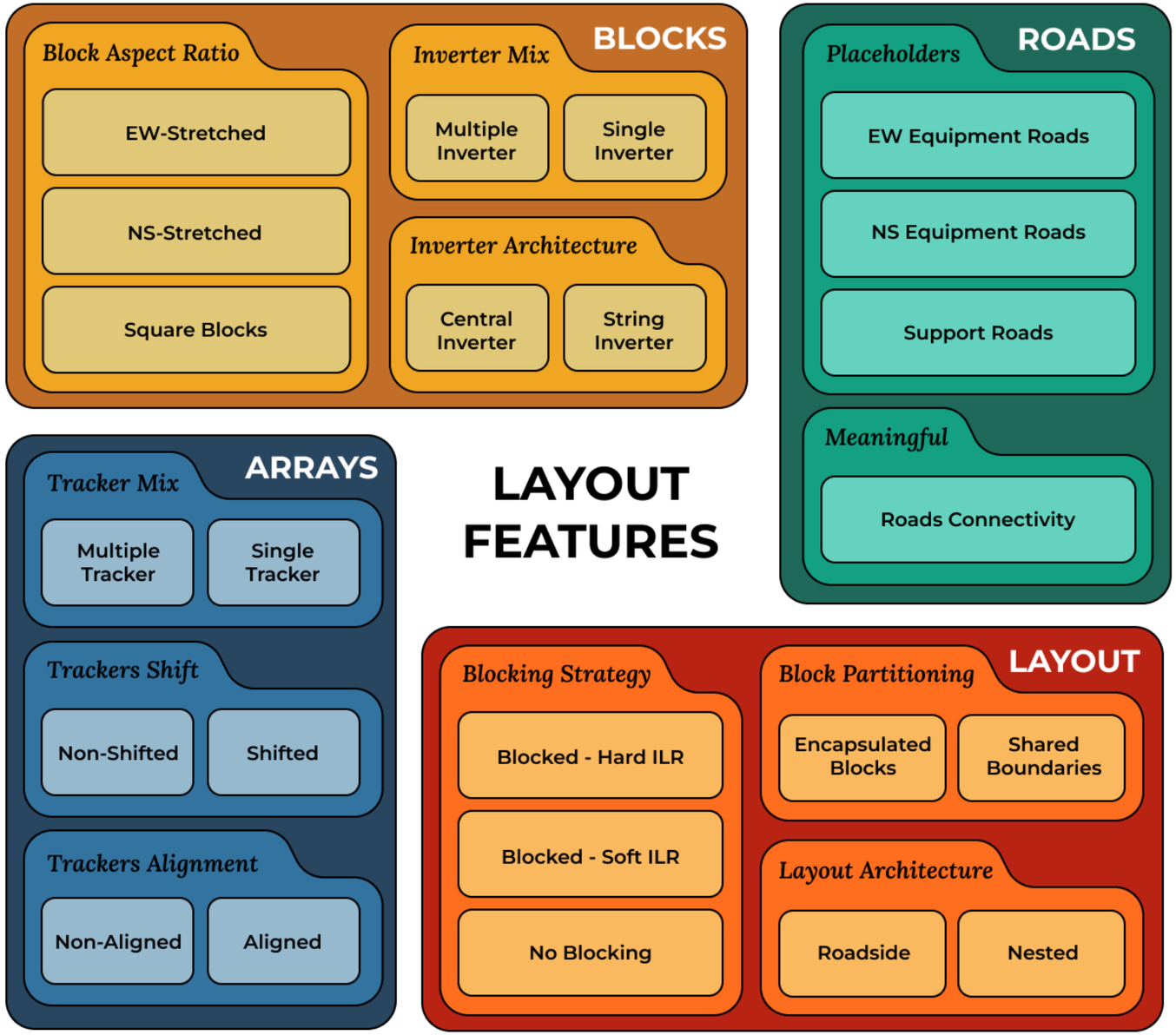
Layout: Parameter Examples

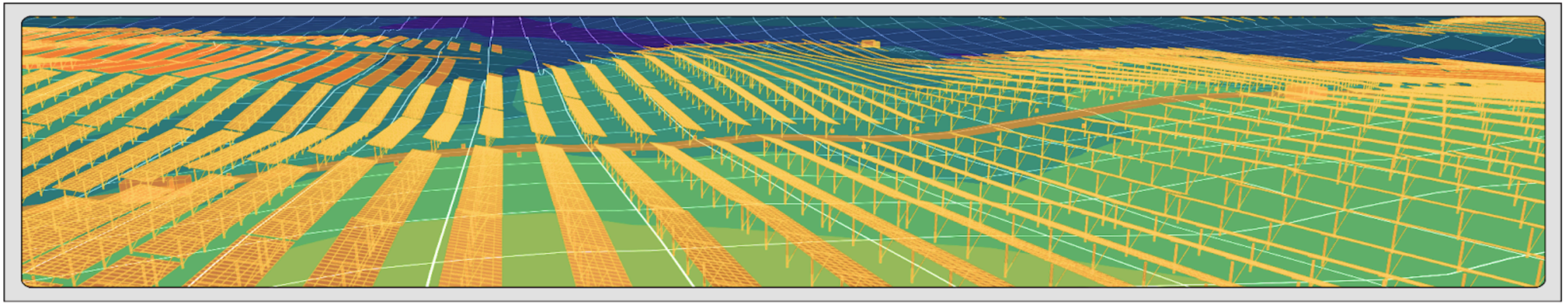
Blocks:
- Block aspect ratio
- Inverter mix
- Inverter architecture

Roads:
- Placeholder
- Meaningful

Arrays
- Tracker mix
- Trackers shift
- Trackers Alignment

Layout:
- Blocking strategy
- Block Partitioning
- Layout atchitecture





Harness - Combiner	EoR	Partial	Single Array	Single
TrunkBus	MoR	Full	Multi Array	Multi
Wire Sequence	CBX/LBD Position	CBX/LBD Clustering	Row Grouping	Harness Configuration

WIRING ARCHITECTURE

String	Thin-film	400A
Central	Monocrystalline	600A
Inverter Selection	Module Selection	CBX/LBD Selection

EQUIPMENT

Simple	Single	Irregular	High Standardization
Complex	Multi	Regular	Per-Run Customization
Boundaries Complexity	Row Height	Block Footprint	Wire Gauges Unification

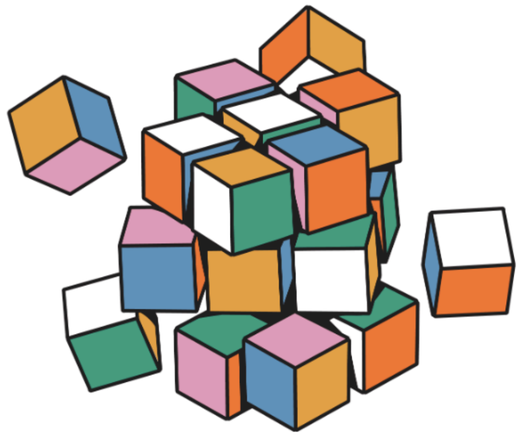
SITE CONTEXT & BUILDABILITY

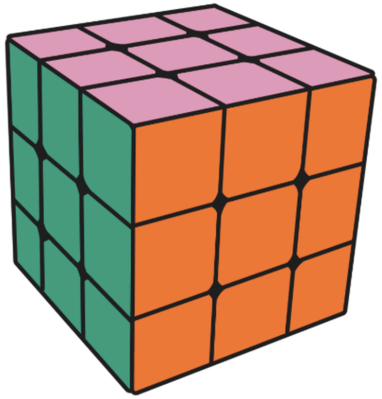
Controlled Comparison Method

Strengthens decision-making by avoiding misleading correlations

1. Lock all other variables and run best vs worst

   (or A vs B) scenarios for that parameter
2. Normalize the result to $/W or $ impact per MW
3. Measure impact





Row Height

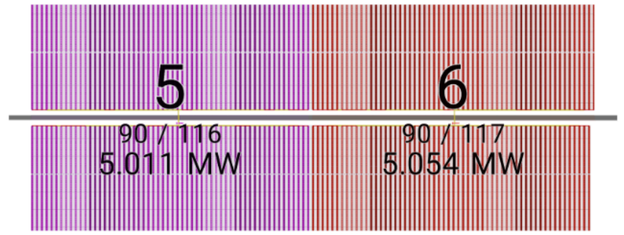
As a Voltage Drop Proxy

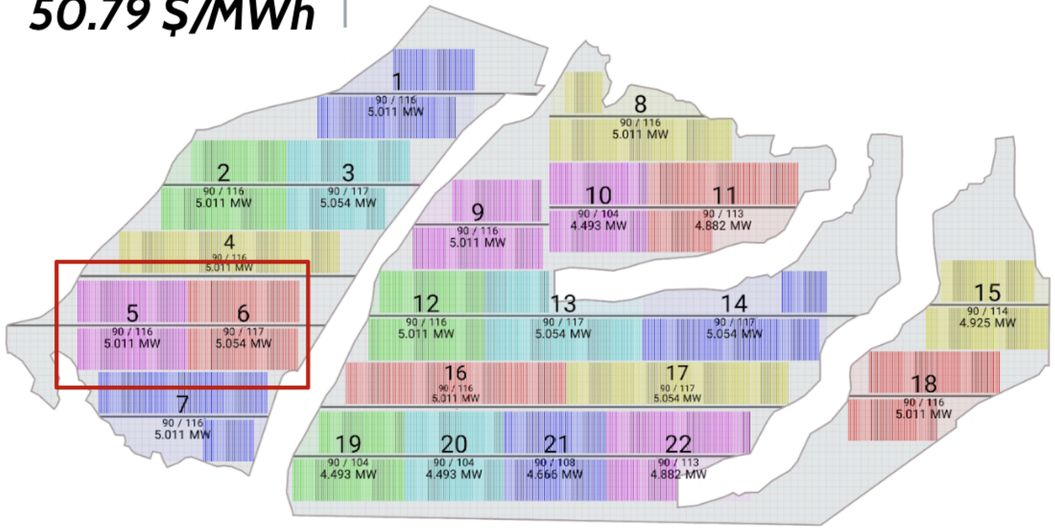
Using Single RH lowers EBOS by **9.8%**
$1.8M saved

Single row height (1)

Electrical CAPEX:
0.1285 $/W

LCOE, $/MWh:
50.79 $/MWh



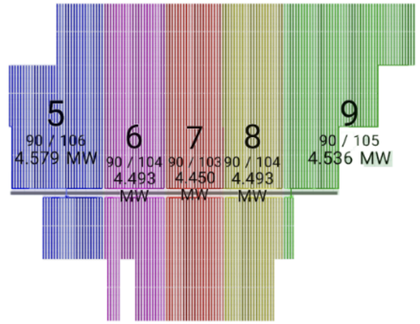


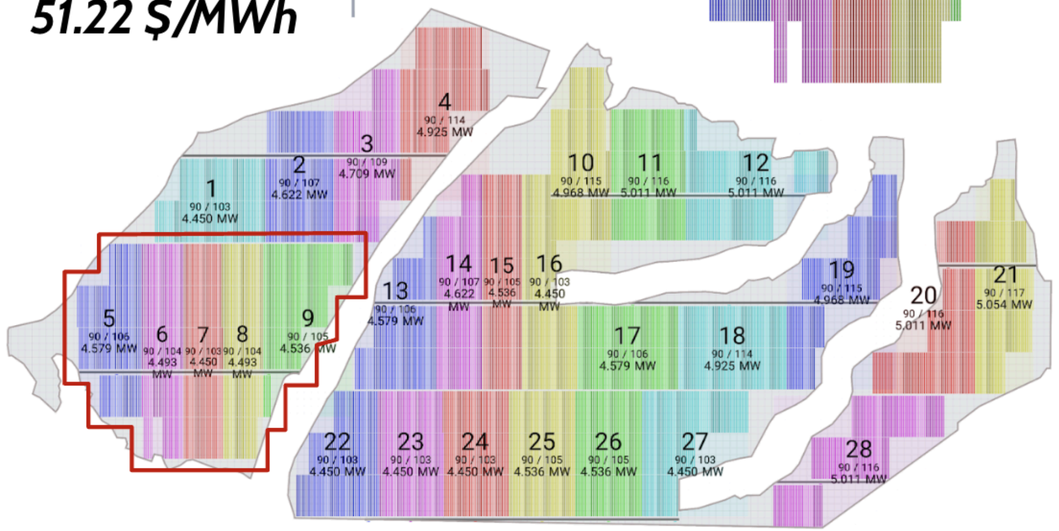
VS

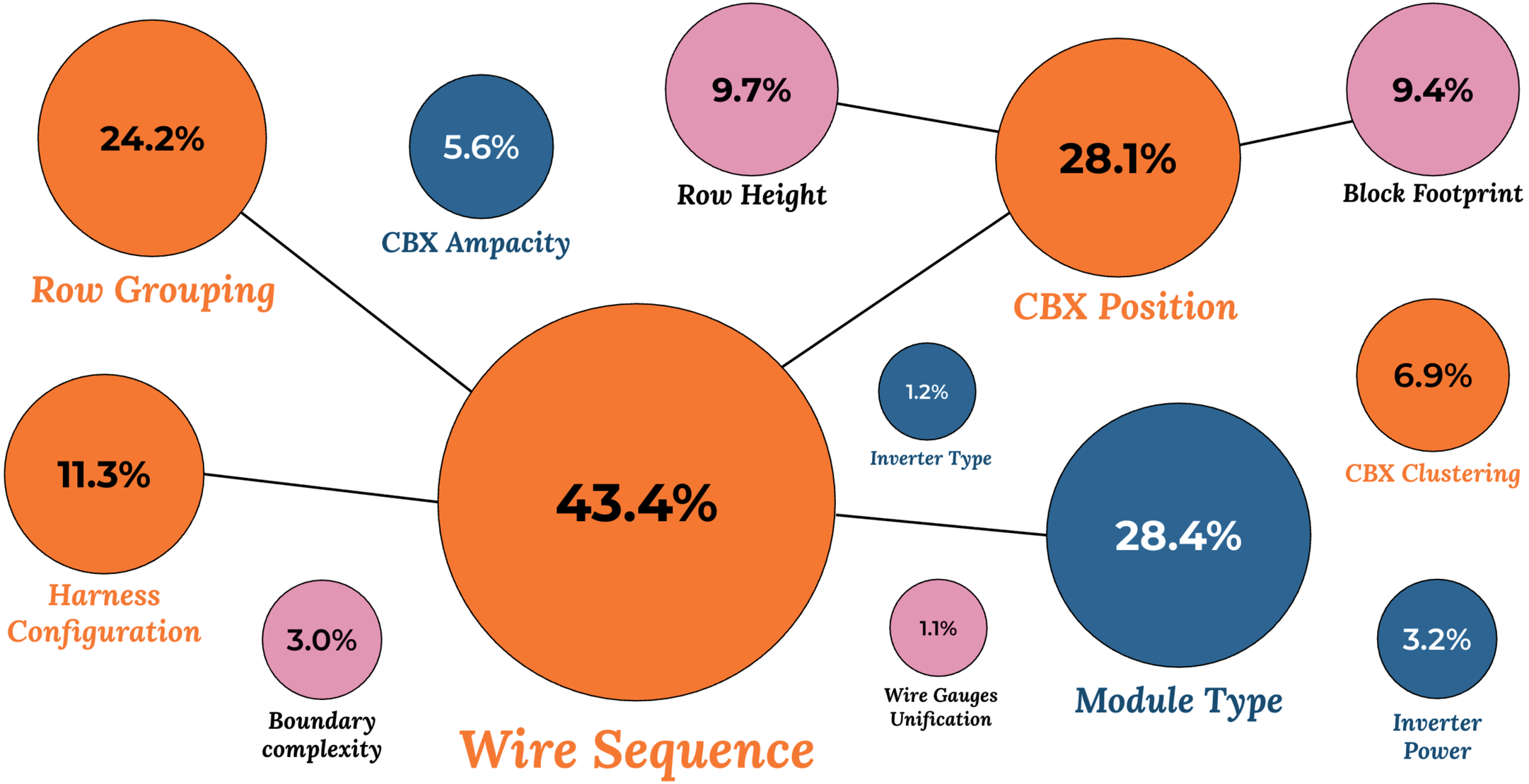
Multiple row height (3)

