ISIS CENTRAL SUGAR MILL CO. LTD.

ISIS CO-GENERATION
"Water Considerations"

by Phil Woods









Water Considerations

- To provide for water of an appropriate **quantity** & **quality** to meet the requirements for processing cane to sugar & the generation of steam and power.
- To minimize wastewater / surplus water disposal from site.
- To minimize the input of additional water & its associated costs.
- Assess these requirements by performing a water balance

Water Balance - General

- Water In = Water Out + Accumulation
- IN :
- Water in Cane + Auxiliary Water Supplies
- OUT:
- Water in Products / Byproducts [Bagasse, Filter Mud, Boiler ash, Molasses, Sugar]
- + Water Losses
- ACCUMULATION:
- Water retained in onsite tanks / dams

Water Losses

- As Water Vapour
- Direct vent loss of steam / vapour

+ Evaporation from:

  - Surface Waters
  - Cooling towers /spray ponds
  - Stockpiles
  - Wet scrubber

- As Water
- Treated wastewater / stormwater leaving site

Accumulation

- Accumulation is important because:
- Operations are inherently variable
  - Eg. cane quality varies across the season with maturity, also variety, district, etc...
  - Start / Stops eg. Rainfall interrupts supply
- Operations in the process are transient
  - Eg. batch pan operation
- Accumulation – Normally address with adequate buffer storage.

Water Recycling / Reuse

- Much of the water in a mill is recycled.
  - Eg. Steam → primary condensate → boiler feedwater → steam

- Water extracted from the cane is used back in process and re-extracted.
  - Eg. Secondary condensate used for mill maceration re-extracted from evaporator vapours as secondary condensates.

Water Balance

- Will include :
  - Material balance
- May include:
  - Energy balance
  - Component / Quality balances in water
- Balance may range from individual process unit to full site.
- The degree of complexity dictated by answer you are seeking.

Water balance - Quality Aspects

- Quality is important.
  - Tells if water is OK for reuse for a specific duty or needs extra treatment.
- Should look at both concentration & nature of the contaminant.
- Look at:
  - Persistence of contaminant in a given system
  - Acceptable contaminant levels for reuse
  - Implications on accumulation in a system from concentration cycling due to evaporation

ISIS MILL STATISTICS

- **Crushing Capacity** — **1 to 1.3 million t per annum.**
- **Crushing Rate** — **430 t/hr - 10,320 t / day**
- **Co-gen Plant (2005)** — **25MW Condensing / Extraction**
- **Max Feed / Passout / Cond** — **160 / 120 / 40 ⟺ 160 / 40 / 120**
- **Other Generators** — **5.8MW Allen, 2.7MW Stal**
- **Boiler Capacity MCR** — **CBH 200t/hr Thomp. 130t/hr**
- **Boiler (HP) Press/ Temp** — **1725 kPa.g , 285^{o}C [Low Pres Blr]**
- **Exhaust (LP) Press** — **105 kPa.g**
- **Electrified Mill Drives** — **Internal Power Use ~ 8MW**

- **Quin Effect Evap.** — **18,230m^2 (No Vapour Bleeding)**
- **Juice Heaters** — **1,267m^2**
- **Batch Pans.** — **587m^3**
- **Current LP Steam on Cane** — **>50%.**
- **(Plenty of scope for Improved LP Steam Efficiencies)**

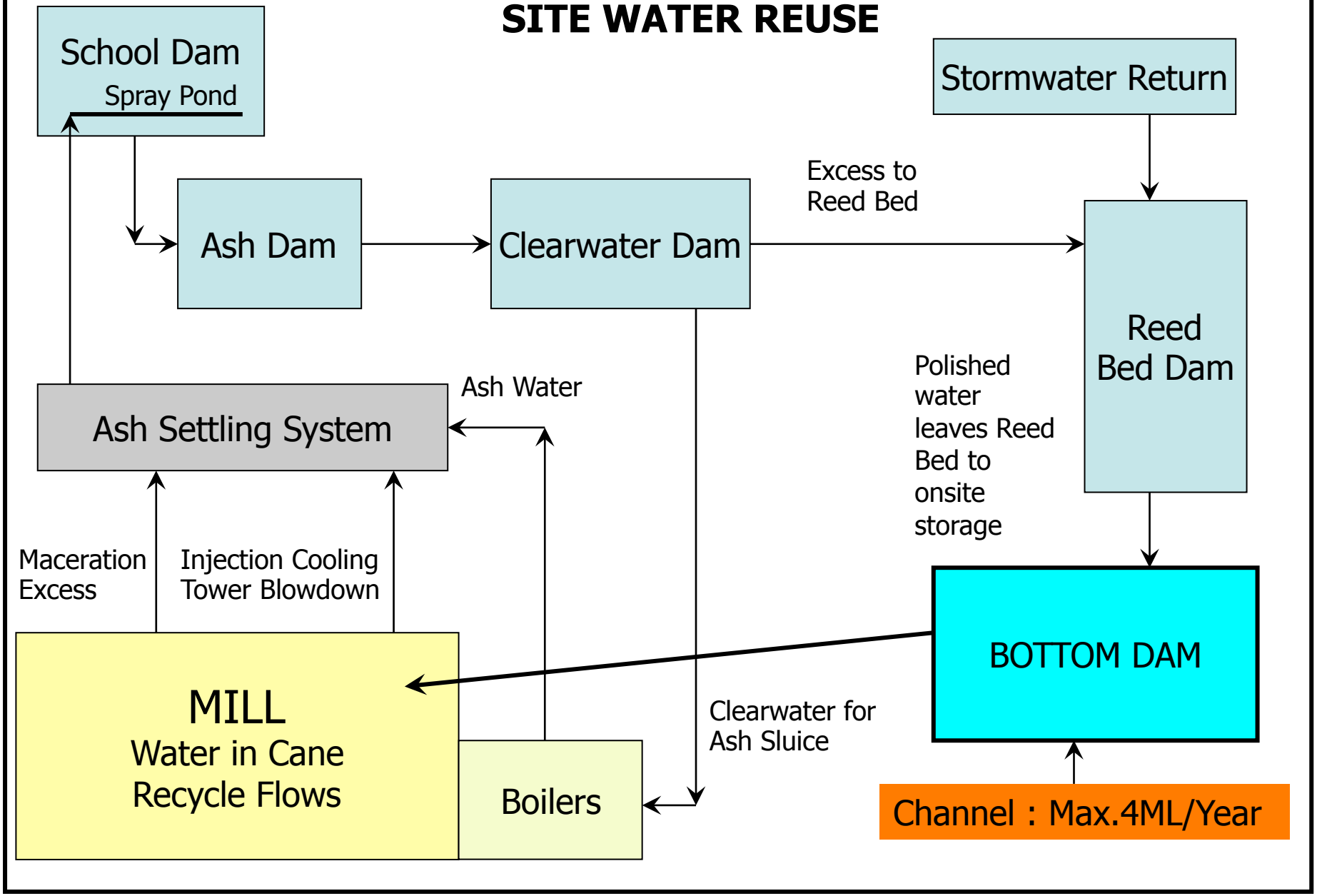
Isis - Background

- Isis relies mainly on Water supplied in cane and onsite storage dams.

