FGD Purge ZLD

Reality At Enel

ENERGY IN TUNE WITH YOU.

Presentation By

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McIlvaine Webinar November 12th 2008

ZLD
Zero Liquid Discharge

"Concentration"

A Solution To Pollution!

ZLD A Viable Reality

ENEL, Italy Locations

ZLD A Viable Reality

ENEL Location	Power MW (Wet FGD)	ZLD Cap. in GPM	Date Stopped Discharge
Brindisi	4 x 660	BC 2 x 300 FC 1 x 77	August 2008
Fusina	2 x 330 2 x 165	BC 2 x 150 FC 1 x 55	May 2008
Sulcis	1 x 240	BC 1 x 55 FC 1 x 22	June 2008
LaSpezia	1 x 600	BC 1 x 66 FC 1 x 27	November 2008 (Under Testing)
Torrevaldaliga	3 x 660	BC 2 x 155 FC 1 x 62	December 2008 (New Power Plant)

BC = Brine Concentrator FC = Crystallizer GPM = Gallons / Minute MW = Megawatt

Typical FGD Purge WW

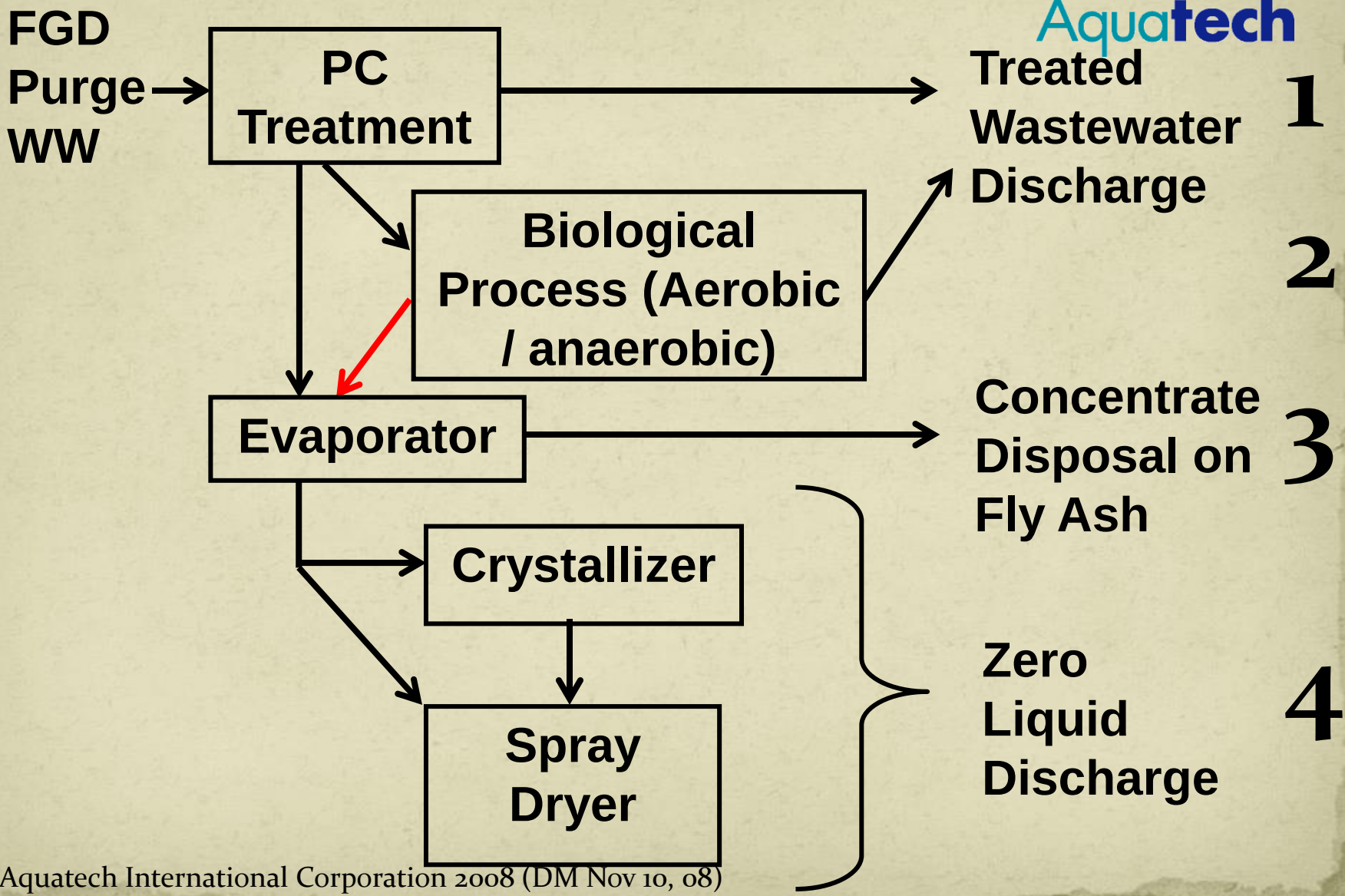
pH:	6.5	–	8.0	
Temperature:	100	–	110	°F
Hardness (Ca + Mg):	17,500	–	28,000	ppm $CaCO_3$
Sulfates:	3500	–	7000	ppm
Chlorides:	10,000	–	30,000	ppm
Total dissolved solids:	20,000	–	50,000	ppm
COD / BOD:	None	–	1500	ppm *
Trace Heavy metals:	10	–	100	ppm
Selenium:	0.5	–	15	ppm
Boron:	25	–	650	ppm
Ammonia Nitrogen:	5	–	35	ppm
Nitrate Nitrogen:	25	–	500	ppm