Electrical CAPEX:
0.1425 $/W

LCOE, $/MWh:
51.22 $/MWh





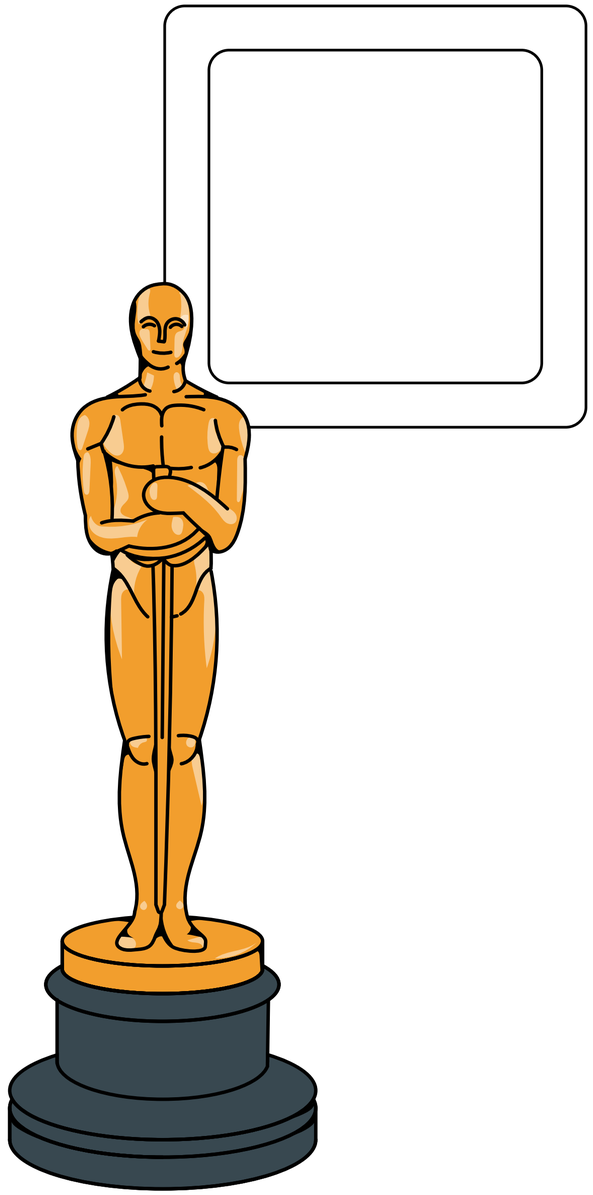

24.2%
Row Grouping
5.6%
CBX Ampacity
9.7%
Row Height
28.1%
CBX Position
9.4%
Block Footprint
11.3%
Harness Configuration
3.0%
Boundary complexity
43.4%
Wire Sequence
1.2%
Inverter Type
1.1%
Wire Gauges Unification
28.4%
Module Type
6.9%
CBX Clustering
3.2%
Inverter Power

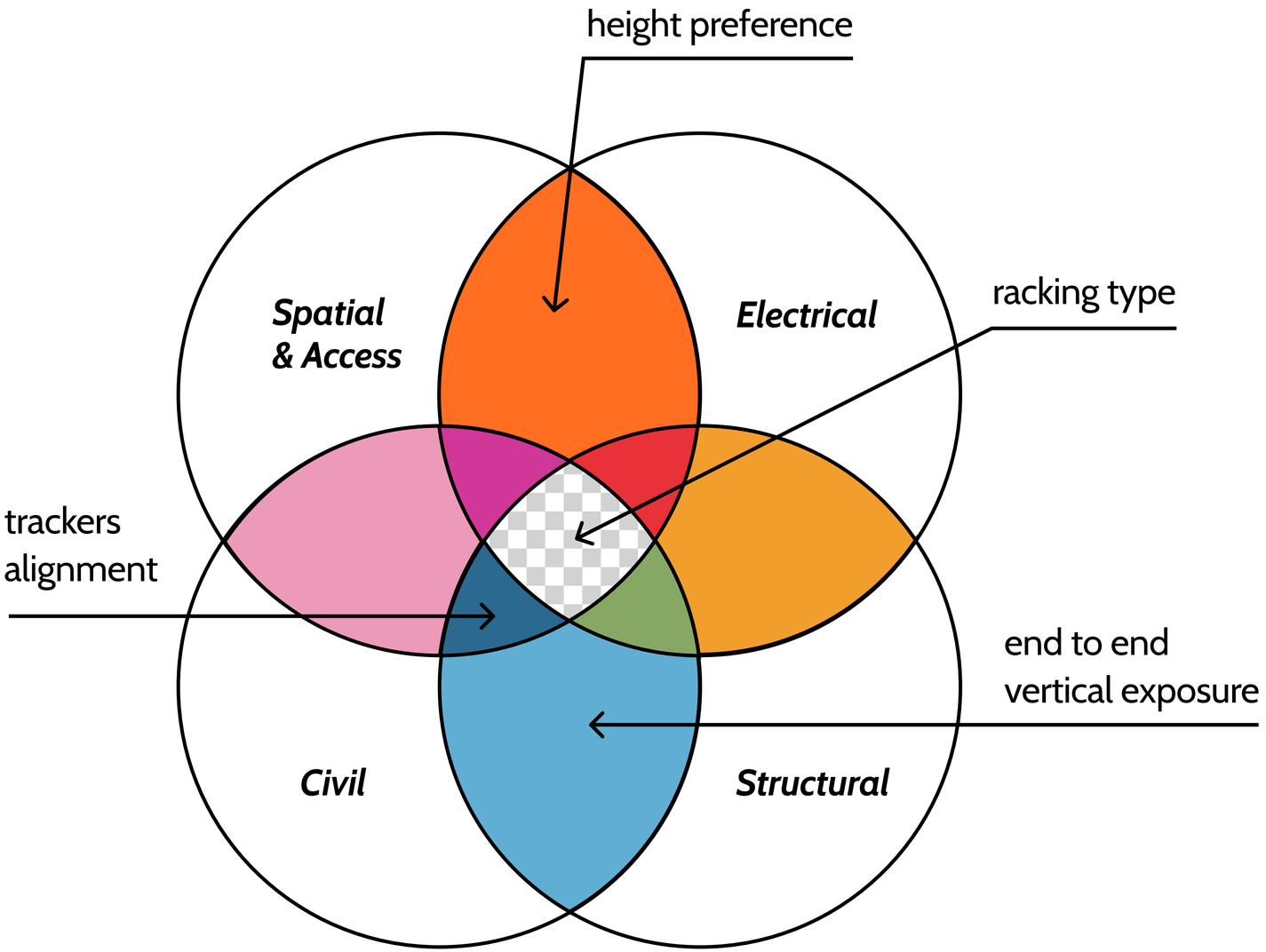
	Electrical parameters	Feasibility	Conceptual design 10%	Preliminary design 30%	Detailed design 60%	IFC 90%	Value
Equipment	Inverter Type	0	1	0	0	0	4
	Inverter Power	0	0	1	0	0	3
	Module Selection	1	0	0	0	0	5
	CBX/LBD Selection	0	0	1	0	0	3
Wiring Architecture	Wire Sequence	0	0	0	1	0	2
	CBX/LBD Position	0	0	1	0	0	3
	CBX/LBD Clustering	0	0	1	0	0	3
	Row Grouping	0	0	1	0	0	3
	Harness Configuration	0	0	0	1	0	2
Site Context & Buildability	Boundaries Complexity	1	0	0	0	0	5
	Wire Gauges Unification	0	0	0	0	1	1
	Block Footprint	0	0	1	0	0	3
	Row Height	0	1	0	0	0	4

	Energy	Layout	Blocking	Electrical Engineering	Procurement	Value
Inverter Type	1	1	1	1	1	5
Inverter Power	1	1	1	1	1	5
Module Selection	1	1	1	1	1	5
CBX/LBD Selection	0	0	0	1	1	2
Wire Sequence	0	0	0	1	1	2
CBX/LBD Position	0	0	0	1	0	1
CBX/LBD Clustering	0	0	0	1	0	1
Row Grouping	0	0	0	1	1	2
Harness Configuration	0	0	0	1	1	2
Boundaries Complexity	0	1	1	0	0	2
Wire Gauges Unification	1	0	0	1	1	3
Block Footprint	0	1	1	0	0	2
Row Height	0	1	1	0	0	2

Scored Parameter List

Electrical Parameters	*Cost Impact*	*Lock-In-Risk*	*System Interaction*	*Total Score*
Module Selection	3	5	5	13
Inverter Type	1	4	5	10
Wire Sequence	5	2	2	9
Boundaries Complexity	2	5	2	9
Inverter Power	1	3	5	9
CBX/LBD Position	4	3	1	8
Row Grouping	3	3	2	8
Row Height	1	4	2	7
CBX/LBD Selection	1	3	2	6
Block Footprint	1	3	2	6
CBX/LBD Clustering	1	3	1	5
Harness Configuration	1	2	2	5
Wire Gauges Unification	1	1	3	5

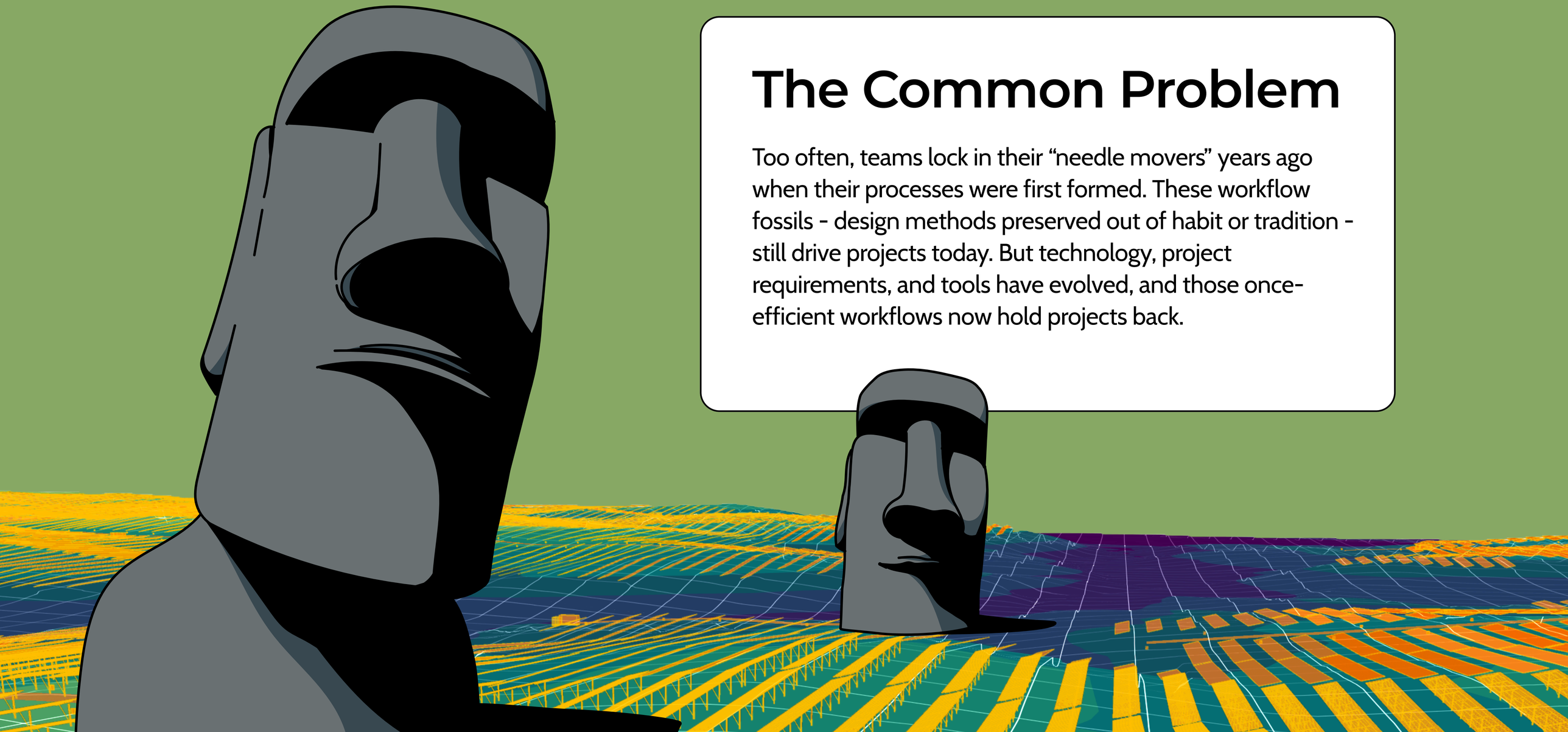




LOCAL NEEDLE MOVERS
the most important parameters within each discipline

GLOBAL NEEDLE MOVERS
the most important parameters that affect a couple of disciplines simultaneously

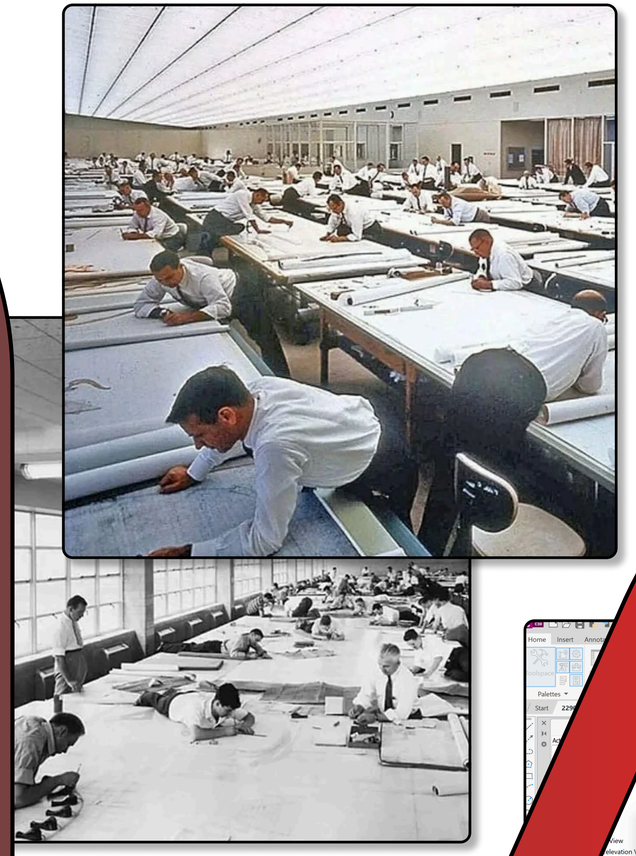
WORKFLOW NEEDLE MOVERS
the discipline that should lead the optimisation way



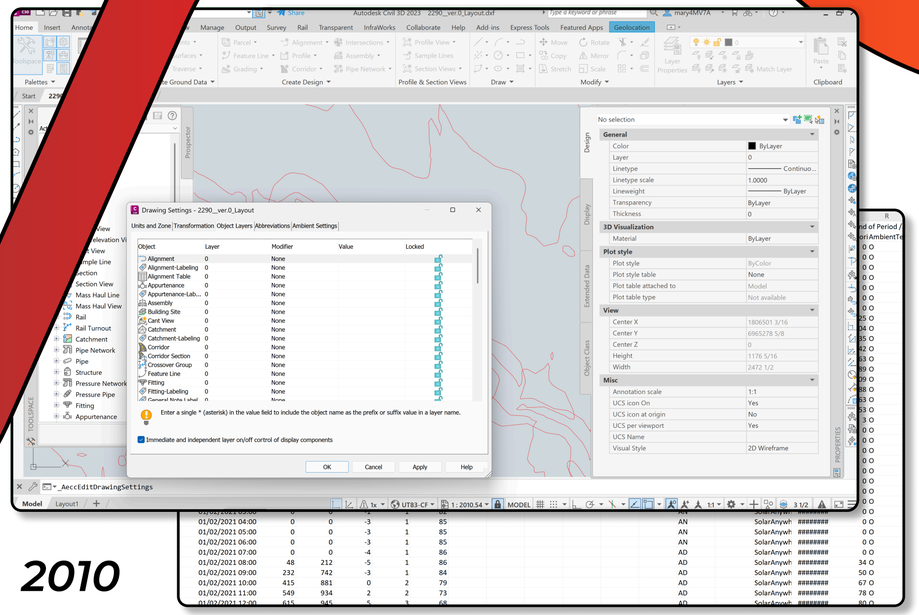
The Common Problem

Too often, teams lock in their “needle movers” years ago when their processes were first formed. These workflow fossils - design methods preserved out of habit or tradition - still drive projects today. But technology, project requirements, and tools have evolved, and those once-efficient workflows now hold projects back.

