KEY ISSUES AND NEEDS

The following is a list of key issues and needs that were identified during the colloquium. No attempt was made to obtain consensus on the relative importance of the individual items, but the list does represent a summary of the items felt to be important by those attending the colloquium. The list is divided into the following categories: black liquor gasification and combustion fundamentals, recovery boiler processes, particle formation, deposition and removal, black liquor gasification processes, corrosion and material issues, auto and self causticizing processes, computer modeling of recovery boilers and gasifiers, and general.

Black Liquor Gasification and Combustion Fundamentals

Formation/destruction of tars. Need data and interpretive models for tars formation and destruction as a function of temperature and pressure and liquor composition. – CPD model looks promising.

Organic compounds. Need more data on behavior of individual organic components during black liquor processing (heating, hydropyrolysis, combustion, gasification). Also, should study semiorganic compounds (organic sodium, organic potassium, organic sulfur).

Sulfur. Clarify the role of sulfur compounds in black liquor gasification and combustion. Determine the degree of sulfur reduction that can be attained in the MTCI and Chemrec processes. Also, determine why kraft and soda liquors behave so differently.

Effect of temperature. Need reliable data on the effects of temperature on devolatilization yields, species, rates, etc. Data is particularly needed for short times.

Char gasification kinetics. Need reliable data on char carbon gasification kinetics as functions of temperature and pressure. Should measure development of internal surface area of both low temperature and high temperature chars throughout gasification and relate internal surface area to gasification rates. Also, try to relate the rate to the sodium metal content relative to the organic carbon (mole/mole), especially if dealing with industrial (i.e. fast-pyrolysis)chars.

Char properties. There is a need for a better characterization of char, the role of inorganics in char, how inorganics form from the alkali-inorganic compounds in black liquor, and the rheological and structural characteristics of char-inorganic mixtures above the inorganic melting point.

Addition of salts. Determine the effect of recycled dust and crystallized sulfate and carbonate in black liquor on drop burning behavior, sulfate reduction rates, and sulfur release.
Recovery Boiler Processes

Liquor behavior on surfaces. There is a need for additional understanding of processes occurring on boundaries
- floors
- lower furnace walls, especially around airports
- upper furnace walls
- superheaters

Char bed processes. Understand processes occurring in char beds, and how they determine char bed characteristics, structure, and composition.

Recovery boiler air and liquor feed. Carry out a critical review of recovery boiler air systems and firing practices
- what combinations work together
- what are advantages and disadvantages of different approaches
- is there an optimum approach for a given size unit (or loading factor)
- what role does furnace stability play in optimum performance

Videos. There is a need for further work on interpretation of video images from inside recovery boilers.

Non-spherical particles. Need additional liquor spray work focused on the development and behavior of non-spherical particles.

Particle Formation, Deposition and Removal

Fume / ISP / carryover. Determine the interactions between fume, ISP and carryover particles in the formation and strength of deposits in recovery boilers.

Deposit weakening. Effect of boiler variability on deposition, deposit hardening and removal. – Is there an effect where deposits can grow weaker with exposure to recovery boiler atmospheres?

Plugging mechanisms. Investigation of the implications of treating plugging as a series of random, irreversible events that result in gradual accumulation of material that resists removal. Perform studies on boilers to identify how dynamic variations in particle size, composition and gas chemistry affect short-term fouling rate.

Liquor fragmentation and ISP. Need a better understanding of fragmentation processes as black liquors burn and how this influences ISP production.

Carryover composition. Need a better understanding of the composition of carryover prior to deposition at different locations in the boiler.

Unburned liquor. Determine the effect of partially burned liquor on deposit thermal and mechanical properties, deposition and removal.
Sulfur enrichment. Need a better understanding of why we get sulfur enrichment in carryover particles. Is co-deposition of fume responsible for this?

BL spray and carryover. Need a better understanding of the correlation between black liquor spray characteristics and carryover concentration in the flue gas

**Black Liquor Gasification Processes**

Government funding. Commercialization of black liquor gasification is critically dependent on external (government) funding.

