SEHDesign|Build, Inc.

Modern Approaches to District Energy

Utilizing Woody Biomass for Fuel

Presented by *Dale Hedtke*, PE

SEH

Who is SEH?

- More than 80 years of trusted solutions
- Full service consulting firm of engineers, architects, planners, scientists, and other professionals
- Client focused service delivery
- Employee owned
- 600 professionals in over 30 offices

SEH Service Region & Offices

Presented By

Dale Hedtke, PE, MBA. Senior Mechanical Engineer, SEH Inc.

Dale has more than 35 years working in process industries and spent 10 years working for a Swedish pulp machinery supplier. He has designed, managed, and sold projects nationally and internationally in pulp & paper, fiberboard, specialty chemical extraction (larch), oleochemicals, glycerin refining, and biodiesel production. He has regularly worked with process design, material handling, pressure vessels, and plant layout/design.

Dale leads the biomass-to-energy effort with the SEH Energy team

dhedtke@sehinc.com
218.279.3000
Duluth, MN office

SEH Design|Build, Inc.

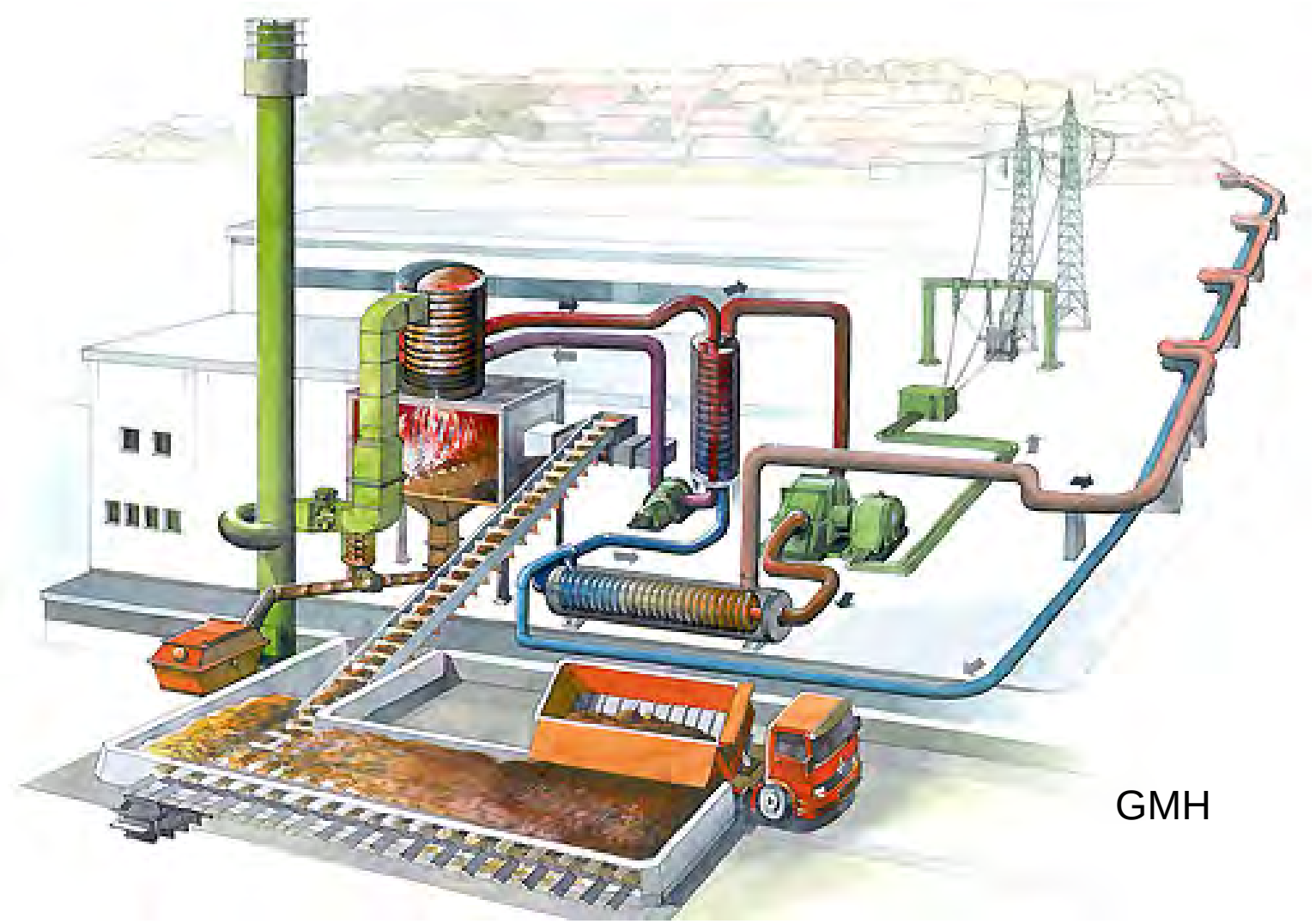
Municipal District Heating Plant

Fueled with woody biomass-Hibbing, MN

SEHDesign|Build, Inc.

District Energy
For Heating & Cooling

Integrated Biomass Power Plant with District Heating



GMH

SEH Energi

- Mid size CHP application-woody biomass
  - 10-60 MWth (thermal)
  - ~2-20 MWe (electric)
  - Steam or hot water
  - Flue gas condensation option (for more hot water)
- Hot water only
  - Biomass or pellets
  - 1-15 MW thermal output midsize units (community)
  - 25 kW-2 MWth output smaller units (neighborhood)
  - Modular equipment for simpler installation

A CHP plant supplying steam, hot water, and power to a dairy plant producing dried milk (Far back left)

Do you have a project?

- Is there biomass available in the region?
  - 75 mile radius is about the maximum
  - Are there logging operations in the area? Sawmills? Paper mills?
  - How sustainable is the biomass resource? (CHP plants have very long lives)
- Is the local energy source expensive?
  - Propane and fuel oil are already expensive
  - Natural gas is not very expensive right now, but is expected to rise
