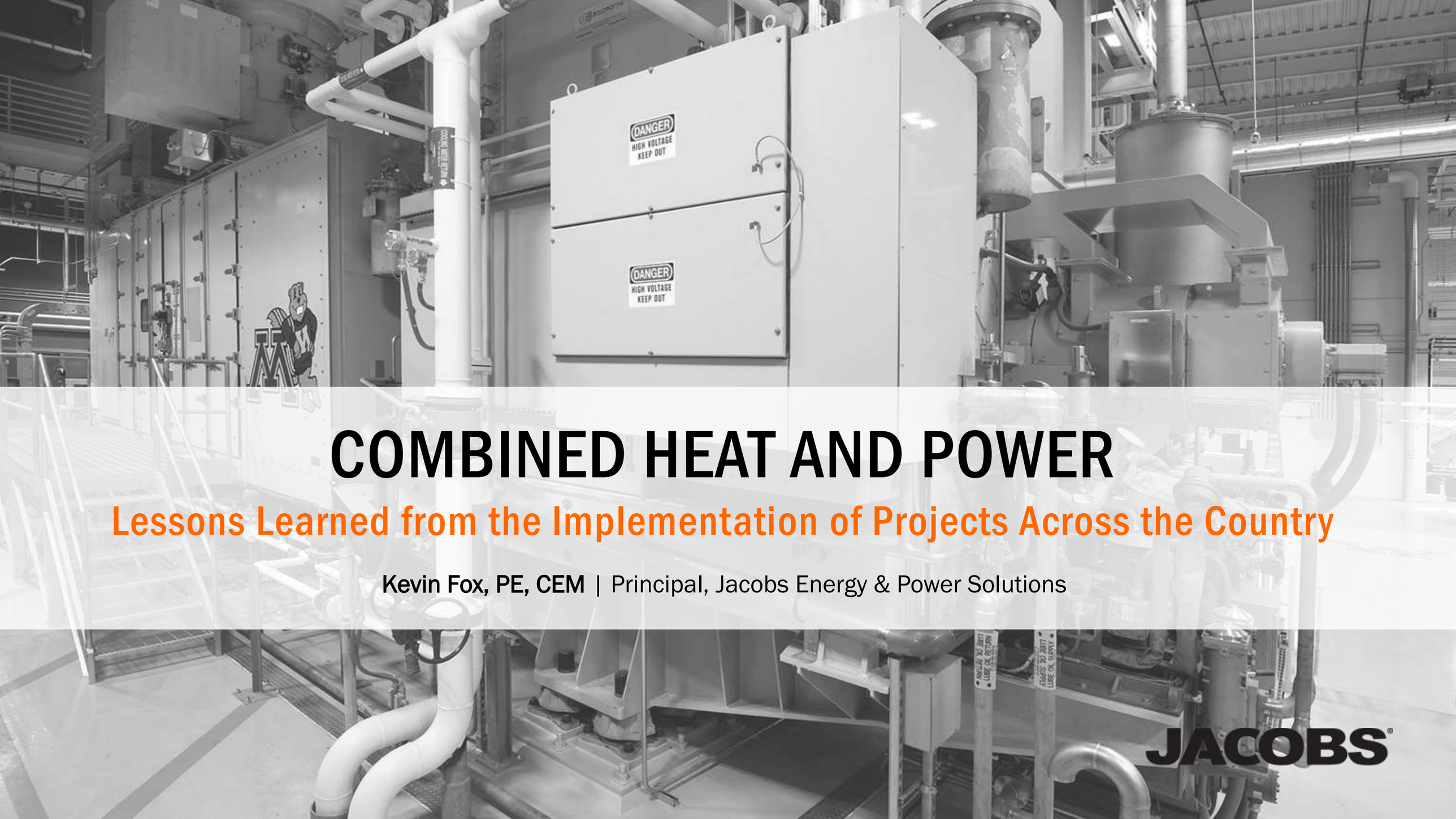


COMBINED HEAT AND POWER

Lessons Learned from the Implementation of Projects Across the Country

Kevin Fox, PE, CEM | Principal, Jacobs Energy & Power Solutions

JACOBS®

Background

- Perspective from:
  - Designing and implementing systems over 15+ years
  - Successes
  - Bumps and bruises
  - Failures to launch
- Not a CHP 101 discussion
- Addressed toward privately-owned CHP, not utility side
- Names changed to protect the innocent

Industrial Enhanced Oil Recovery
20 MW CHP

Lesson #1

CHP is not for everyone!

