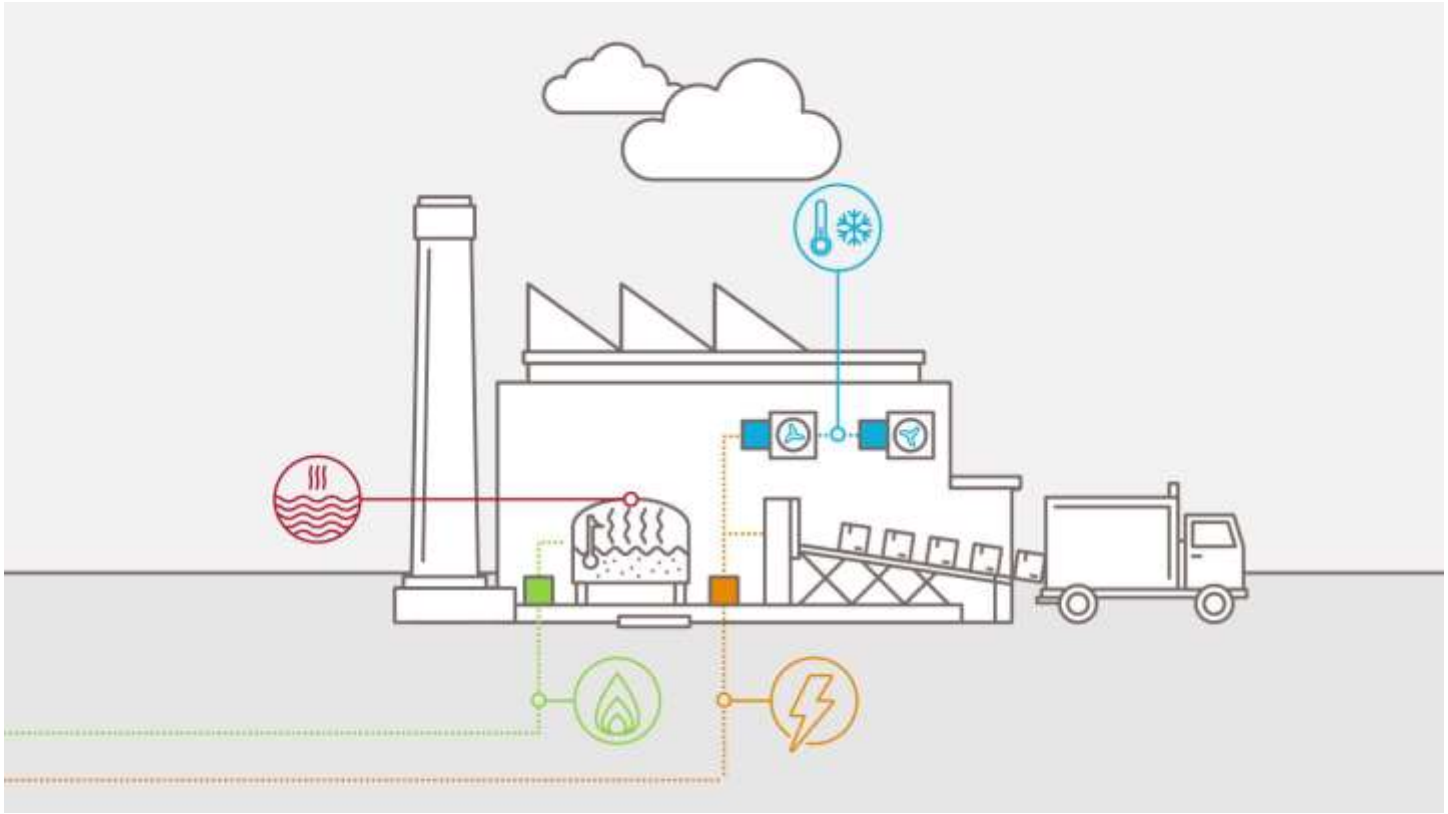
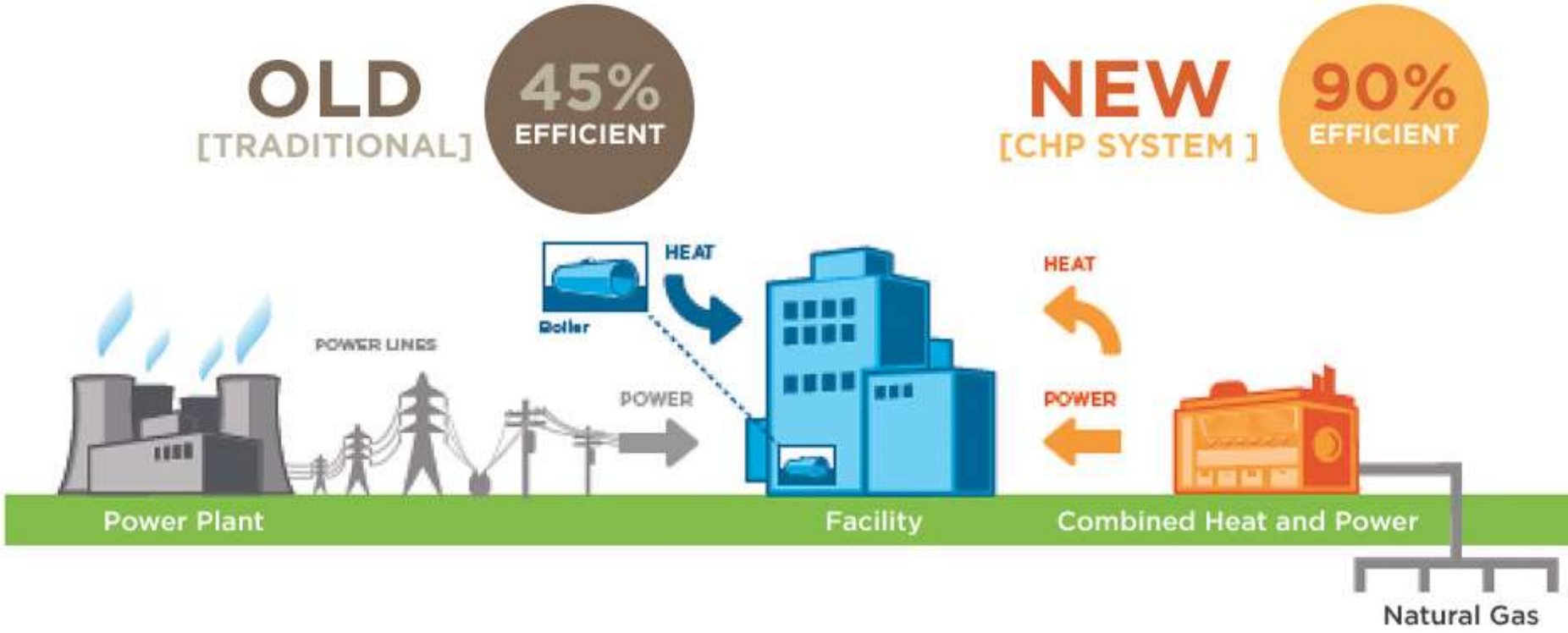
CHP