- Is there a local market for “green” electricity?
- Do you have a “local champion” to drive the project?
- What economic development resources do you have?
- Conduct a preliminary feasibility study
  - Can you find funding for this? $40,000-$100,000 may be needed
  - This effort will help you understand the complex issues

Preliminary Feasibility Study Goals

- Visit site-gather data
- Define the project
- Develop design criteria
- Develop preliminary plant sizing including:
  - C20 (+/- 20%) capital equipment costing
  - Plant operating data
  - Site and climate data
- Path forward-next step recommendations
  - Financial viability analysis-pro forma
  - Heat and power purchase agreement overviews
  - Project development plans
  - Project financing strategies
- Fuel supply-overview and options

*Renewable*CHP Combinations

Energy from Biomass

- BioCHP DE (District Energy & Power)
  - Energy for heating and cooling for buildings
  - Energy for heating domestic hot water
  - Energy for power generation
  - Very good thermal efficiency (~70%)

*Renewable*CHP Combinations

Energy from Biomass

- BioCHP DE (District Energy & Power)
  - Energy for heating and cooling for buildings
  - Energy for heating domestic hot water
  - Energy for power generation
  - Very good thermal efficiency (~70%)
- BioH DE (District Energy only)
  - Energy for heating and cooling for buildings
  - Energy for heating domestic hot water
  - Good thermal efficiency (up to 90%)

*Renewable*CHP Combinations

Energy from Biomass

- BioCHP DE (District Energy & Power)
  - Energy for heating and cooling for buildings
  - Energy for heating domestic hot water
  - Energy for power generation
  - Very good thermal efficiency (~70%)
- BioH DE (District Energy only)
  - Energy for heating and cooling for buildings
  - Energy for heating domestic hot water
  - Good thermal efficiency (up to 90%)
- BioP (Power production only)
  - Low thermal efficiency because of no “heat client” (~30%)

BENEFITS OF DISTRICT ENERGY

- Energy efficient
- Environmentally sound
- Easy operation & maintenance
- Reliable
- Lower life cycle costs
- Design Flexibility-individual buildings have no boiler or stack
- 70% of energy money stays in the community