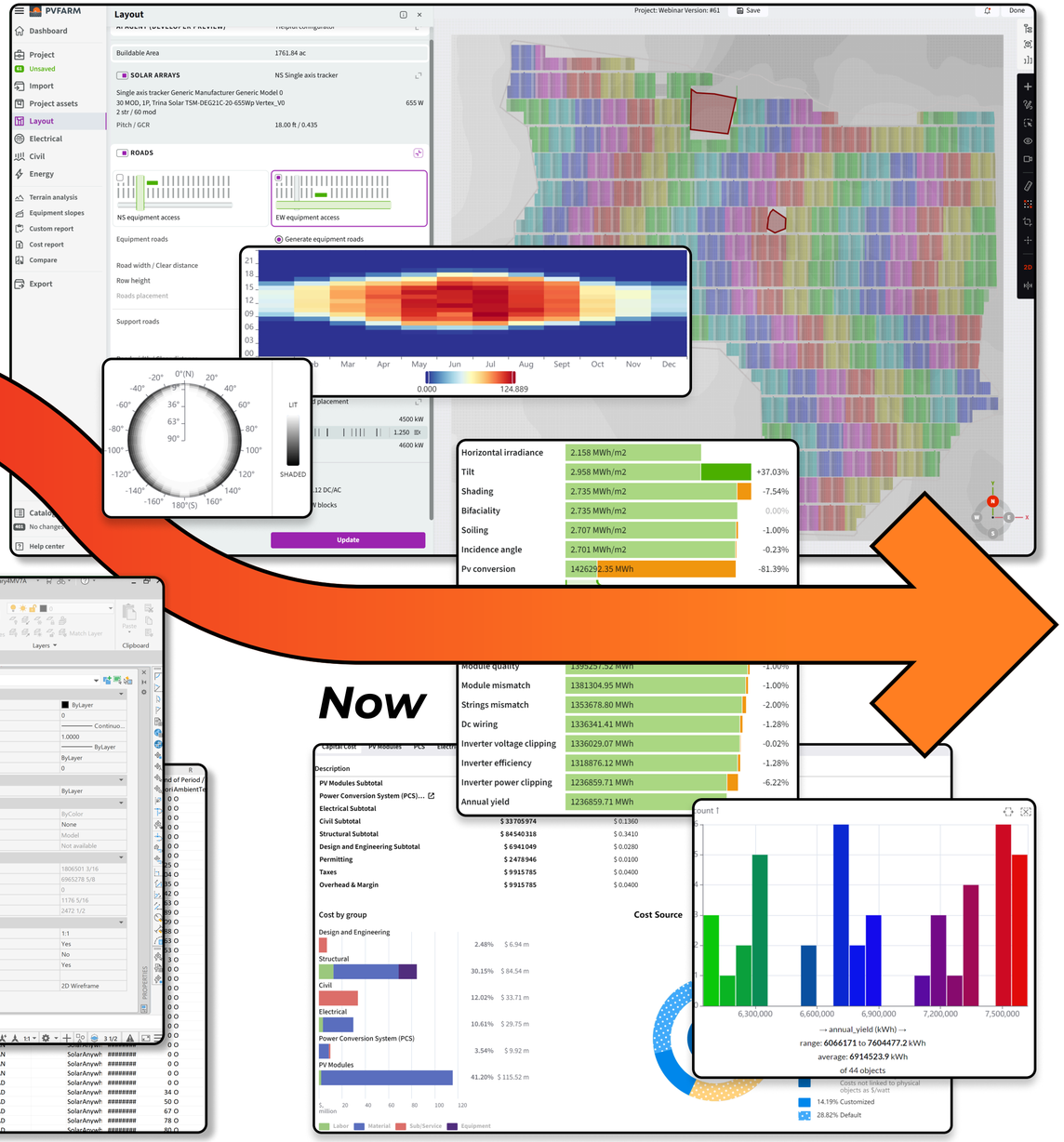
Evolution of Tools & Softwear



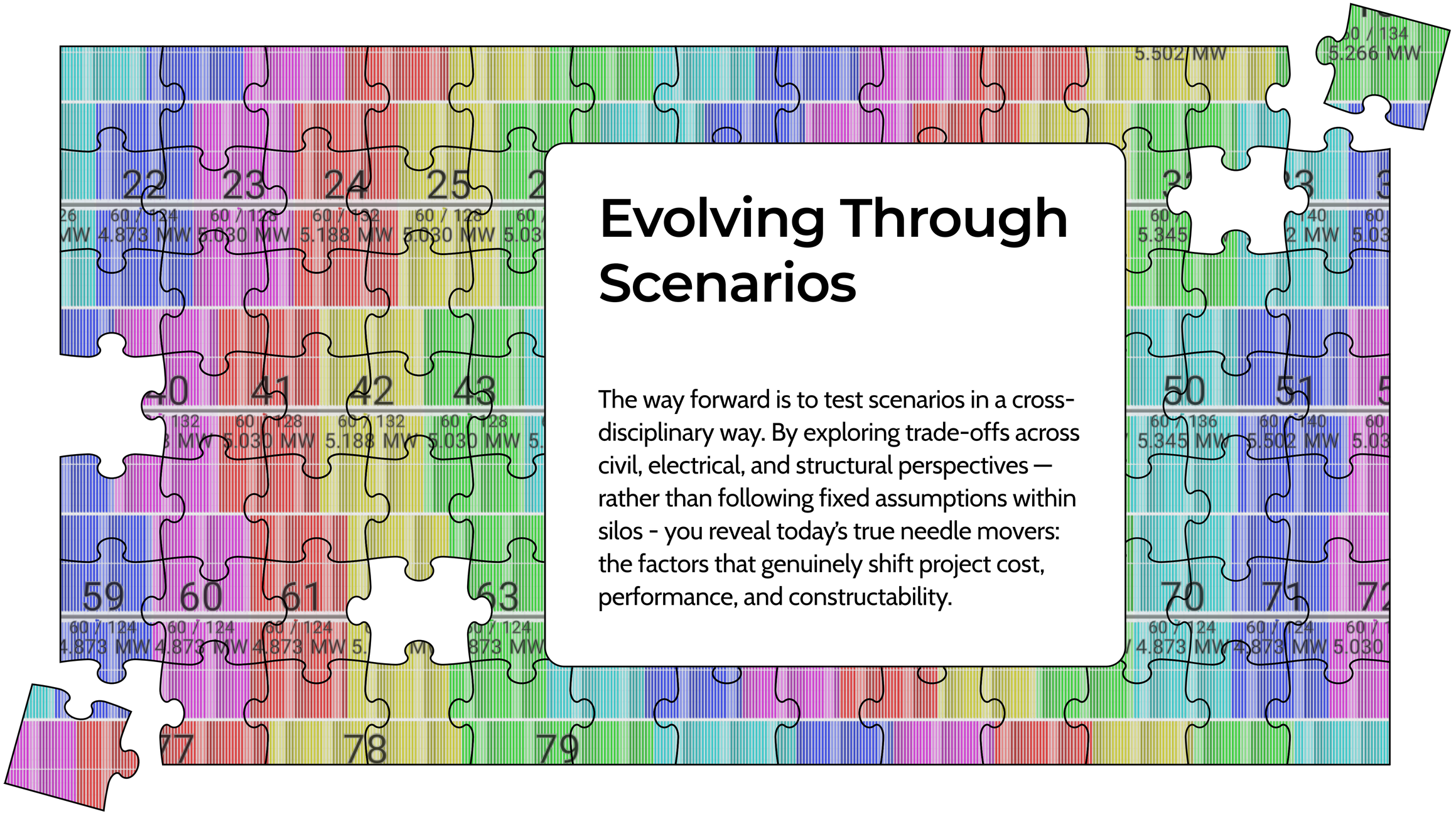
1980



2010



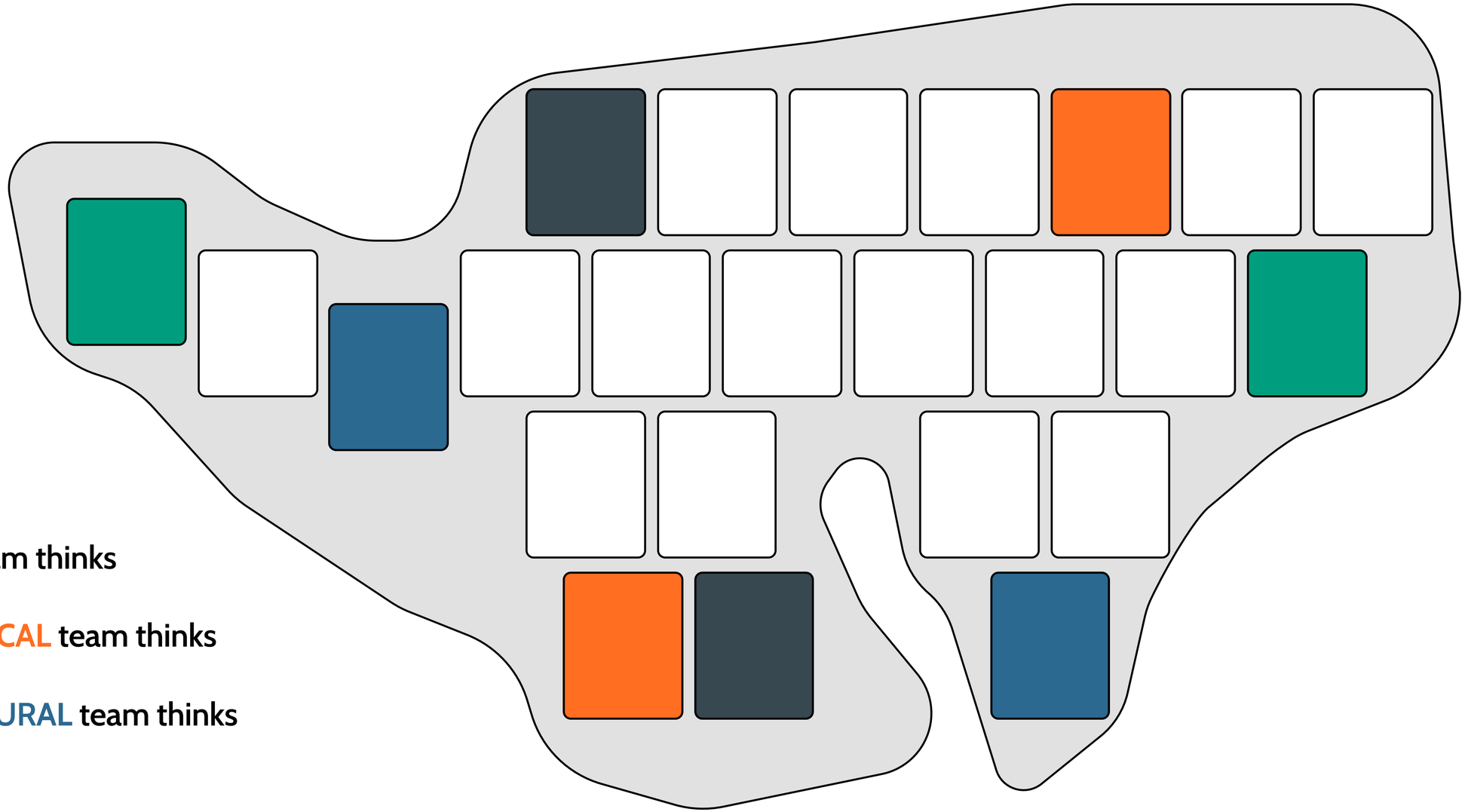
Now



Evolving Through Scenarios

The way forward is to test scenarios in a cross-disciplinary way. By exploring trade-offs across civil, electrical, and structural perspectives — rather than following fixed assumptions within silos - you reveal today's true needle movers: the factors that genuinely shift project cost, performance, and constructability.

Highest Cost Blocks:

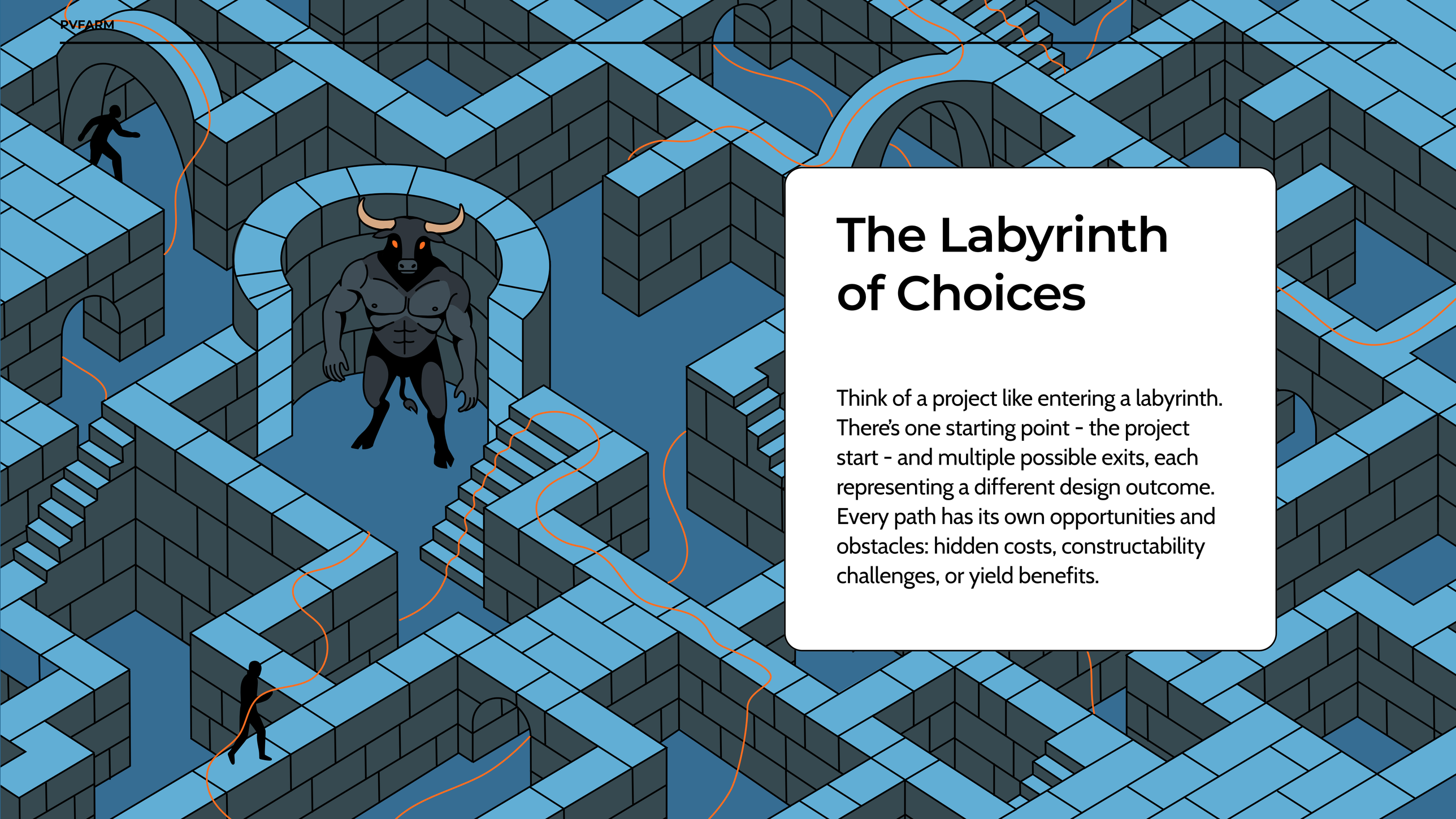


As CIVIL team thinks

As ELECTRICAL team thinks

As STRUCTURAL team thinks

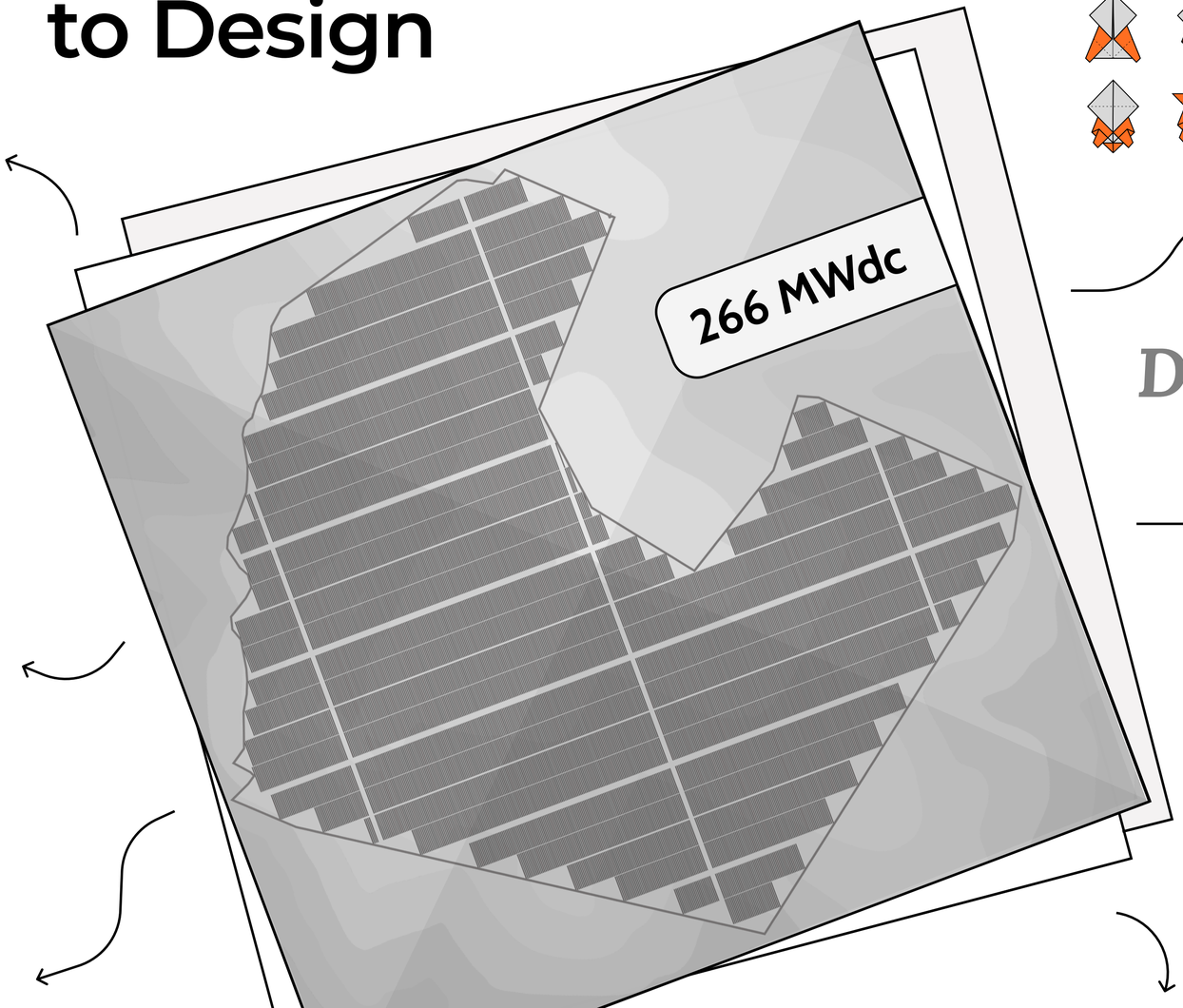
In FACT

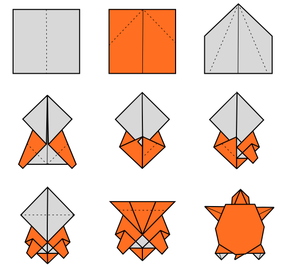


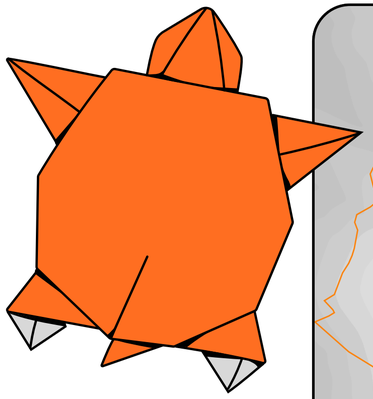
The Labyrinth of Choices

Think of a project like entering a labyrinth. There's one starting point - the project start - and multiple possible exits, each representing a different design outcome. Every path has its own opportunities and obstacles: hidden costs, constructability challenges, or yield benefits.

