Generating Useful Data with Computer Vision Tools:
2 Use Cases (PDFs & Imagery)

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gis.utah.gov/presentations

Overview

Utah Department of Health & Human Services

- Two Computer Vision (CV) Projects
  - DHHS Cooling Towers Project
  - UDOT Parcel Detection Project
- Motivation
- Process
- Results

UDOT Keeping Utah Moving

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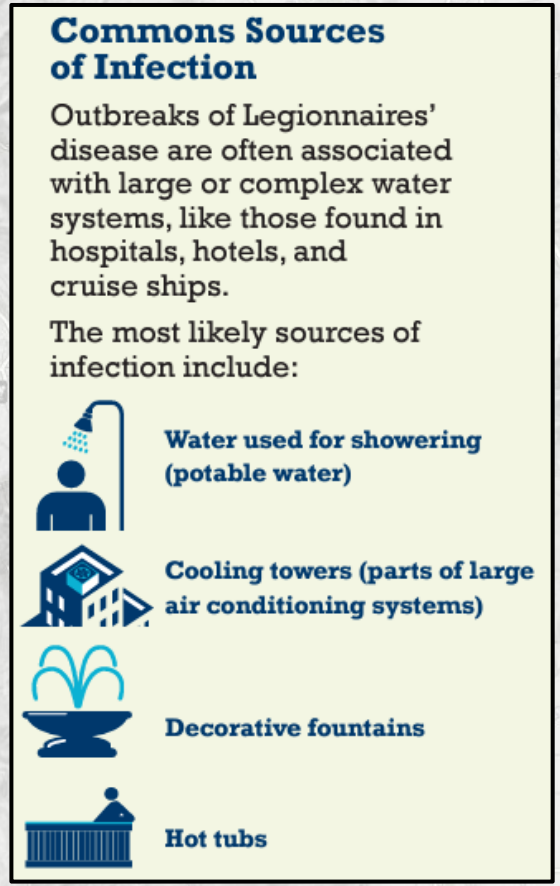
Motivation - DHHS Cooling Towers

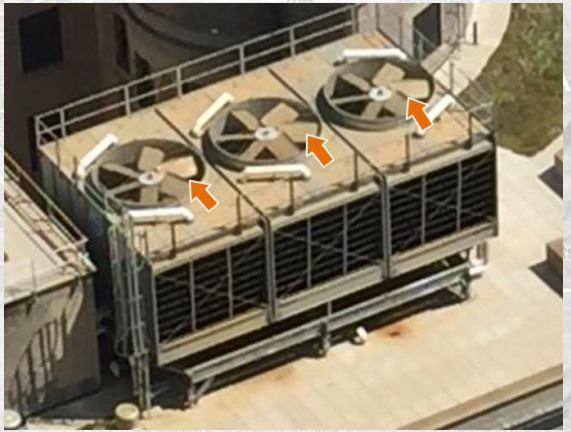
- Legionella bacteria can cause a serious type of pneumonia called Legionnaires' disease
- Legionella can grow/spread in large building water systems
  - Water tanks, HVAC, large/complex plumbing systems, cooling towers
- Cooling towers are concerning because they can release aerosolized water into the atmosphere
  - If Legionella is present, the aerosolized water can spread the bacteria over miles*

*CDC - Controlling Legionella in Cooling Towers



CDC - Legionnaires' Fact Sheet

Motivation - DHHS Cooling Towers



CDC - Photos of Cooling Towers

- Cooling towers can cause outbreaks of Legionnaires' disease when they are not adequately maintained
- They are often investigated & located using aerial imagery during Legionnaires' outbreaks
- Cooling towers have distinctive features that make them identifiable
- Researchers and the CDC have used object-detection models to identify potential cooling towers in aerial imagery (TowerScout)