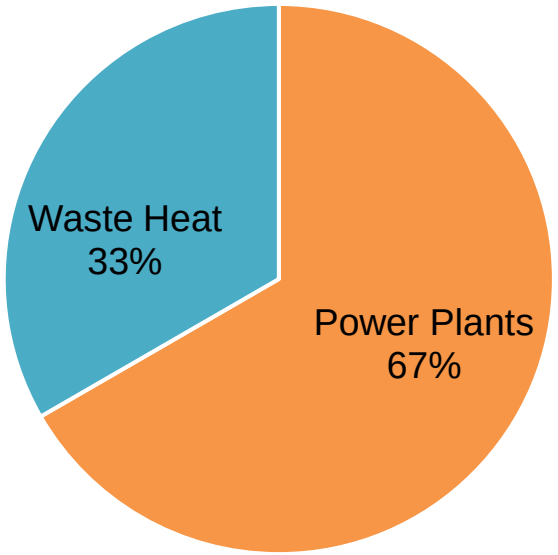

OLD
[TRADITIONAL]
45%
EFFICIENT
NEW
[CHP SYSTEM]
90%
EFFICIENT
HEAT
Boiler
POWER LINES
POWER
HEAT
POWER
Power Plant
Facility
Combined Heat and Power
Natural Gas

