COMBINED HEAT AND POWER

Lessons Learned from the Implementation of Projects Across the Country

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Background

- Extensive topic
- Perspective from:
  - Designing and implementing for 10+ years
  - Successes
  - Bruises
  - Scores of flameouts…
- Not CHP 101
- Addressed toward private CHP, not utility
- Names changed to protect the guilty

Industrial Enhanced Oil Recovery
20 MW CHP

Lesson #1

CHP is not for everyone!

CHP is Not for Everyone

Big Idea

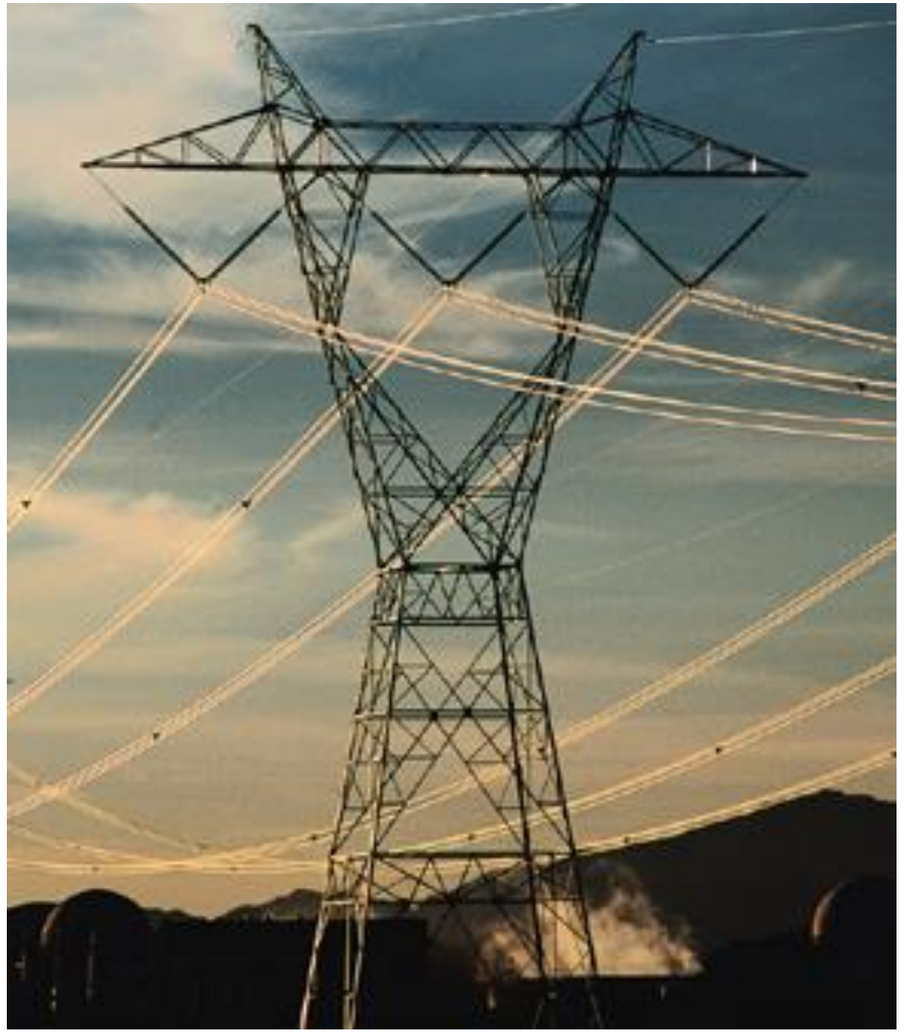
- Understand what is driving your project
- Accept that the right answer might be:
  - Maybe later
  - NO
  - NEVER!

Words of Wisdom

- If all your friends jumped off a bridge, would you jump too? – *Your Mother*

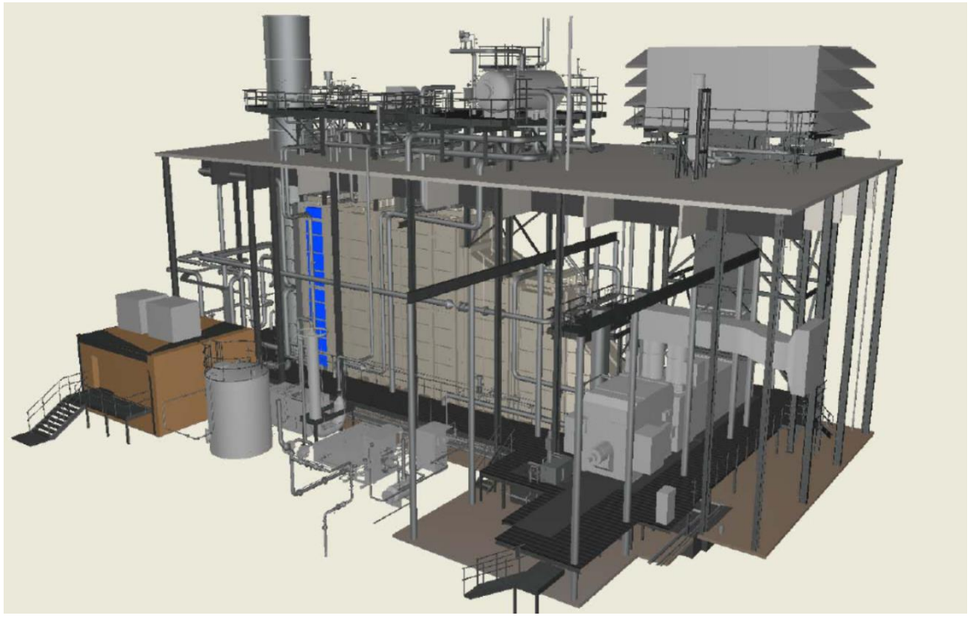
CHP is **NOT**:

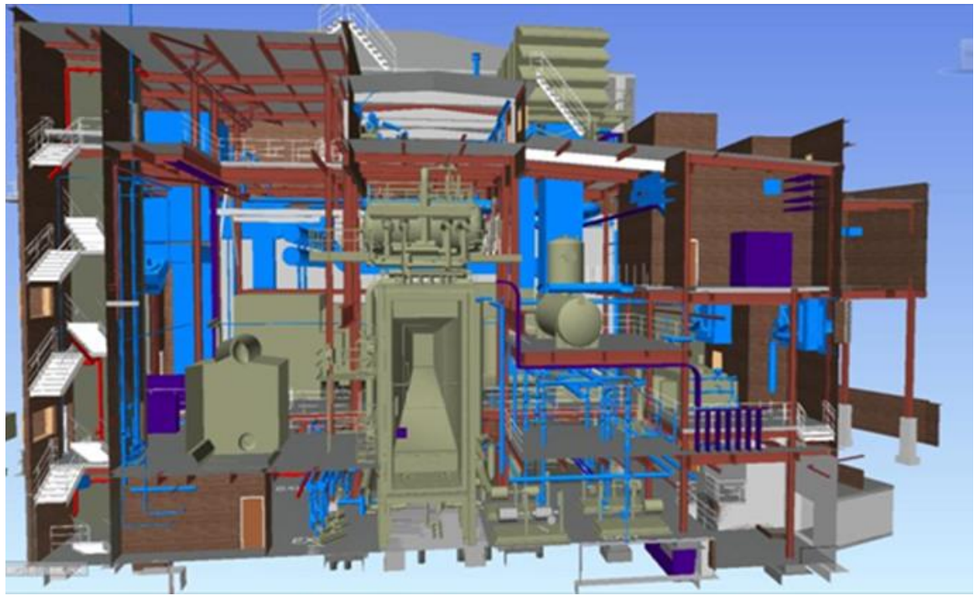
- A means to beat your utility at their own game
  - Frustration with your utility is a poor motivating force
  - The utility will always win, one way or another
    - Standby charges
    - Departing load charges
    - Interconnection fees
    - Time (they dictate this)
- Always the cleanest form of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



CHP is **NOT**:

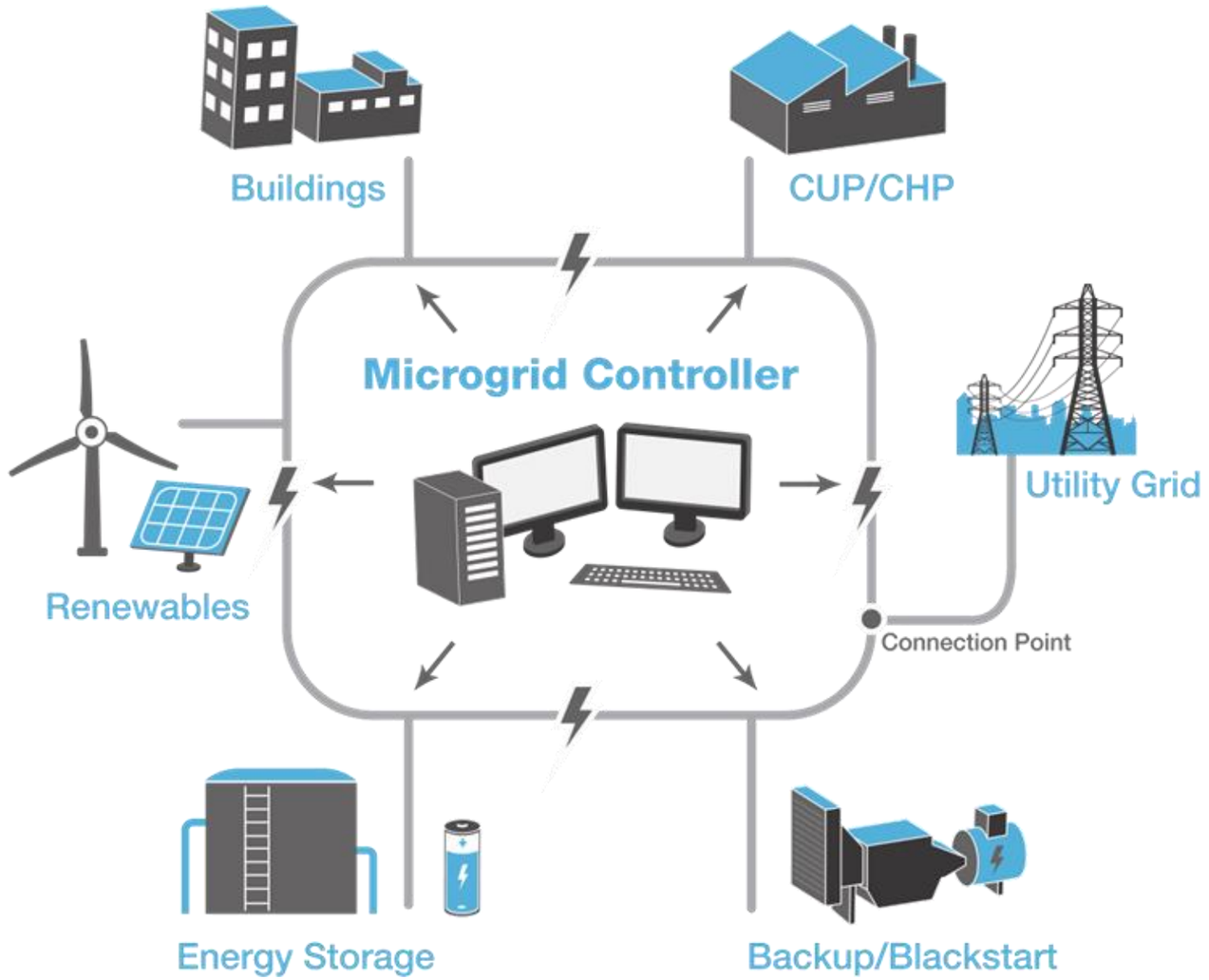
- A universal solution
  - Every system is unique
  - Beware of keeping up with the Jones'
- The California Highway Patrol
  - Understand your audience
  - Understand their motivation
    - 95% of time = $$$
- Fast, cheap or easy!
  - See remaining lessons…