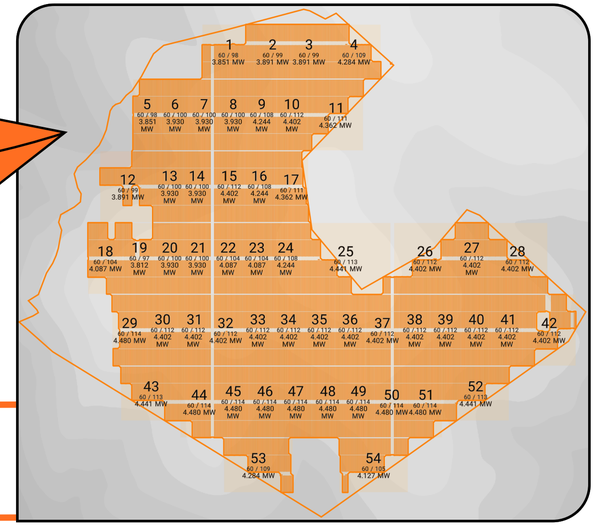
Same context. But Many Ways to Design



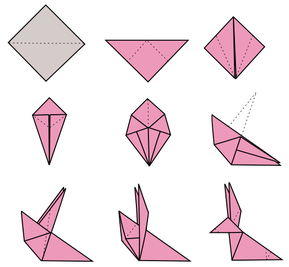




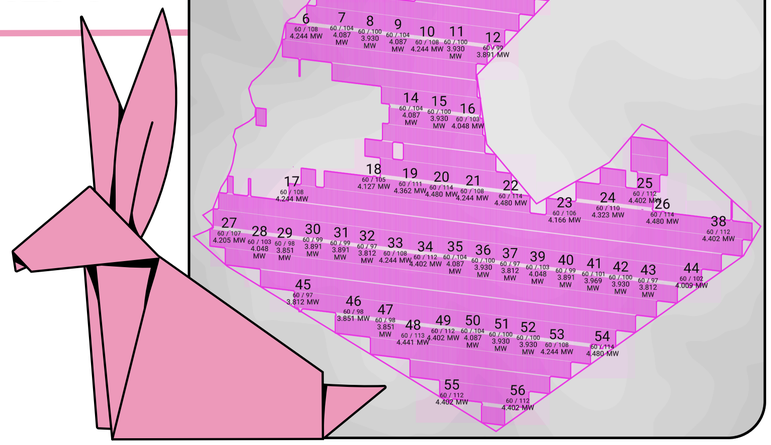
$250.7M



Don't default — design with intent.



$273.2M

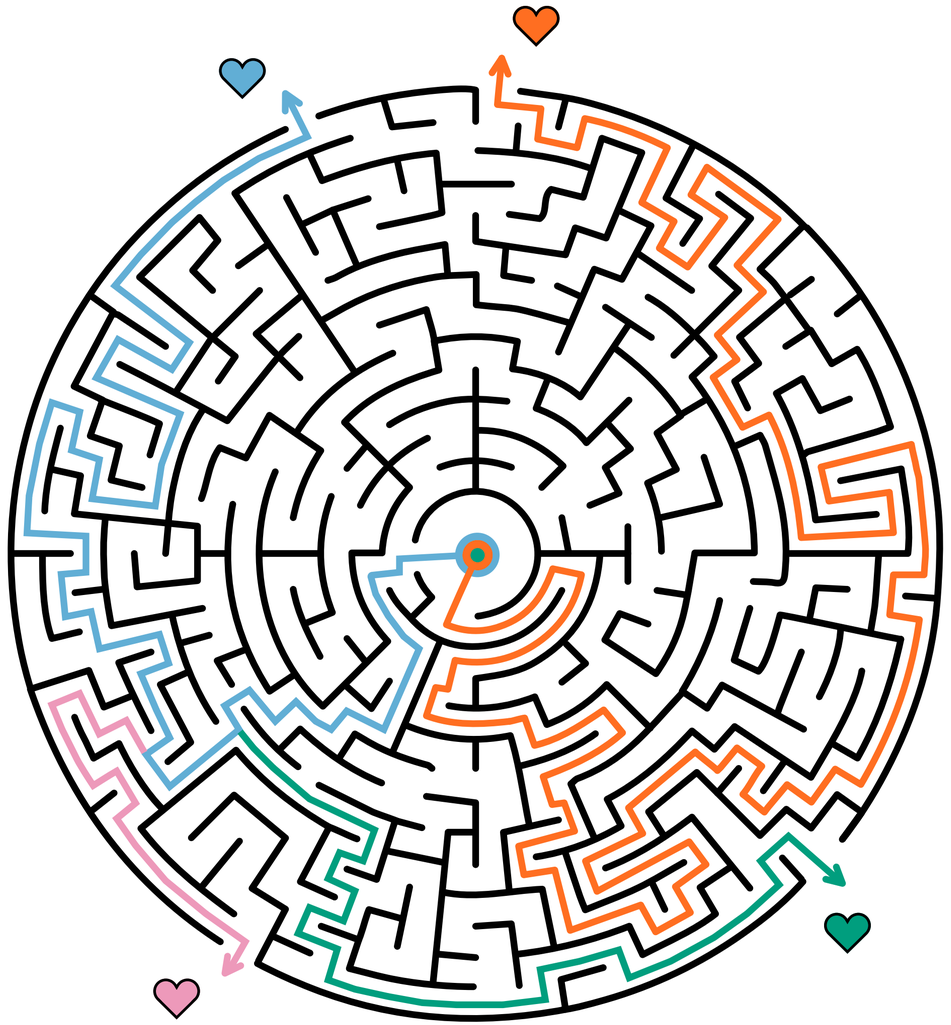


The Labyrinth of Choices

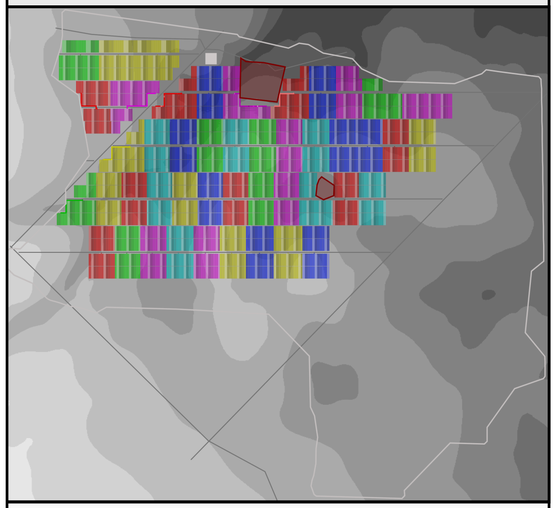
- Spatial/Access Design FIRST
- Civil BOS FIRST
- Electrical BOS FIRST
- Structural BOS FIRST

Teams often end up following the same “worn path,” repeating familiar workflows without considering that alternative routes might exist and even be better. The real goal is to quickly see the different possible routes, iterate through them, and select the path that leads to the best overall outcome.

This is exactly what new tools make possible: instead of being locked into one predictable path, you can explore multiple strategies, compare them, and adapt the process to the site itself.

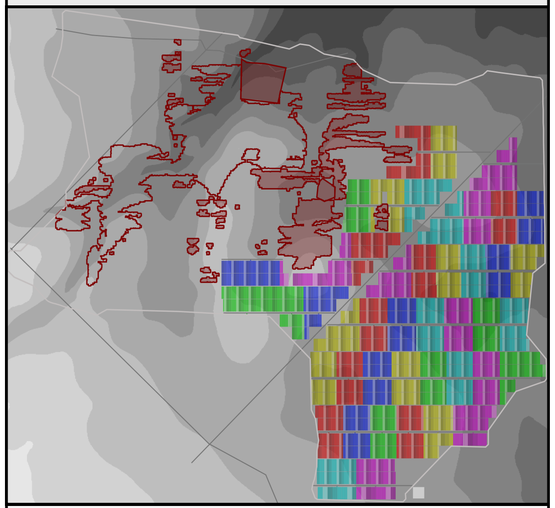


Spatial/Access Design FIRST



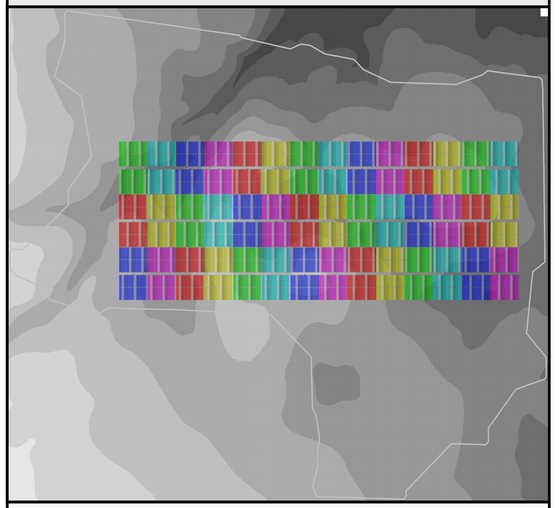
$206.2 MLN
0.88 $/W

Civil BOS FIRST



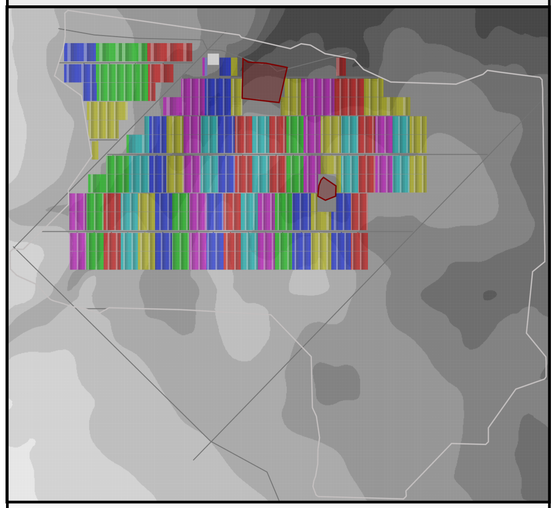
$201.7 MLN
0.87 $/W

Electrical BOS FIRST

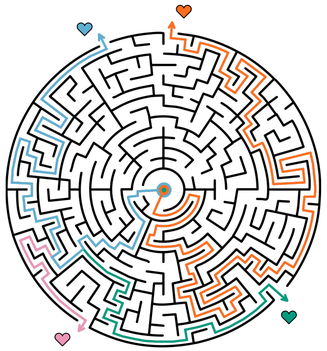


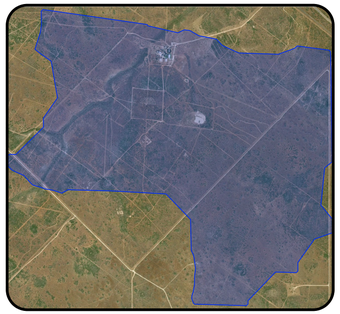
$202.0 MLN
0.87 $/W

Structural BOS FIRST



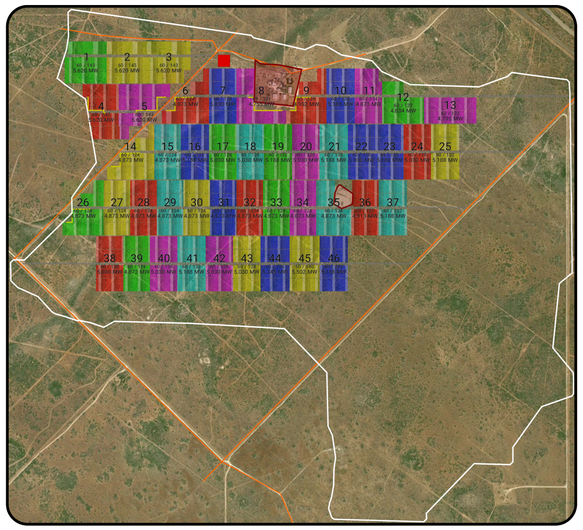
$205.4 MLN
0.89 $/W



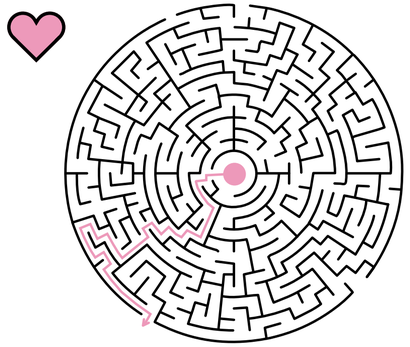


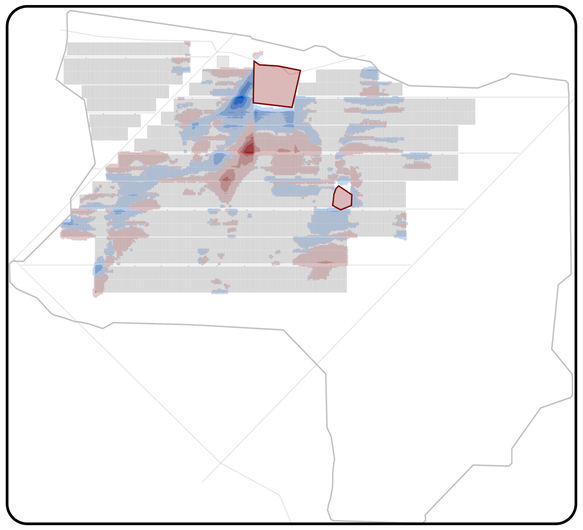
1780 acres & 230.0 MWDC

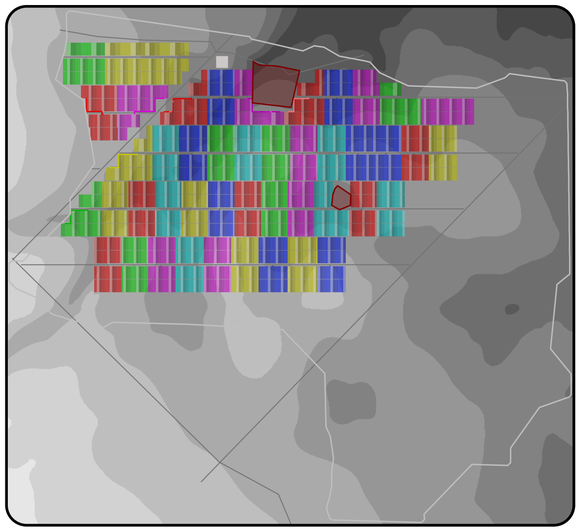
Same site, same target - but a different order of design decisions. When you change the sequence in which constraints are handled - civil before electrical, access before structure - you change the outcome