Rationale

- **It makes sense to produce electricity on-site if you can make money at it.**
- **How can you make electricity cheaper than a utility?**
  - You can be more efficient by utilizing waste heat (CHP)
  - You can use opportunity fuels which give you energy at a discount
- **But except in rare cases, you need to be able to change your mind**
  - "Make or buy" decisions vary over time
  - When you are not "making" you need to have the heat

The "Case" for CHP

- **Most power plants throw out 2/3 of the energy consumed through combustion**
- **Power generation at sites where waste heat can be used can capture another 1/3 of the lost power**
- **The waste heat use replaces other means of heating which otherwise be needed.**

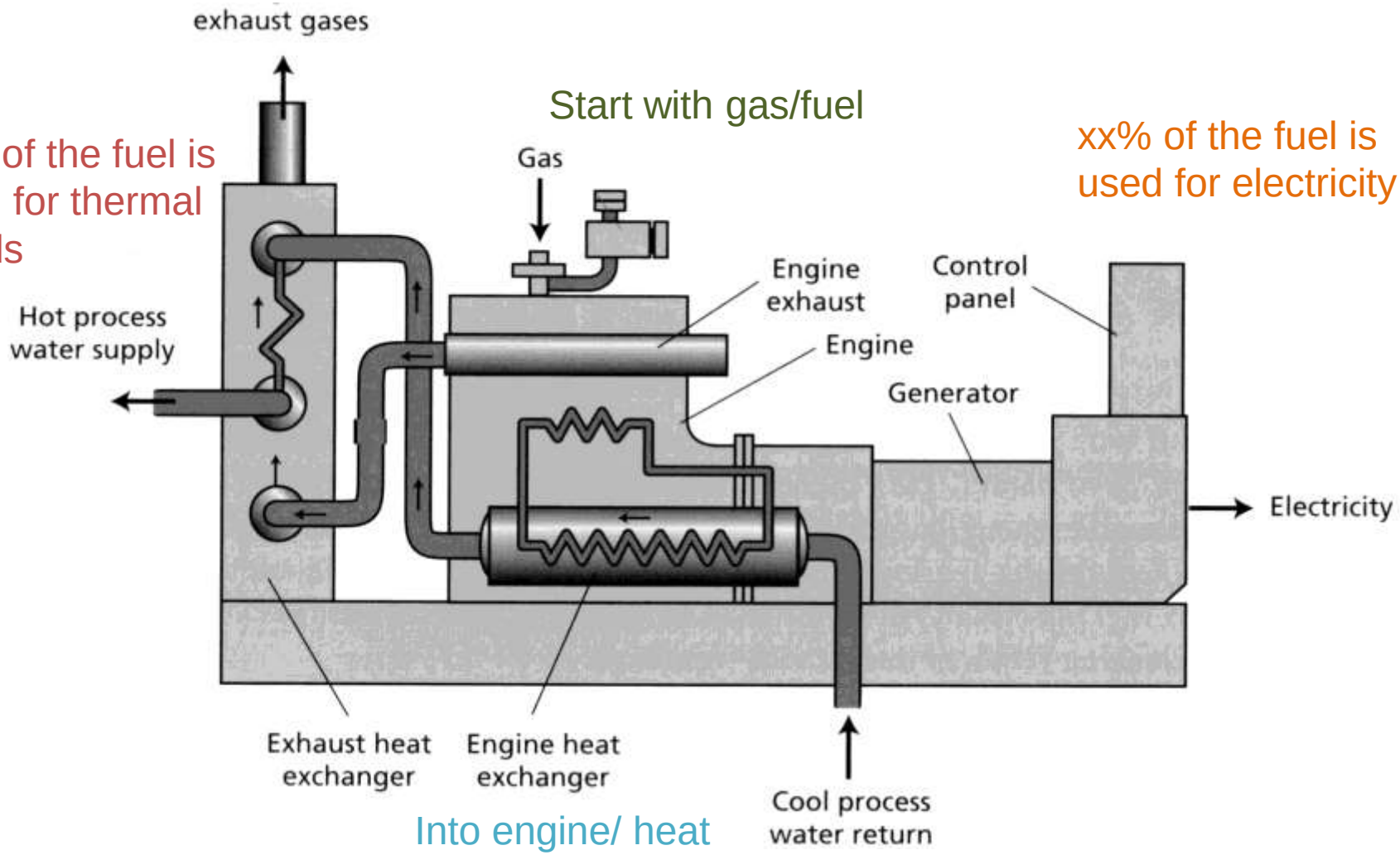


3 parts to a CHP system

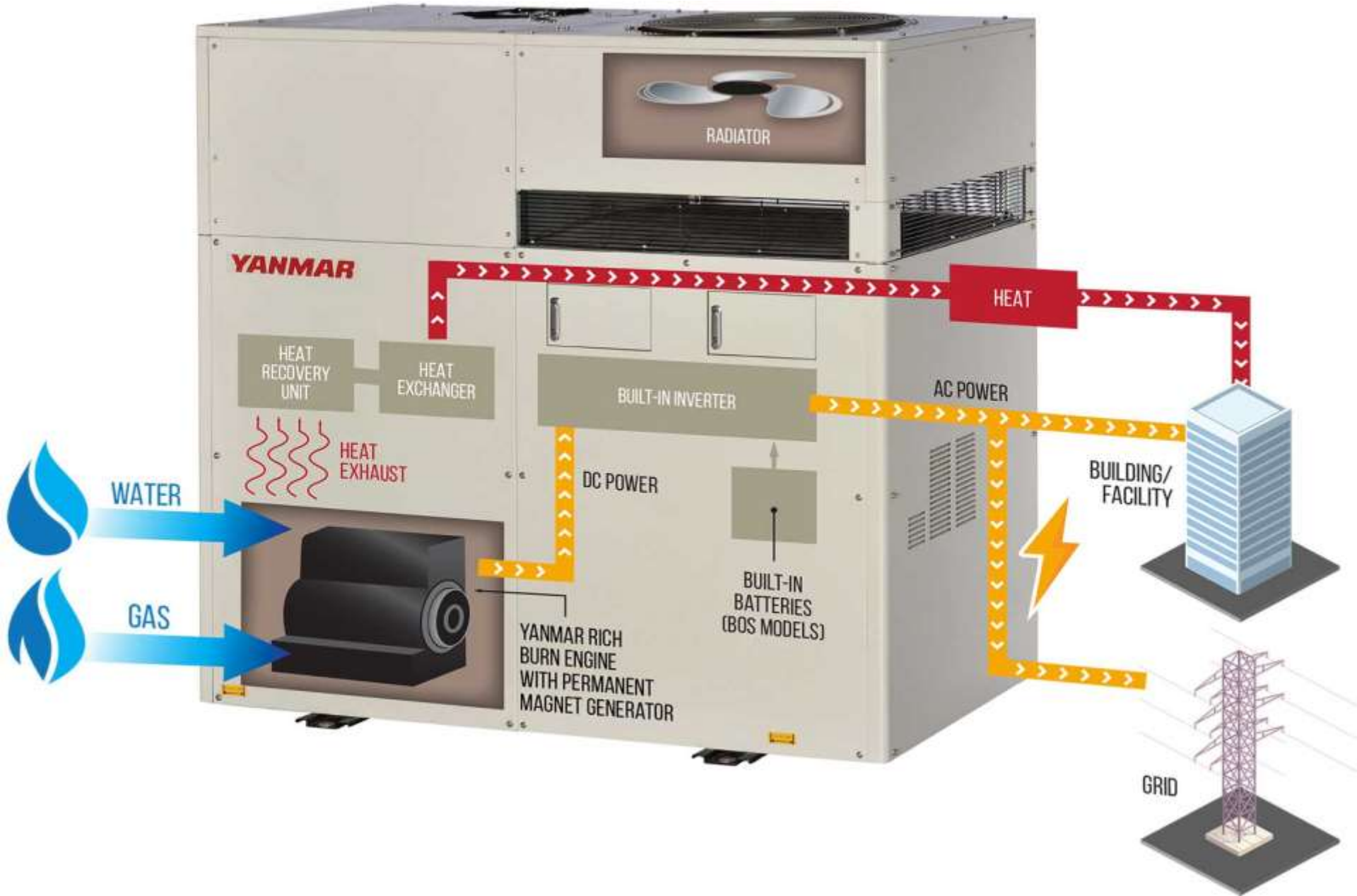
There are three basic elements to most combined heat and power (CHP) technologies