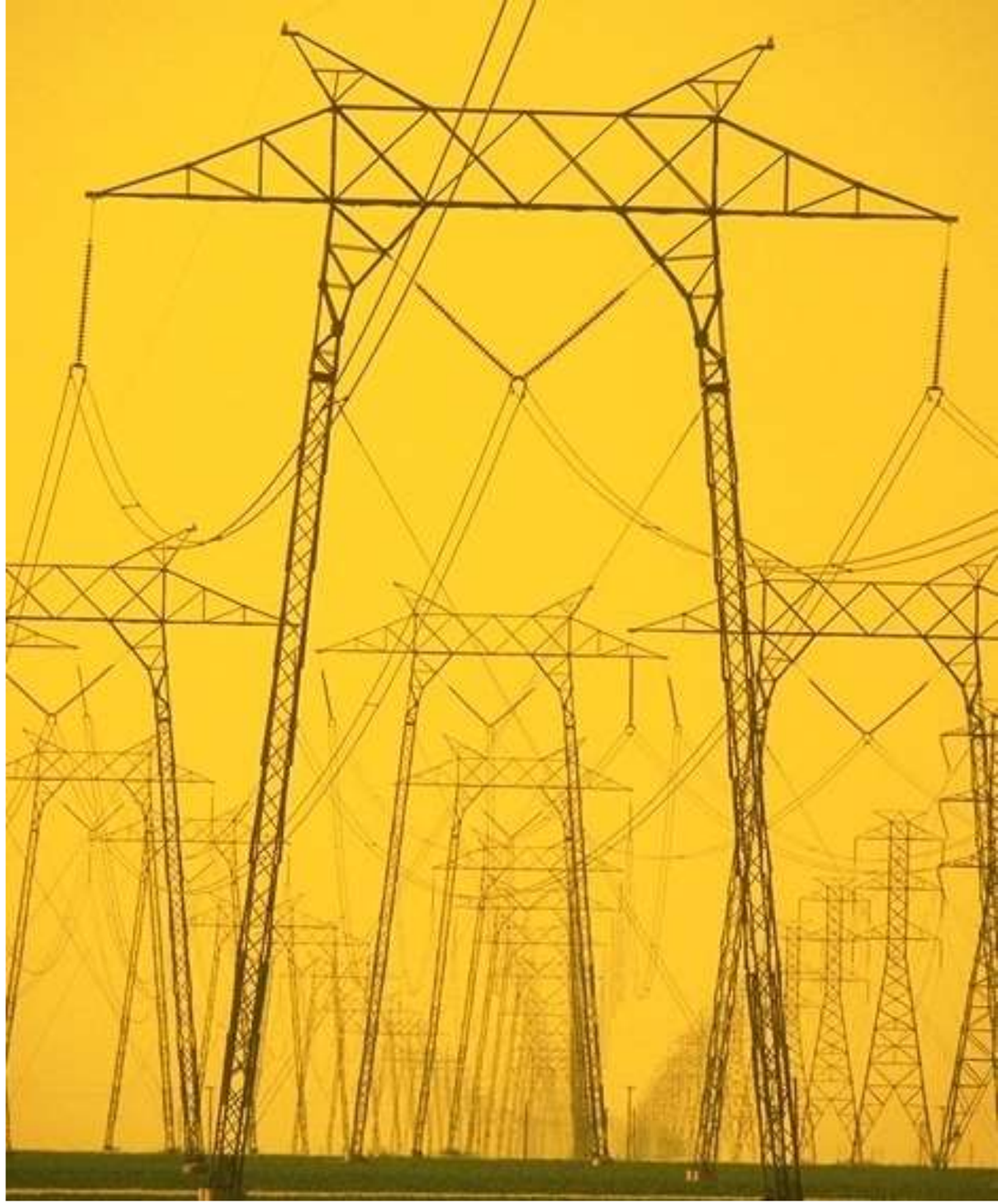
CHP is *not* for everyone

Big Idea

- Understand your project drivers
- Accept that the right answer might be:
  - Yes!
  - Maybe later
  - No
  - Never!

CHP is **not**:

- A means to beat your utility at their own game
  - Frustration with your utility is a poor motivator
  - The utility will always win, one way or another
    - Incentives
    - Standby charges
    - Departing load charges
    - Interconnection fees
    - Time (they dictate this)
- Always the cleanest form of electricity
  - Comparisons can be confusing



CHP is **not**:

- A universal solution
  - Every system is unique
  - Beware of peer pressure
- The California Highway Patrol
  - Understand your audience
  - Understand their motivation
    - How much?
    - What's the benefit?
- Fast, cheap or easy!
  - See remaining lessons…

CHP might be right when:

- Coincident thermal and electrical demands
- Consistent thermal demand baseline
- Electricity is expensive, fuel is cheap
- Resiliency is in play
- Financial and policy incentives exist
- Sustainability is a goal
  - GHG goals
  - Eliminate coal