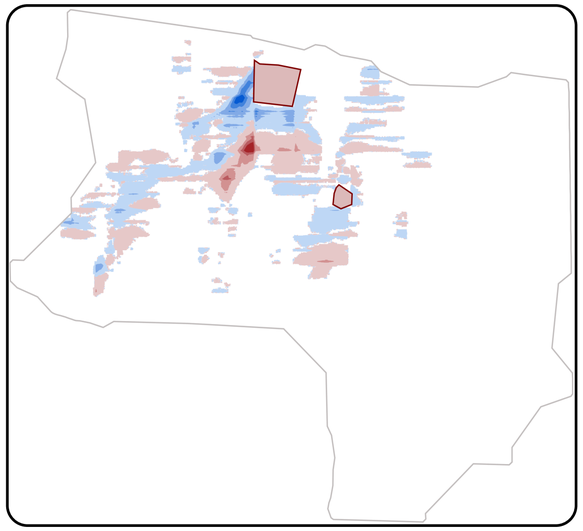


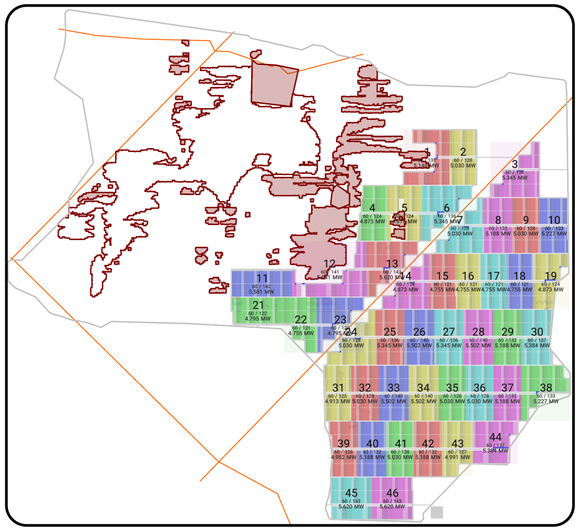
Spatial/Access Design FIRST



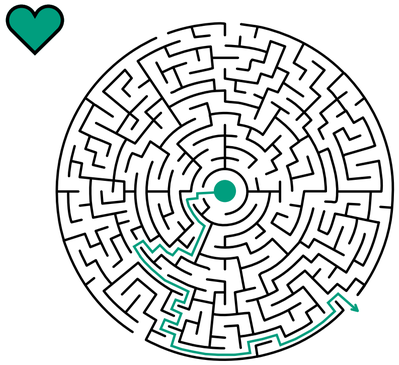


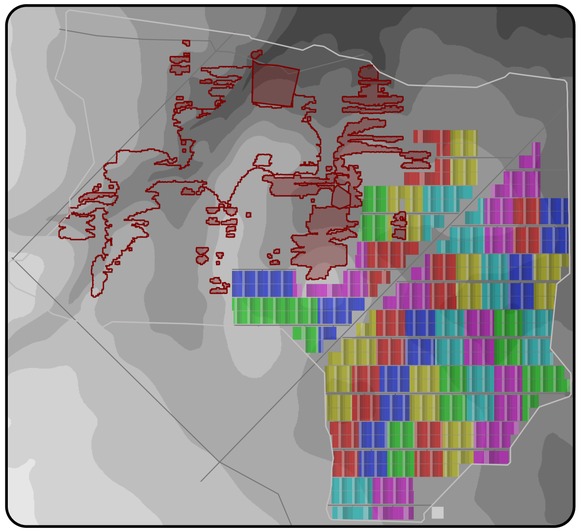


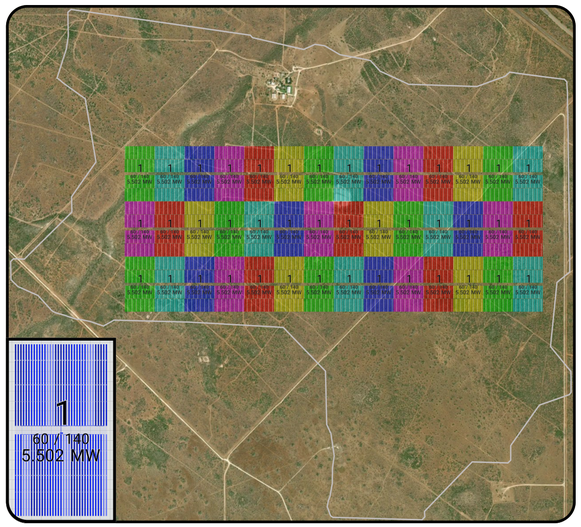




Civil BOS FIRST

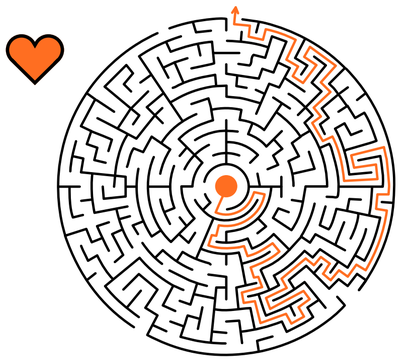


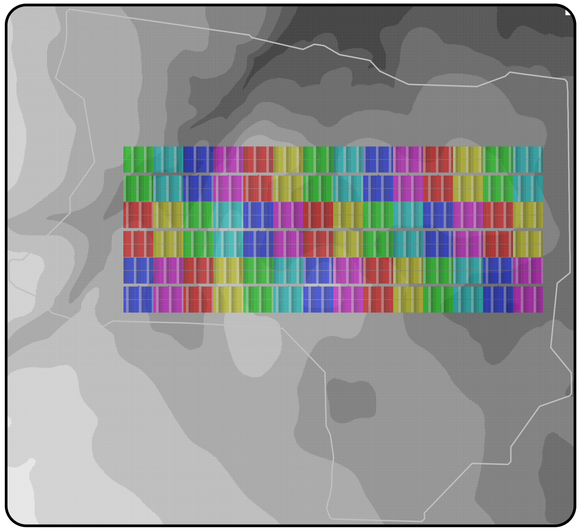


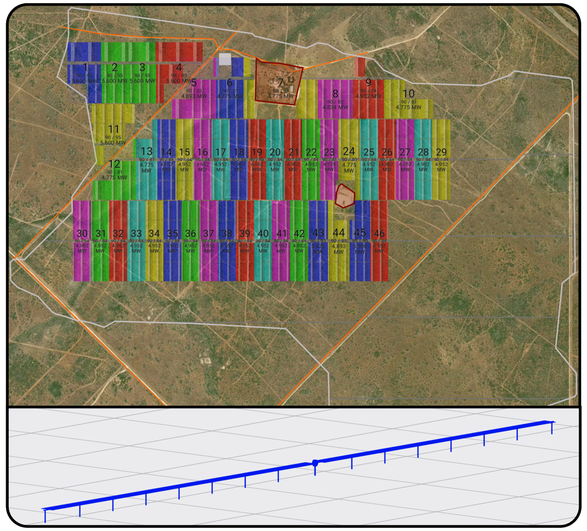




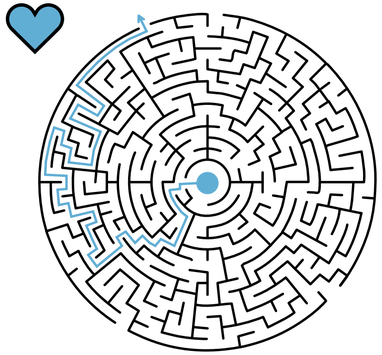
Electrical BOS FIRST



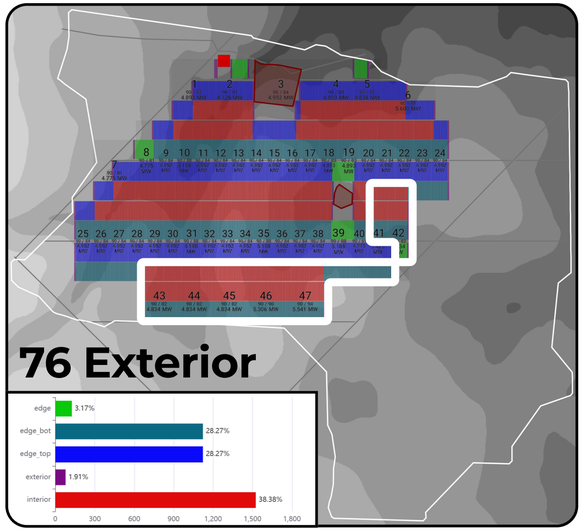


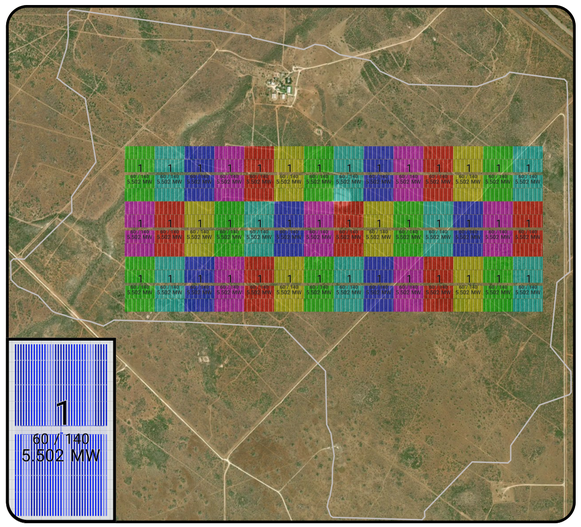


Structural BOS FIRST



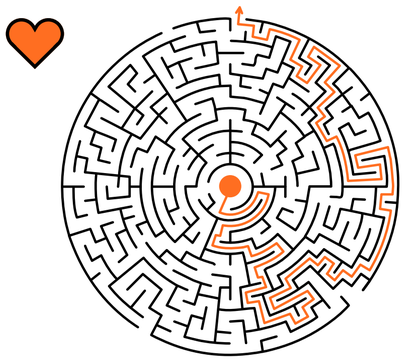


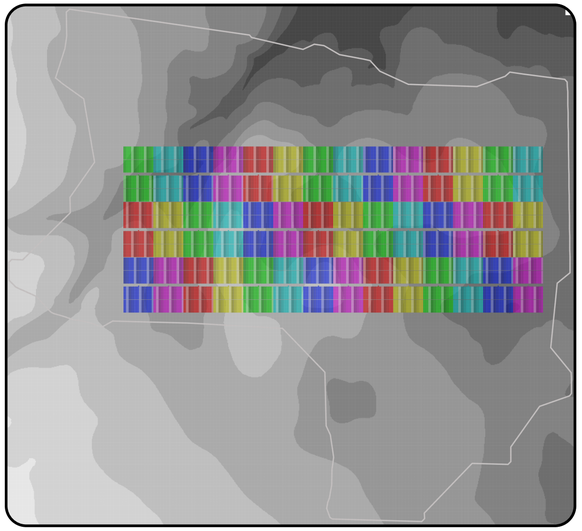


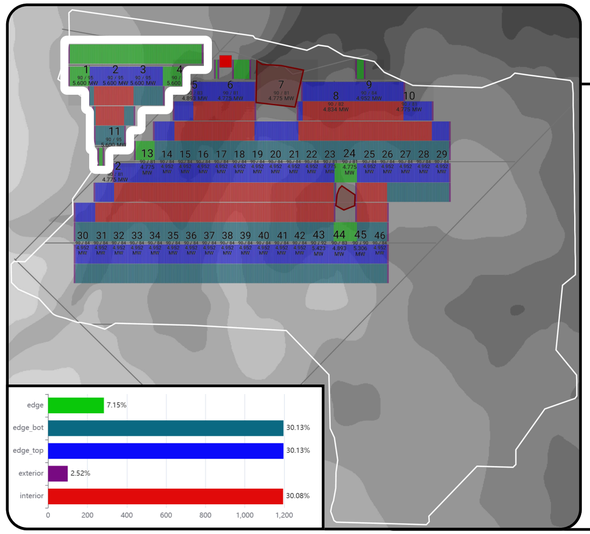




Electrical BOS FIRST





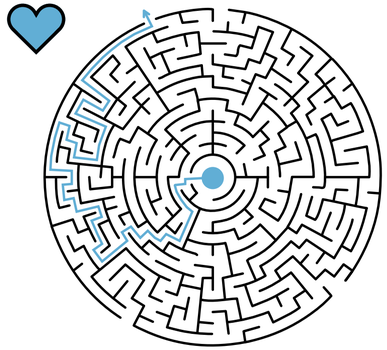


100 Exterior
234.2MWDC

NO GRADING
$201.4 MLN
0.86 $/W

GRADING
$205.0 MLN
0.88 $/W

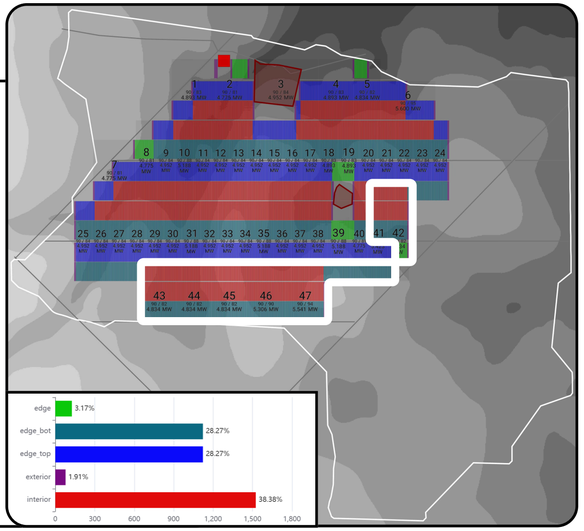
Structural BOS FIRST



76 Exterior
234.2MWDC

NO GRADING
$201.1 MLN
0.86 $/W

GRADING
$209.0MLN
0.89 $/W

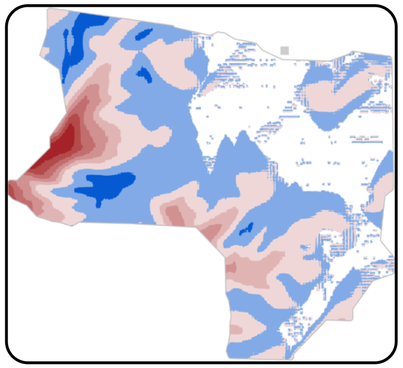


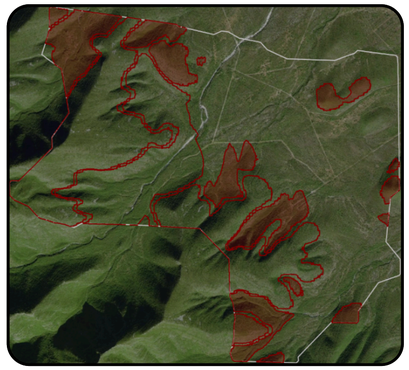
What If ..?

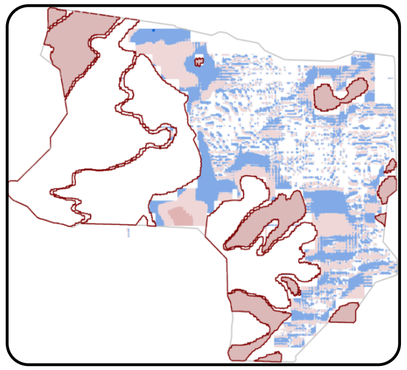
A couple of examples where wrong needle mover was selected