CHP *might* be right when:

- Electricity is costly, fuel is cheap
- Coincident thermal and electrical demands
- Consistent thermal demand baseline
- Coal is a target
  - Carbon valuation?
- Resiliency is in play
- Financial and policy incentives exist



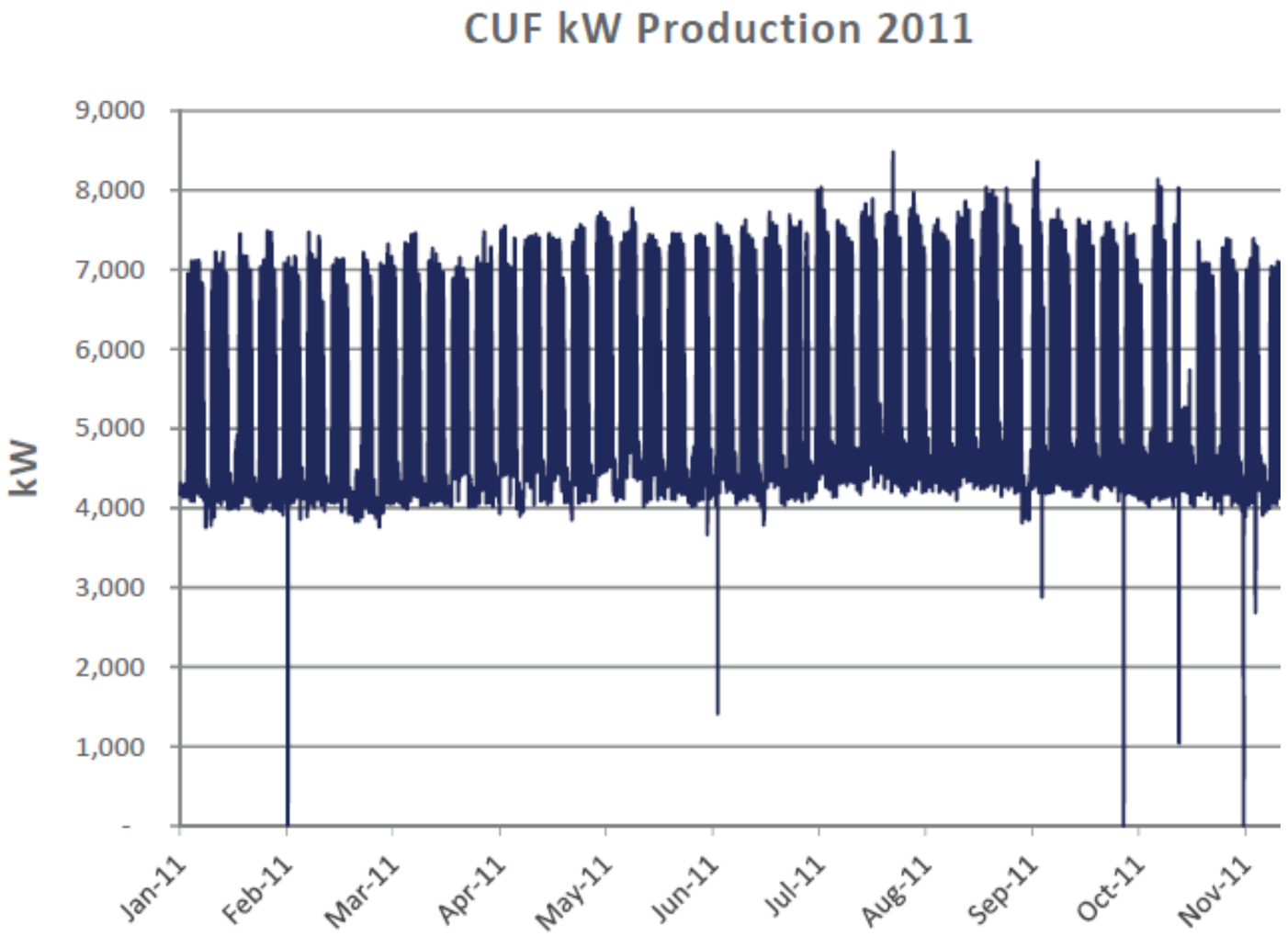
Application

Case Study

- Client 1
- Client 2
- Client 3

Application

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