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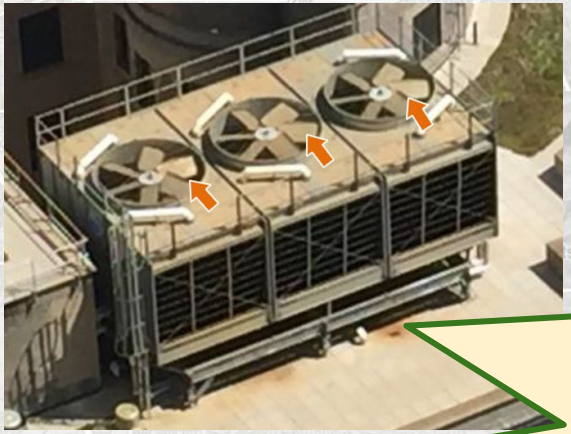
CDC - Procedures for Identifying Cooling Towers

Motivation - DHHS Cooling Towers



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This problem is solvable with computer vision!

CDC - Photos of Cooling Towers

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CDC - Procedures for Identifying Cooling Towers

DHHS Cooling Towers - Process Overview

- 1) Build Index & Footprint
- 2) Download Images
- 3) Detect & Locate Towers
- 4) Post-process results
- 5) Build Web Map

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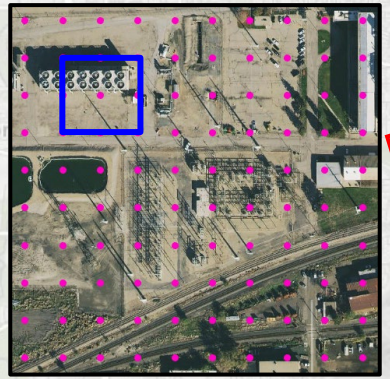
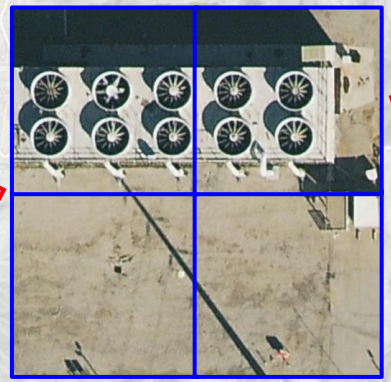
1



Build Index

2



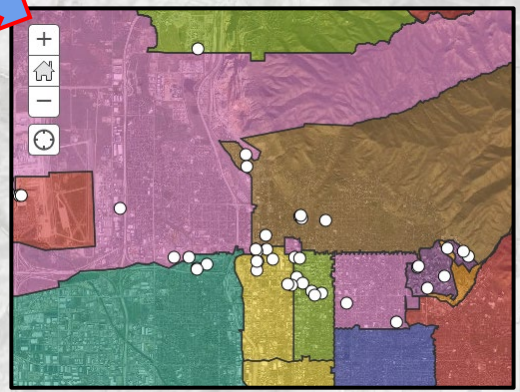
Download Images

3

Detect & Locate Towers

4/5

Build Web Map



Step 1 - Build Imagery Index & Footprint

- Discover Web Map Tile Services (WMTS) used for statewide imagery
- Must build imagery index at highest zoom level (20)
- Create point for upper left corner of each WMTS tile (row, col)
  - Calculate latitude/longitude based on row/col values
  - 275,000,000 tiles cover the state of Utah!
- Create processing footprint to select a subset of all image tiles
  - Buffer census places by 800m
  - Buffer large buildings (>5k sq ft) by 800m
- Select WMTS indices of tiles in processing footprint
  - Load tile index and footprint into Google BigQuery
  - Run Spatial SQL query to select tiles to process (~6%)
  - (data is waaaayyy too big for desktop GIS)