Energy studies. More in-depth comparisons of energy efficiency should be conducted, taking into consideration pressure losses, equipment sizes, equipment cost, corrosion and fouling issues, and focusing particularly on gas cleaning, gas treatment and arrangement of heat exchange equipment. Should consider efficiency using existing technology, short-term (one or two novel steps) and long-term (more than half of process steps untried).

Materials. Need materials that will withstand environments within black liquor gasifiers for reasonable time periods.

Focus of fundamental work. Fundamental work on gasification processes is most needed when commercialization of different approaches is being attempted. Currently, most research on black liquor fundamental processes is being driven by gasification needs and this is expected to continue.

BLG alternatives. Are current commercialization efforts (low-temperature bubbling bed and high-temperature EFR) the “best” approach for ultimately replacing the Tomlinson recovery boiler?

Gas cleaning. Need increased focus on gas cleaning and conditioning with focus on removal of tars, acid gases and particulates. Hot gas clean up is desirable but is not a critical short term need.

Optimum gasification conditions. What is the “right” temperature and pressure for black liquor gasification relative to

- tars
- chemical products
- materials
- yields
- energy efficiency

Spraying BL on walls of high-temp gasifiers. Ramifications of black liquor spray deposition on the walls of high-temperature entrained-flow gasifiers with respect to reactor containment (corrosion and chemical attack of refractory) and performance (e.g. carbon conversion, raw gas quality, green liquor quality).

Fate of minor species. Need understanding of chloride and potassium impacts in BLG-based recovery cycle.
Corrosion and Materials Issues

**Predictive methods.** Predictive methods for focusing inspections on critical areas with respect to local heating and/or local corrosive environments, especially following upgrades and retrofits

- areas in upper furnace where sulfidation of tubes may occur
- local high heat flux regions

**Corrosion research needs.** The following issues deserve additional study

- corrosion and chemical attack on refractories
- primary air port corrosion and cracking issues
- superheater corrosion at temperatures below the first melting point of deposits
- Cl-induced corrosion in the upper furnace

Auto and Self Causticizing Processes

**Borate autocausticizing.** Further work on rate processes and inherent kinetics in borate autocausticizing with the focus on applying the results to processes occurring within the recovery boiler that can optimize conversion efficiencies at higher borate loadings.

**Titanate kinetics.** Kinetic data including suppression effects is needed for self causticizing with titanates.

**Titanate dead load.** A good analysis of the effects of titanate dead loads on operation and energy efficiency of recovery boilers and gasifiers is needed to determine if this approach is feasible.

Computer Modeling of Recovery Boilers and Gasifiers

**Droplet burning model.** Provide a document containing a consolidated current version of the single-drop black liquor burning model, periodically updated and peer-reviewed.

**Droplet gasification model.** Develop a similar single-drop model for entrained flow black liquor gasifiers.

**Non-spherical droplets.** Recovery boiler models should look at the effects of including non-spherical liquor droplets and a stochastic description of swelling on model predictions.

**Generic recovery boiler modeling.** There could be significant benefit to using modeling to look at generic issues on recovery boilers instead of the current approach of modeling a specific boiler and looking at the effects of a small number of changes on it.

**Modeling pressurized entrained-flow gasifiers.** Need to address challenges in modeling high-pressure, O₂ blown gasifiers, specifically the high particle concentrations, small particle diameters, and extreme temperatures and velocities near the inlet. In addition, radiant heat transfer and strongly-coupled gas-phase chemical kinetics must be handled properly.
General

Publications. Provide synthesis and integration of existing knowledge
- review papers
  - NO\textsubscript{X} formation in recovery boilers
  - Fouling in recovery boilers
  - Cl and K removal
- books, monographs

Automatic process Control. Determine the primary factors inhibiting the applications of automatic process control to recovery boilers and to the pulping and recovery system as a whole, and develop means for overcoming these inhibitions.