- Until recently Isis had no access to an external auxiliary supply [eg. municipal supply, river, etc].

- As a result, Isis mill has always practised substantial water recycling and reuse.

ISIS CLOSED CIRCUIT WATER MANAGEMENT
SITE WATER REUSE



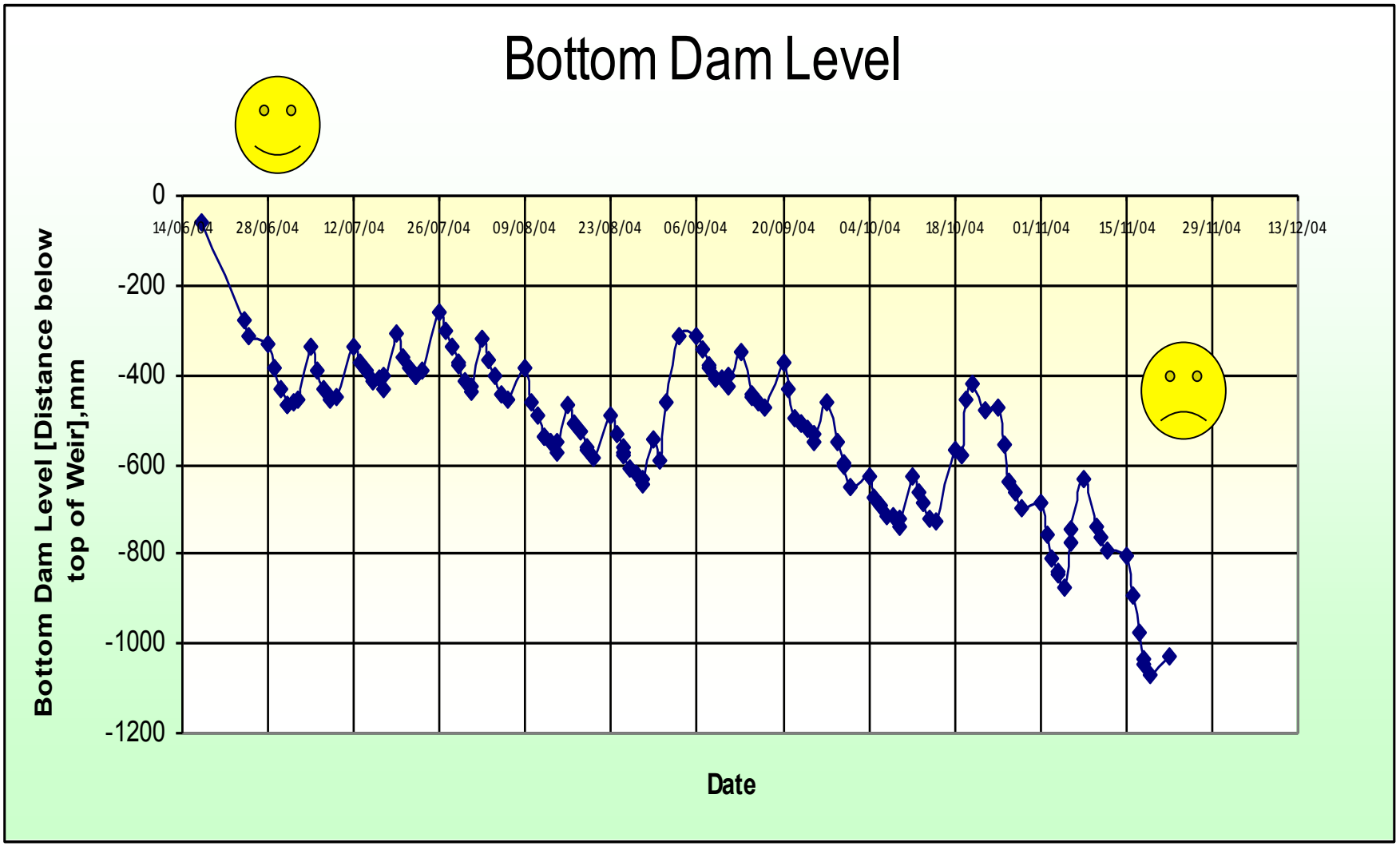
OVERVIEW : ISIS CENTRAL SUGAR MILL



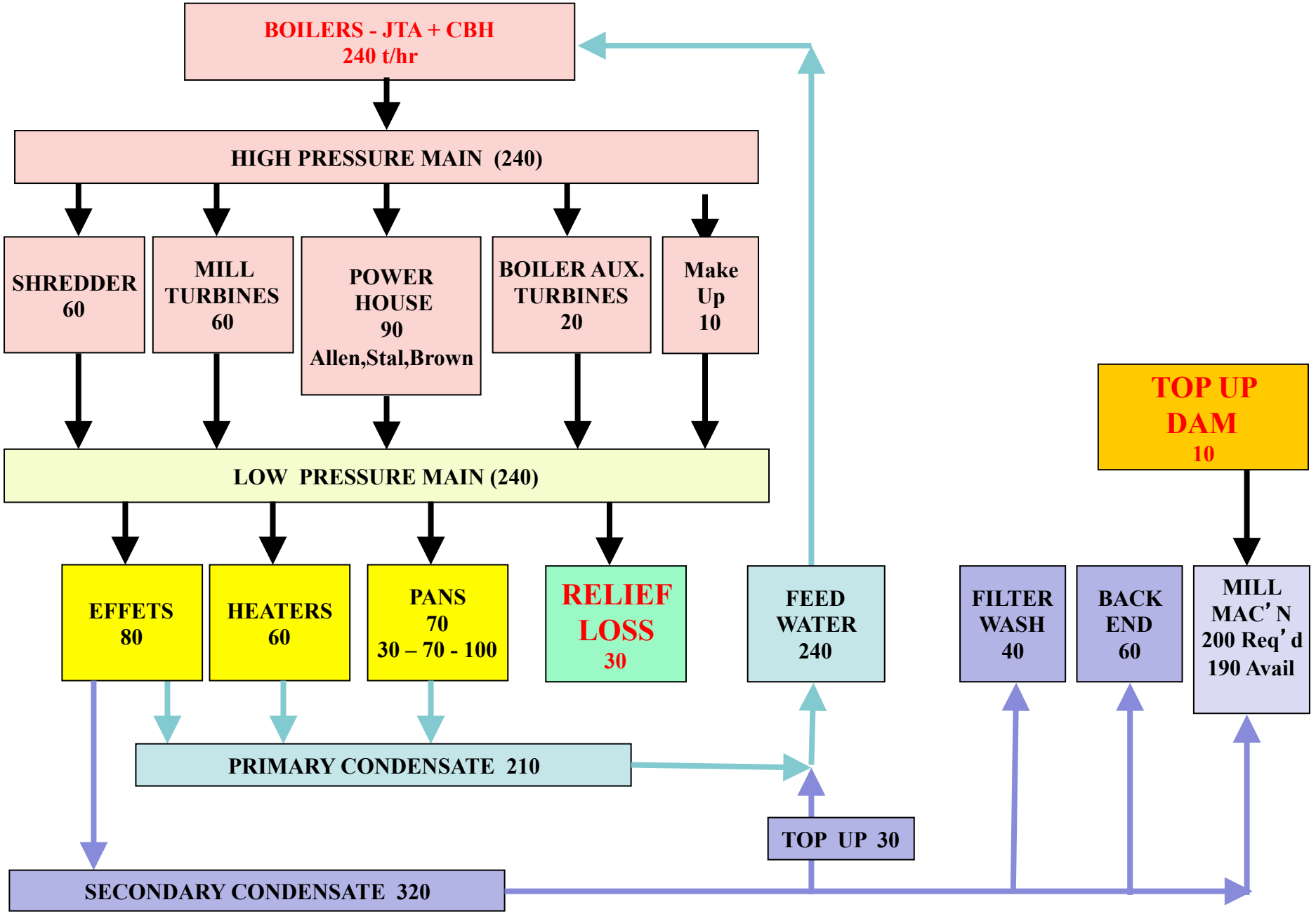
Background

- Traditionally mill was operated to maintain a manageable bagasse stockpile.
- All bagasse was burnt to generate steam.
- Surplus steam was vented to atmosphere which resulted in substantial water & energy losses.
- Onsite dams levels reduced over the season.

Typical Onsite Dam Level Trend - Season



PRE COGEN - SIMPLIFIED WATER BALANCE



Background Cogen