Build Index

Create Footprint

Step 1 - Bu

Footprint

- Discover Web Ma
  statewide imagery
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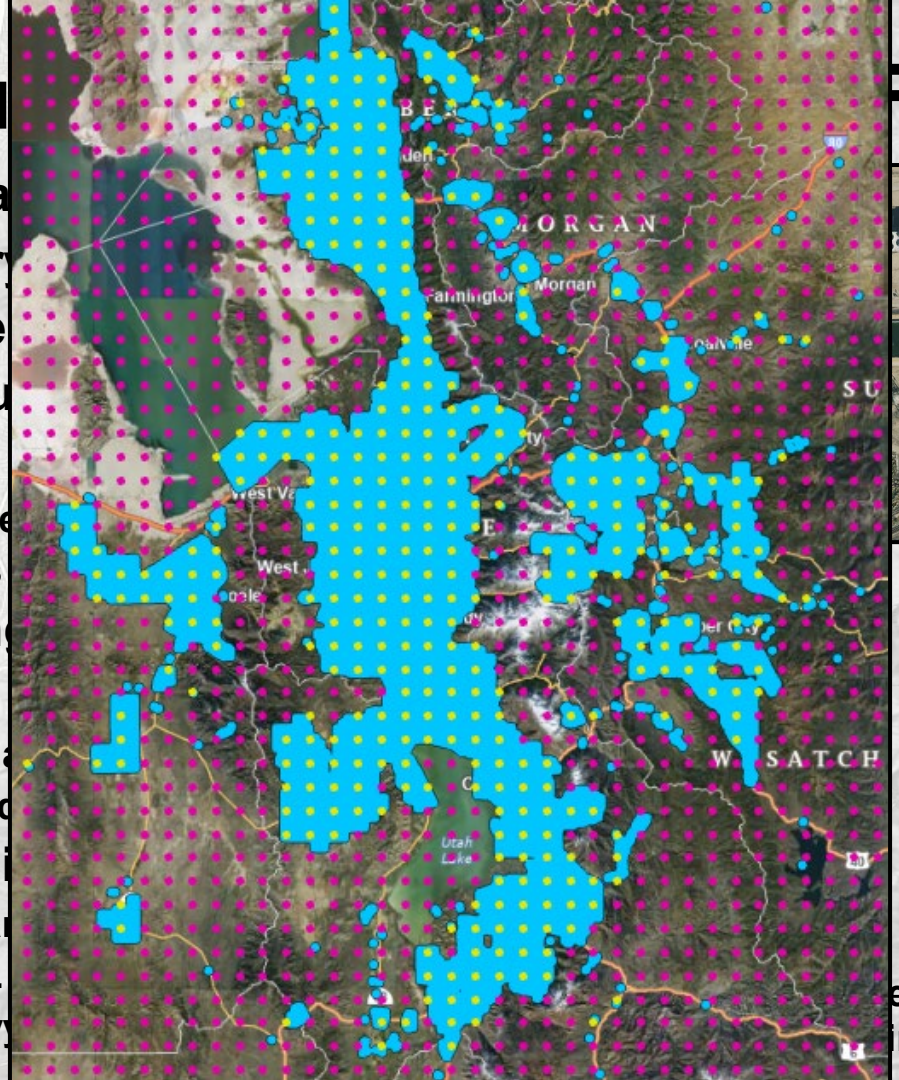
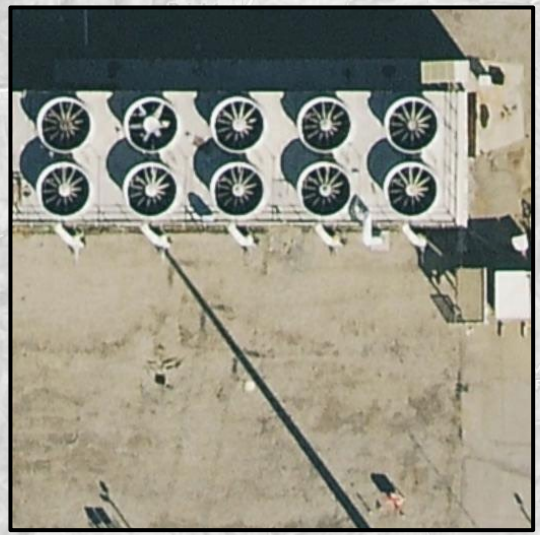