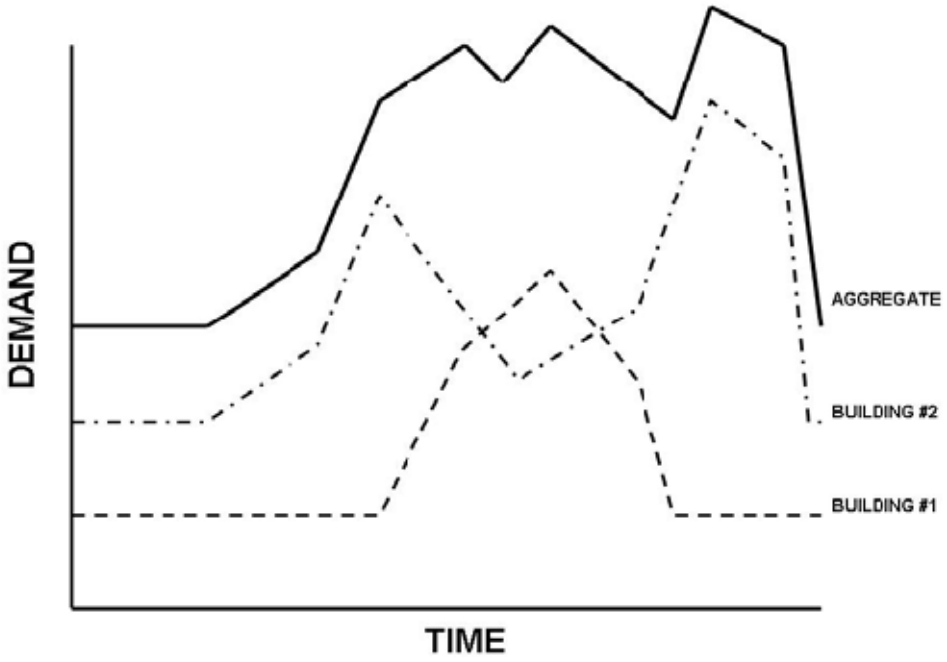
Typical Project Components

- Feasibility study
  - Fuel availability and its long term sustainability
  - Demand for heat and/or power
- Technology selection
- Engineering team
- Site selection
- Finance = debt + equity
- Legal
- Economic assistance-grants, loans
- Contractor-EPC (including bonding)
- Interconnect to power grid
- Power Purchase and/or heat agreement (PPA)

Benefits of *Renewable* District Energy

- Energy efficient due to load leveling and economies of scale. Also, the cost of biomass fuel is often lower
- Reduced Emissions - Using renewable energy reduces emissions of greenhouse gasses (CO Neutral) and other airborne pollutants.
- Systems are easy to operate and maintain
- Stronger Stakeholder Relationships - Using renewable energy can help to enhance image & relationships with customers, communities, employees and shareholders. (JOBS!)

Energy Demand Leveling



- Demand leveling reduces the size of the energy supply needed
- The overall economics are improved

Turbine and Generator

- Type, Model and Manufacturer Specific to Each Project
- Custom Designed, Sized and Configured for Each CHP Application
  - Back pressure turbine - exhaust heat from the turbine is recovered in a condenser which generates hot water for district heating/cooling
  - Extraction/condensing turbine - extraction steam from the turbine feeds a steam header that supplies steam for process use
- Various Manufacturers – Dresser-Rand, MAN Turbo, Siemens, etc. (typically best efficiency from Europe)

Go with Proven Technology

- Utility Grade Design – 97% to 99% Operational Up-Time
- Utility Grade Automation
  - Designed for Unmanned or Remote Operation (up to 72 hours unmanned operation is required in Sweden)
  - Reduced Staffing Requirements
  - System Loading Flexibility
  - Advanced Process Monitoring and Corrections
- Fuel Efficiency – 99%+ (<1% un-burnt)
- Low Maintenance and Operating Costs
- Flexible Turn Down Ratio – 100% to 30%
- Highly automated
  - Frees up operators
  - Better load management and emission control
  - Adjusts automatically to changing loads and fuels

Proven Technology cont.

