



Clean Energy Systems, Inc.

power without pollution

Pressurized Oxy-Combustion of Coal: Zero Emissions Power Plants

Clean Energy Systems, Inc.
Rancho Cordova, California, USA

Keith Pronske

24 March 2011

Introduction

Clean Energy Systems (CES)

- Founded in 1993 by retired aerospace engineers, Incorporated in 1996
- Located in California:
 - Headquarters: Sacramento, Ca
 - Demonstration Plant: Bakersfield, Ca
- Issued 25 patents on zero-emissions oxy-combustion power cycles
- Focused on process rights (IP) and manufacturing enabling technology – oxy-fuel combustors & turbine

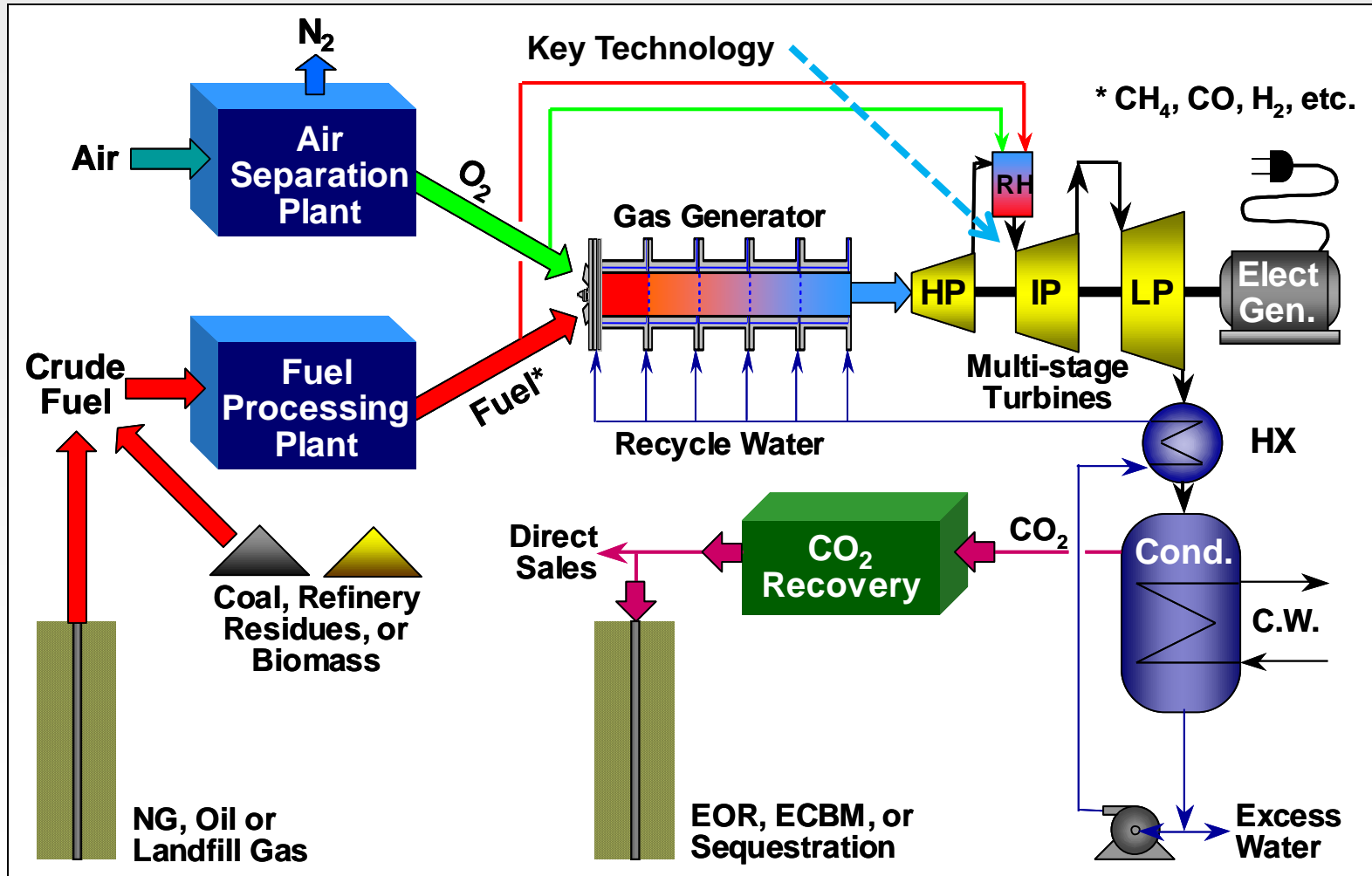
Vision

A new way to make power without pollution.

We use aerospace technology to change the way power is produced, and eliminate atmospheric emissions.

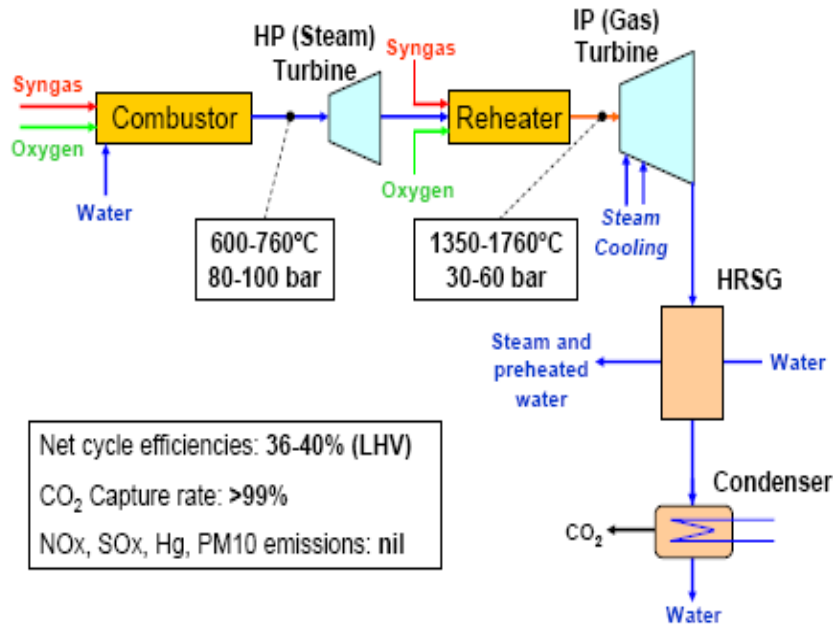


The CES Process



Main Features

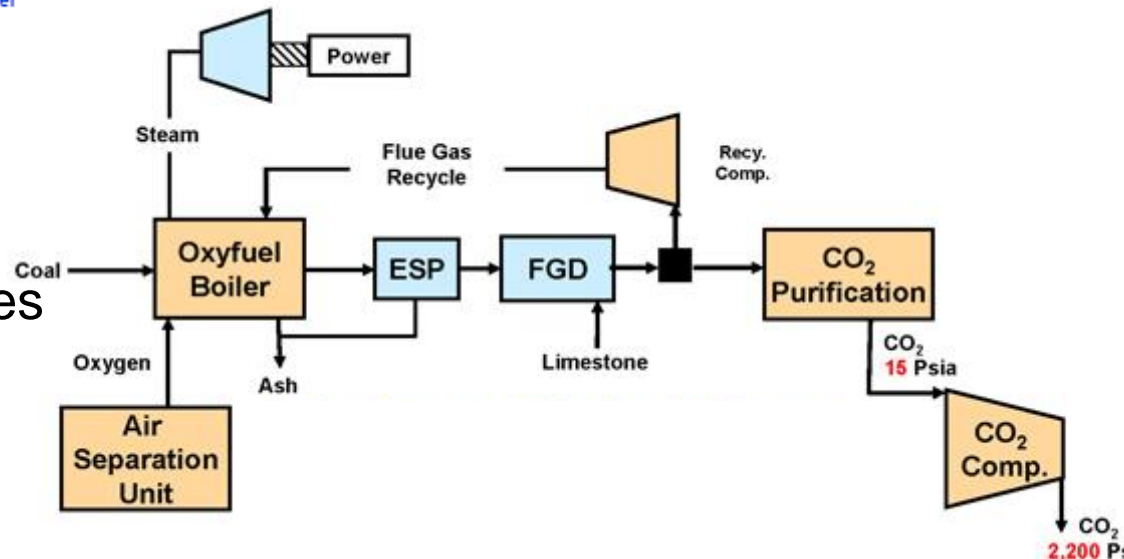
“Oxy-Turbine” vs. “Oxy-PC”