- Isis had looked into recovering the lost energy & water in the vented steam by using a condensing turbine. This would retain at least some of the vapour as water onsite.
- A large LP boiler was installed in 1996 There was surplus boiler capacity available.
- In 2002, Ergon approached Isis about a Cogen project.
- Result : Isis - Ergon Cogen Project.

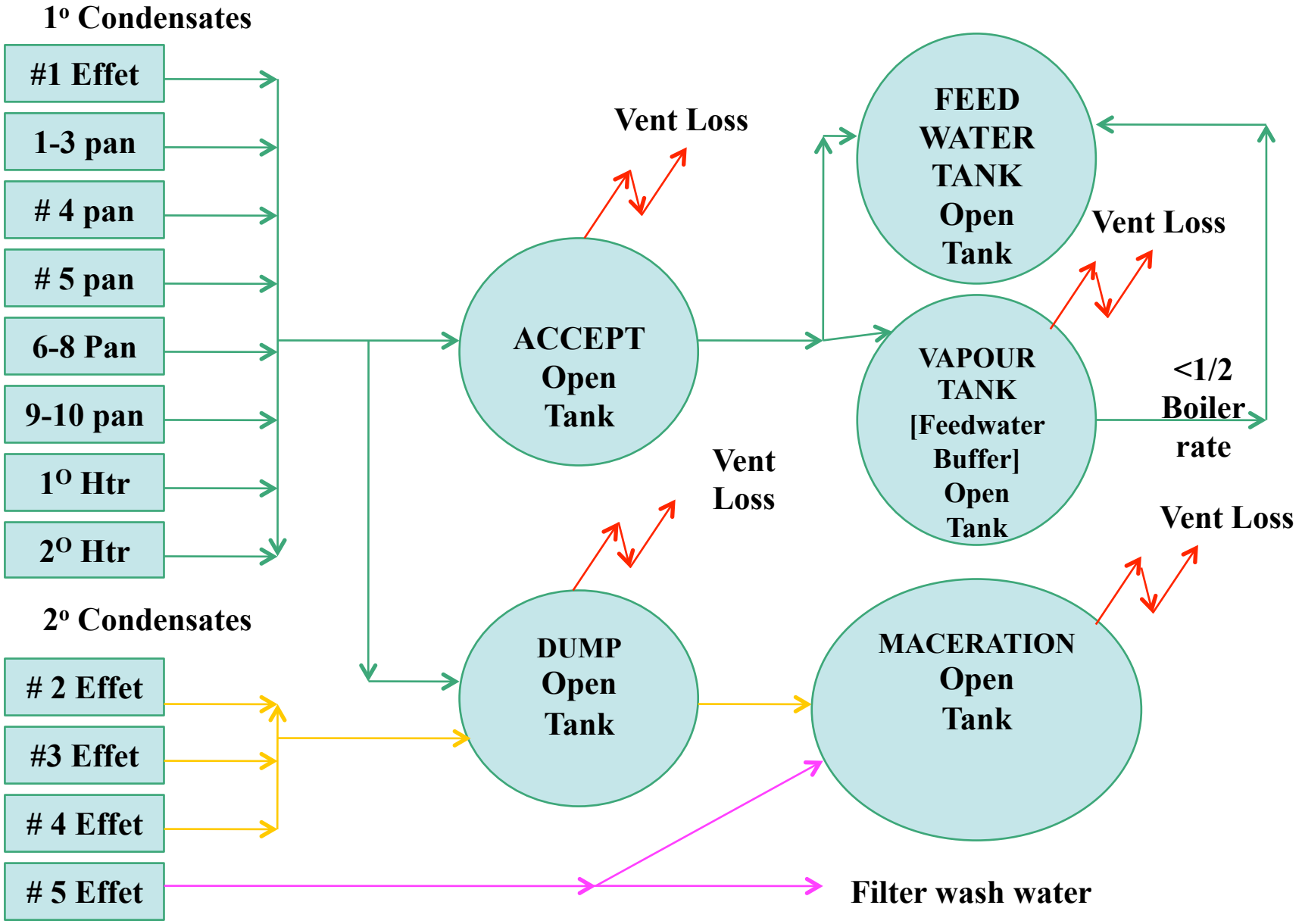
Basis : Isis - Ergon Cogen

- To utilize the available surplus capacity in the existing low pressure boilers & to burn all available bagasse during the season.
- This would require reasonably low investment costs (TA & ancillaries - no boiler)
- The lower investment cost meant we *would not need to operate the TA out of season & would not need to source additional fuels.*