- The first is the ‘Prime Mover’ which is the ‘engine’ that creates the mechanical power.
- The second is the electrical generator.
- The third is the heat recovery unit(s) used for thermal needs.

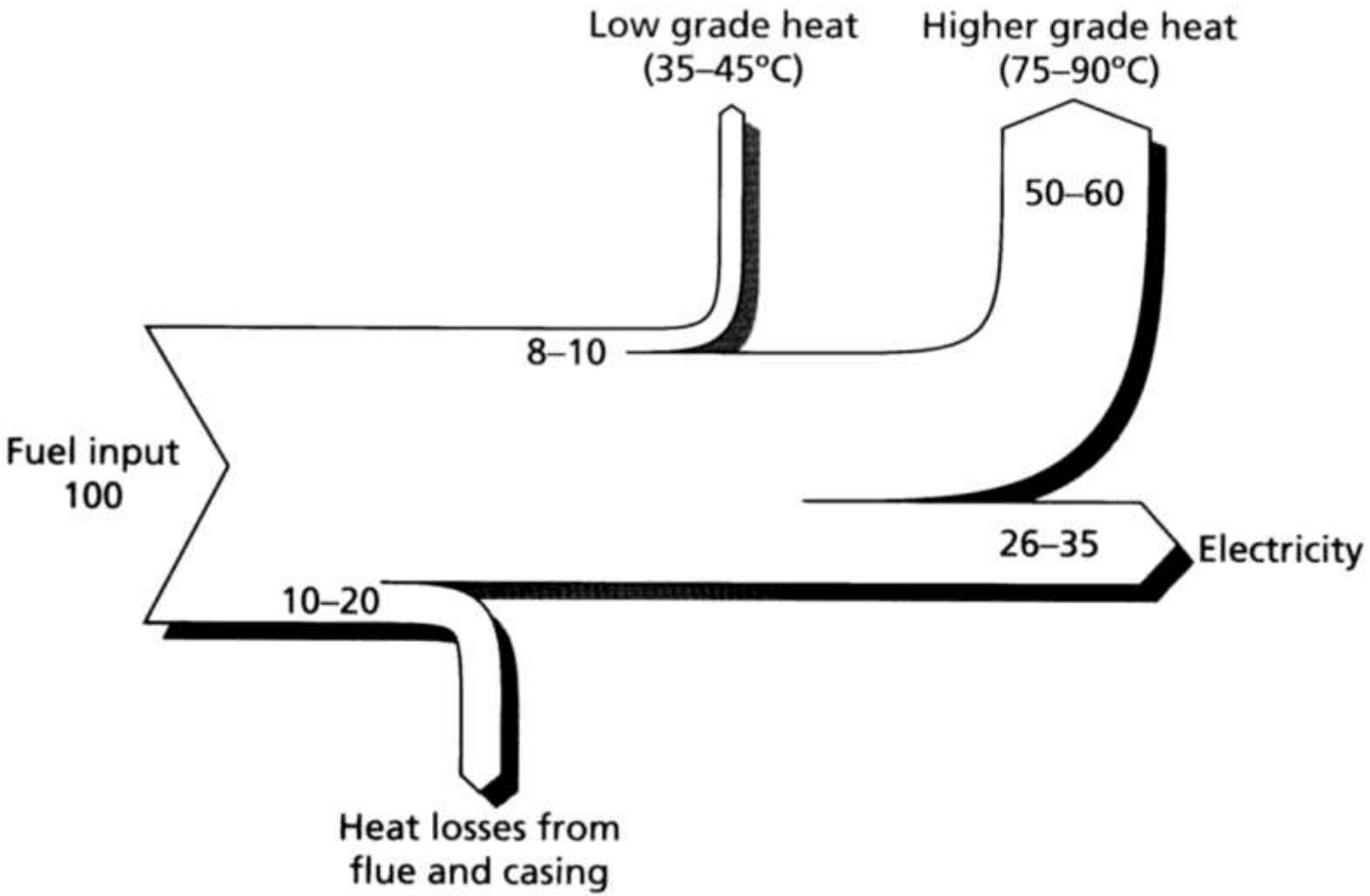
Typical Engine Type CHP System



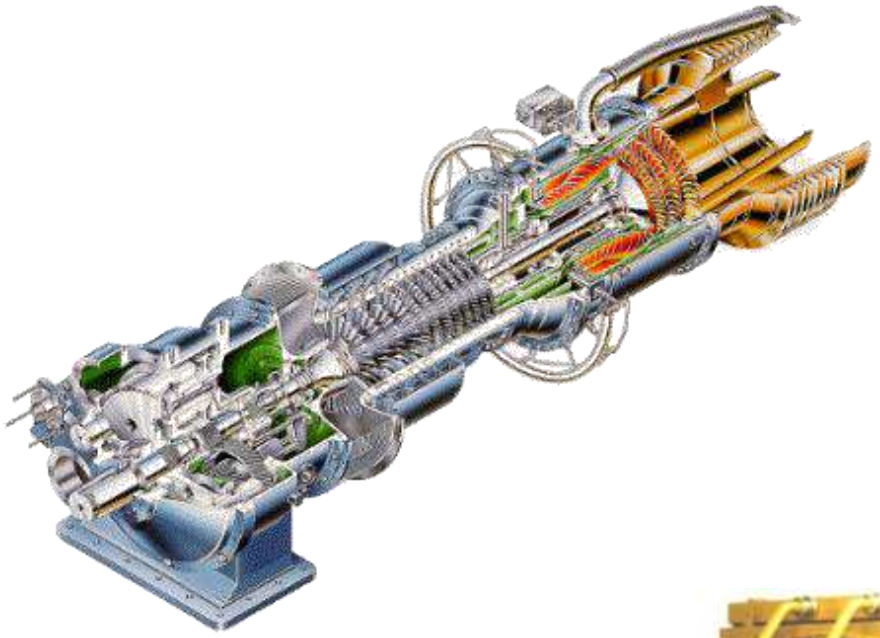
Typical CHP System



Example (cont.)



Prime Movers



- Reciprocating engines
- Combustion/gas turbines
- Boiler/steam turbines
- Microturbines
- Fuel cells

IAC CHP Recommendations

- **We recommend CHP a lot**
  - But paybacks are always high
  - Limited to our larger client – systems of 250 kW+ have more reasonable paybacks
- **Look for rebates through utility**
- **Details of waste heat use are always difficult**
- **Utilities fight installations in many/most areas**
  - Will offer reduced rates to industrial clients
  - This is a win – put this cost incentive in the recommendation

IAC CHP Recommendations

- **Why do we recommend CHP when paybacks are long and utilities against it?**
  - It remains a top idea if waste heat can be used
  - Getting companies thinking about power is a good idea

Other Applications for onsite power

- **Gas powered air compressors or chillers can be used as a reduction in baseload and/or for load shedding**
- **Steam used in industrial processes often has significant backpressure left after its process use**
  - "Back-Pressure Turbine" can generate electricity and replace useless pressure reduction valve

Gas driven chiller

Back pressure turbine in action

More applications for onsite power

- **Volatile organic compounds (VOCs) from solvent-based paints and inks**
- **Anaerobic digestion of biologicals**
- **Both provide fuels for power and/or heating**

Opportunity Fuels and Waste Streams

- Opportunity Fuels – Fuels not traditionally used for electricity generation.
- Has the potential to make power generation economically feasible by displacing natural gas and other traditional fuels.
- Usually, cheap.