The University of Texas at Austin
32 MW CHP

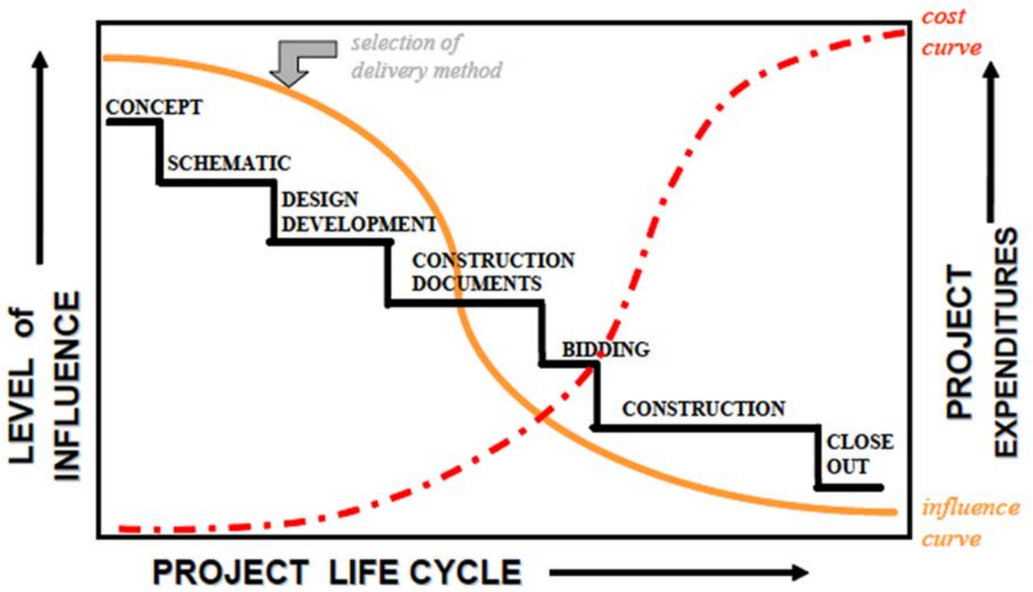
Lesson #2

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
- Be realistic with input and results

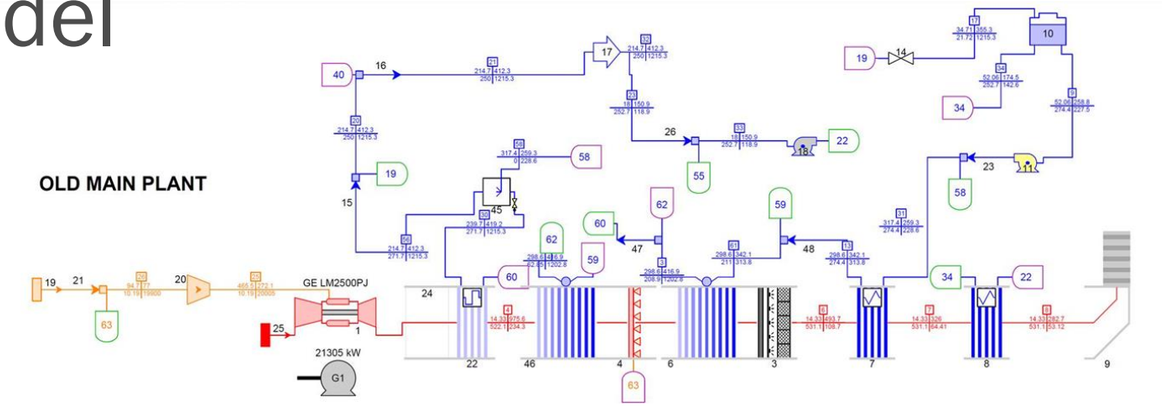


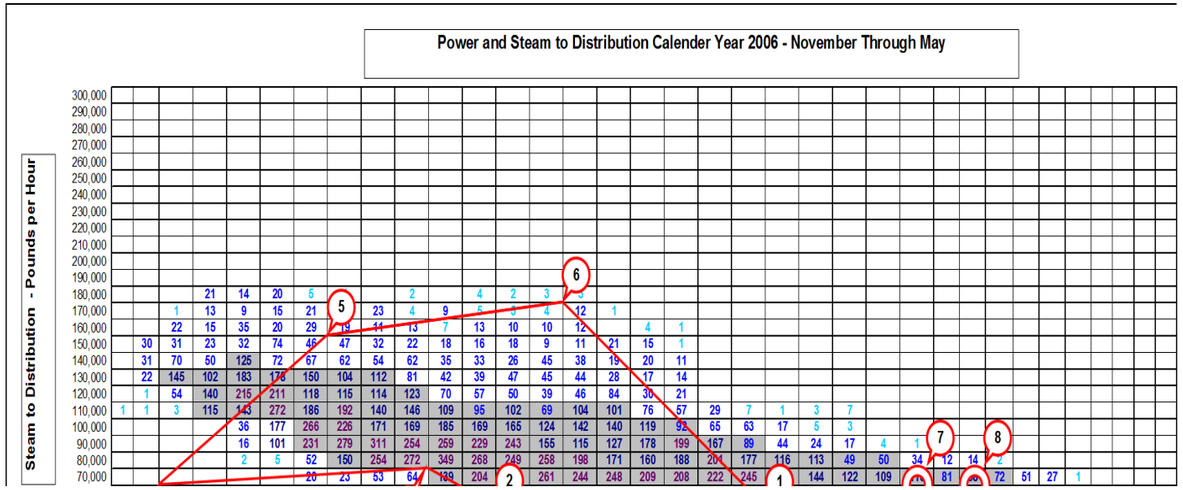
Words of Wisdom

- Give me six hours to chop down a tree, and I'll spend the first four hours sharpening the axe.
  – *Abraham Lincoln*