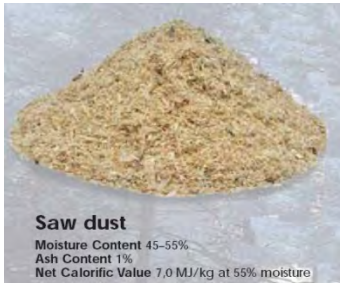
- Fuel Size Variability and Flexibility
  - Use any Wood Based Biomass Fuel
    - Sawdust, Chips, Bark, Logging Residuals, C & D Wood
  - Utilize a Varity of Moisture Contents
    - Up to 60% Moisture Content
    - No Pre-drying
  - Flexibility of Fuel Sizes
    - As Large As 4” x 4” x 16” – Less Than 10% of Fuel Mixture
    - As Small As ¼” – Less Than 5% of Fuel Mixture

Plant Ergonomics

- Community Size
- Frequently Located in Downtown or Urban Settings
- Various “Skins” or Buildings – Equipment is Independently Supported
- Quiet – Well Insulated
- Fuel Delivery and Ash Removal
  - Inside Facility
  - Off Hours

Biomass Fuel Sources

- Woody Biomass
  - Forest products
  - including slash
  - Sawmill wastes-bark, sawdust, slabs
  - “Red trees”
  - Ash trees killed by the Emerald Ash Borer
  - Construction & demolition debris
  - Telephone poles & RR ties
- Wood Pellets & briquettes



Fuel Considerations

- Woody biomass
  - Plentiful in many regions
  - Low density; best obtained within a 75 mile radius of the plant
  - Standardized transportation trailers-self unloading trailers for smaller plants
  - Plants with fuel preparation equipment (shredder, chipper) can receive logs or whole trees.
- Wood pellets
  - Dense way to transport and store fuel
  - Low dust
  - Higher heat content per pound than woody biomass
  - Stable for storage-minimal moisture pickup, no mold, chance of spontaneous combustion
  - Simpler storage and feed equipment-free flowing
  - Transportation equipment not standardized
  - Not widely available

Fuel Considerations cont'd

- Agricultural wastes-stover, cobbs. straw, switch grass, miscanthus
  - Plentiful in many regions
  - Low bulk density. Typically requires densification equipment
  - Not standardized harvest methods
  - Annual harvest requires larger storage area
  - Can contain high mineral content, with potential deleterious affect on combustor
  - Not considered further within the scope of this presentation

Fuel Economics

FUEL	BTU/unit	Unit	Cost $/unit	Unit	$/mmBTU*
Coal	12,000	Lb	$ 40	Ton	$ 1.67
Woody biomass	4,500	Lb	$ 25	Ton	$ 2.78
Pellets-industrial	8,750	Lb	$ 140	Ton	$ 10.00
Pellets-premium	8,750	Lb	$ 180	Ton	$ 12.86
Natural gas	100,000	Therm	$ 8.00	Therm	$ 10.00
#2 Fuel oil	138,500	Gal	$ 2.70	Gal	$ 24.37
Propane	92,500	Gal	$ 2.35	Gal	$ 31.76
Electricity	3,412	kWh	$ 0.08	kWh	$ 23.45
	*Delivered & efficiency adjusted				

New Harvest Equipment

John Deere Slash Bundler

John Deere Slash Bundler

- Densifies forest residue for transport-compresses & twine wraps
- Creates a bundle that can be handled just like a log
- Uses standard log forwarding, handling, and transport equipment
- Requires a grinder in the woodyard
- More that 80 operating in Europe
- Fuel tests are successful

WB-55 Biobaler from Anderson

WB-55 Biobaler from Anderson

- Creates a round bale 4’ diameter X 4’ H
- Transport is on a standard flatbed trailer
- Requires a bale breaker and grinder in the woodyard
- Initial testing show some problems with boiler feed equipment handling small diameter stems, sticks