Biomass

- Crop Residue
- Animal Waste
- Food Processing Waste
- Wood Waste
- Sewage Sludge

Industrial Byproducts

- Black Liquor
- Coke Oven Gas
- Industrial VOC's
- Petroleum Coke
- Waste Process Heat

Commercial / Industrial Waste

- Landfill Gas
- Municipal Solid Waste
- Construction Waste
- Combustible Production Waste
- Tire-Derived Fuel

Are any of these available at your facility?

What can I use the waste heat for?

- **Most common use is for space heating**
  - Good only in winter
- **Waste heat uses often depend on the temperature of the waste heat**
  - Hotter is better
- **Low grade waste heat is a huge challenge**
  - Consider drying technologies
- **There are often secondary heat sources**
  - Consider engine system

Determining Feasibility of CHP

Money Makes it Work

- **High electric prices (> 5¢/kWh)**
- **Difference in $/MBtu between gas and electricity**

Is the Need There?

- **Thermal demand matched closely to electric load**
- **Average electric load > 1MW**
- **Ratio of average electric load to peak load > 0.7 (high baseline usage)**
- **High annual operating hours (>6000)**

Identifying demand for CHP

Sizing system to limiting factor

Ensure all products from system are used year round.

- **Process heating load smaller than electrical demand: Size system to heating needs**
- **Optimum efficiency when 100% of waste heat is being used.**

OR

- **Electrical demand smaller than heating load: Size system to electrical needs**
- **Generation capacity should not exceed smallest hourly demand**
- **Avoid overproducing electricity**
  - Utilities purchase electricity from you at considerably less that market prices

EPA Typical Cost Example

CHP Cost to Generate Power	
Operating Assumptions	
CHP Electric Efficiency (%)	32.0%
CHP Power to Heat Ratio	0.7
Displaced Thermal Efficiency	80.0%
Thermal Utilization (%)	95.0%
Incremental CHP O&M Costs ($/kWh)	$0.0100
CHP Fuel Cost ($/MMBtu)	$8.30
Displaced Thermal Fuel Cost ($/kWh)	$8.30
Operating Cost to Generate	
CHP Fuel Costs ($/kWh)	$0.0885
Thermal Credit ($/kWh)	($0.0480)
Incremental O&M ($/kWh)	$0.0100
Operating Costs to Generate Power ($/kWh)	*$0.0505*
Capital Cost	
Installed CHP System Cost ($/kW)	$1,200
Annualized Cost Factor (%)	8%
Operating Hours	8,500
Capital Charge ($/kWh)	$0.0113
Total Costs to Generate Power ($/kWh)	*$0.0618*

Make or Buy?