➤ Differs from other oxy-combustion processes:

- Combustion takes place at high pressure (up to 100 bar)
- Water/steam/CO₂ used for temperature moderation
- Combustion products (steam/CO₂) directly drive steam turbines and/or modified gas turbines

- + High cycle efficiencies
- + Near 100% CO₂ capture
- + Multi-fuel capability
- Requires advanced turbines
- Requires gasification
- Less retrofit-friendly



Unique Factors



- Zero Atmospheric Emissions
- Base Load
- Scalability
- Multi-Fuel
- Patent Protected
- Proven Technology



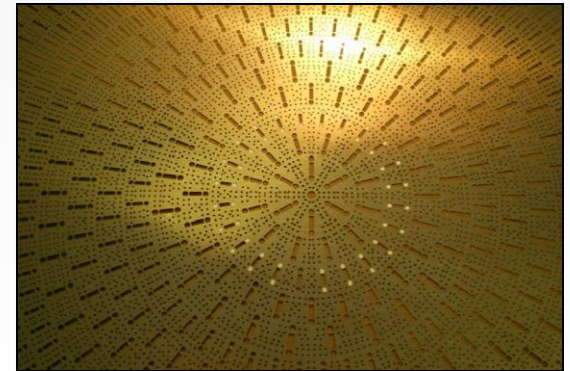
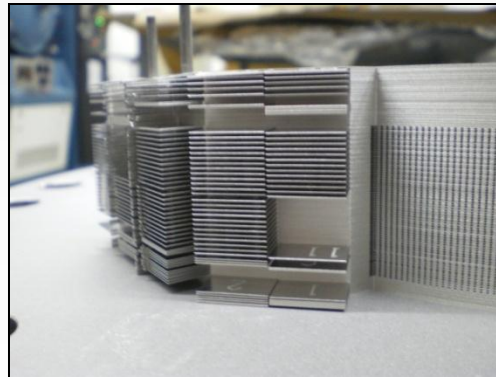
20 MW_t Gas Generator

- Compact and lightweight
- 25 tph steam/CO₂
- Market potential for thermal EOR
- Market for small cogeneration