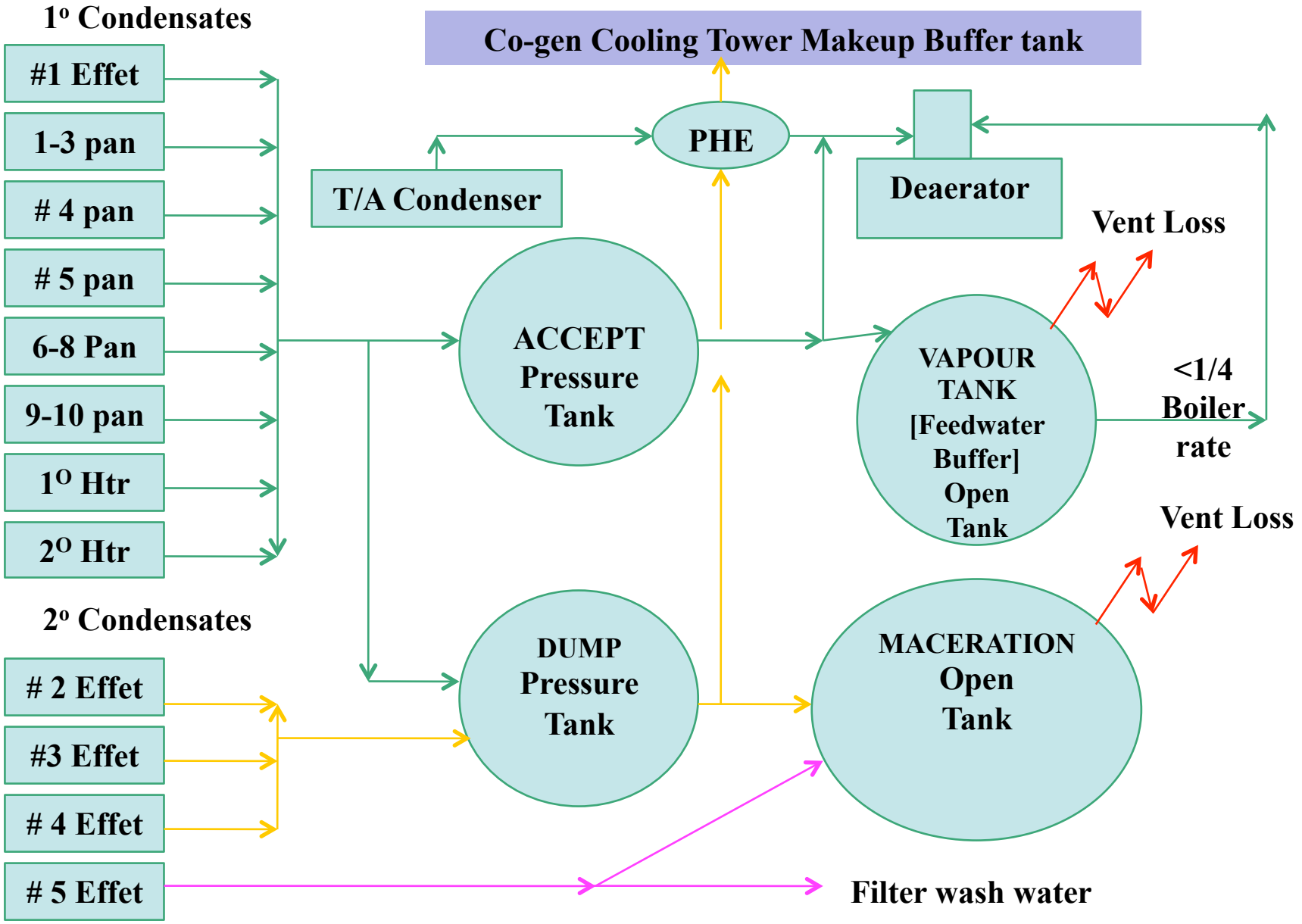
Isis – Ergon Cogen Project

- 2 stage project
- Stage 1 – install new Turboalternator(TA), condenser & cooling tower & replace mill drive steam turbines with electric drives.
- Stage 2 – modify backend to achieve a LP Steam%Cane of 40% to enable greater power generation
- Stage 2 has yet to be completed but has been investigated at length.