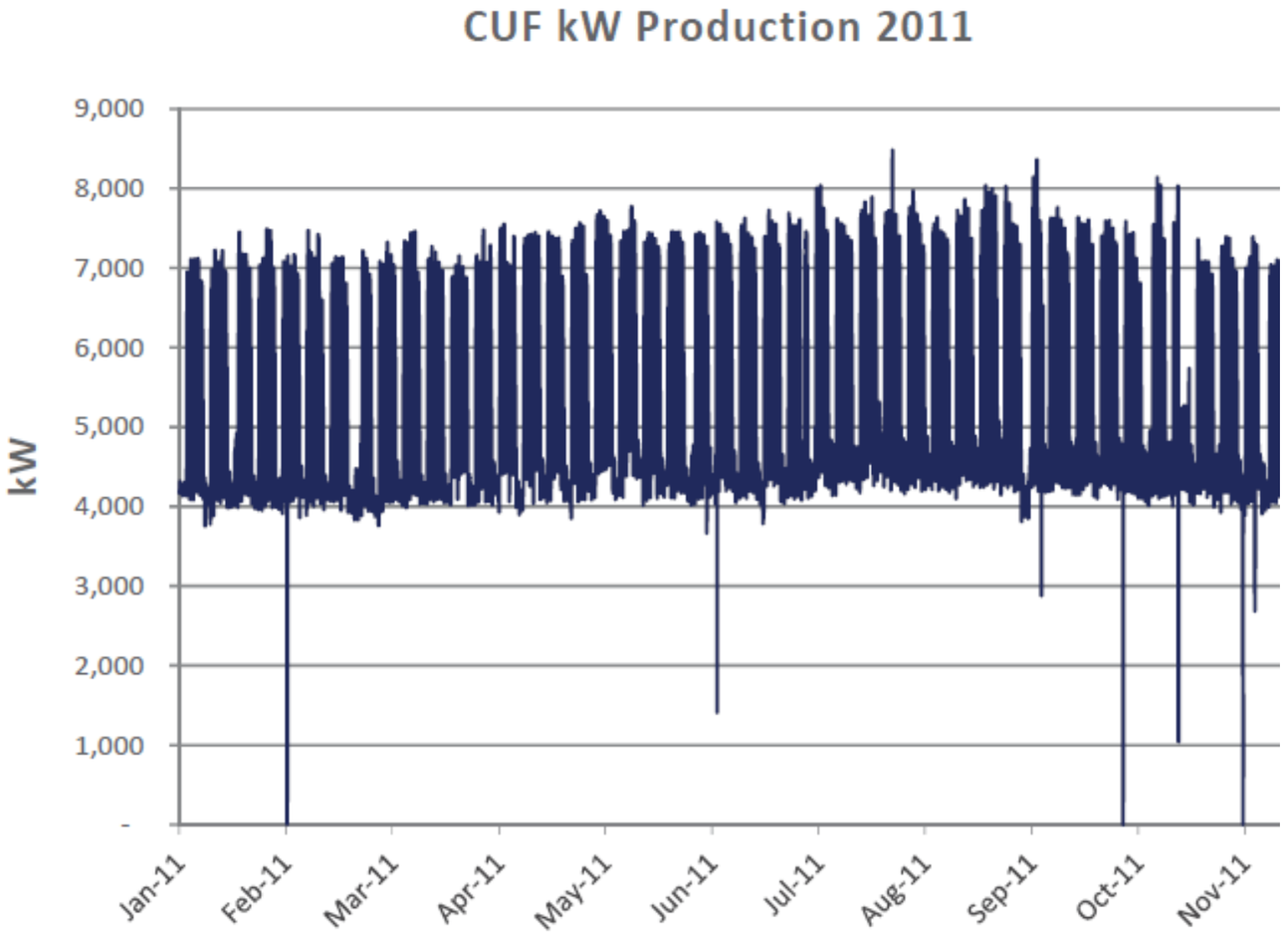
Application

Case Studies

- The “load follower”
- The “grow into it”
- The “free study said it’s a go”

Application

- Understand project drivers, opportunities
- Seek qualified assistance to advance development
- Apply Lesson #2



The University of Texas at Austin
32 MW CHP

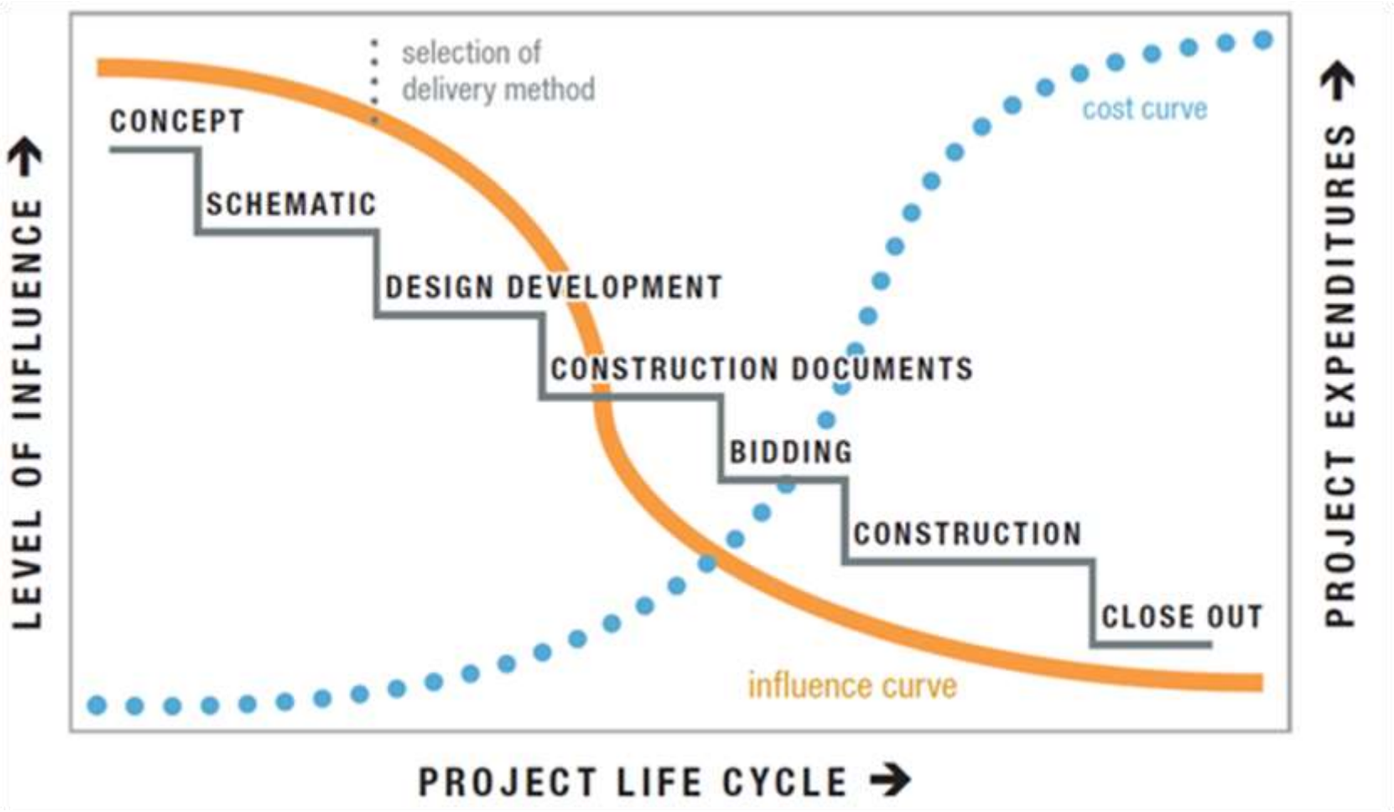
Lesson #2

CHP projects require intense due diligence!