*dependent on usage of buffers like DBA or Formic acid

Key Purge WW Design Variables

- Quality of coal
- Make up water source
- Scrubber design
- Scrubbing agent composition
- Scrubber additives (DBA, other organics)

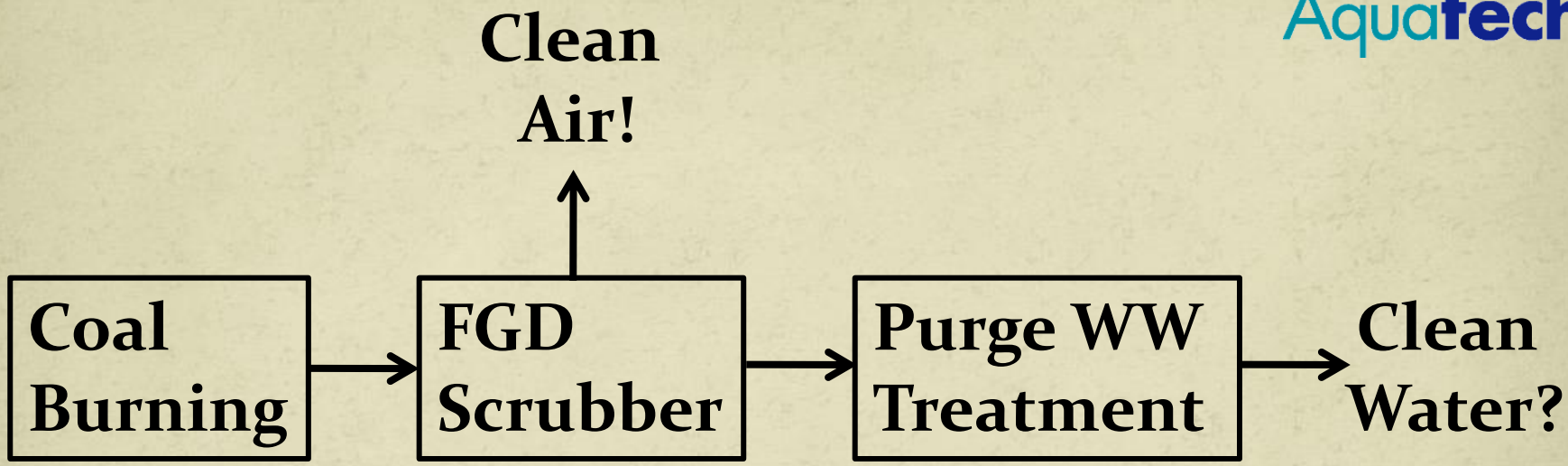
Purge Treatment Options



FGD Purge Treatment In USA So Far

- Physical Chemical (Well Established)
  - Calcium Sulfate desaturation & clarification