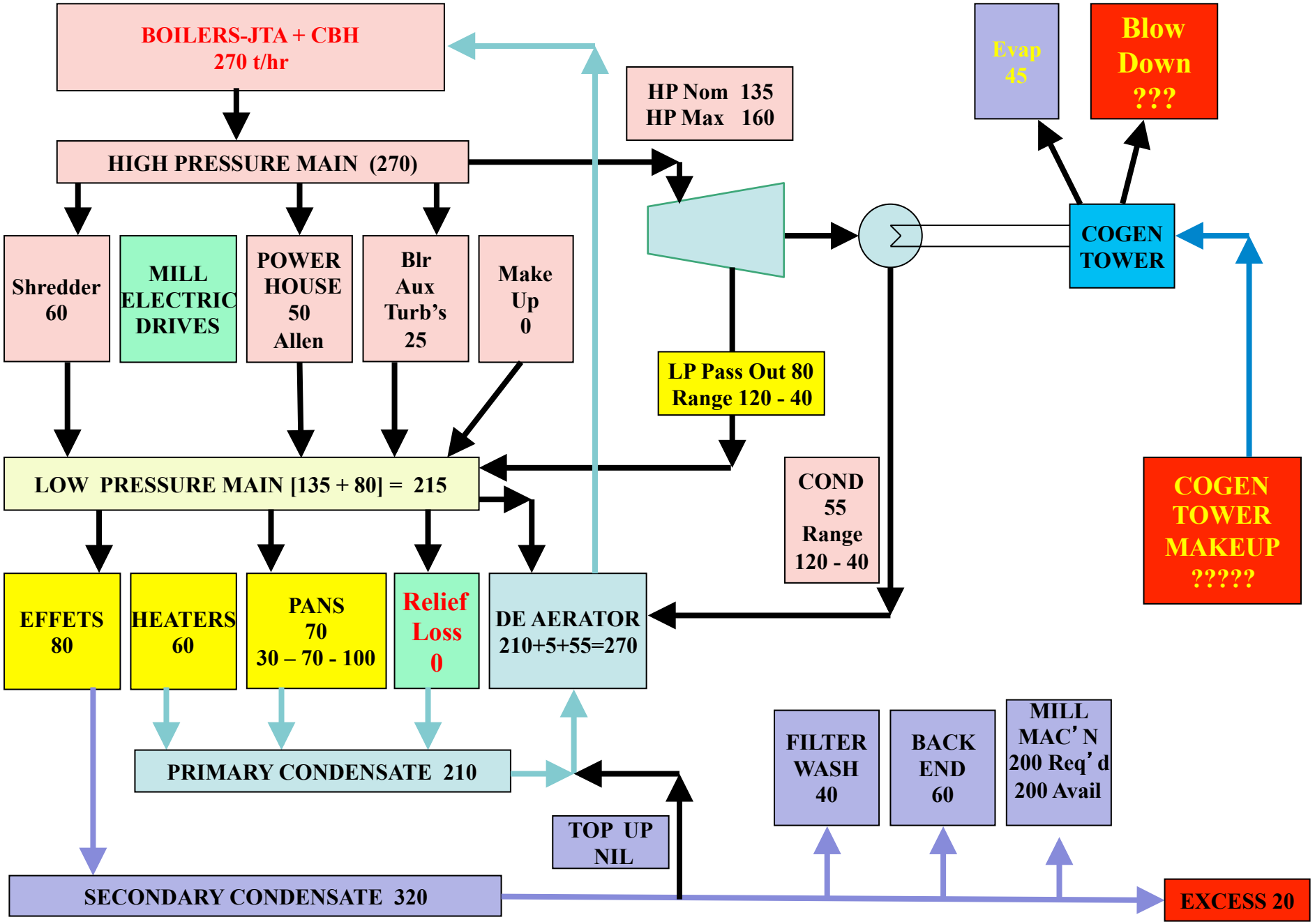
Condensate System – Pre Cogen



Condensate System – After Cogen



PRELIMINARY BALANCE – COGEN



Cogen Tower Makeup Options

- Sources Available:
- 1. Dam Water
- 2. Irrigation Channel Water
- 3. Condensate
- 4. Blends: Condensate / Dam / Channel

- Single source preferred - blends are added complexity but have provision to use if required.

SINGLE SOURCE MAKEUP WATER OPTIONS FOR CO-GEN TOWER

System Limitations : 304 SS in Cooling Water Circuit.

To avoid pitting , limit Max. Chloride level 350ppm.

Consider : Quantity of blowdown waters to handle on site.

Consider : Chemical consumption costs.

	BOTTOM DAM WATER Chlorides too High Cannot use in tower	Irrigation Channel Water 1.7 cycles	Condensate Water 8+ cycles
Makeup at Average condensing load (80 t/hr)		170 t/hr (4.1ML)	80 t/hr (1.9ML)
Chemical Dosing Cost		$260,000 / season	$40,000 / season
Blowdown from Tower		**100 t/hr (2.4ML)**	**10 t/hr (0.24ML)**
Makeup at Full condensing load(120t/hr)		255 t/hr (6.1ML)	120 t/hr (2.9ML)
Chemical Dosing Cost		$300,000 / season	$60,000 / season

Cogen Tower Makeup Preferred Source - Condensate

- **Advantages**:
- Higher Cycles of Concentration
- Lower blowdown requirement – less water to treat / handle
- Lower chemical cost $40k vs $260 k
- **Risks** :
- Unusable at times of gross contamination (process stream / caustic) so need backup system (channel as backup)
- Condensate volatiles can increase chemical consumption
- Not steady output / use – need buffer storage
- High temperature
- Potential condensate shortfall for traditional condensate users
- Soft water not buffered showing greater variability

Cogen Tower Condensate Makeup System Implemented

Order of Priority for Condensate Use

1. Boiler Feedwater [Primary / Secondary Condensate]
2. Backend use eg. For pans, fugals, drier
3. Cogen Tower Makeup
4. Mill Maceration

Cogen Tower Condensate Makeup Risk Issues Addressed

Gross contamination	**Channel Backup**
Mill maceration shortfall	**Channel Topup**
Variable Unsteady Supply	**1 ML Buffer Tank**
High Temperature	**PHE Heat recovery**
Variable Quality / Soft	**Automatic Tower Control System incl. online chlorides & routine lab analysis**