Simplified Biomass Delivery

Scandinavian side dump chip truck and trailer

Woodyard

Woodyard

Reliability of the fuel feed is paramount

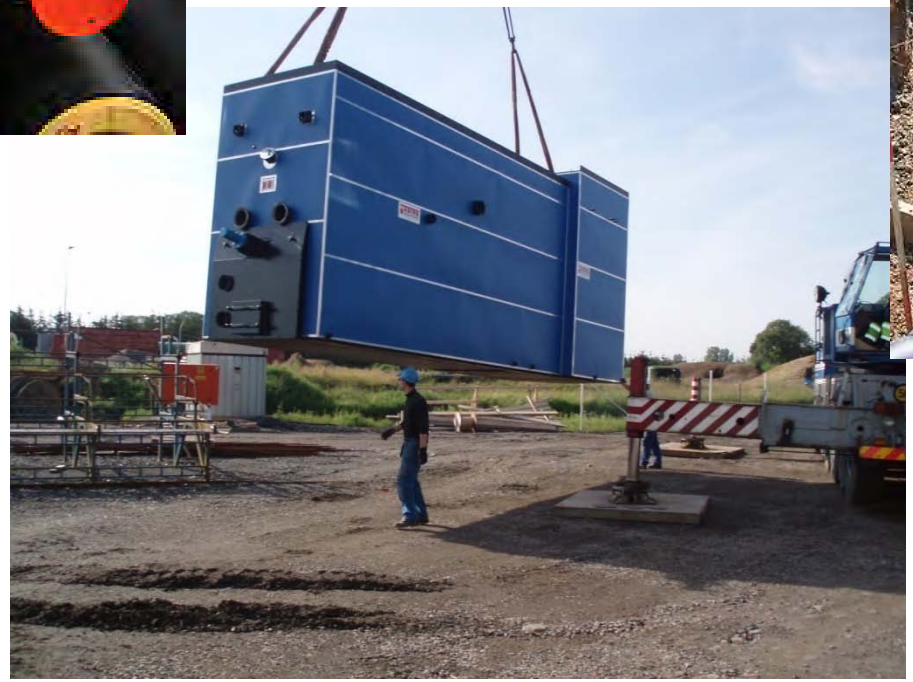
Woodyard Considerations cont'd

- Will the woodyard be on-site?
  - Requires more space at the boiler site
  - Simplifies material handling
  - Increased dust and noise at the boiler site
- Off site
  - Requires additional material handling & logistics to deliver to boiler site
  - Can be as large and elaborate as local conditions require
  - Can serve more than one boiler in its "service territory" (LEA)
- Transportation
  - Logs
  - Bundles
  - Chips/hog fuel
- Dust, congestion
  - A larger problem in urban settings
  - Proper dust control necessary