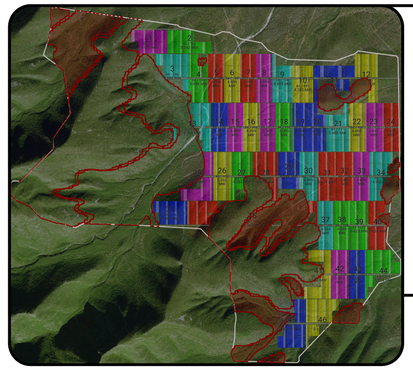


Main terrain



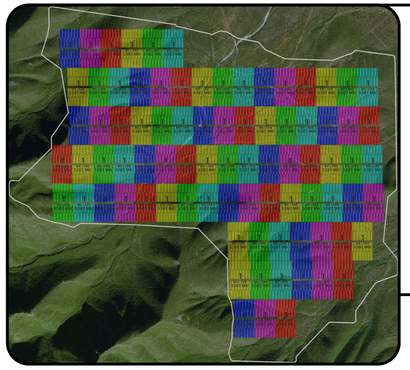






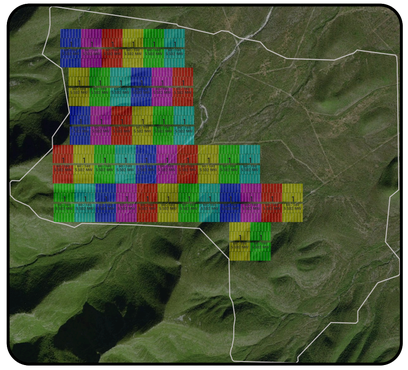
230 MWDC

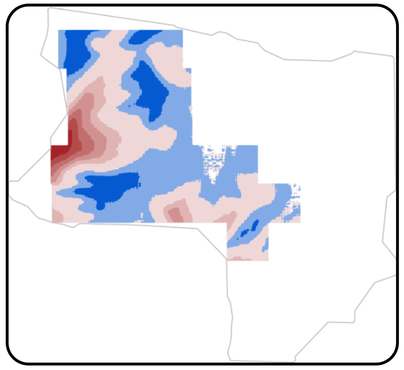
$259.2 MLN
1.12$/W

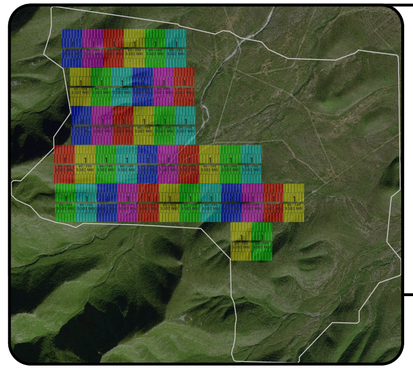


462 MWdc

target is 230MWdc



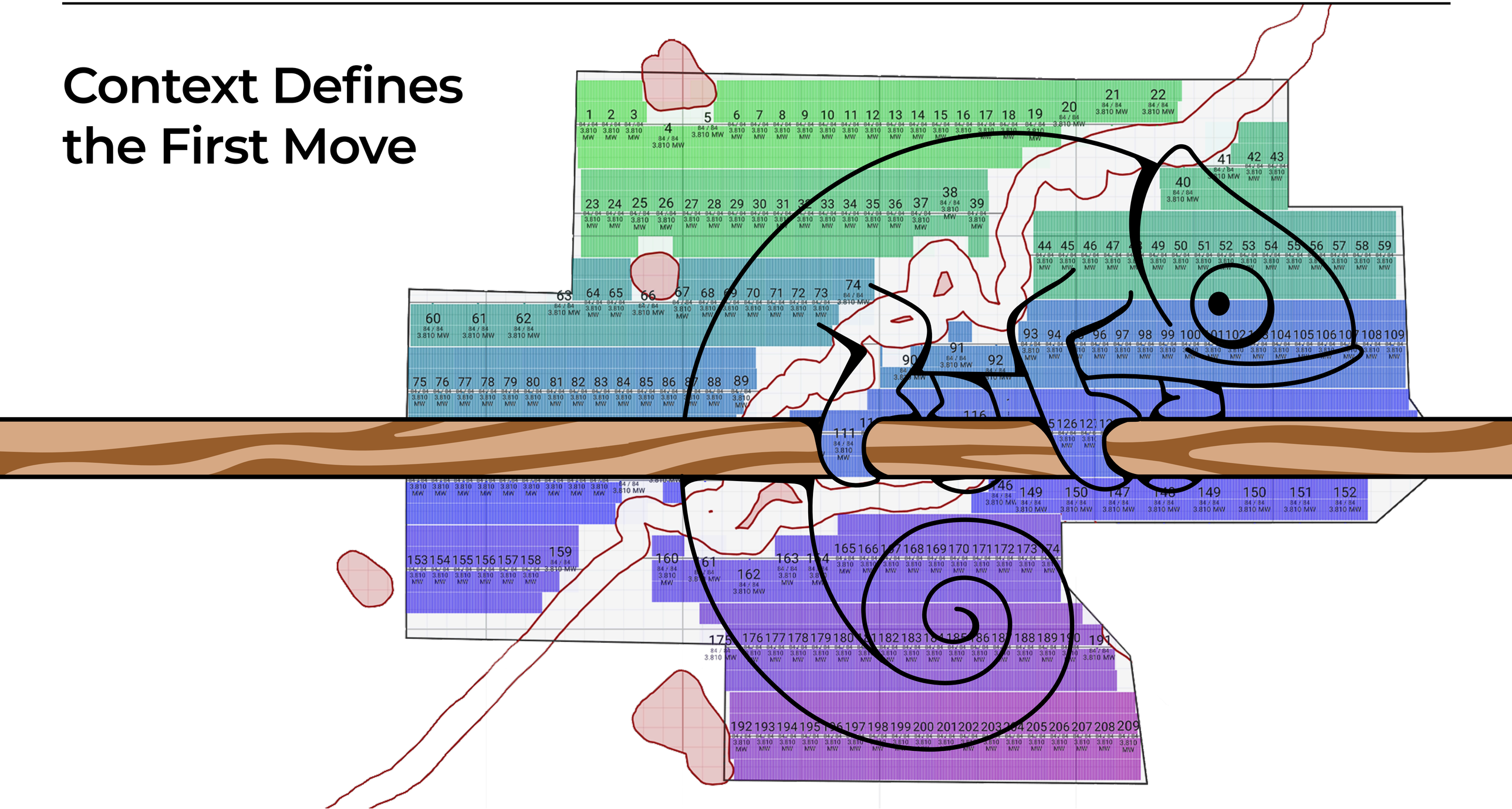


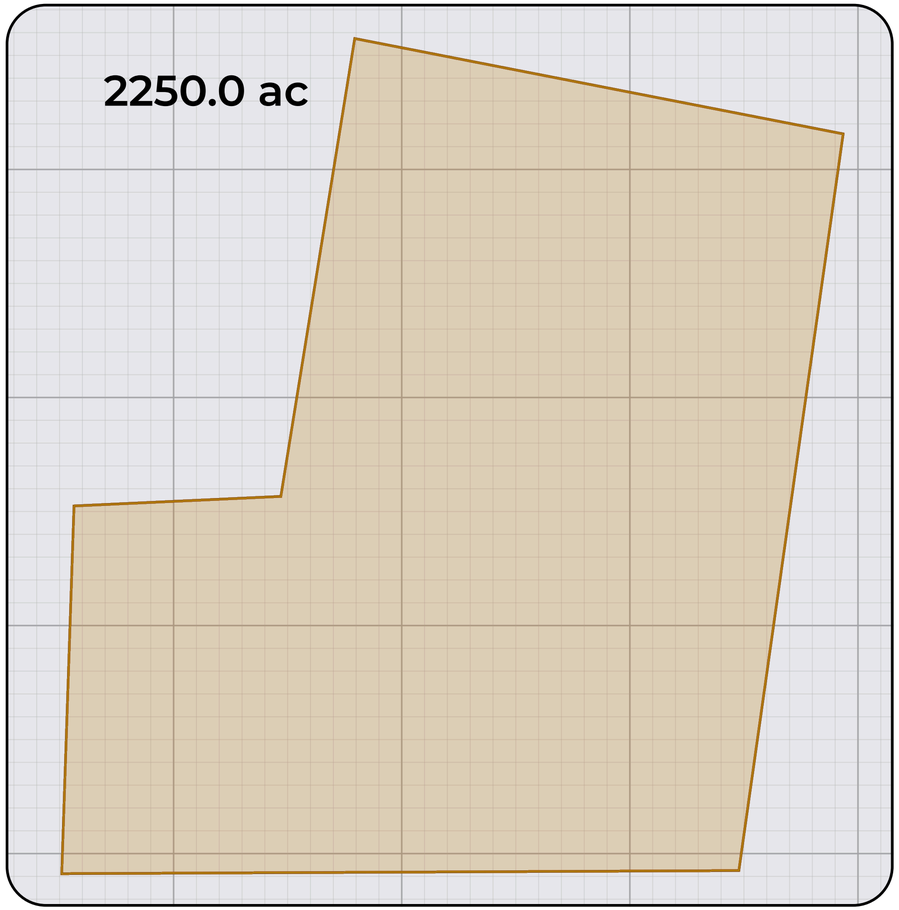


230 MWdc

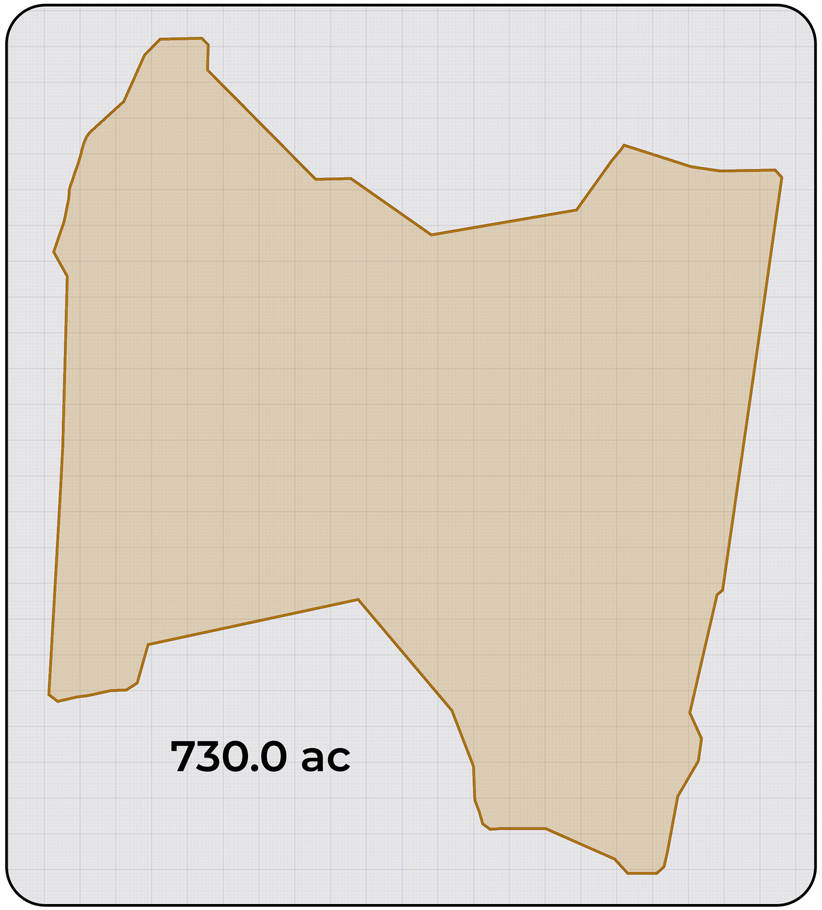
$684.7 MLN
2.96$/W

Context Defines the First Move

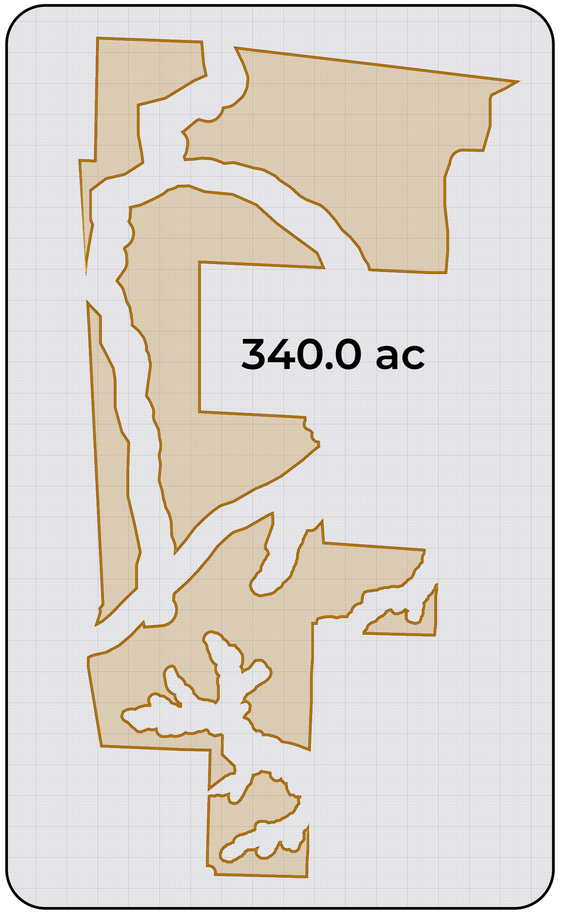




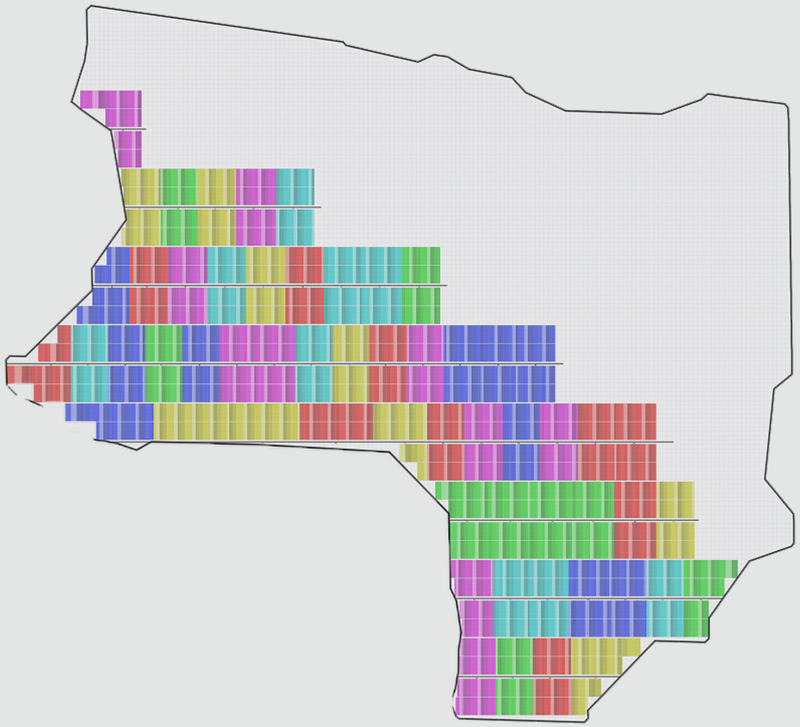
Big Boxy & Easy



Medium Chunky Puzzle



Complex Swiss Cheese

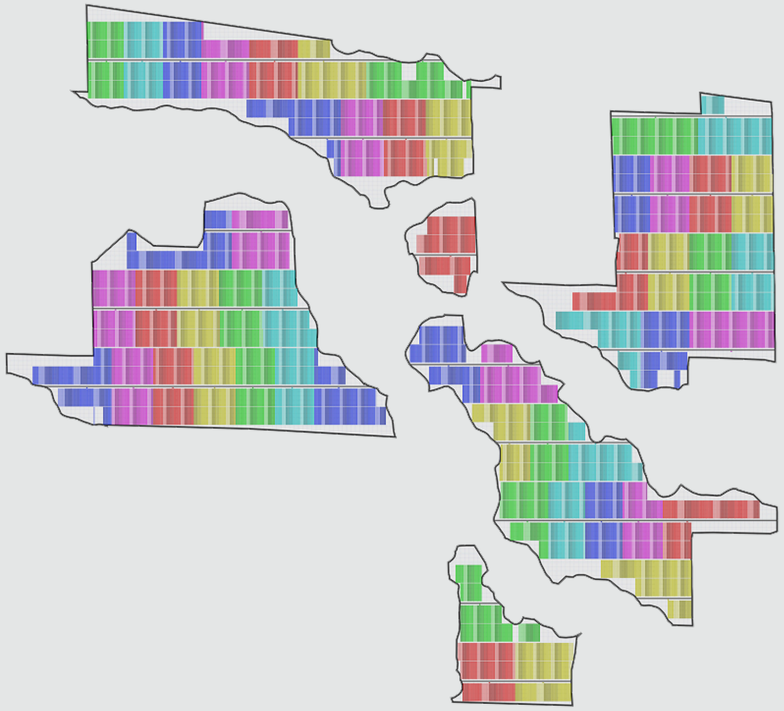


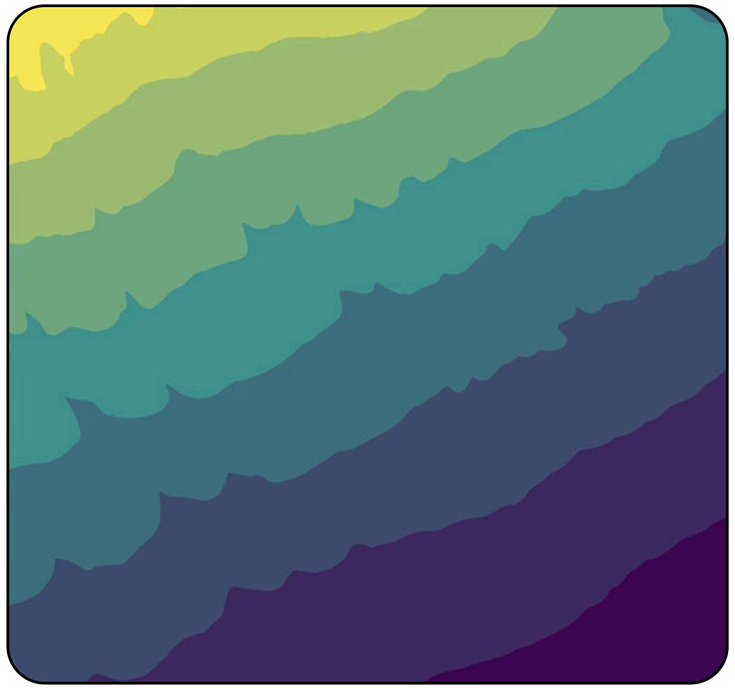
Abundant land:

plenty of space for DC target
[interconnection constraint]

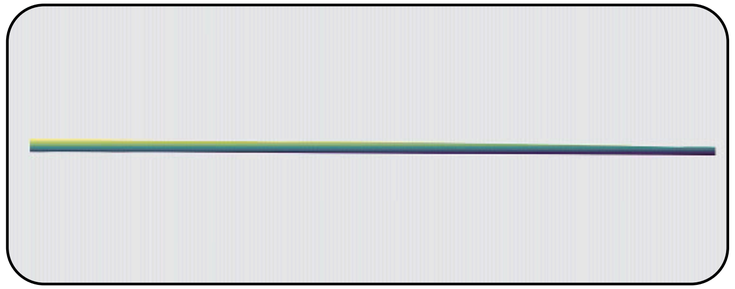
Tight fit:

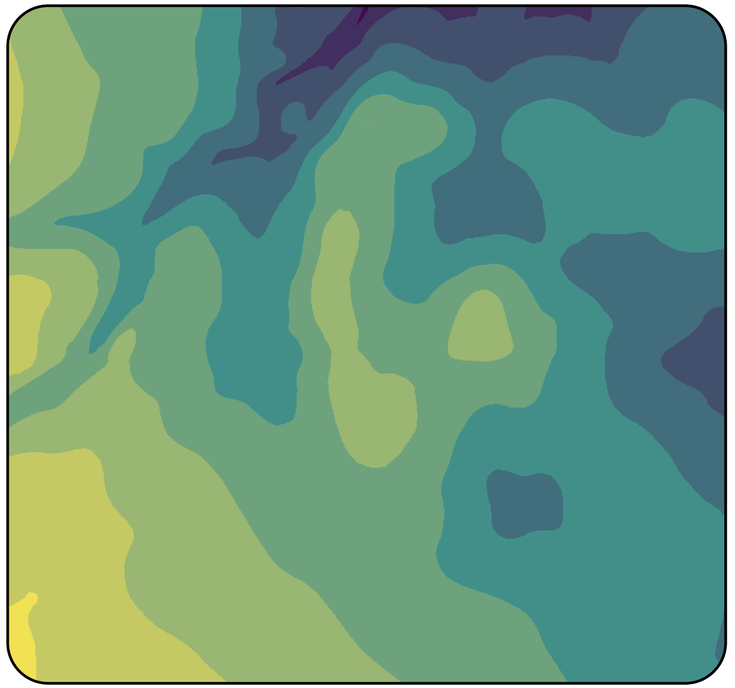
just enough space for DC target
[land constraint]