CHP projects require intense due diligence

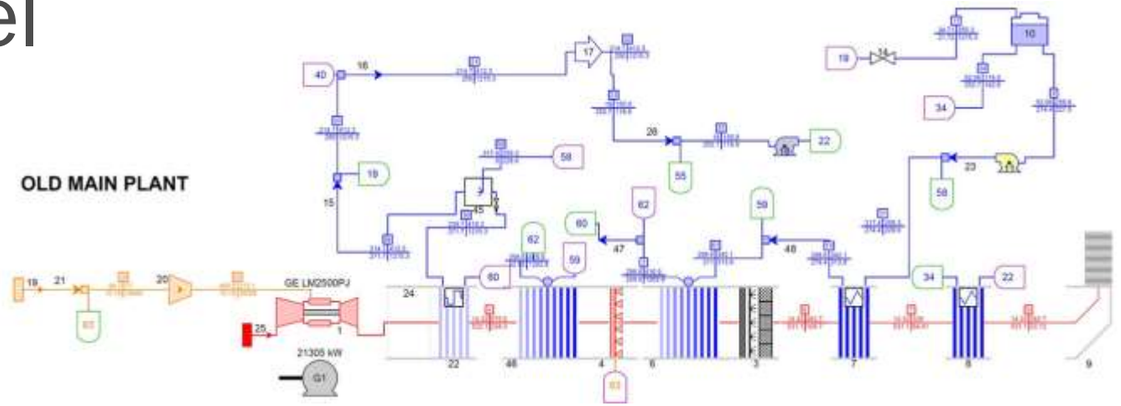
Big Idea

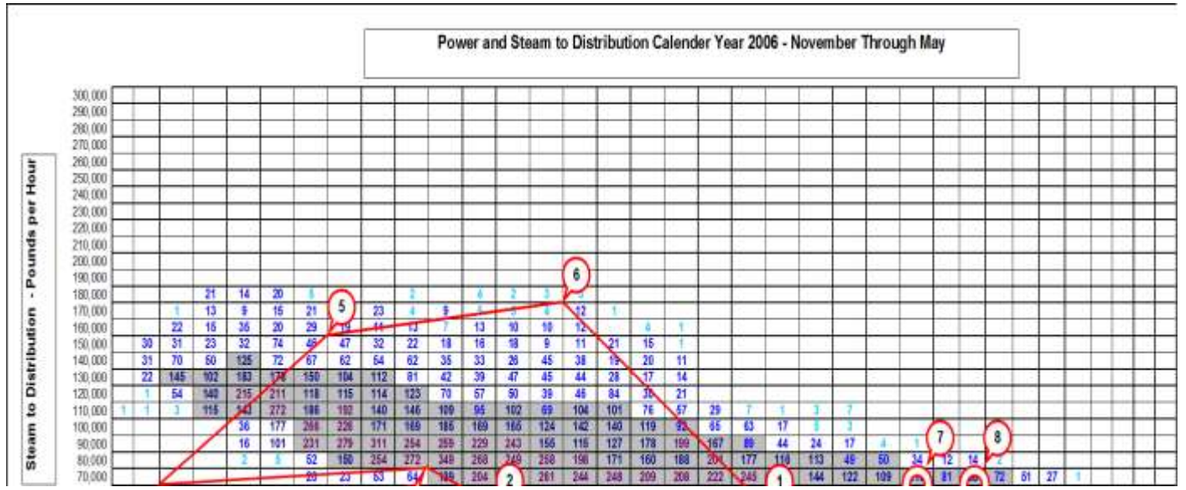
- EARLY is when to do the project right
- Do your homework
- Ask the right questions
- Consider every step of development
- Be realistic with input and results



Invest in a rigorous and detailed study

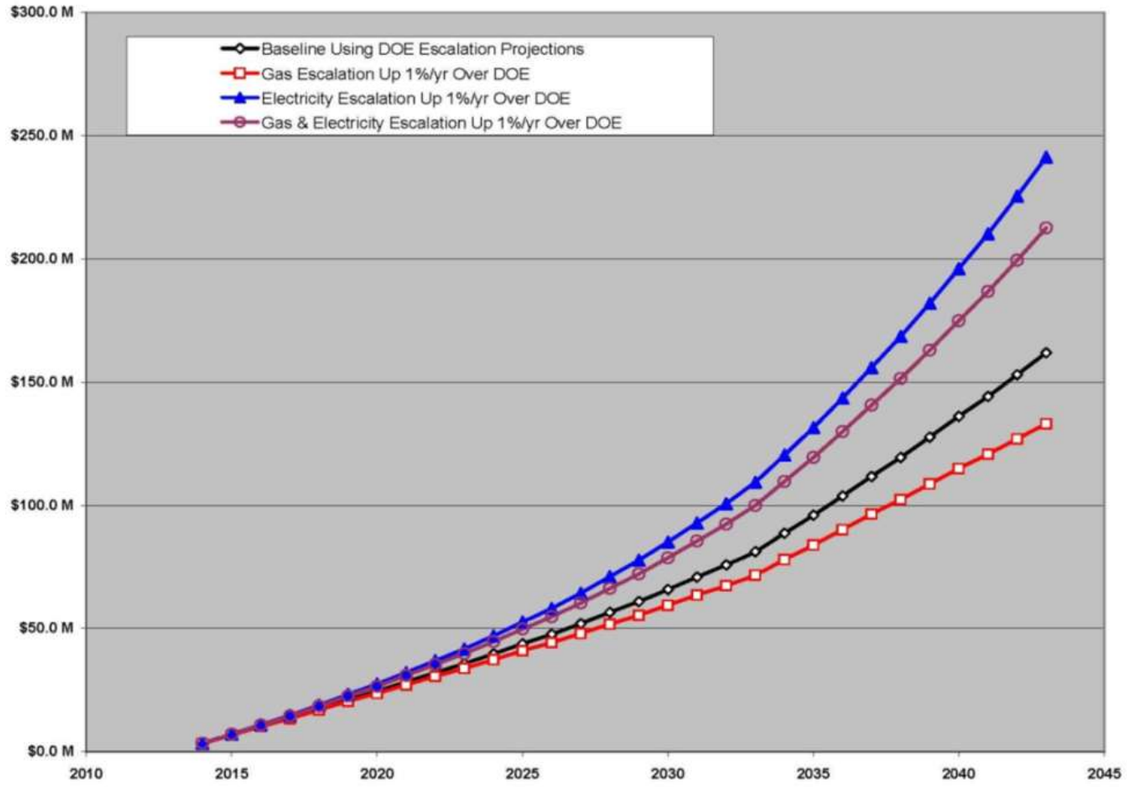
- Detailed thermodynamic model
  - Quality (hourly, metered) data
  - Caution re: future projections
  - Mindful of parasitic loads
  - Explore and optimize:
    - Economizers
    - Inlet air cooling
    - Condensate pre-heaters
    - Low grade heat recovery
    - Water usage