  - Sulfide precipitation & clarification
- Biological treatment (Developing)
  - Selenium & heavy metal reduction
  - BOD & or N reduction

Clean Air! Clean Water?



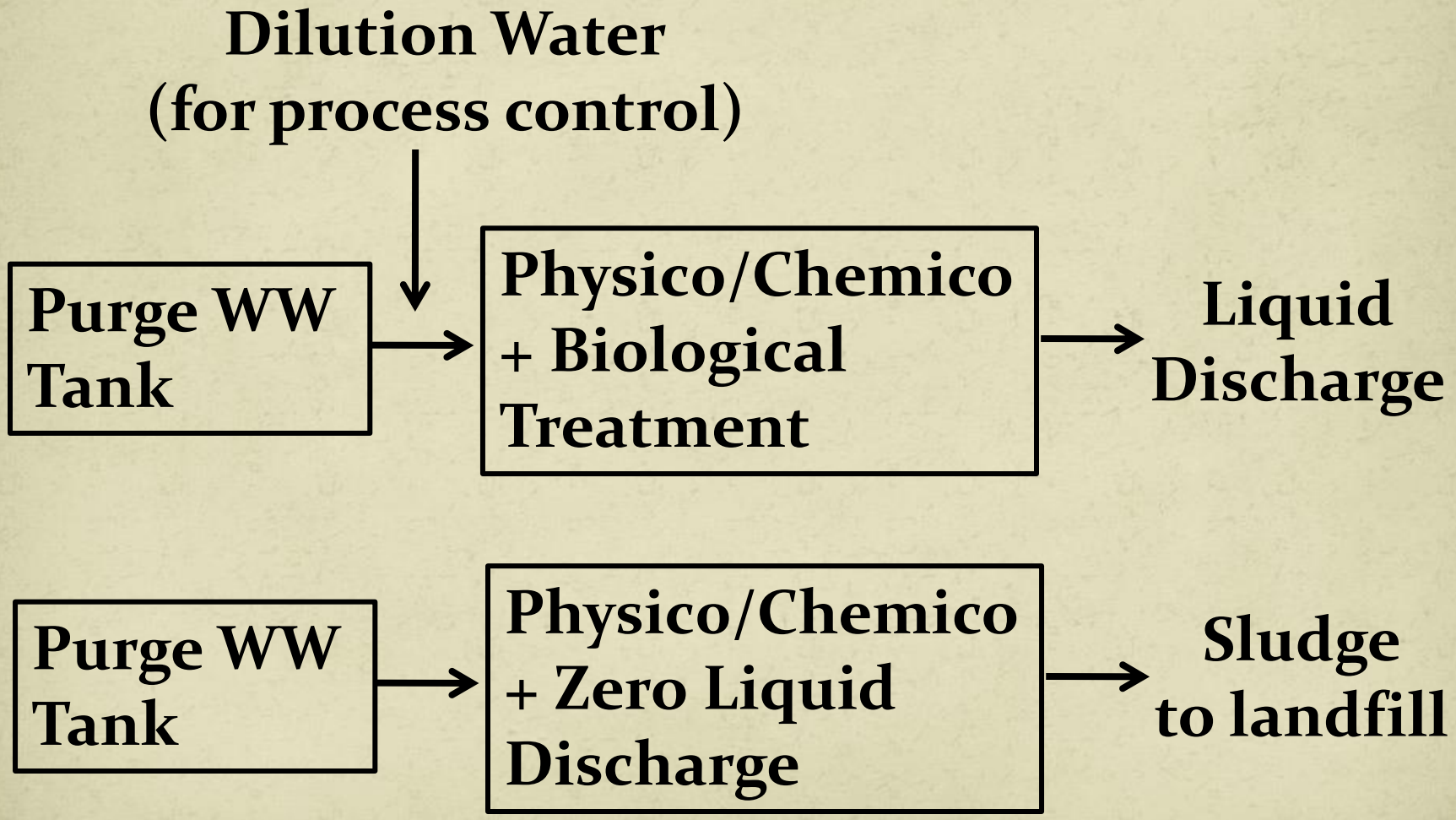
- Is this <u>really</u> a complete solution?
- <u>Limited number</u> of constituents <u>reduced</u>
- <u>High salinity still being discharged</u>
- What about tightening regulation?