Invest in a Rigorous and Detailed Study

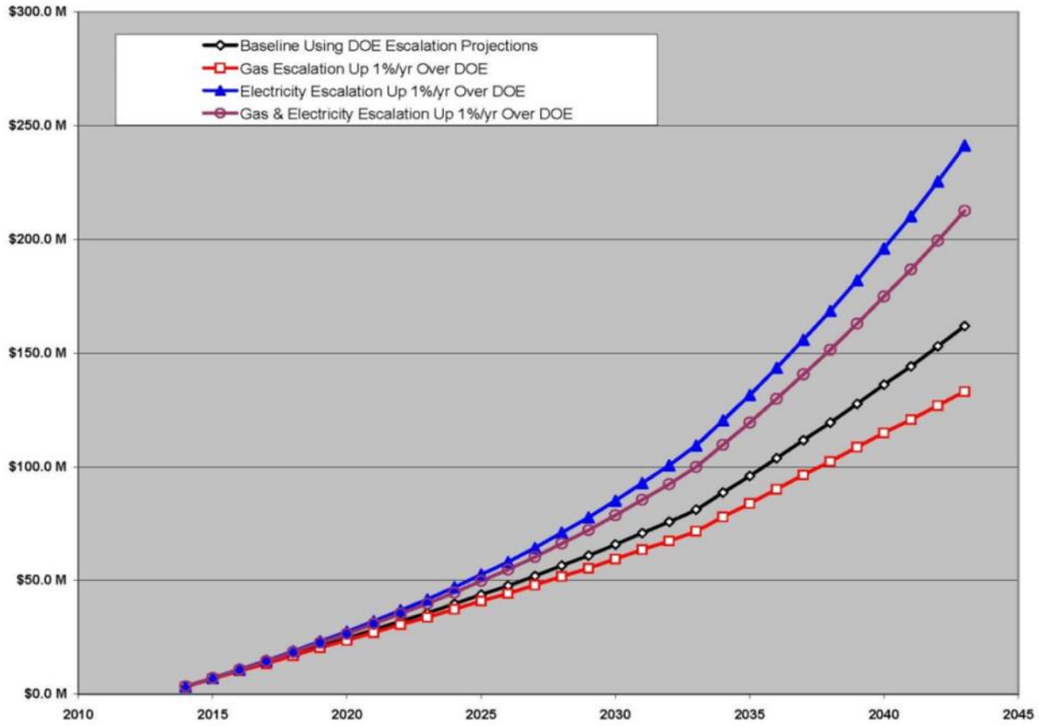
- Detailed thermodynamic model
  - Quality (hourly, metered) data
  - Caution re: future projections
  - Explore and optimize:
    - Economizers
    - Inlet air cooling
    - Condensate pre-heaters
    - Low grade heat recovery
    - Water usage





