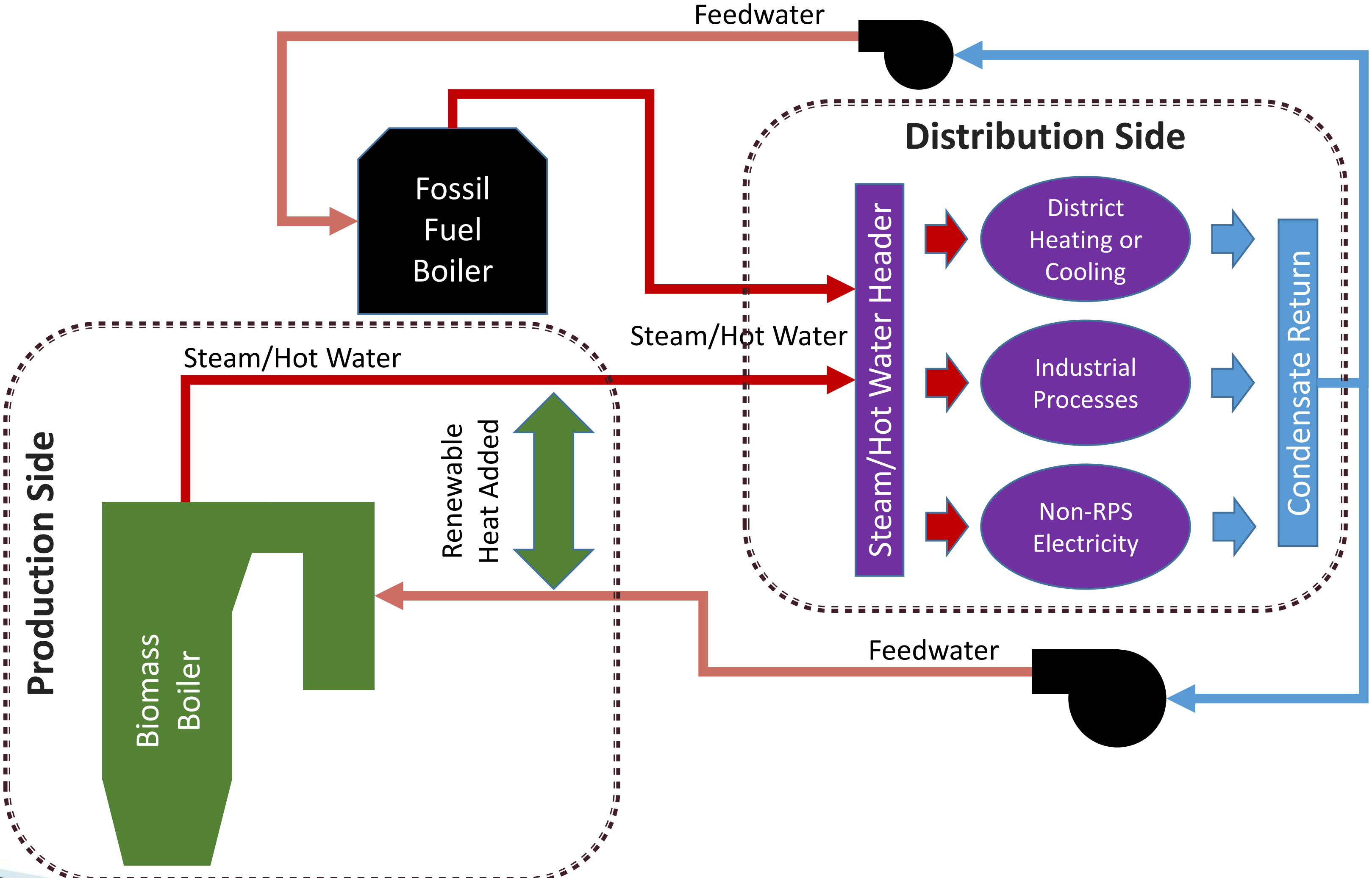
Biomass Thermal Energy

Metering Principals

A Few Other Thoughts

- Principals generally applicable regardless of system size or whether steam/hot water
- Small-scale systems
  - More likely to use hot water as working fluid
  - Less instrumentation needed for operation
  - Less likely to be CHP
- Large-scale systems
  - More likely to use steam for working fluid
  - More likely to include power generation
  - Industrial process heat
  - More instrumentation-ideally

Metering Concept



Thermal Metering – Net Useful Energy

- Net Useful biomass energy delivered to distribution
  - Gross renewable thermal energy production continuously metered at the inlet of boiler and prior to distribution
  - Adjustments applied to determine net useful thermal energy
- General Equation for Net Useful Thermal Energy (U_{th})

$U_{th} = Q_{out} - Q_{ret} - Q_{rps} - Q_{adj} - Q_{par} + Q_{wh}$; **where**

U_{th} = useful thermal energy

Q_{out} = energy leaving BECD

Q_{ret} = energy returned from process

Q_{adj} = energy adjustment for non-renewable energy inputs

Q_{par} = energy adjustment for parasitic loads downstream of Q_{out} metering point

Q_{RPS} = thermal energy used to produce RPS compensated electricity

Q_{wh} = waste heat recovered from exhaust gas

Gross Thermal Production

- Continuous Metering: Boiler input and output
  - Temperature, flow and pressure sensors installed after feedwater pumps and at inflow to main steam header
- Thermal Generation formula