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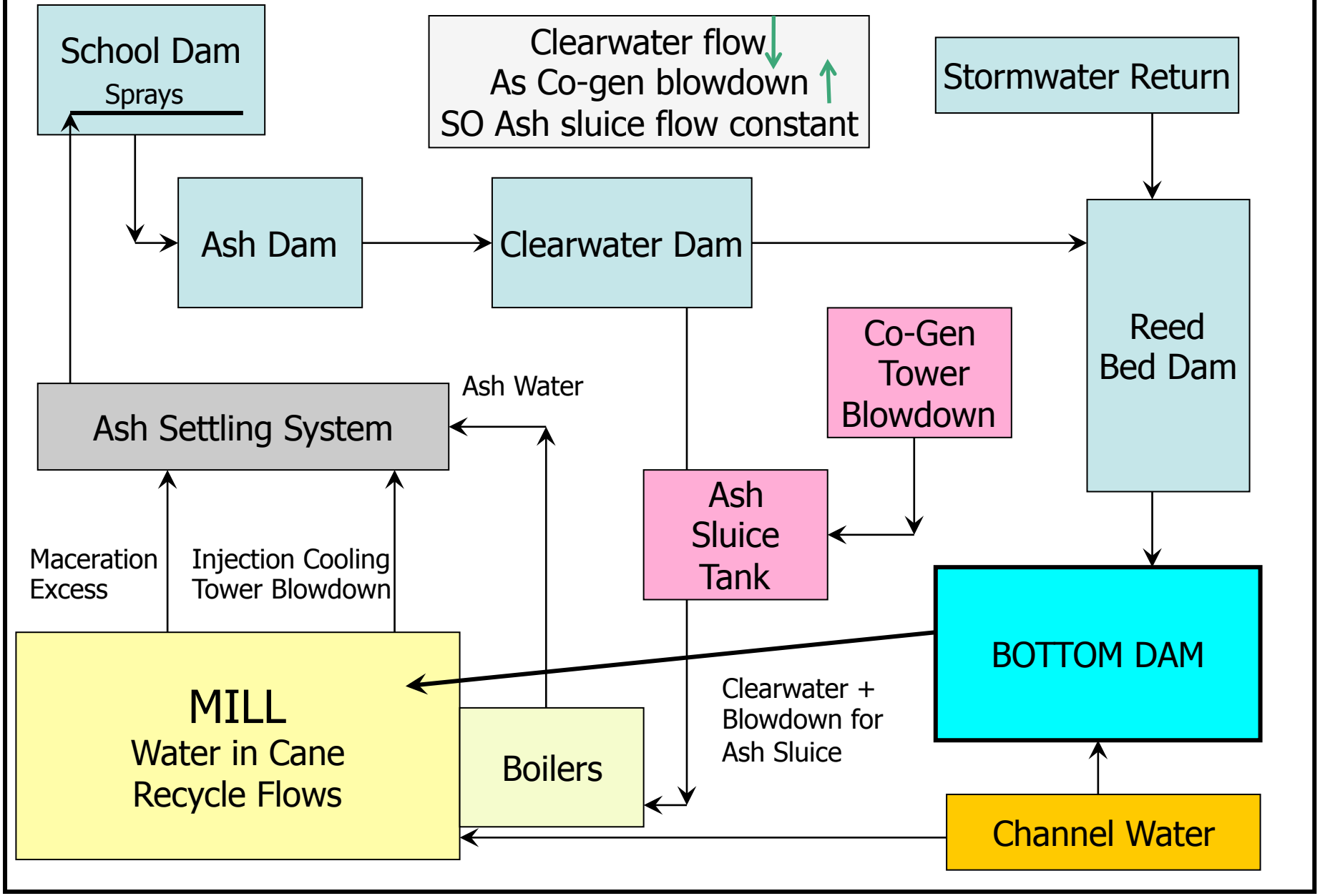


Tower Chemical Control Considerations

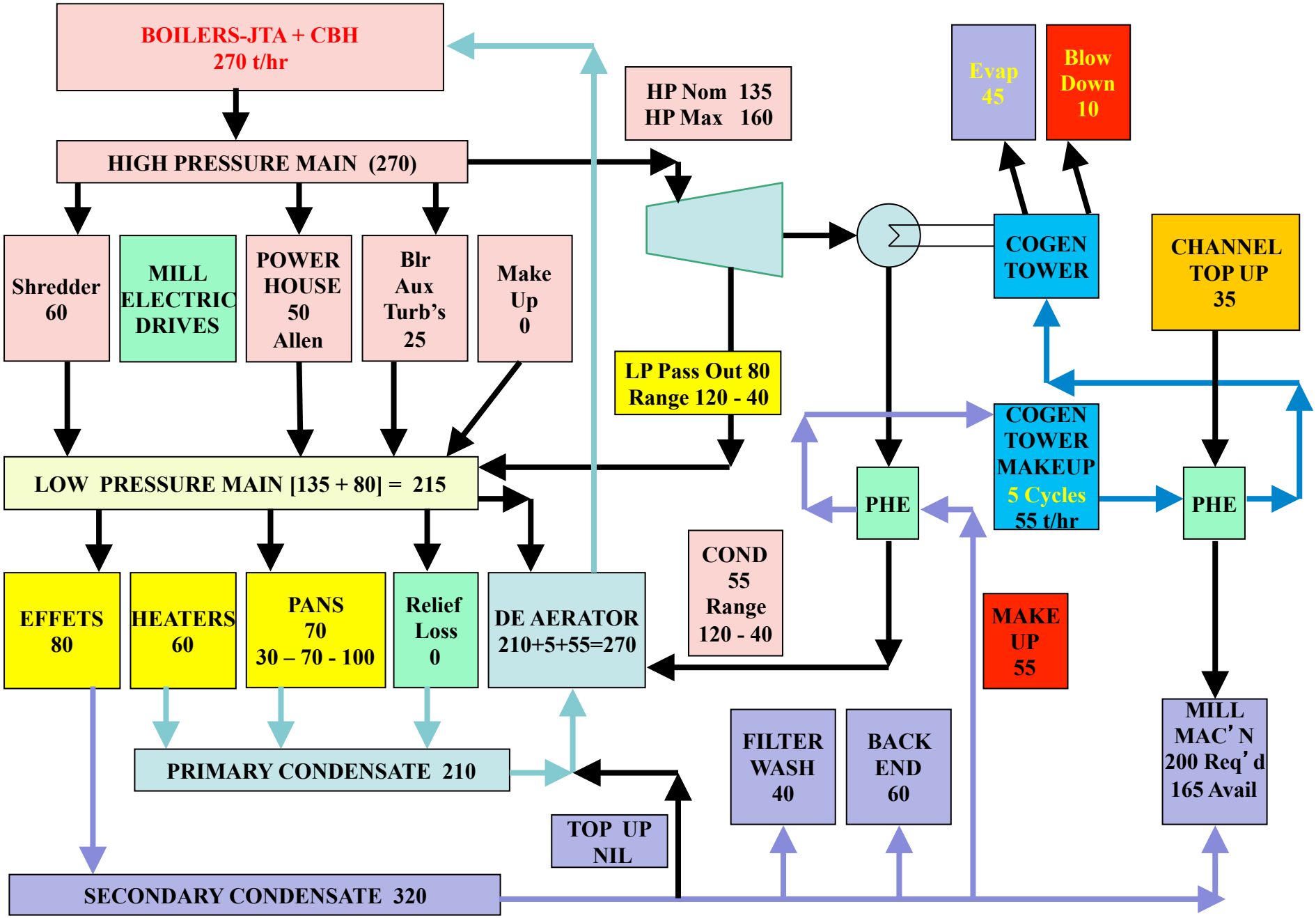
- Tower blowdown is to the Site water reuse system
- Must consider the chemicals used for tower control
- Want to limit the use of chemicals with a substantial persistence in the environment
- Oxidizing biocides used as reasonably short lived.
- Corrosion resistant materials chosen for system to minimize Inhibitor use : FRP, PVC Fill, SS