Invest in a rigorous and detailed study

- Understand requirements of CFO & Finance
- Sensitivities
- Value for carbon/GHG?
- Full project cost
  - Construction
  - Permitting
  - Utility interconnect
  - Design
  - Existing conditions
  - Permits
  - Owner contingency
  - Commissioning
  - Training
  - Project management



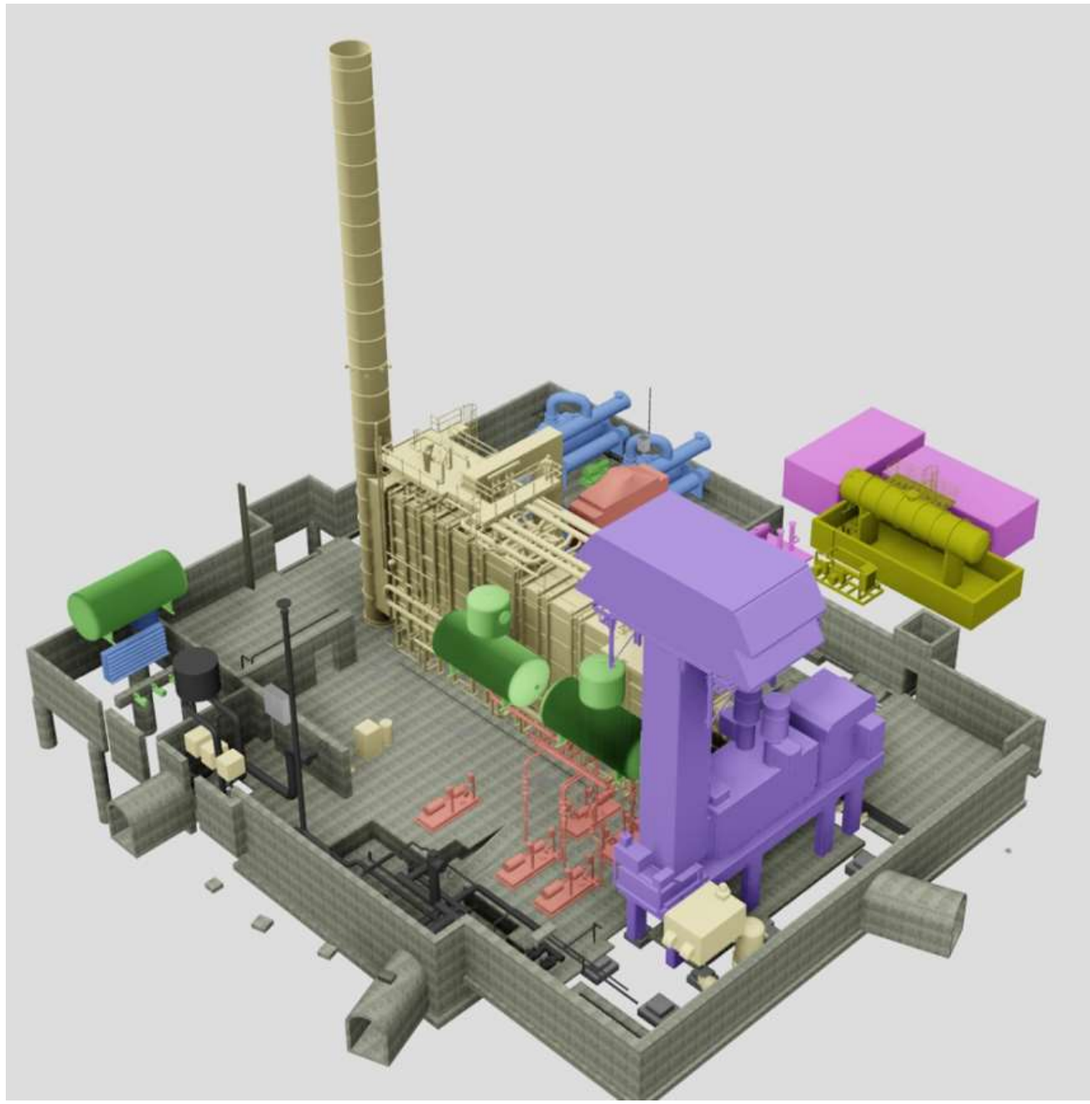
Application

Case Study

- University of Minnesota
  - LCC Savings – $94M
  - GHG Savings – 35,700 tons annually

Application

- Understand financial metrics necessary for approval
- Growing into a project is risky
- A screening does not a project make