Piping and Equipment

Insulated piping

Burying piping



Modular Boiler-mid size

Energy Piping

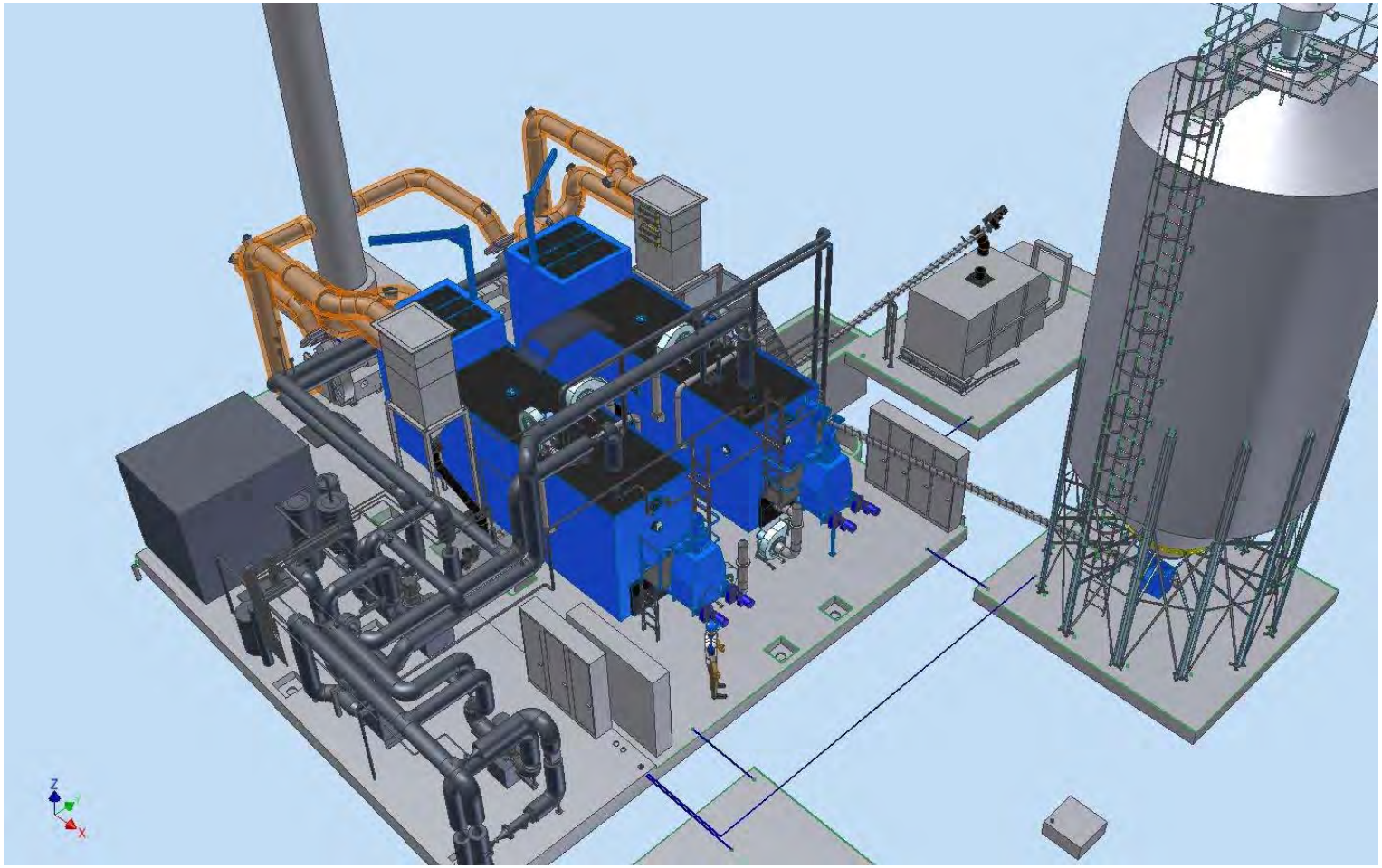
Energy Piping

Equipment Details cont'd.