Invest in a Rigorous and Detailed Study

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



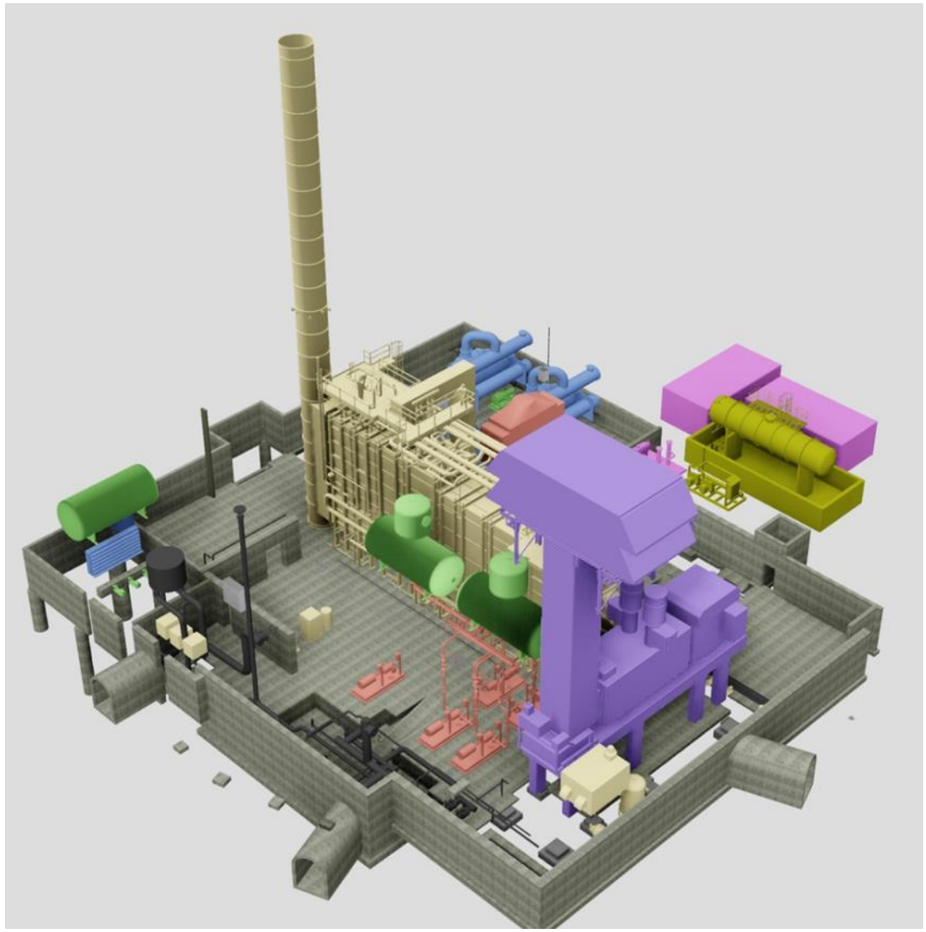
Application

Case Study

- University of Minnesota
  - LCC Savings - $94M
  - GHG Savings – 35,700 tons annually
- Redacted Client(s)
  - Growth into system size

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.

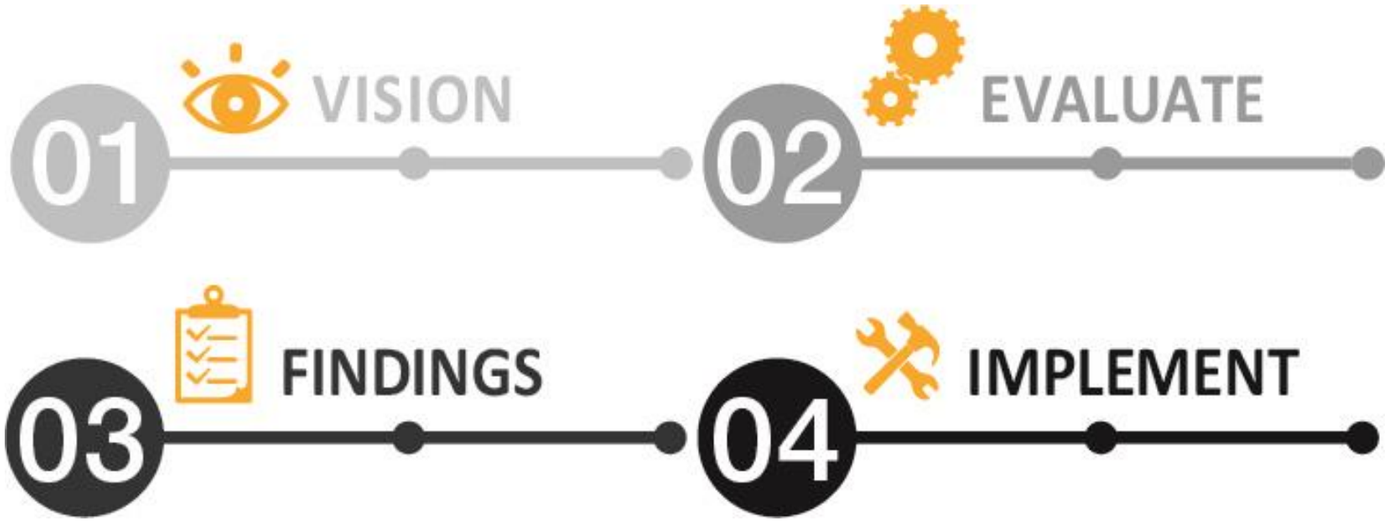
CHP Projects Take Time

Big Idea

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

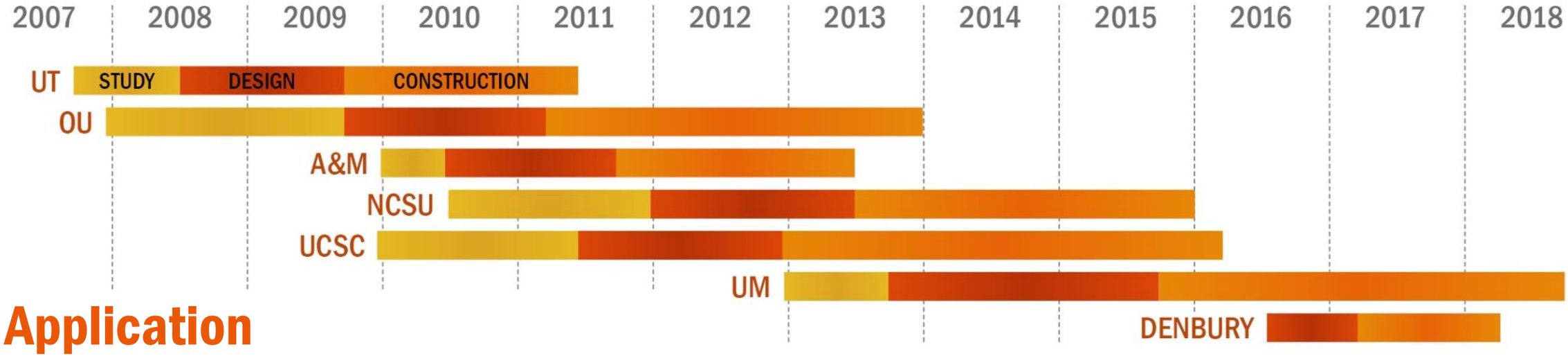
Words of Wisdom

- Overnight success stories take a long time. – *Steve Jobs*



Application

Case Studies



Application

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

Steps for Development

Idea → Approval → Design → Construction → Closeout

Texas A&M University

43.5 MW CHP

Lesson #4

Design and coordination of systems.
Beyond the power island.