Build Index

Step 2 - Download Images

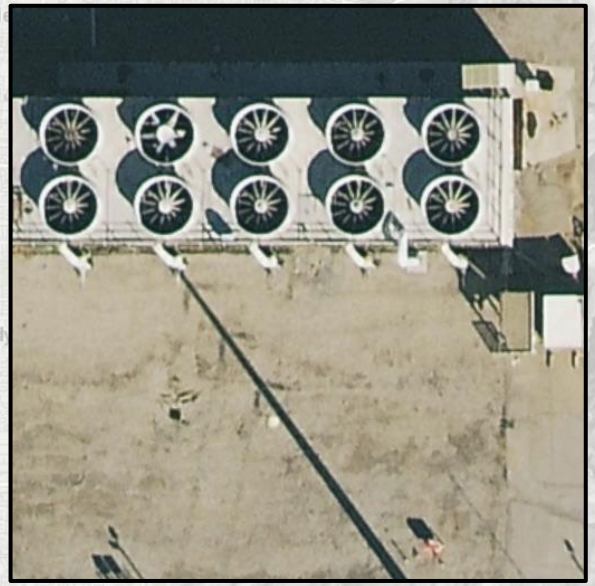
- Iterate through tile indices within footprint
  - Download primary tile and 3 neighboring tiles with HTTPS GET requests:
  - https://discover.agrc.utah.gov/login/path/{quad-word}/tiles/15cm_hexagon_utah/20/{col}/{row}
- Build mosaic image
  - Each WMTS tile is 256x256 pixels
  - Model input performs best on 512x512 images

{col}, {row}



Step 3 - Detect & Locate Towers

- Run PyTorch model on each mosaic
  - Pre-trained "TowerScout" model, provided by CDC
  - YOLOv5 backbone
- Get results as a dataframe



Detect Towers

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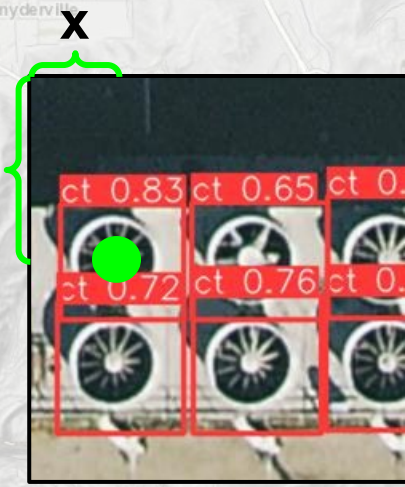
*TowerScout created by Karen Wong, Jia Lu, Gunnar Mein, and Thaddeus Segura, licensed under CC-BY-NC-SA-4.0

Step 3 - Detect & Locate Towers

- Calculate X/Y coordinates of tower centroid
  - PyTorch model provides tower location bounding box in pixels from upper-left corner
  - Centroid is calculated from xmin, xmax, ymin, ymax values
  - Able to convert pixels into geographic space because we know:
    - 1) coordinates of the tile's upper-left corner
    - 2) pixel size at WMTS zoom level 20 (0.1492910708688 meters)



	xmin	ymin	xmax	ymax	confidence	x_centroid_px	y_centroid_px	x_centroid_3857	y_centroid_3857
9	265.932	130.687	347.821	217.394	0.633	306.877	174.041	-12460145.259	4978279.451
8	100.593	78.307	185.93	151.344	0.654	143.262	114.826	-12460169.686	4978288.291
7	184.386	135.914	268.444	220.131	0.676	226.415	178.023	-12460157.272	4978278.857

```
#: x, y = upper-left corner coordinates of tile in web mercator
#: calculate centroid x/y coords in web mercator
meters_per_pixel = 0.1492910708688
results_df["x_centroid_3857"] = x + results_df["x_centroid_px"] * meters_per_pixel
results_df["y_centroid_3857"] = y - results_df["y_centroid_px"] * meters_per_pixel
```