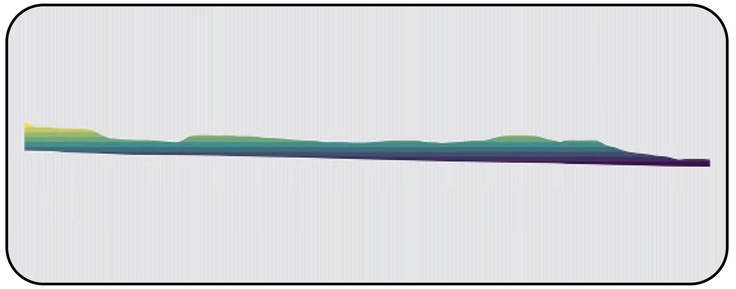


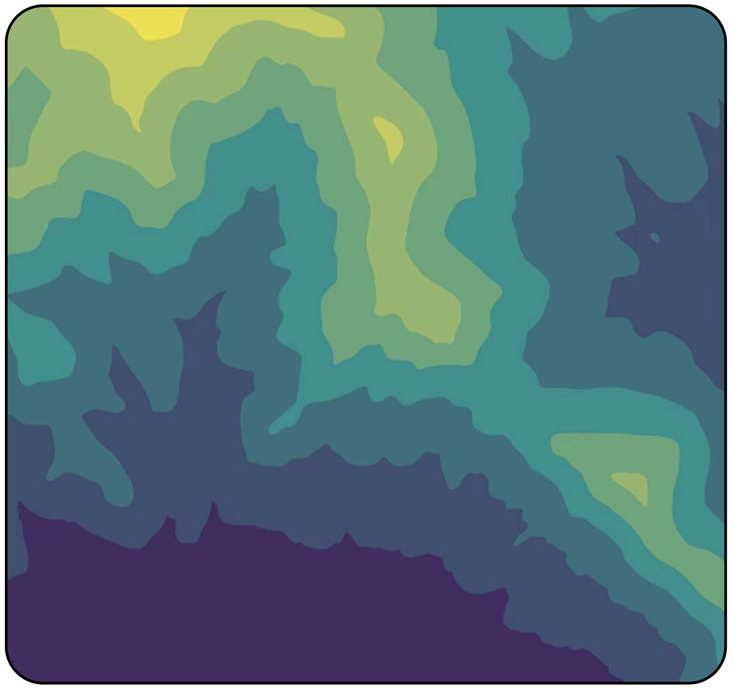
Flat & **Simple**



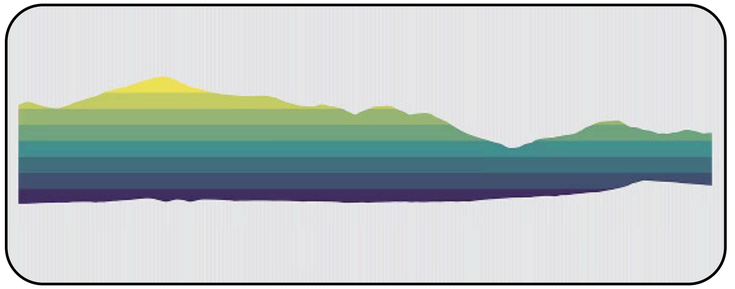


Rolling & **Moderate**





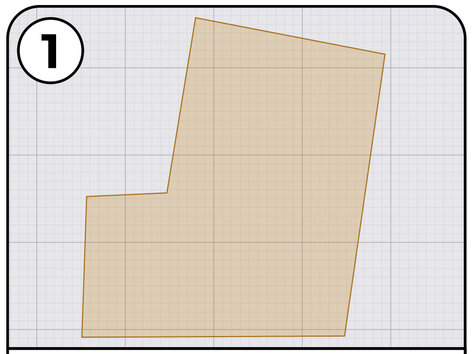
Hilly & **Complex**



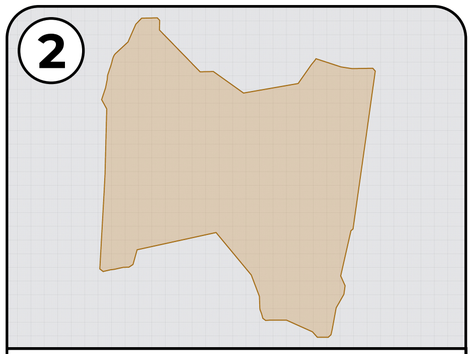
I. Abundant

Interconnection-Limited

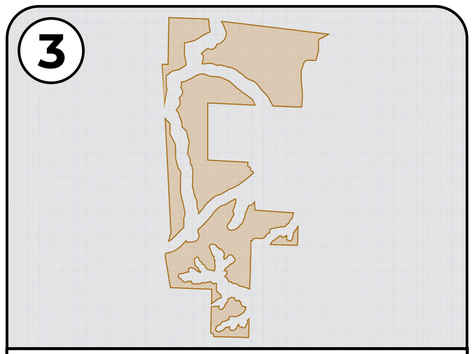
Civil	*Electrical*
Layout	*Both & Repeat*



Big Boxy & Easy



Medium Chunky Puzzle



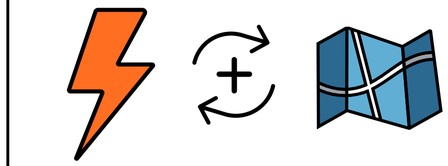
Complex Swiss Cheese

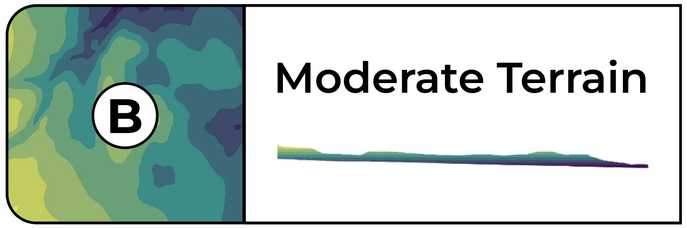


Simple Terrain

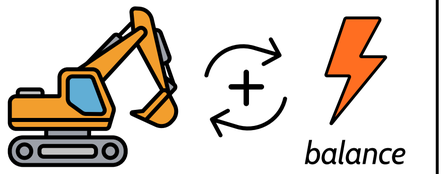
1 step *2 step*

1 step *2 step*



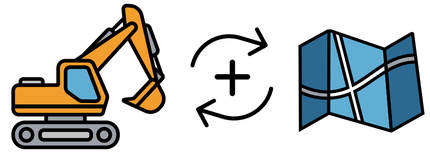


Moderate Terrain



1 step *2 step*

supports





Complex Terrain

1 step

grading

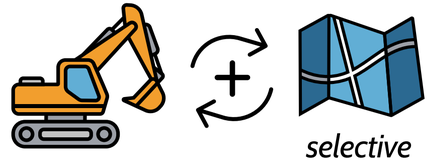
2 step

listen to your heart

1 step

2 step

cluster strategy

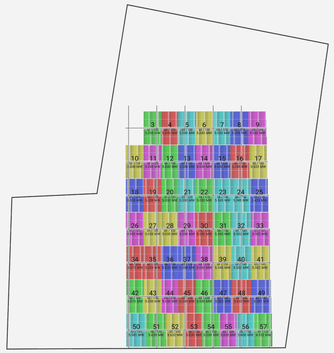


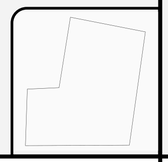
PVFARM

I. 1-A

284.0 MWDC

$245.1 MLN
0.86 $/W

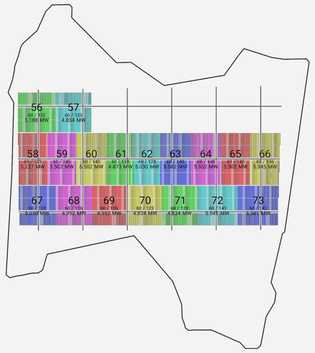


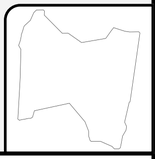


I. 2-A

96.5 MWDC

$83.8 MLN
0.87 $/W

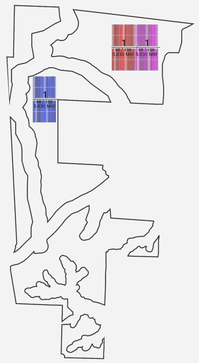




I. 3-A

20.1 MWDC

$18.7 MLN
0.93 $/W

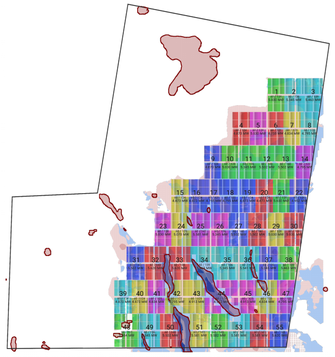




I. 1-B

284.0 MWDC

$400.1 MLN
1.41 $/W

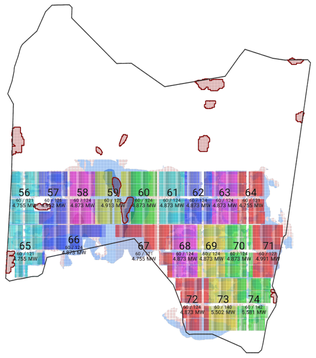


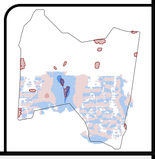


I. 2-B

93.7 MWDC

$107.11 MLN
1.14 $/W

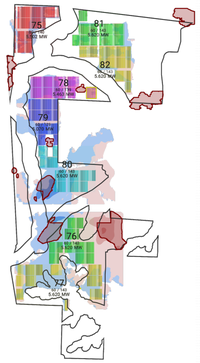


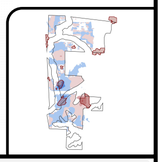


I. 3-B

44.1 MWDC

$71.4 MLN
1.62 $/W

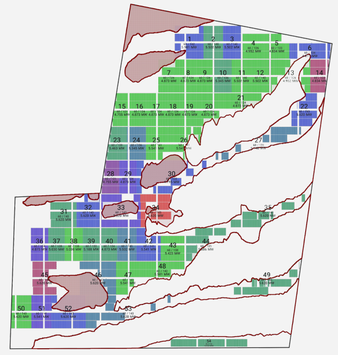


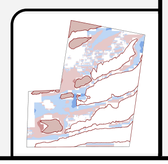


I. 1-C

284.0 MWDC

$517.0 MLN
1.82 $/W

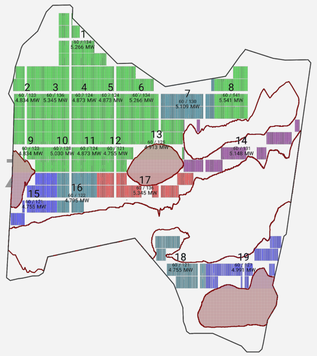




I. 2-C

96.5 MWDC

$127.4 MLN
1.32 $/W

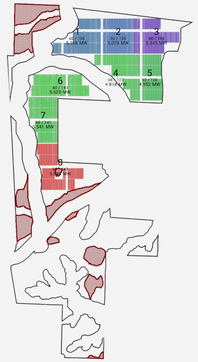




I. 3-C

44.1 MWDC

$41.9 MLN
0.95 $/W

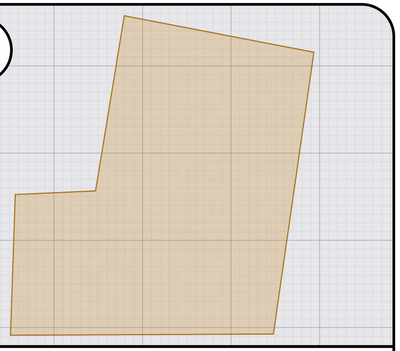
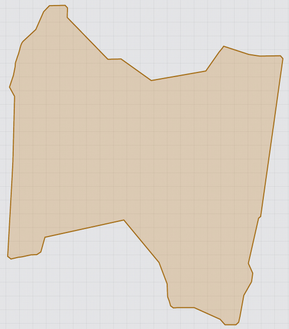




II. Tight Fit

Land-Limited

Civil	Electrical
Layout	Both & Repeat

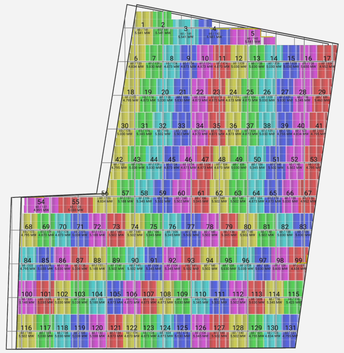
	1	2	3
			
	Big Boxy & Easy	Medium Chunky Puzzle	Complex Swiss Cheese
A Simple Terrain	1 step density 2 step	1 step density 2 step	density +
B Moderate Terrain	1 step 2 step balance	tweaks +	clustering +
C Complex Terrain	zones +	selective use	cluster & selective build zones