Modular Boiler Installations

Twin Boiler Installation

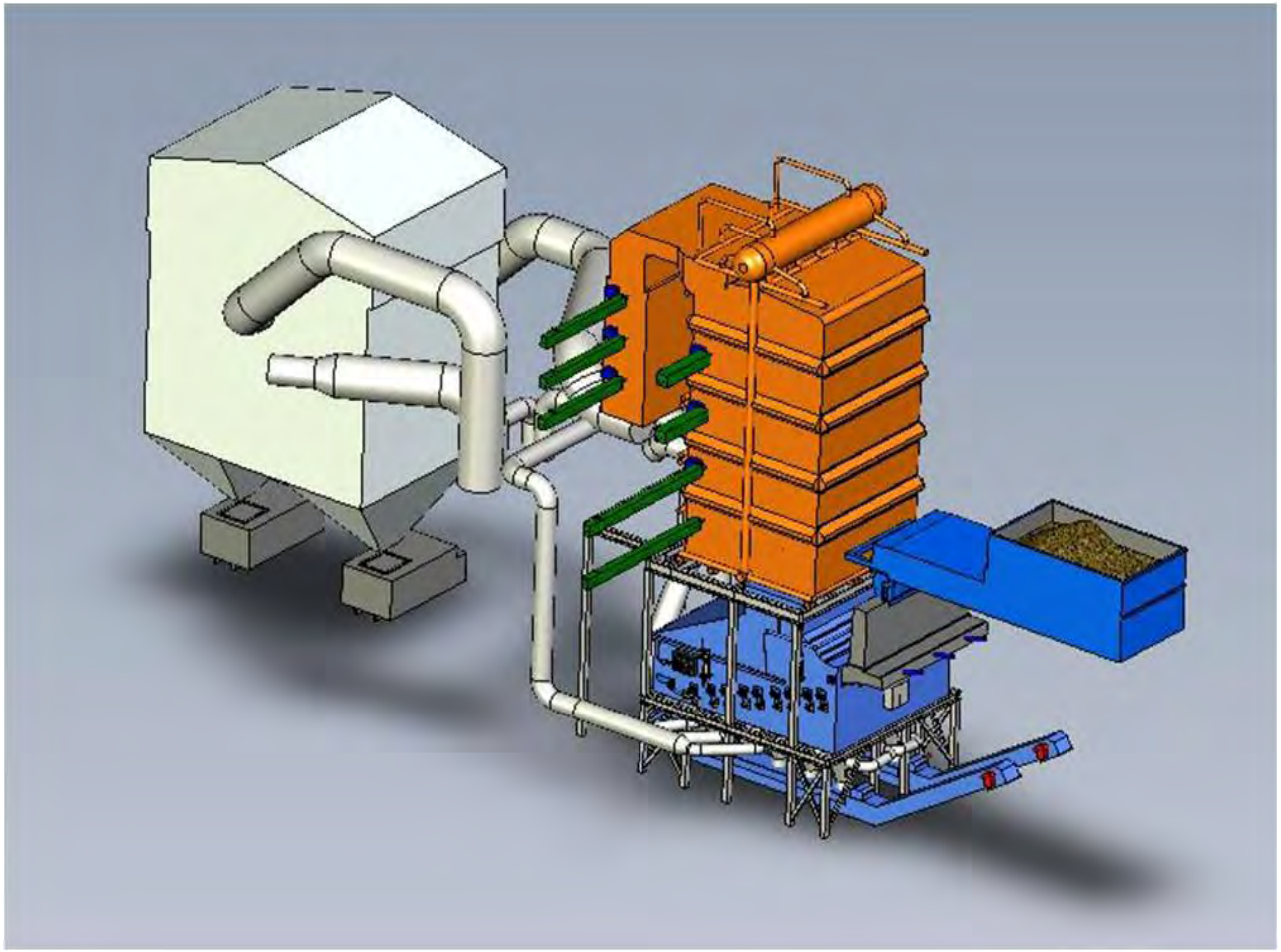
Hot water



Twin Boiler Installation

Boiler House

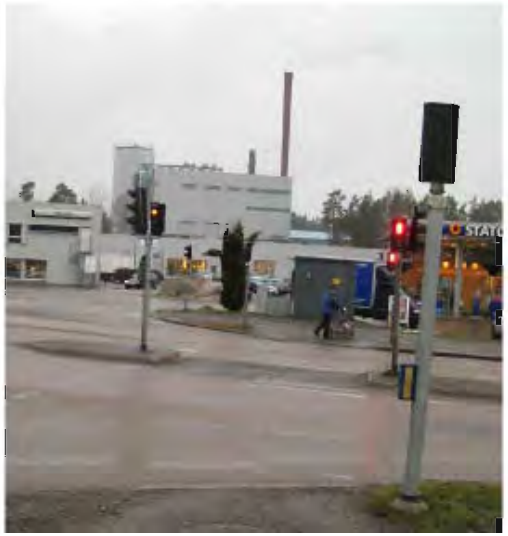
High Pressure Combustor



Site Construction-High Pressure Boiler

CHP Plant-Control Room


SKOMA



Our teaming partners

EnvioEnergi
Renewable Energy Systems

Power Island

Wolf

Material Handling/Woodyard

Mechanical Systems Design

District Energy Piping Design