Calculate X/Y

- Upload results to Cloud SQL Table

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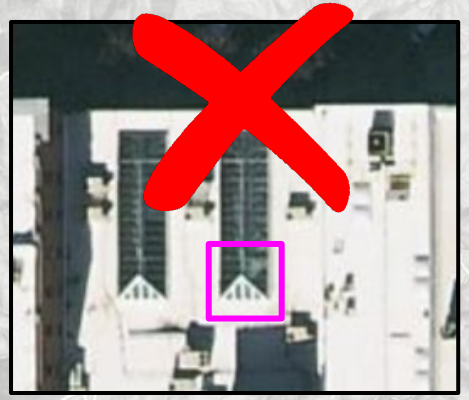
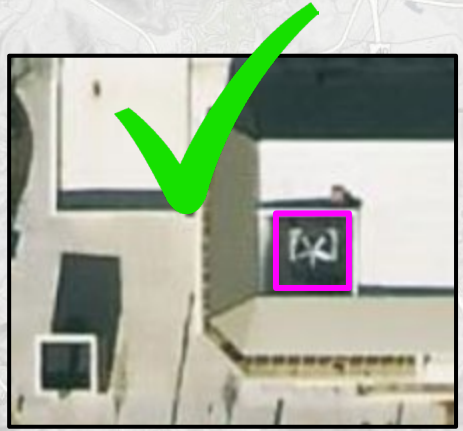
Step 4 - Post-process Results

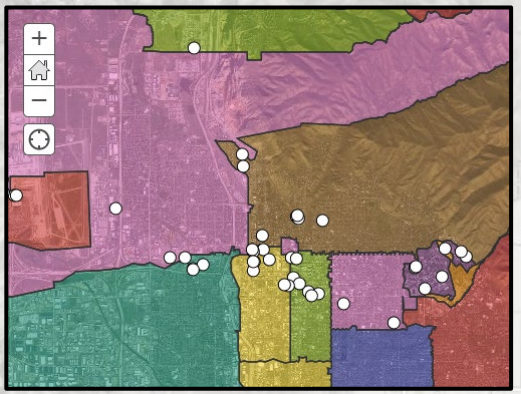
- Manually validate detected cooling towers
- Enrich data with attributes from other statewide datasets
  - Nearby address
  - County
  - City
  - Zip Code
  - Small Health Statistical Area





Step 5 - Build Web Map

- Create hosted feature layer of cooling tower locations
- Build a web map for DHHS users
- Add other relevant, health-related layers and tools



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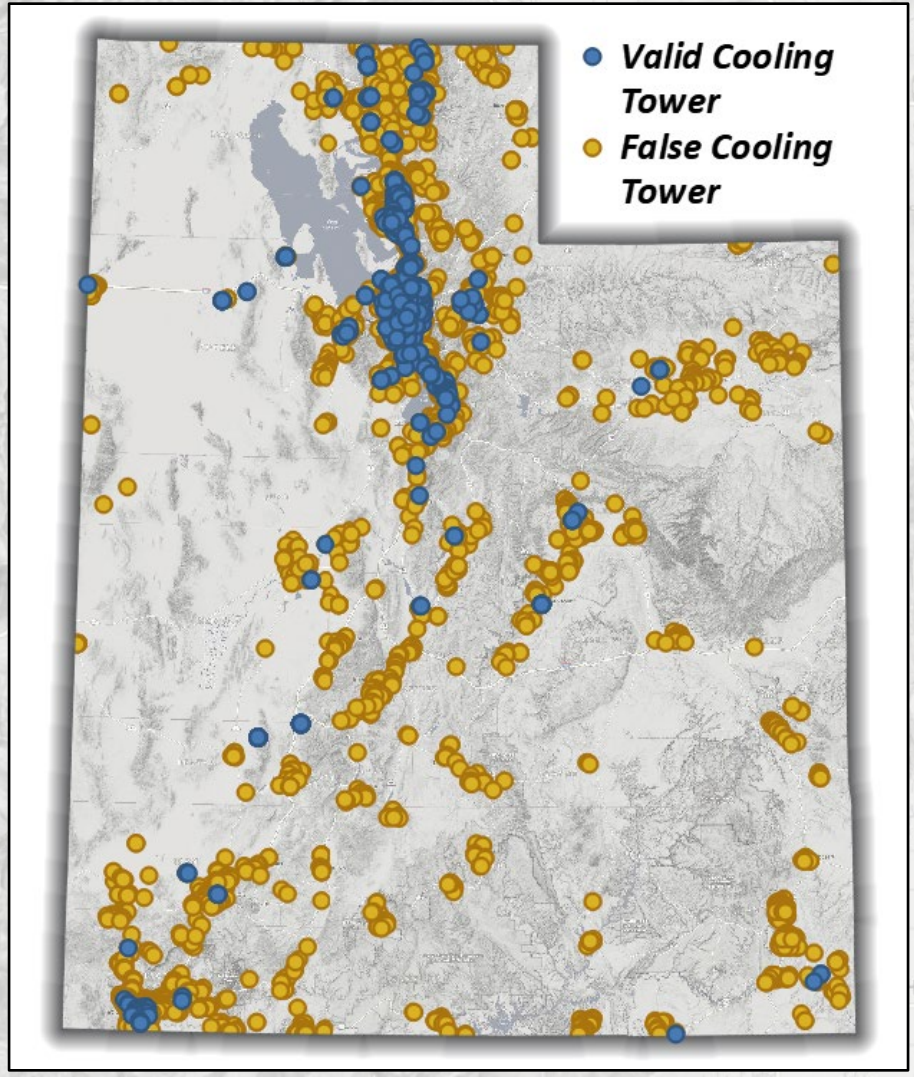
DHHS Project Results