Troubling Constituents

Constituent	Key Issue / Discharge Limit	Impact by physical chemical or biological treatment
Calcium	Scaling	Reduction by precipitation
Sulfate	Scaling w/hardness	Settling in clarifier w/hardness
Chloride	Corrosion	No reduction
TDS	Discharge issues	No reduction; likely to increase
Mercury	Limits getting stringent i.e. in ppt	Reduction possible; requires elaborate process including ion selective ion exchange resins
Selenium	Limits getting stringent i.e. ppb	Selenites can be reduced in physical chemical; lower limits require biological treatment
Nitrates	Some cases have seen 3 ppm total nitrogen	Requires nitrogen reduction via biological process; difficult in high TDS environment
Trace metals	Site specific issues	Depends on the trace metal
Boron	Site specific issues	No reduction

TDS = total dissolved solids ppt = parts per trillion ppb = parts per billion

Dilution Vs. Concentration



Myths Against ZLD

- Technology does not exist
- Existing technology
  - Does not work
  - Is extremely expensive
  - Is difficult to operate

Fact Check!!!

- Technology does ~~not~~ exist
- Existing technology
  - Does ~~not~~ work
  - Is extremely ~~expensive~~ cost comparable to physico chemical & biological treatment
  - Is ~~difficult~~ straight forward to operate
- No liquid discharge; complete solution
- Process simplicity; elimination of biological treatment possible
- No specialty bugs or bacteria; doesn't require a biologist or biochemist to run the unit
- Higher operating reliability

ZLD Selection Criteria

- Corporate social initiative (ENEL)
- Permitting issues
  - Discharge not allowed
  - Discharge limits stringent or not achievable by physical chemical or biological treatment
- Waste water characteristics
  - Variation due to variety of coal used
  - Constituents not treatable by other processes e.g. boron
- Cost of waste water treatment
  - Cost comparison with biological treatment
  - Capacity of waste water treatment unit

ENEL Design Purge WW

Parameter as ppm	Brindisi	Fusina	LaSpezia	Sulcis	Torrevaldaliga
Suspended Solids	1 to 1.5%	1 to 1.5%	1 to 1.5%	1 to 1.5%	1 to 1.5%
Calcium, Ca	42,00	8,400	8,400	1,200	12,000
Magnesium, Mg	250	4,500	4,500	1,200	6,400
Sulfate, SO_4	11,900	10,900	10,900	24,500	17,700
Chloride, Cl	22,800	25,000	25,000	15,400	30,000
Nitrate, NO_3	300		300		300
Fluoride, F	25		350		1,000
Alkalinity, HCO_3	80		600		600

- Each power plant uses multiple sources of coal; worst value from several coal values reported above for each parameter
- Each ZLD plant designed for over 30,000 ppm TDS in feed