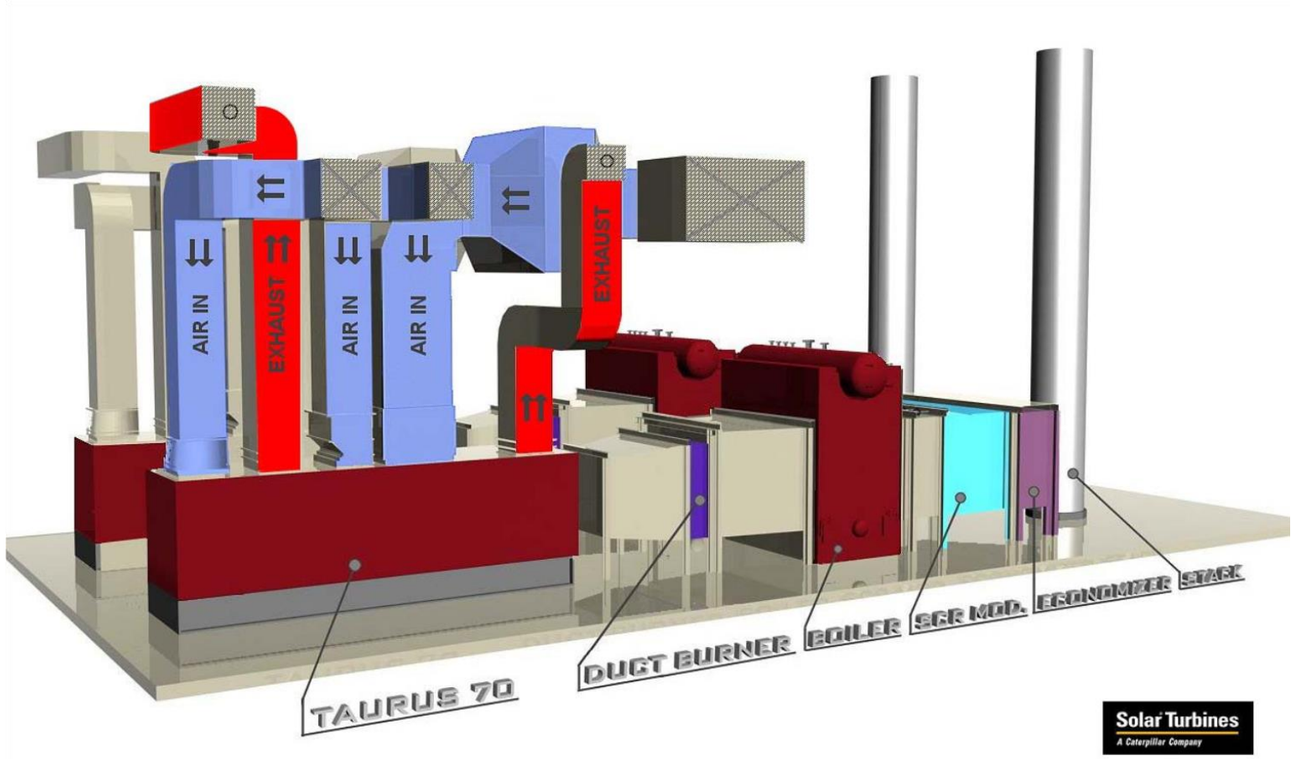
Design and Coordination of Systems

Big Idea

- Selection and Optimization of the Power Island is important
- So is everything else…
- Pre-purchase is a must