University of Oklahoma
15 MW CHP

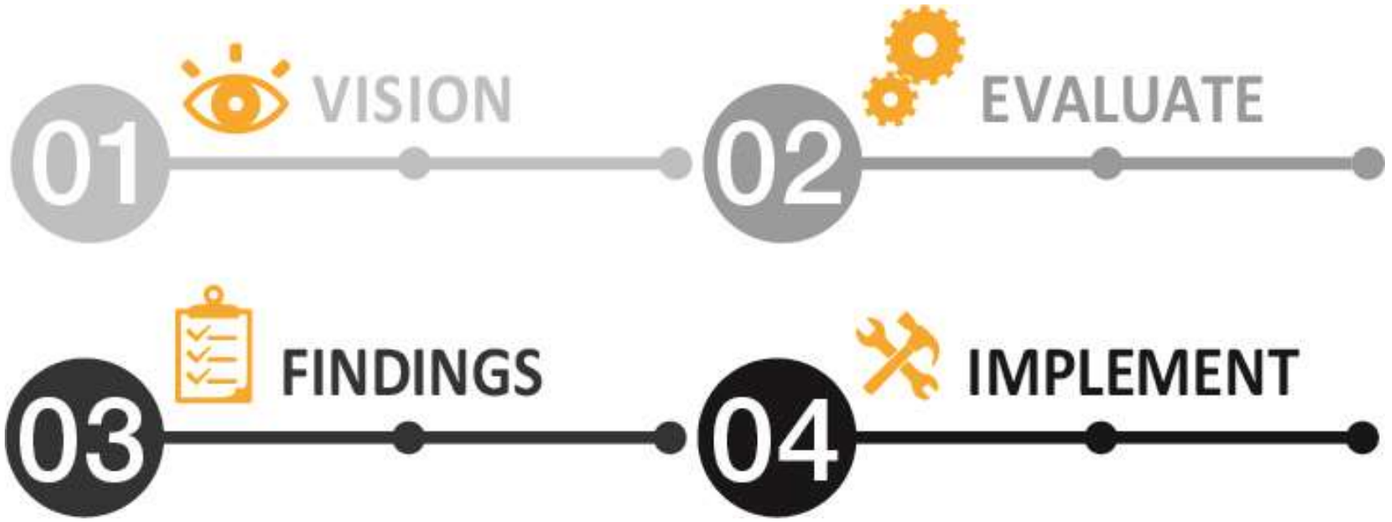
Lesson #3

CHP projects take time. Lots of time.
Longer than you expect. Plus more.

CHP projects take time

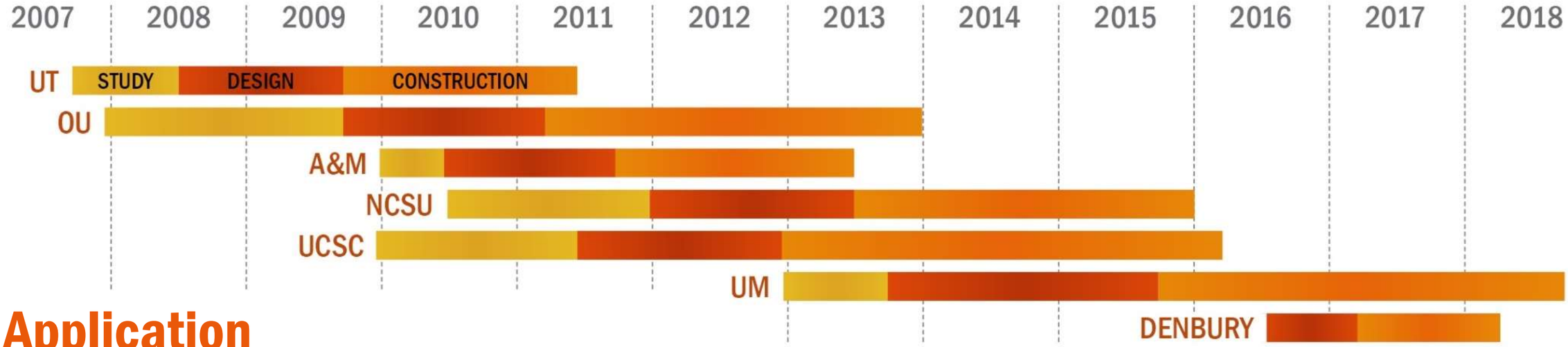
Big Idea

- Understand the steps of developing a CHP opportunity
- Have reasonable expectations
- Create schedule margin
- You are not always in control