Q_{th} = Q_{out} – Q_{ret} **where**

Q_{th} = biomass thermal energy produced (Btu/hr)

Q_{out} = energy leaving BECD (Btu/hr)

Q_{ret} = energy returned from process (Btu/hr)

Adjustment for Parasitic Loads

- Parasitic Thermal Loads
  - Feedwater heaters, deaerators, plant heating/cooling, etc.
- Not all loads will require adjustments, only those that may result in overstatement of useful thermal energy
  - Those outside of metering boundaries, or cross metering boundaries
- Adjustment process
  - Identify relevant parasitic thermal loads;
  - Use plant energy audit techniques to quantify these loads (P_{load})
- Calculate parasitic load coefficient as percentage of gross thermal output

$$Q_{par} = Q_{out} * P_{load}$$

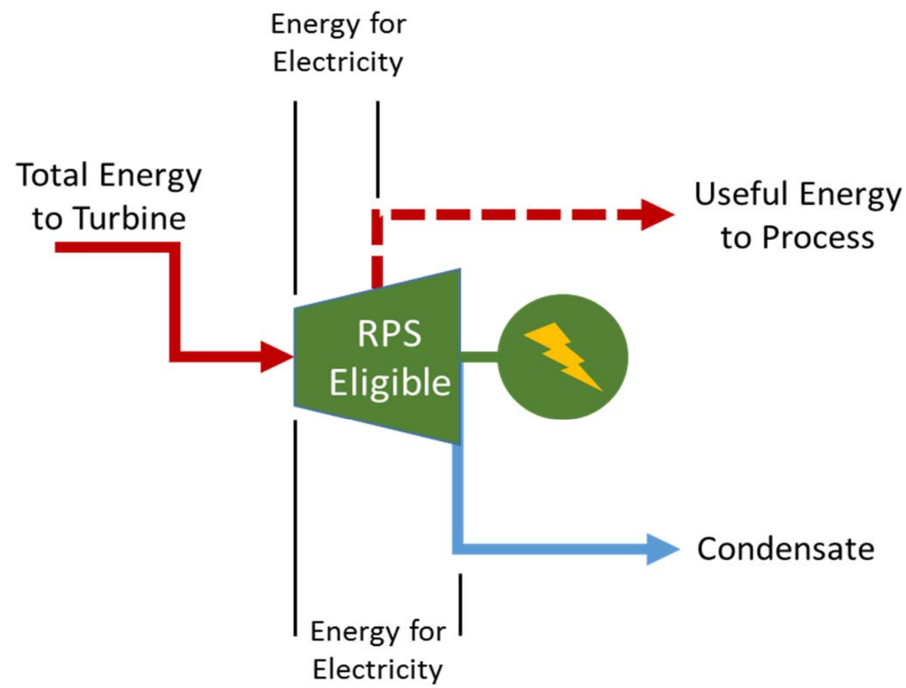
RPS Power Deduction

- Deduction for RPS Power Generation
  - Deduction excludes thermal energy used to produce Electric RECs (avoids double counting)
- Calculation of energy extracted for electricity will depend on type of turbine.
  - Back pressure turbine
  - Extraction turbine, back pressure
  - Extraction turbine, condensing
  - Hybrids (multi-turbine)

RPS Power Deduction

Q_{RPS} = Q_{Tin} – $Q_{process}$ – Q_{Tout}; where
Q_{RPS} = total energy generate RPS electricity;
Q_{Tin} = total energy to the turbine inlet;
$Q_{process}$ = total energy from turbine to process
Q_{Tout} = the total energy in condensate; and

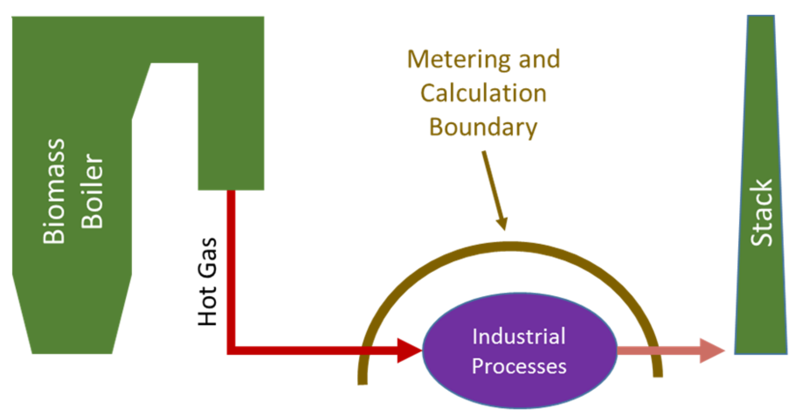
- General formula
  - Q_{RPS} is the adjustment factor



CHP WITH RPS ELECTRIC - DETAIL

Waste Heat Recovery Adjustment

- Addition for Waste Heat – Case by Case
  - Addition credits the recovery of useful process energy from exhaust gases
  - Assumes that waste heat is used to add value to a product that is not consumed at the plant
    - Drying lumber = OK
    - Drying wood fuel = parasitic use



WASTE HEAT RECOVERY

Additional Considerations

- Methodology ensures that RECs created by power generation for the RPS do not overlap RECs created by thermal energy production

- Adjustment must be made if fossil boiler operated in parallel – case by case, but methodology does accommodate this
  - Qadj = energy adjustment for non-renewable energy inputs

- Meter choices have a big impact and freedom for proper specification for each application must be provided. An overall accuracy adjustment factor seems appropriate to be fair to all parties.