Commercial Gas Generator

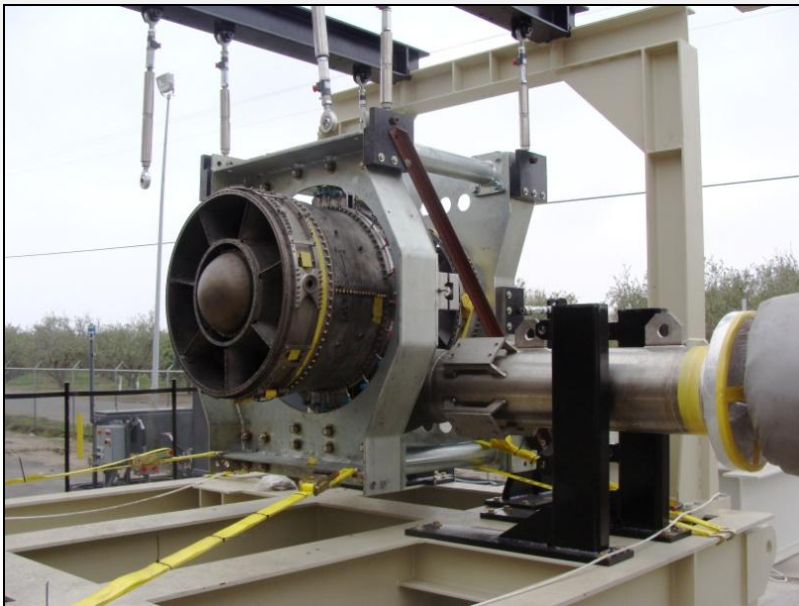


- Suitable for 50 - 200 MW Plants
- 250 tph steam/CO₂
- Compact



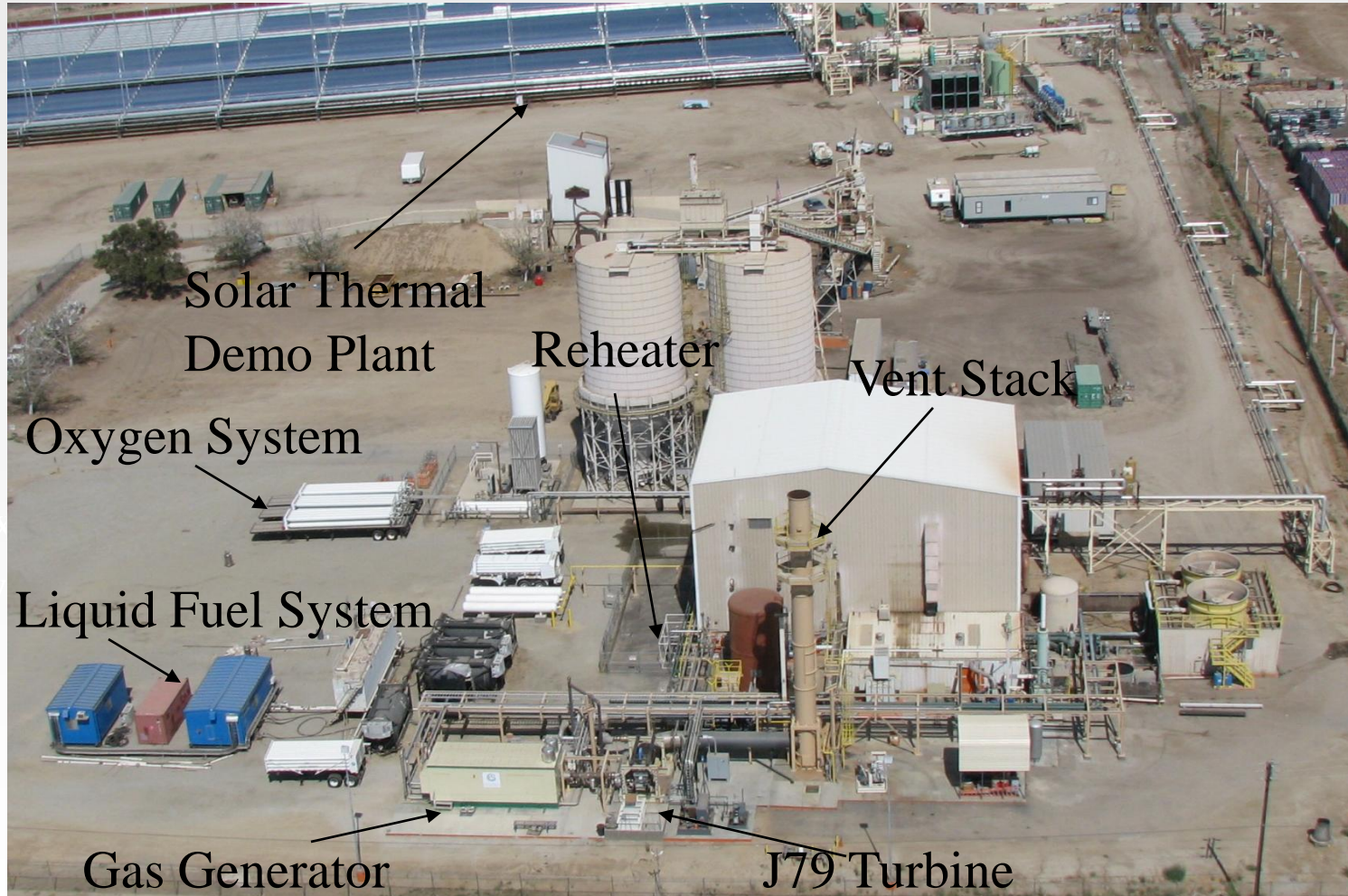
First Generation Turbine

- Originally a GE J79 turbine
- Used for 12 MW industrial applications (at right)
- Converted to a 40 MW oxy-turbine (below)