Application

Case Studies

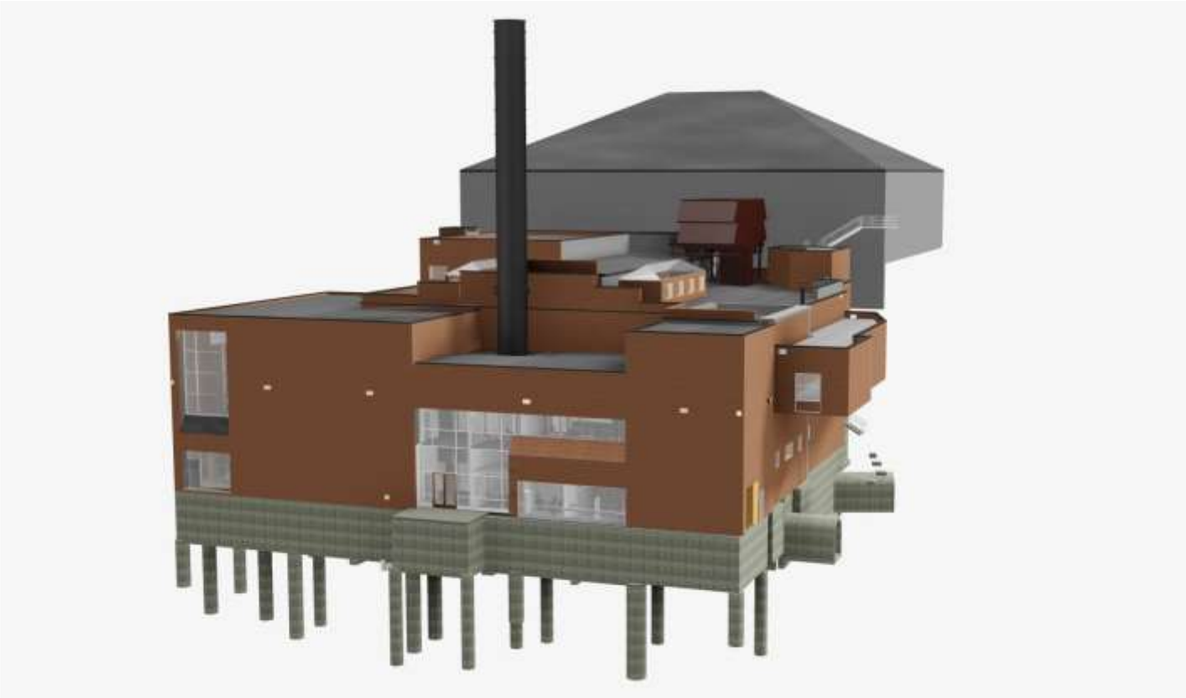


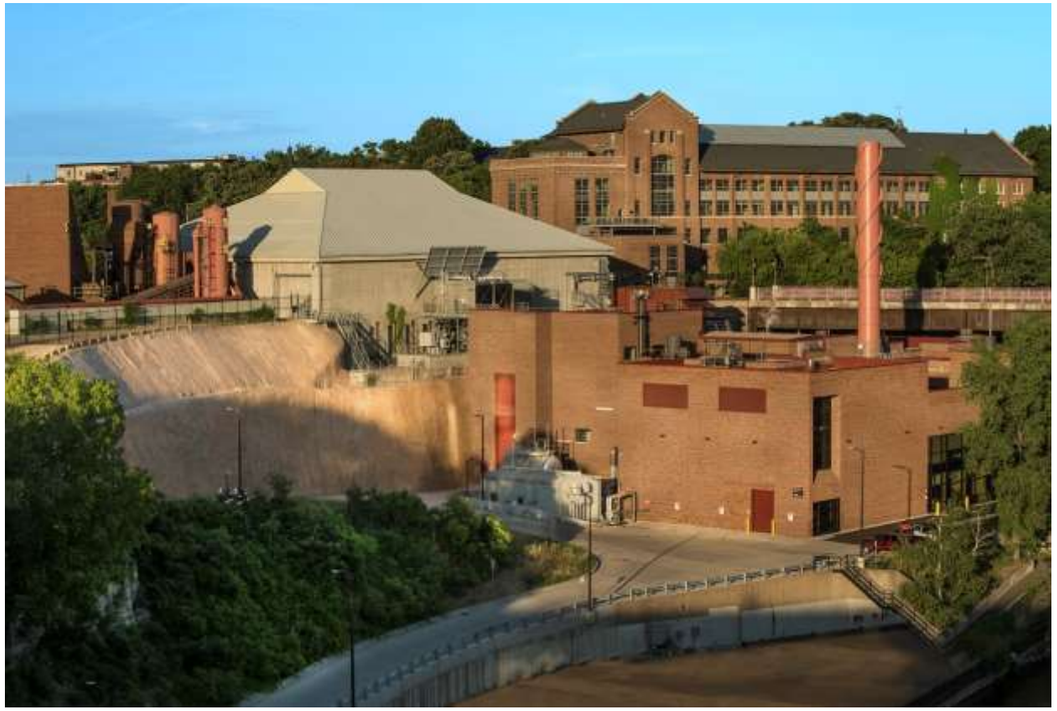
Application

- EPA permitting = 9-12 months
- ISO permitting = 9-12 months (before paralleling)
- Equipment procurement = 12+ months
- Set realistic expectations for all stakeholders
- Time = $$$
- Beware of project fatigue

Steps in Development

Idea → Approval → Design → Construction → Closeout





Texas A&M University
43.5 MW CHP

Lesson #4

Consider safety in design and operations.

Plant safety

Big Idea

- Take safety seriously
- Safety is a cultural topic
- Take a leadership role

OSHA Guidance

- 29 CFR 1910.269
- 29 CFR 1926 Subpart V

Design tips

Safety Hazards in a Power Plant

- Electrical safety
- Machine safety
- Working at elevation
- Excavation work
- Lifting operations
- Confined spaces
- Chemical hazards
- High temperature piping and ductwork
- Vehicle movement
- Control of contractors