- Data
  - 6,324 potential cooling towers detected with confidence > 0.5
  - 1,561 validated cooling towers (25%)
- Processing
  - 225 days (5,400 hours) worth of wall-clock computing time completed
  - Scaling up with cloud computing enabled completion in 9 calendar days!



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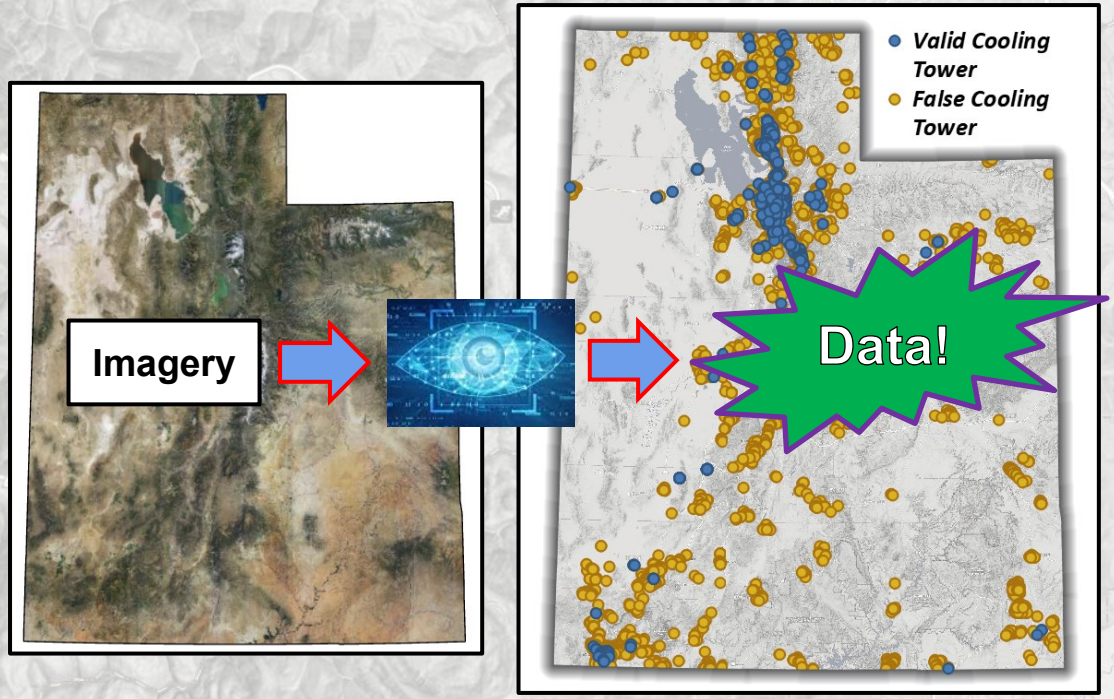
Final words

- A lot of useful data and information can be locked away in imagery (or documents)
- Computer Vision tools can help unlock that data
- Cloud computing can reduce processing time by orders of magnitude
- DHHS cooling towers and UDOT parcel detection projects highlight these possibilities



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github.com/agrc/dhhs-cooling-towers