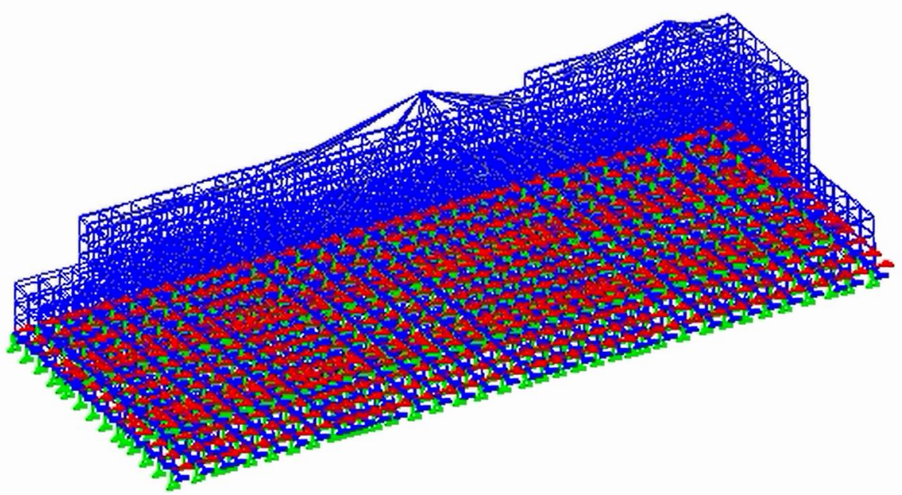
Words of Wisdom

- The whole is more than the sum of its parts. – *Aristotle*



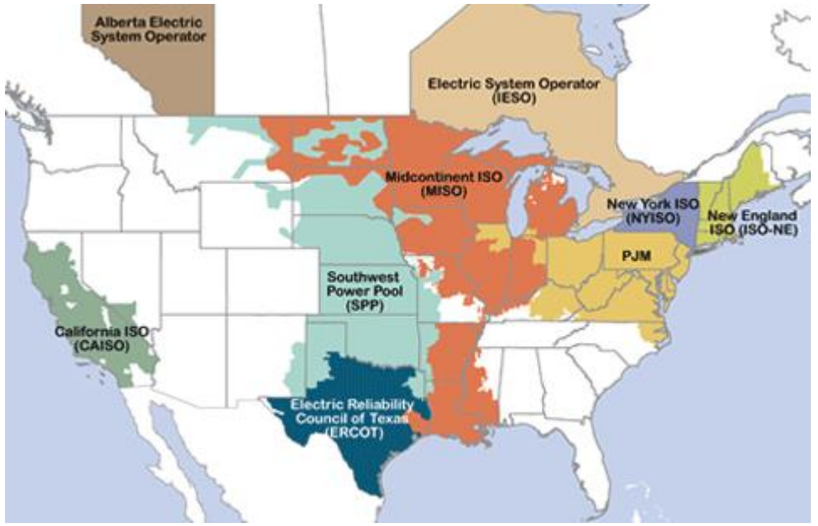
Design Tips

- LIDAR scans in existing plants
- Plant interface with existing systems
  - Condensate return
  - Controls
- Consider early control system integrator involvement
  - Efficient design
  - Integration of vendor systems to plant DCS
- Turbine foundation design - dynamic
  - ACI 351.3R, Ch. 4 – Analytical Methods for Calculating Soil Impendence



Design Tips

- Specifications and vendors
  - Plan around standard options
  - Controls interface
- ISO/FERC regulations
- Air intakes
  - Corrosion
  - SCR reaction
- Water treatment coordination
- Hazardous location requirements



University of California Santa Cruz

5 MW CHP

Lesson #5

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

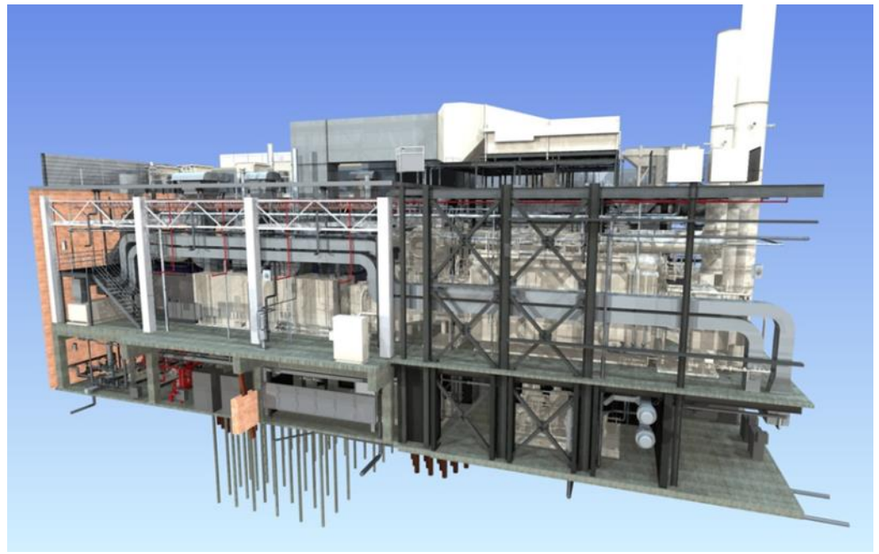
Plant Aesthetics

Big Idea

- The engineer gets to drive!
- Think from inside to out

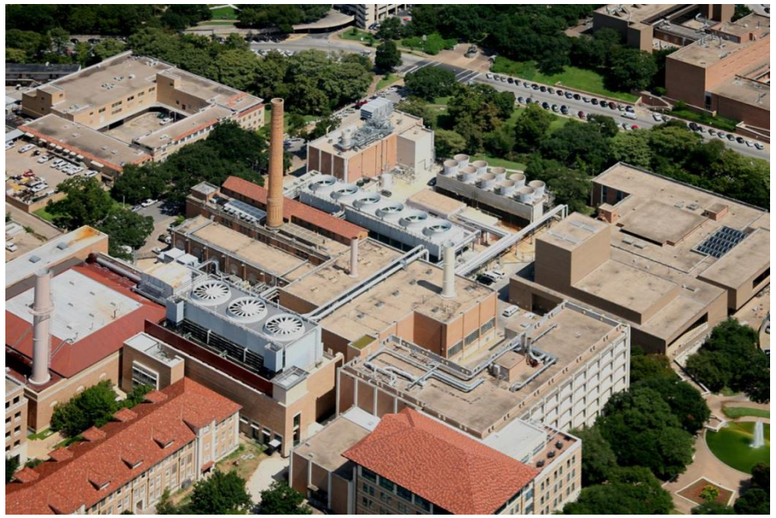
Words of Wisdom

- Beauty is only skin deep. But ugly goes clean to the bone. – *Dorothy Parker*



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, rooftop equipment
  - Electrical gear
    - Single source
- Remember the operators!



Application

Case Study

- University of Oklahoma
- University of Minnesota

Application

- Engineering first
- Safe and functional second
- Aesthetics third

Oregon State University

6.5 MW CHP

Other Lessons:

6. CHP plants and safety.
7. Natural gas compressors.
   You don't want one.
8. Issues with electrons.
9. Project delivery methods; choose wisely.
10. Your contractor probably hasn't built one of these before.
11. CHP projects are tough to commission.
    But worth it every time.
12. Train your operators!

Questions?

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