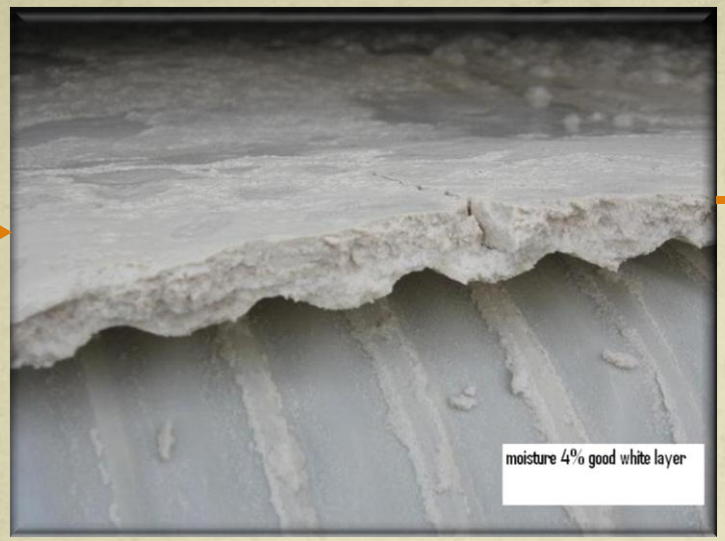
Brindisi Pictures

Lime Clarifiers

Brine Concentrator

Crystallizer

Brindisi Pictures



Belt Press

Sludge Handling

Sludge For Disposal

Aquatech

Fusina

Sulcis

LaSpezia

Torrevaldaliga

 ration 2008 (DM Nov 10, 08)

ENEL Plant Operation

- Coal
  - Imported from several countries
  - Variability in purge waste water
- Evaporator
  - Operated in seeded slurry mode
  - WW feed variability managed by local operators
- Sludge
  - Calcium carbonate sludge recycled to scrubber
  - Evaporator sludge
    - Approx. 85% plus dry solids
    - Non classified; disposed through authorized agency
    - Passed leachability (TCLP)
- Distillate recycled to scrubber and cooling tower

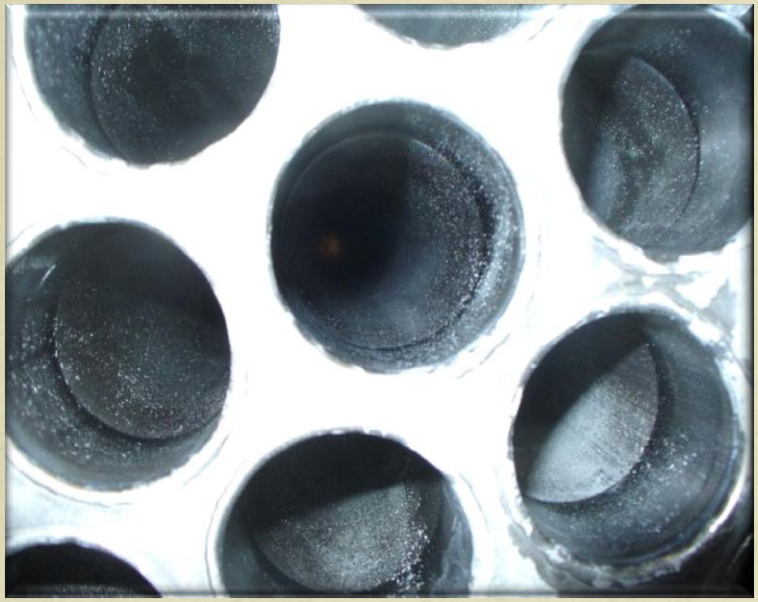
ZLD Design

- Requires prior experience
- Careful consideration of waste water data
- Proper selection of metallurgy
- Proper selection of operating parameters i.e. pH, concentration factors, etc.
- Design safety margin important