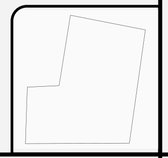
PVFARM

II. 1-A

670.3 MWDC

$583.9 MLN
0.87 $/W

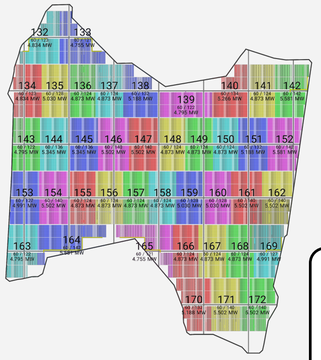


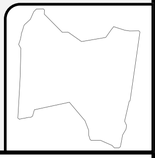


II. 2-A

208.8 MWDC

$181.0 MLN
0.87 $/W

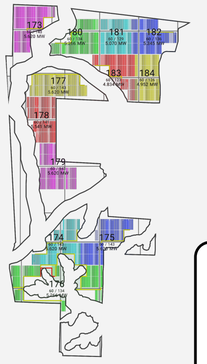




II. 3-A

64.4 MWDC

$56.1 MLN
0.87 $/W

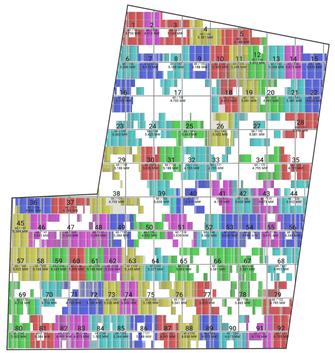


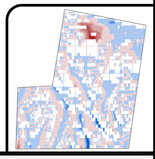


II. 1-B

472.7 MWDC

$616.9 MLN
1.31 $/W

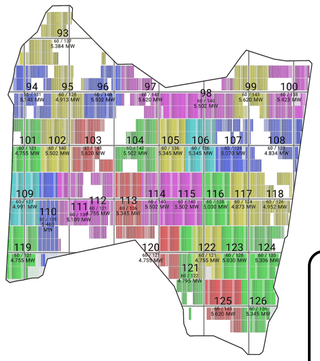


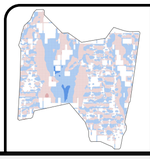


II. 2-B

177.0 MWDC

$191.4 MLN
1.08 $/W

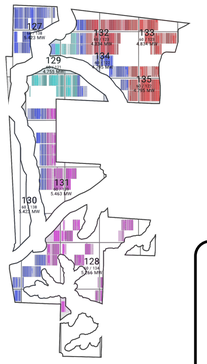




II. 3-B

45.6 MWDC

$52.5 MLN
1.15 $/W

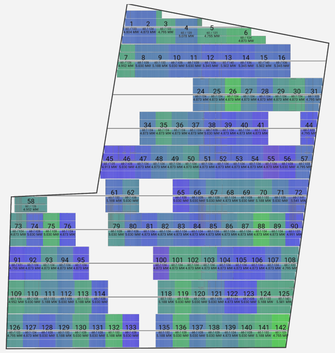


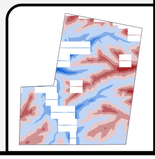


II. 1-C

582.3 MWDC

$2,362.3 MLN
4.06 $/W

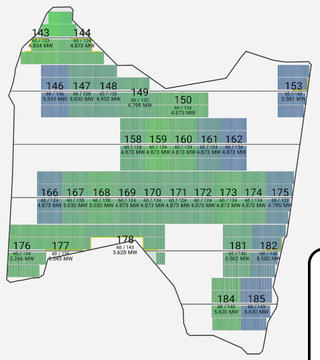


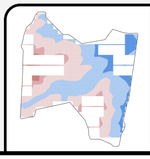


II. 2-C

152.1 MWDC

$598.9 MLN
3.94 $/W

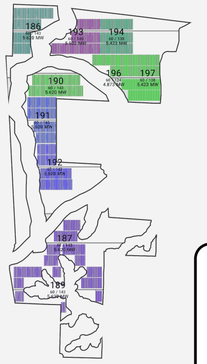


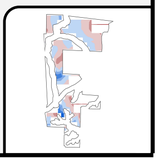


II. 3-C

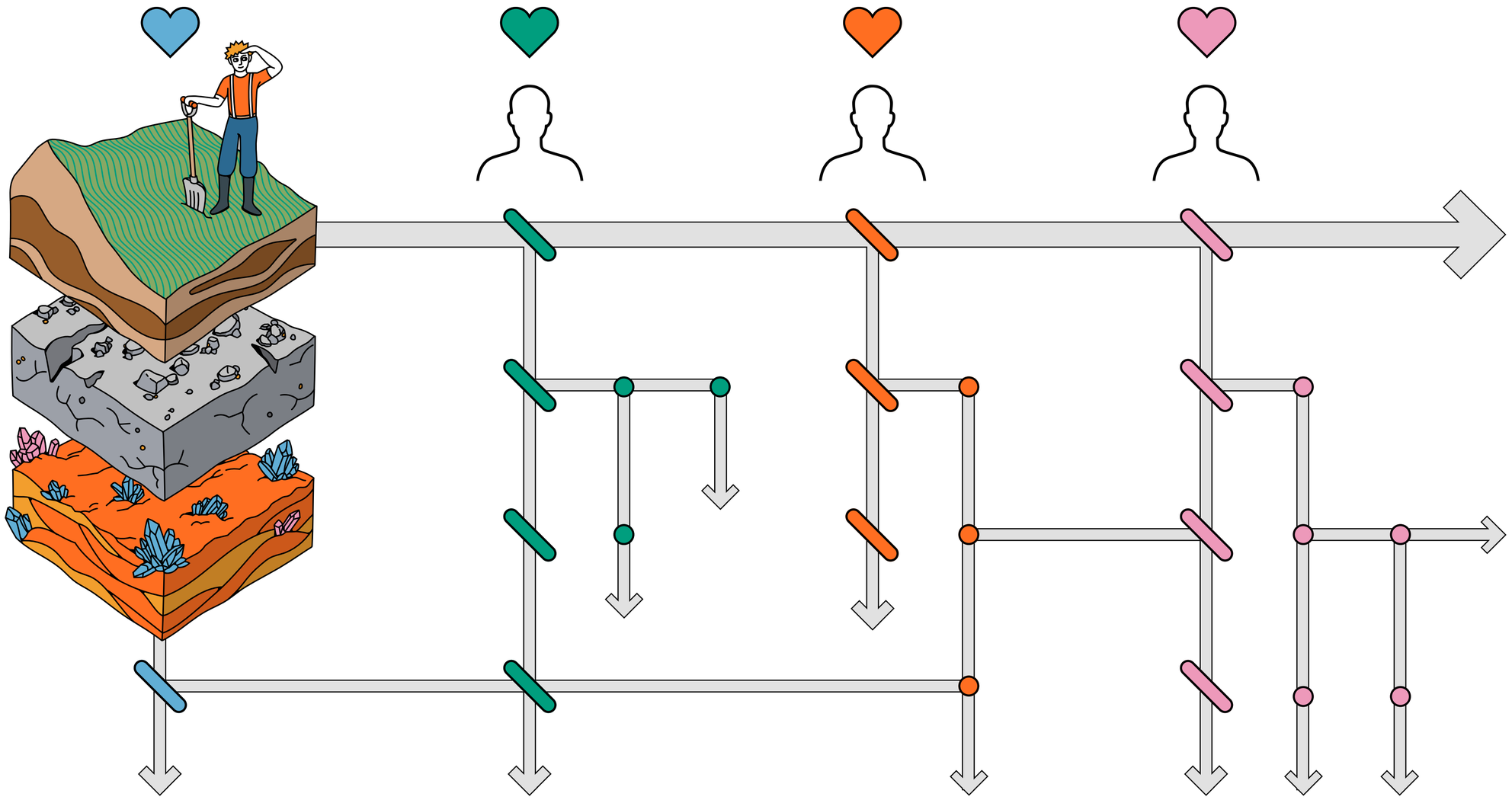
54.94 MWDC

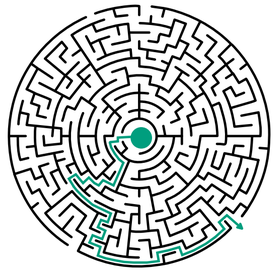
$153.3 MLN
2.79 $/W





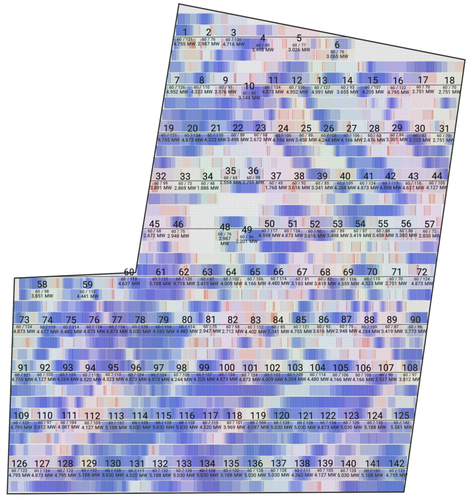
Design Iterations





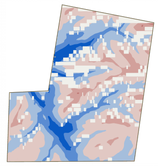
Civil scenario #1

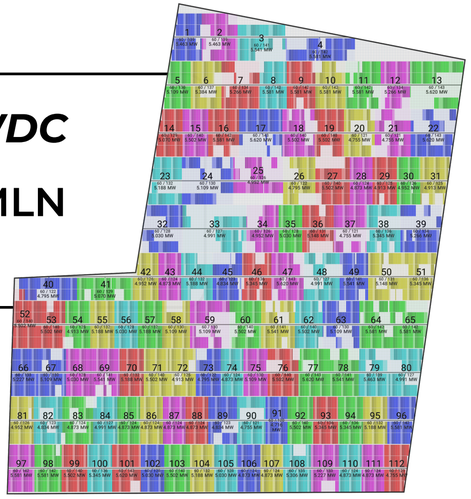




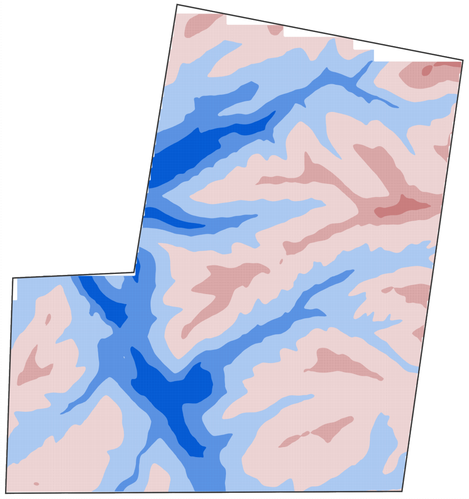
582.7MWDC

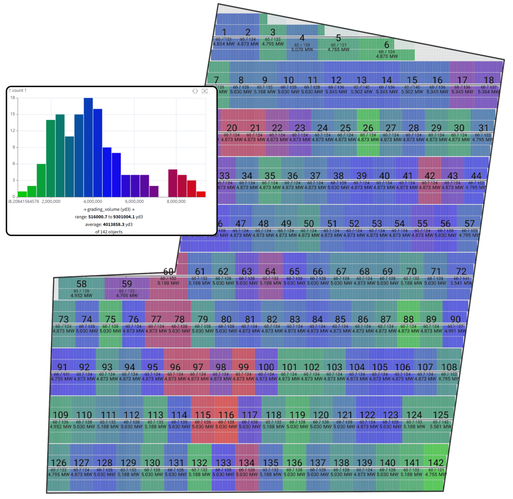
$2,851.0MLN
4.89$/W





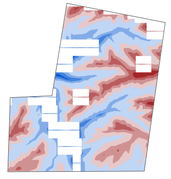
Civil scenario #2

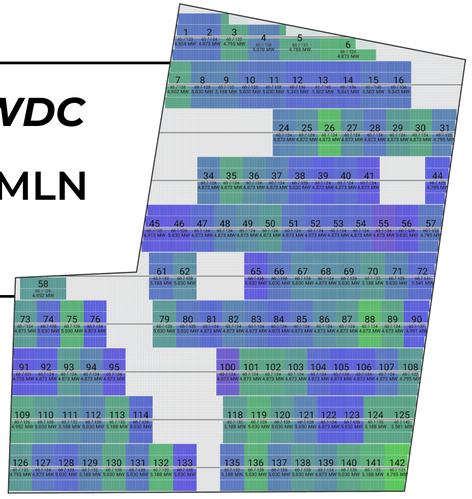




582.3 MWDC

$2,362.3 MLN
4.06$/W



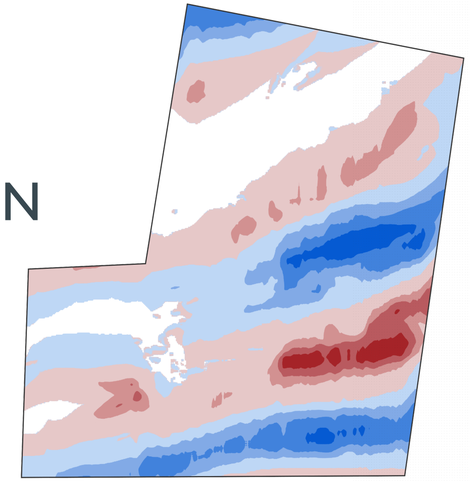
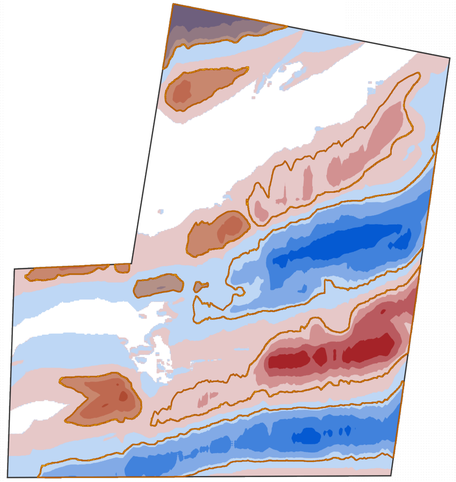
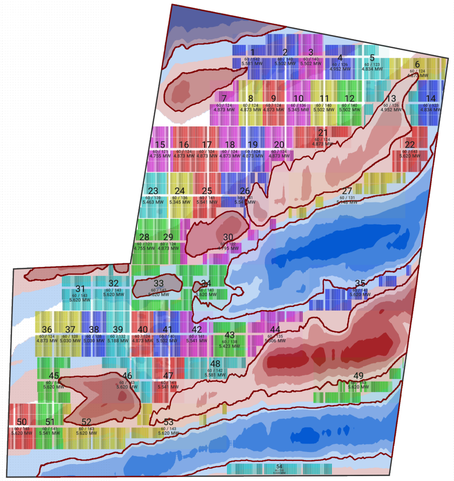


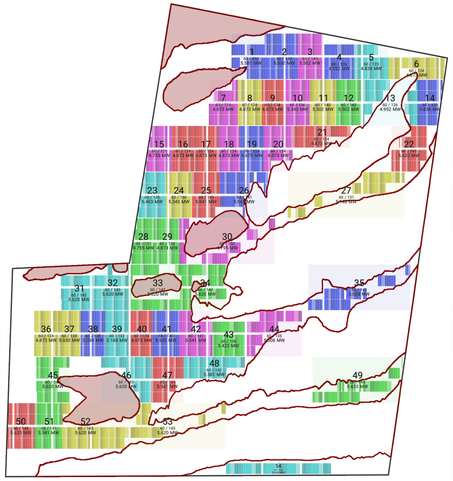
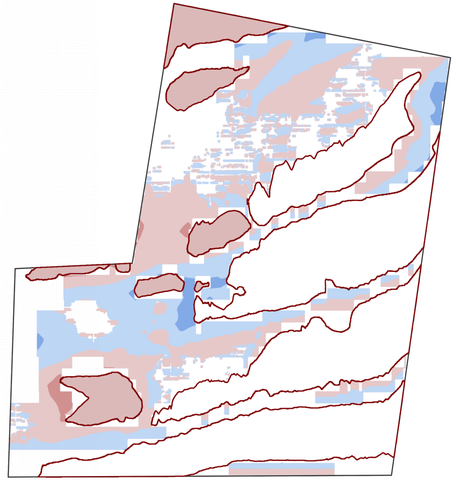
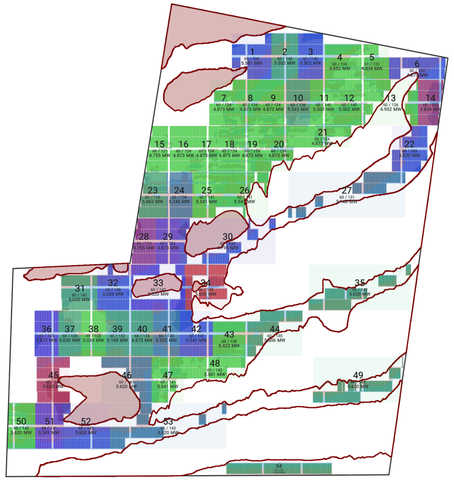
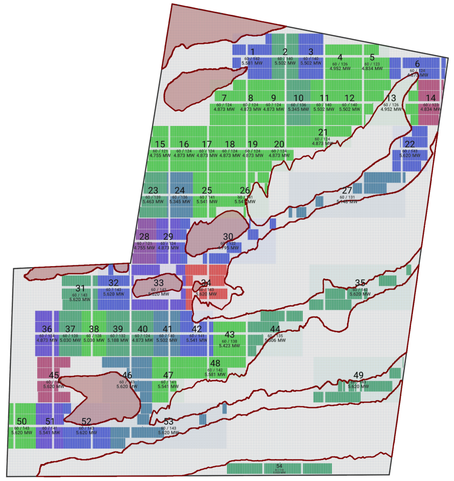
I. 1 - C

1 step	2 step
 grading	other

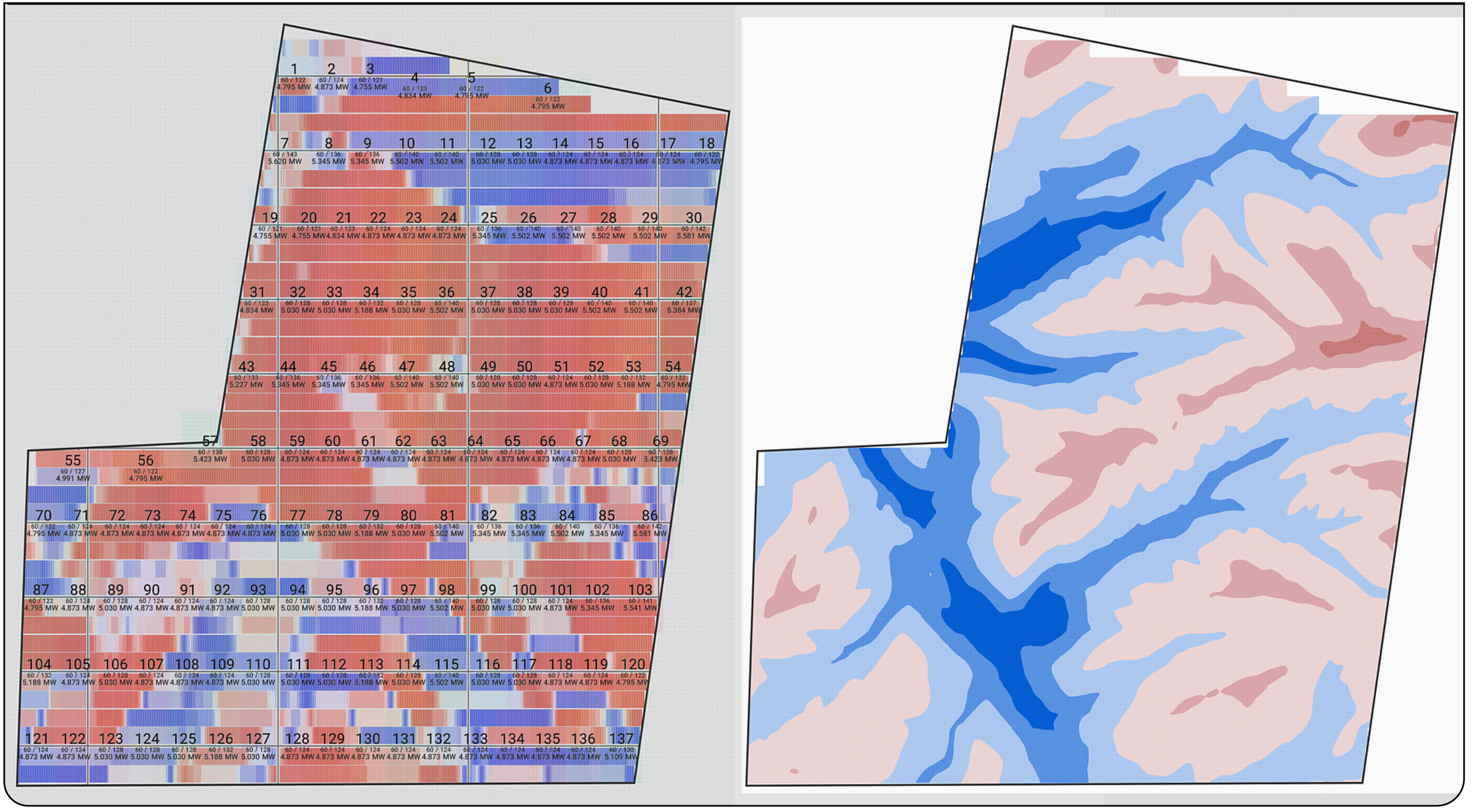
$517.0 MLN
1.82$/W

284.0 MWDC

PVFARM



Closing thought

A “needle mover first” mindset means starting with the most critical strategic decisions - not the easiest, not the most familiar. When we get those right early, the rest of the design falls into place, and project success follows.

Thank you!

Any questions?