- “No-load” testing commenced in 2010. “Load testing” to be completed 1Q 2011

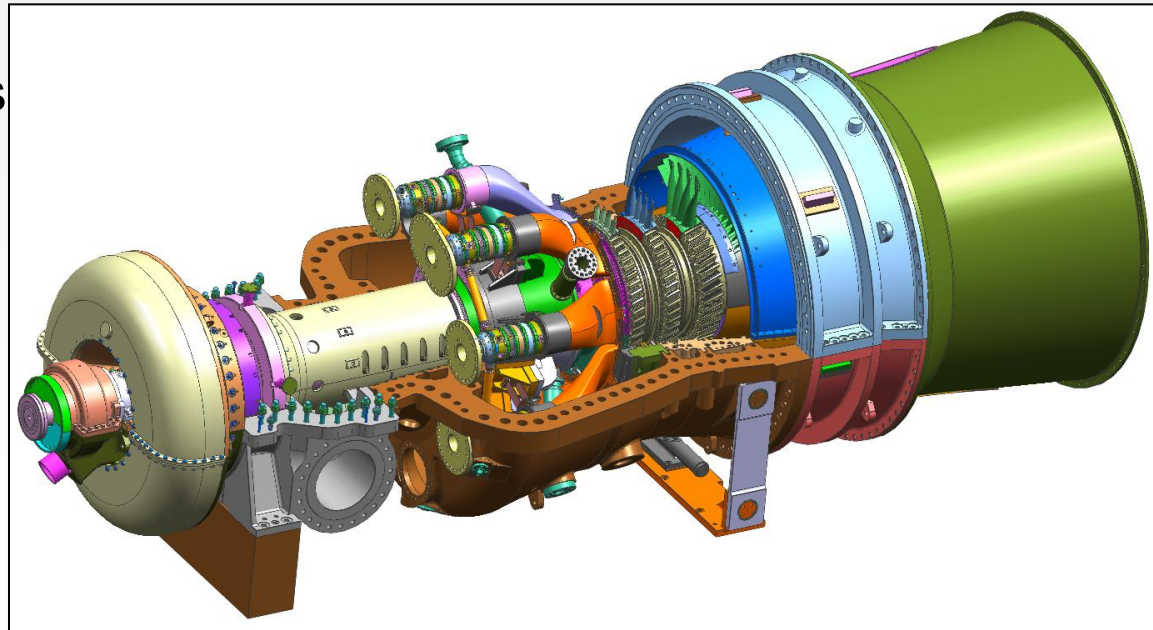
Oxy-Fuel Test Facility: World's Largest



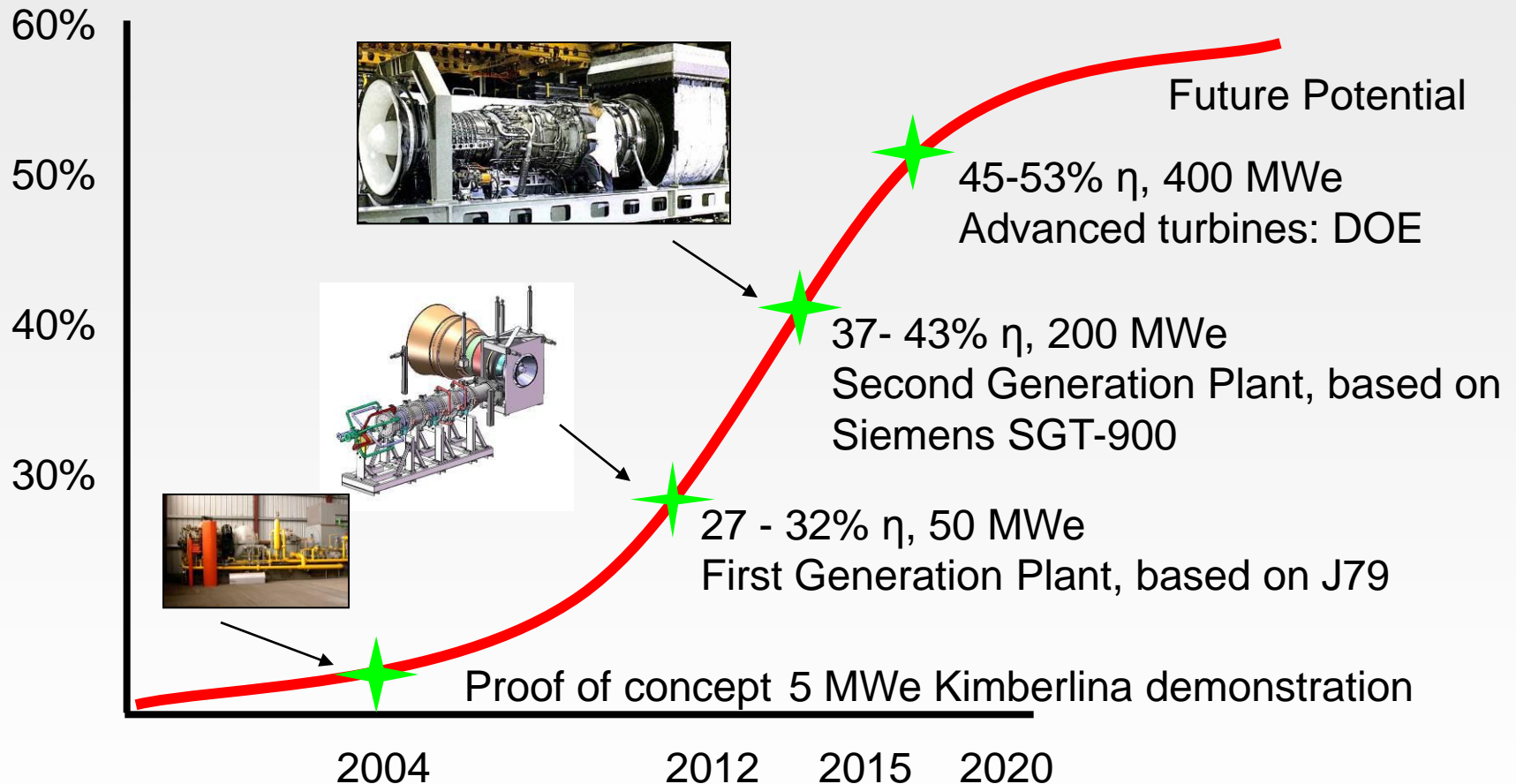
2nd Gen O-F Turbine System

DOE Funded:

- Objective: Design, Develop & Test a Commercial-Scale Oxy-Fuel Turbine (OFT) for use in Industrial O-F Plants
 - Capture and Sequester 99% of produced CO₂
 - Competitive Cycle
 - Using Diverse Fuels
- Used SGT-900 purchased Jan 2011
- Ready for testing July 2012



Technology Deployment



*Note: Efficiencies shown are for natural gas plants
Syngas efficiencies are 7-8 percentage points lower*

Our Products (and customers)

- Captured CO₂ for EOR/EGR
- Steam or CO₂ for Heavy Oil EOR, UCG
- Excess water (from the combustion)
- Zero Atmospheric Emissions Electricity
- Broad range of fuels: gaseous (gasified coal), solid, or liquid
- Water, Hydrogen, Other Products
- Peaking Power (no carbon capture but no NO_x, cheap and fast)

- *The key to zero emissions coal plants: Industrial scale, with sale of CO₂ and Electricity*



Clean Energy Systems, Inc.

power without pollution



Thank you!

www.CleanEnergySystems.com