Once properly designed,

operating issues are straight forward

ENEL Operation



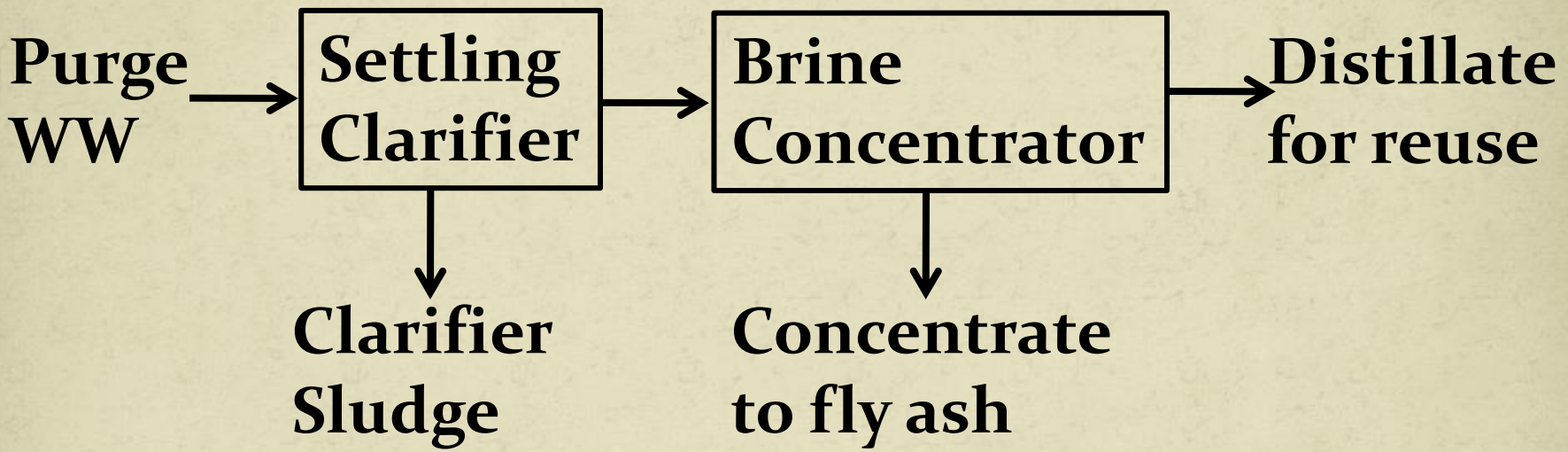
- Clean tubes after 6 months of operation
- Equipment operated by local operators
- Operating parameter controls already set

Aquatech's Other Coal Connections

- Aquatech evaporators in IGCC units operating for 20 to 25+ years
  - North Dakota Gasification (Lurgi Process)
  - Tampa Electric (Texaco Process)
  - Demkolec IGCC (Shell Process)
- Upcoming IGCC projects
- CO_2 capture retrofits or new units
- Coal plant cooling tower ZLD