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CO-GEN TOWER BLOWDOWN



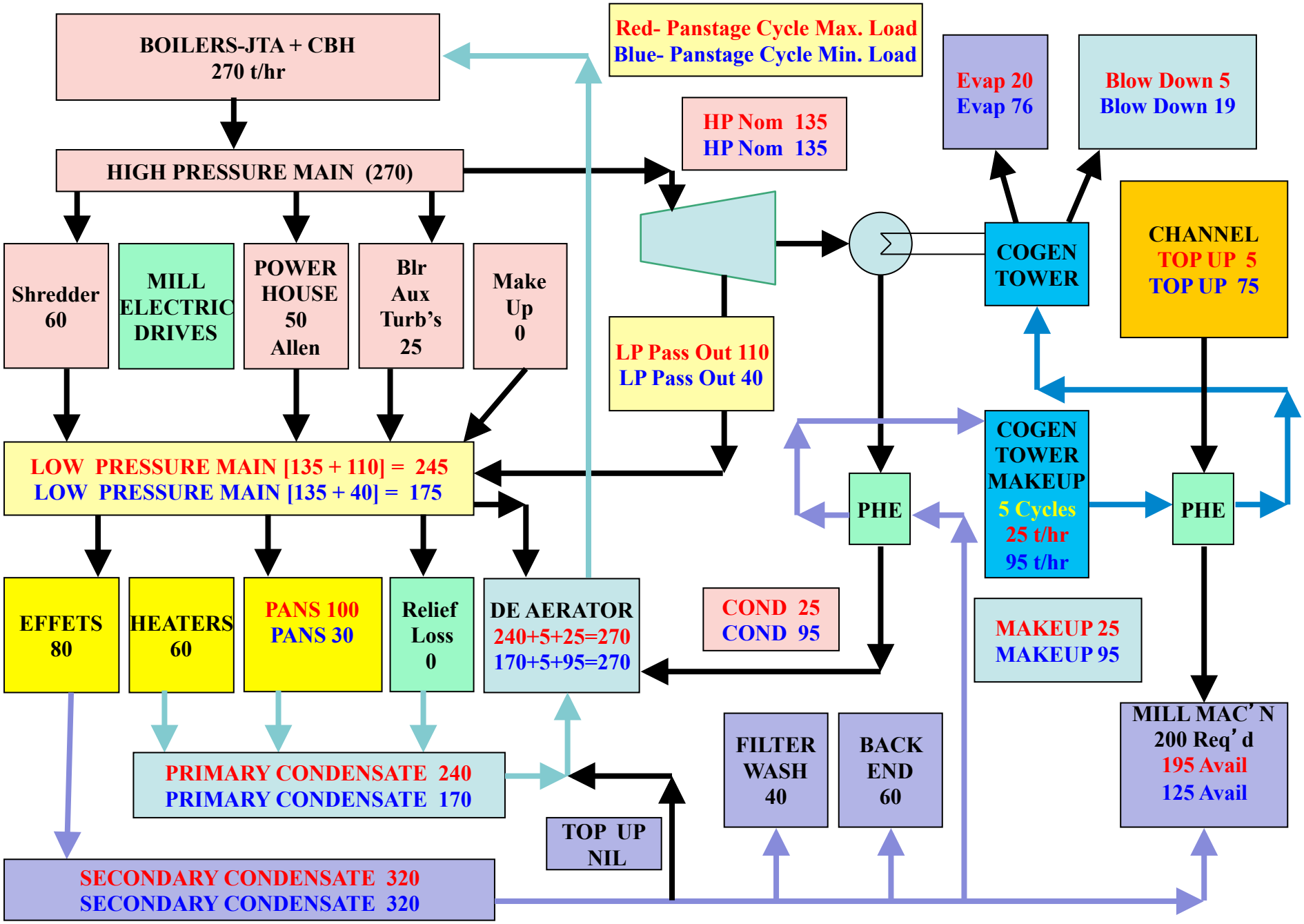
COGEN – WATER BALANCE - TOWER CONDENSATE MAKEUP



Cogen Balance – Steam & Condensate Variability

- Must Design for System Variability
- Main Variability from:
  - The **batch pan cycles** - steam swings +/- 30t/hr about average of 70 t/hr
  - Cogen tower **makeup source change** from condensate to channel. Eg. if gross contamination of condensate
- Other variability from :
  - secondary condensate swings - pan washout at end of round, swings in & out to supplement feedwater due to boiler blowdown, switching is full stream,
  - mill stop / starts

COGEN – WATER BALANCE –PAN FLOW CYCLES -MAX / MIN



Flexibility in Makeup / Blowdown system
- Pan stage Swings
- Tower Makeup Change

Pan Stage Steam Load	***70 t/hr [Avg]***	***100 t/hr [Max]***	***40 t/hr [Min]***	***Max Cond Load***
Condenser Load	***55 t/hr***	***25 t/hr***	***95 t/hr***	***120 t/hr***
Tower Evaporation, t/hr	44	20	76	96
Makeup Source Water	*Condensate*	*Condensate*	*Condensate*	*Condensate*
Cycles	5	5	5	5
Blowdown, t/hr	11	5	19	24
Makeup, t/hr	55	25	95	120
Makeup Source Water	*Channel*	***Channel***	***Channel***	*Channel*
Cycles	1.7	1.7	1.7	1.7
Blowdown, t/hr	63	29	109	137
Makeup, t/hr	107	49	185	233

Cogen Balance – Steam & Condensate variability

- The cogen systems must be capable of meeting this high degree of variability including the TA itself, the Condenser as well as the cooling tower systems & condensate collection system.