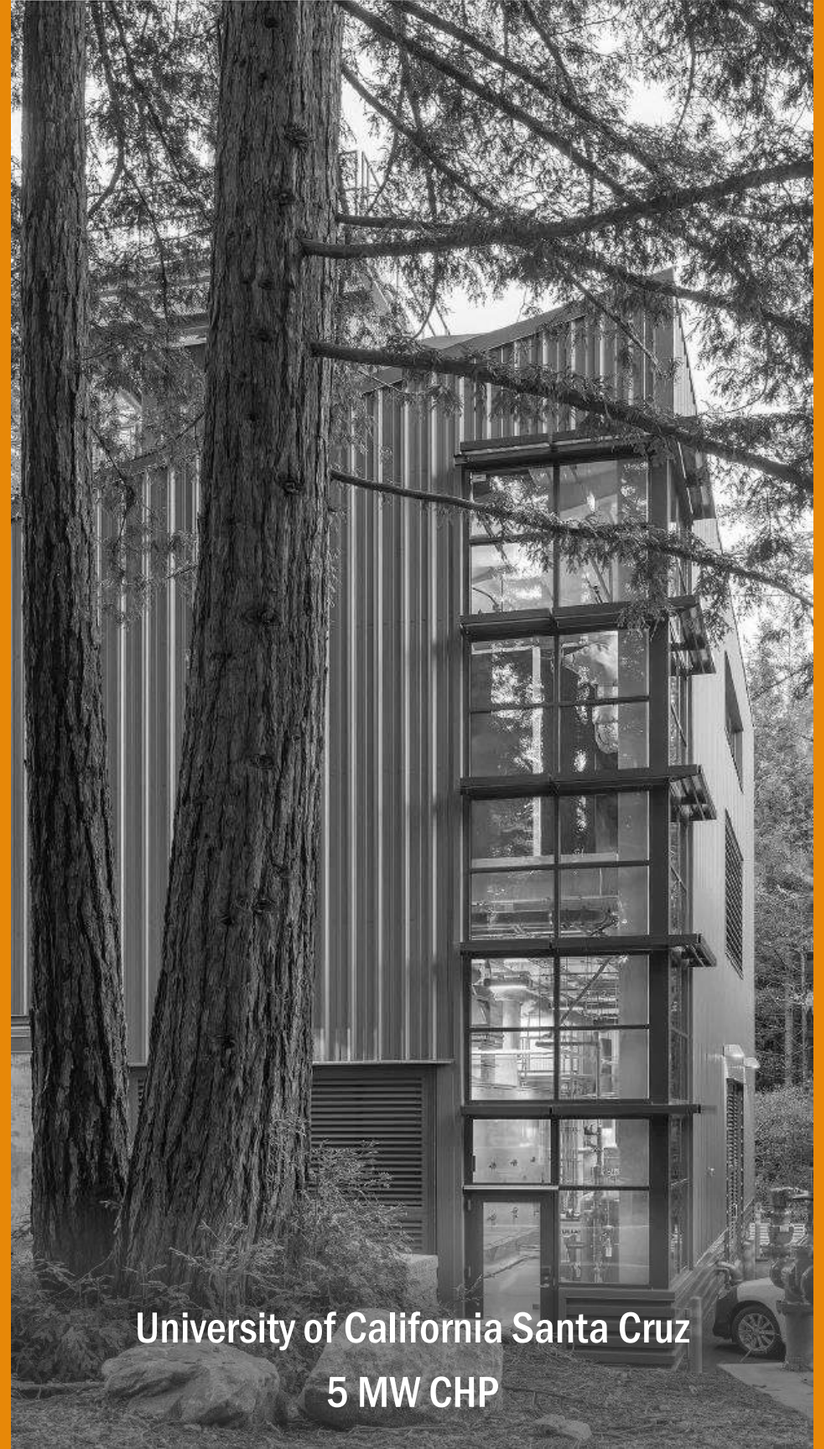
Application

Case Study

- Jacobs project
  - 11 employees killed

Application

- Evaluate ALL risks
- Create a culture that values safety, transparency and accountability
- Don’t let a tragedy serve as the stimulus



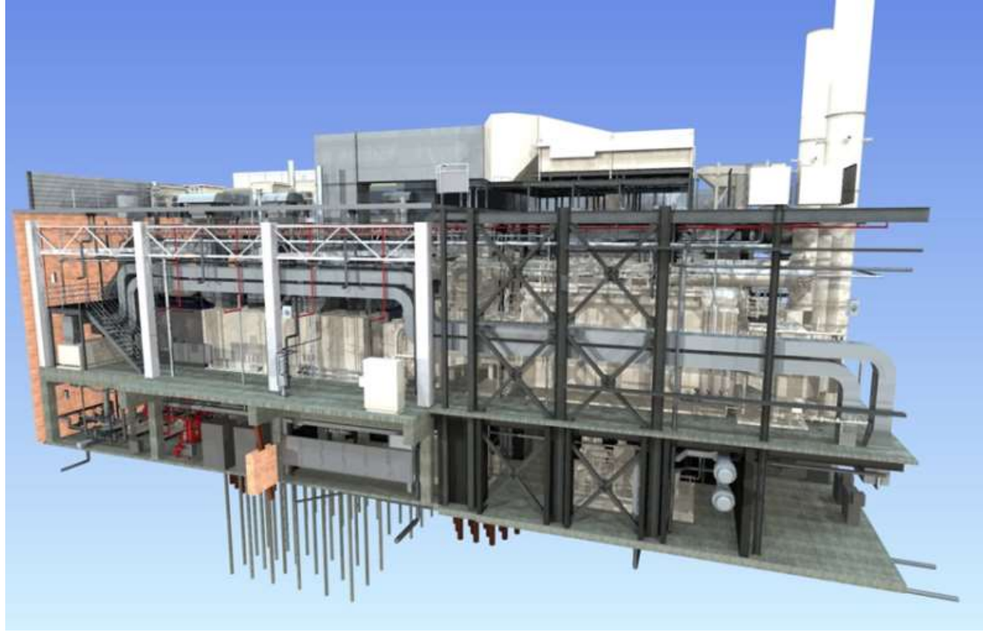
Lesson #5

CHP plants don’t have to be ugly.
But don’t make them pretty first.

Plant Aesthetics

Big Idea

- Design from inside to out
- The engineer gets to drive!
- PFDs yield systems to plan around
- Consider O&M and traffic flow
- Plan around noise, drift and emissions



Design Tips

- **CHP = Engineered System**
  - Start with PFD, not rendering
  - Engineering led
  - Architecturally supported
- Design from the inside out
  - Plan around largest equipment
  - Stacks, air intakes, vents and rooftop equipment
  - Electrical gear
    - Single source

Application

Case Study

- University of Oklahoma
- University of Minnesota

Application

- Engineering first
- Safe and functional
- Aesthetics third

Oregon State University

6.5 MW CHP

Parting Shots:

6. Natural gas compressors. You don’t want one.
7. Project delivery; choose wisely.
8. Permitting: Go local, start early.
9. Don’t forget Cx – later in this broadcast…

JACOBS®

Kevin Fox, PE, CEM
Booth #58

kevin.fox@jacobs.com