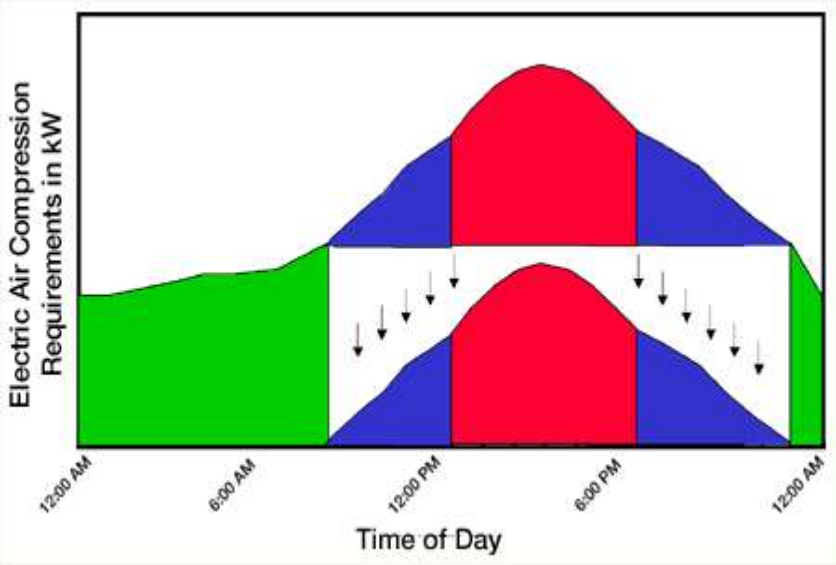
- **To optimize savings, it is important to make electricity only when it makes economic sense**
- **You need to be able to provide heat without making power**
  - Don’t get rid of those old boilers
- **Companies provide this as a service**

Utility Standby Capacity Charge

- **Charge by utility to maintain generation capacity in case CHP is shutdown either for emergency or scheduled maintenance**
- **Standby charges tend to be expensive**
  - Can make or break the CHP deal.
- **Standby charges fail to recognize benefits of highly efficient distributed generation**
  - Likely to be smaller in the future
- **Smaller systems have less trouble**

Demand Shaving

- **Running CHP during peak hours results in minimizing the electricity bought at during the peak period when the utility's demand charges are highest.**
- **Higher peaks lead to higher demand charges.**
- **CHP directly counters peak electrical draw from the utility**



Economies of Scale

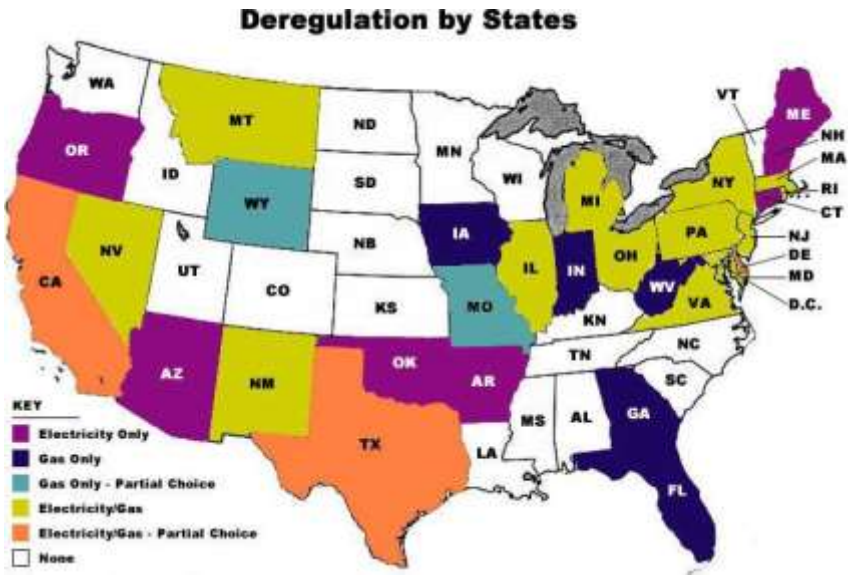
- **Consider the minimum size CHP that becomes economically feasible**

$$kW_{\min} = \frac{BOP}{Payback \times Hrs \times (\$/kWh) - (\text{CapCost per kW})}$$

- **A payback of 3.5 years, rate of $0.10/kWh, and a BOP (balance of project) ratio of 0.4 yields a minimum size of 1 MW.**

Working with your Utility

- **CHP installations can use significantly more natural gas than a normal industrial user.**
- **Utilities can work with facility to offer lower natural gas rates.**
  - Sometimes utilities pay additional fuel and O&M costs depending on on-site plant capacity
- **Are you in a Deregulated Energy Market?**
  - Ability to choose gas/electric supplier gives better chances for favorable gas rates



Important Sister Program