Cogen Turboalternator Load Variation Capabilities

HP FEED	Max PassOut	Min Cond	Min PassOut	Max Cond
160	120	40	40	120
150	120	30	30	120
140	120	20	20	120
135	120	15	15	120
130	117	13	10	120
120	108	12	0	120
110	99	11	0	110
100	90	10	0	100
90	81	9	0	90
80	72	8	0	80

Minimum Condensing requirement 10% of HP feed up to a max of 120t/hr
Can operate between the two extremes

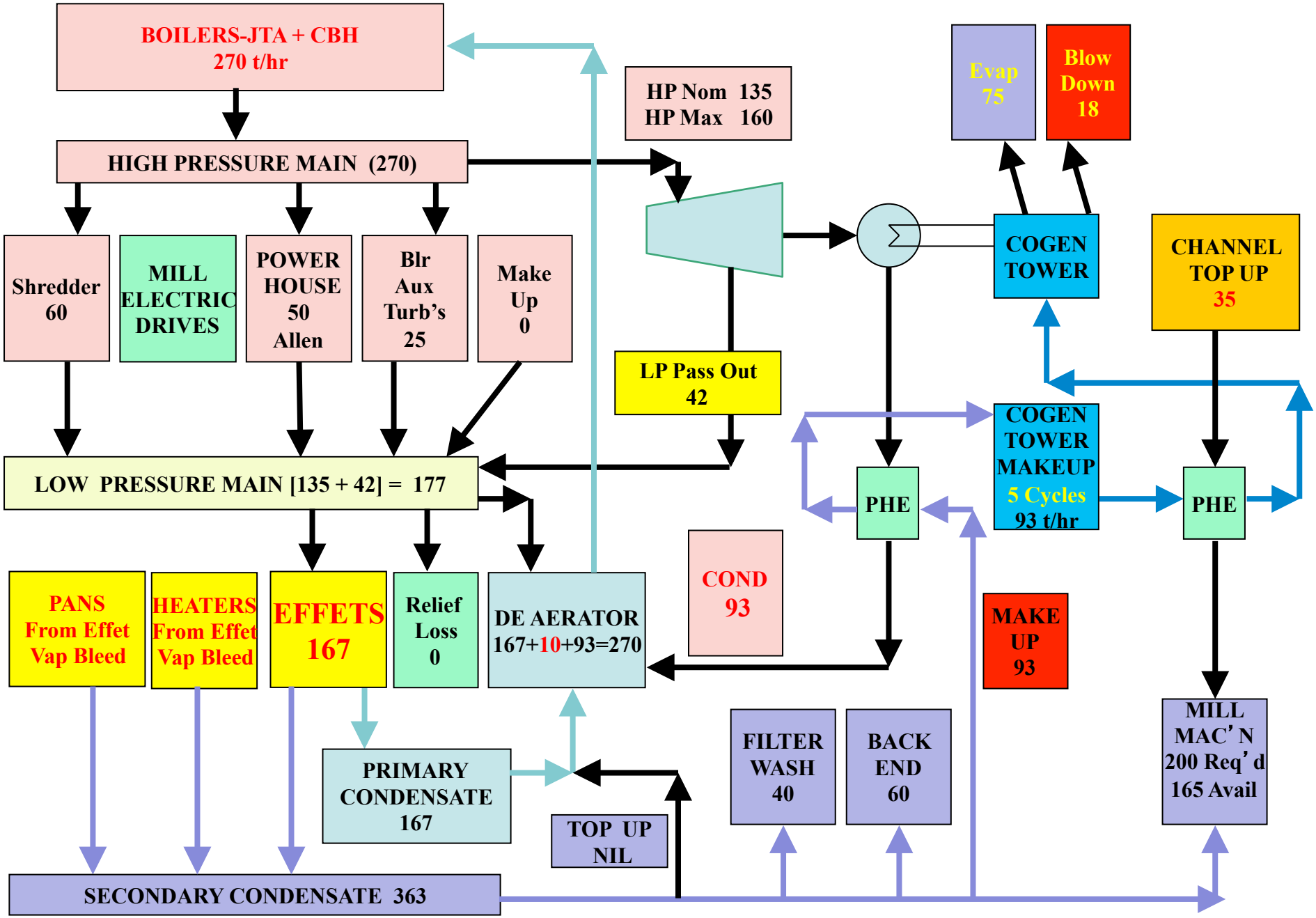
Balance Stage 1 vs Stage 2 In Brief

- Stage 1 - LP SOC requirement is the same as pre cogen. Water losses to the injection tower will also remain the same.
- Stage 2 - LP SOC reduced to 40% by substantial vapour bleeding from effets.
- The injection cooling tower load & evaporative loss will drop significantly.
- Cogen condensing load will rise significantly as will Cogen cooling tower evaporative loss, makeup & blowdown

Balance Stage 1 vs Stage 2

- Stage 2 - Same HP from boiler as Stage 1
- Stage 2 -Same channel topup to mill maceration as stage 1
- Main difference stage 1 to stage 2 is an increase in TA condensing loads & more lower temp condensates due to increased vapour bleeding → increase in deaerator LP steam requirement.

COGEN – WATER BALANCE – INDICATIVE STAGE 2



Cogen Cooling Tower Requirements for Variability

- Tower needs to be flexible to cope with extensive variability .
- Tower control needs to be able to respond to suit the load & ambient changes so that pressures are controlled in the condenser.
- Isis Mill - Ambient conditions quite variable.
- Summer (Twb= 25.6 C design)
- Winter Mean Twb ~ 12 C (9am)
- Winter Twb often lower diurnal min ~ 6am + often frosts
- For fixed tower operation, with low Twb & low load would get very low tower water temps

TA / Condenser Pressure Limitations

- High Pres Limit
- Reduced power output
- Max design temp limit for the condenser.
- Low Pres Limit
- Limitation due to blading bending stress limits of final turbine stages and / or choking.

Condenser Pressure Limitations

- For Isis TA condenser :
- Design Pressure : 11 kPa.a

- Pressure without Tower Control: 5.7 kPa.a

  120 t/hr (max) condensing load @ winter mean Twb

  → Water Temp to 18C
- Nominated Low Pres Limit : 7.5 kPa.a
- = Blading Bending Stress Limit

- Tower outlet water temperature control is critical for condenser pressure control

Tower Design & Control

- **Desired elements**:
- Control tower cold water temp to design temp to maintain condenser pressure
- Vary water flow to maintain tower range for variable condensing load.
- Vary air flow to compensate for off design Twb.
- Multi-cell tower design for better tracking of condenser load
- Cells isolatable on water & air side will leave remaining cells in use able to run close to their design L/G (water/air ratio)

Tower Design & Control

Implemented system:

Tower of 6 cell design, each cell for nom. 20t/hr condenser vapour load.

Variable speed pumps to proportionally match condenser vapour load.

Variable speed fans on 3 of 6 cells to match changes in ambient conditions.

BUT No water side cell isolation.

Control issues: Higher power use at part load relative to system with full cell isolation. Increased drift / windage losses & higher chemical use.

ISIS CO-GENERATION
“Water Considerations”



ANY QUESTIONS ?