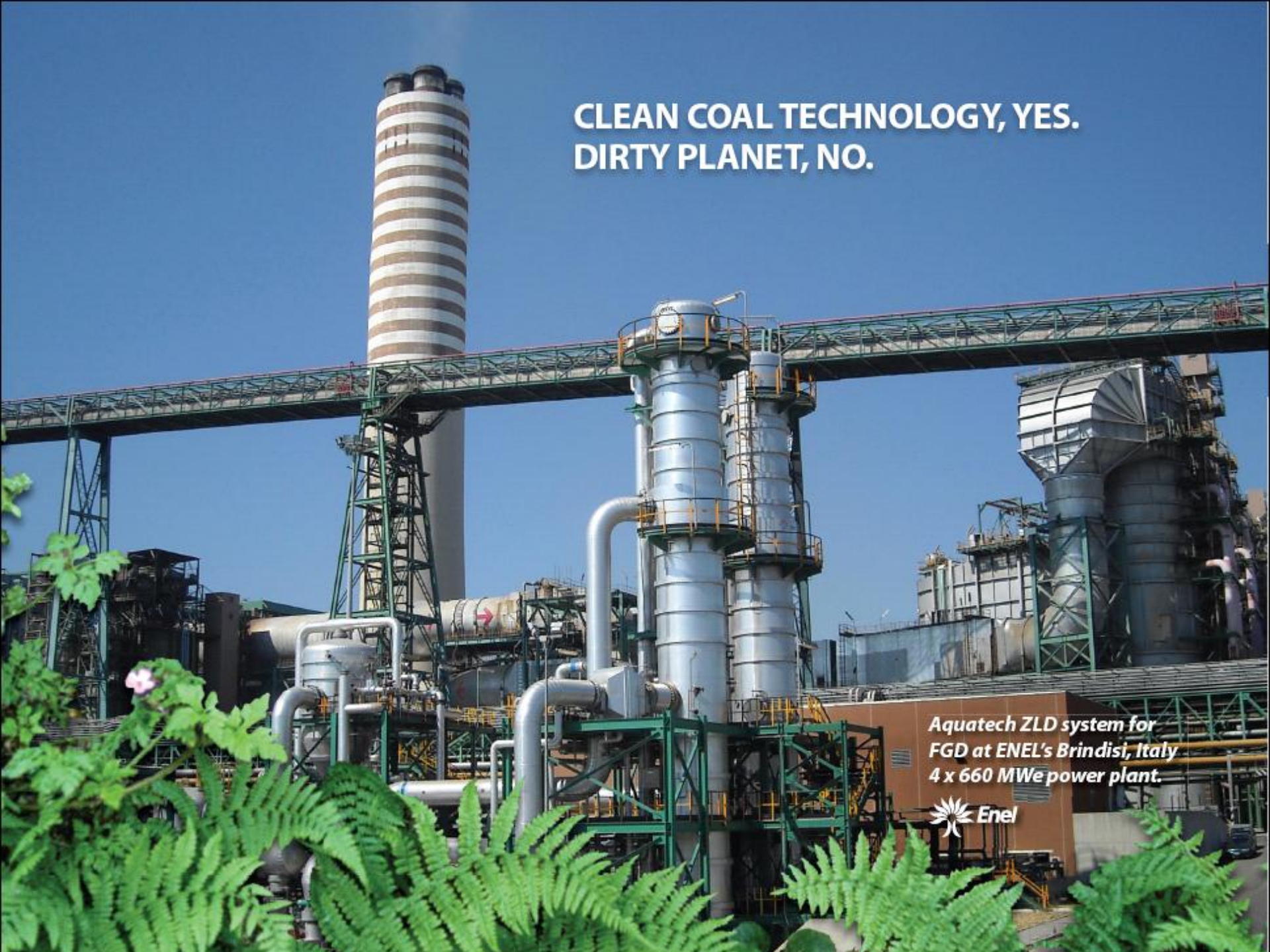
2 x 30 gpm Going On Line 2009
Kansas City Power & Light

KCPL System



KCPL Design Purge WW

pH	6.0	
Suspended solids	30,000	ppm
Calcium	4,250	ppm
Magnesium	950	ppm
Sodium	590	ppm
Potassium	25	ppm
Iron	15	ppm
Chloride	10,000	ppm
Sulfate	1,320	ppm
Nitrate	90	ppm
Fluoride	12	ppm
Silica	28	ppm
Alkalinity	280	ppm


CLEAN COAL TECHNOLOGY, YES.
DIRTY PLANET, NO.
Aquatech ZLD system for
FGD at ENEL's Brindisi, Italy
4 x 660 MWe power plant.
Enel

FGD Purge ZLD

"Truly Part Of" Clean Coal

Additional Information

- Devesh Mittal 281.794.3113 or mittald@aquatech.com
- Aquatech Technical Material
  - International Water Conference Papers
    - IWC 06 Hoskin & Mittal
    - IWC 06 Bjorklund
    - IWC 07 Mandigo
    - IWC 08 Donadono & Rao
  - Project profiles
  - Technical write ups and flow diagrams
- Project specific design assistance

Powergen 2008

Floor Give Away Sponsor

Make or model of the car is yet to be declared. Above from 2007

Booth # 1412