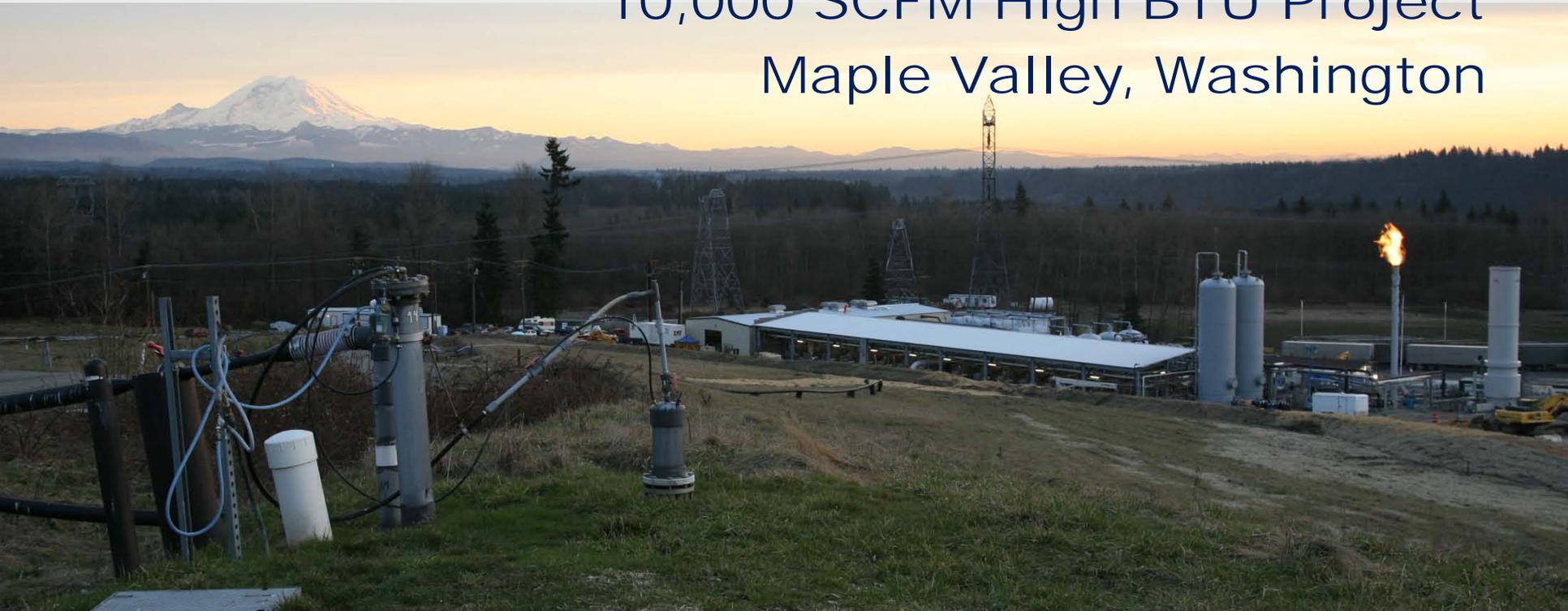




INGENCO

D i s t r i b u t e d E n e r g y

LESSONS LEARNED FROM CEDAR HILLS
10,000 SCFM High BTU Project
Maple Valley, Washington



Cedar Hills Landfill

- Cedar Hills is a county landfill serving King County, Washington
- Total area 920 acres
- Over 1,000 gas collection wells
- > 800,000 tons waste added per year
- Flowing ~ 10,000 SCFM landfill gas

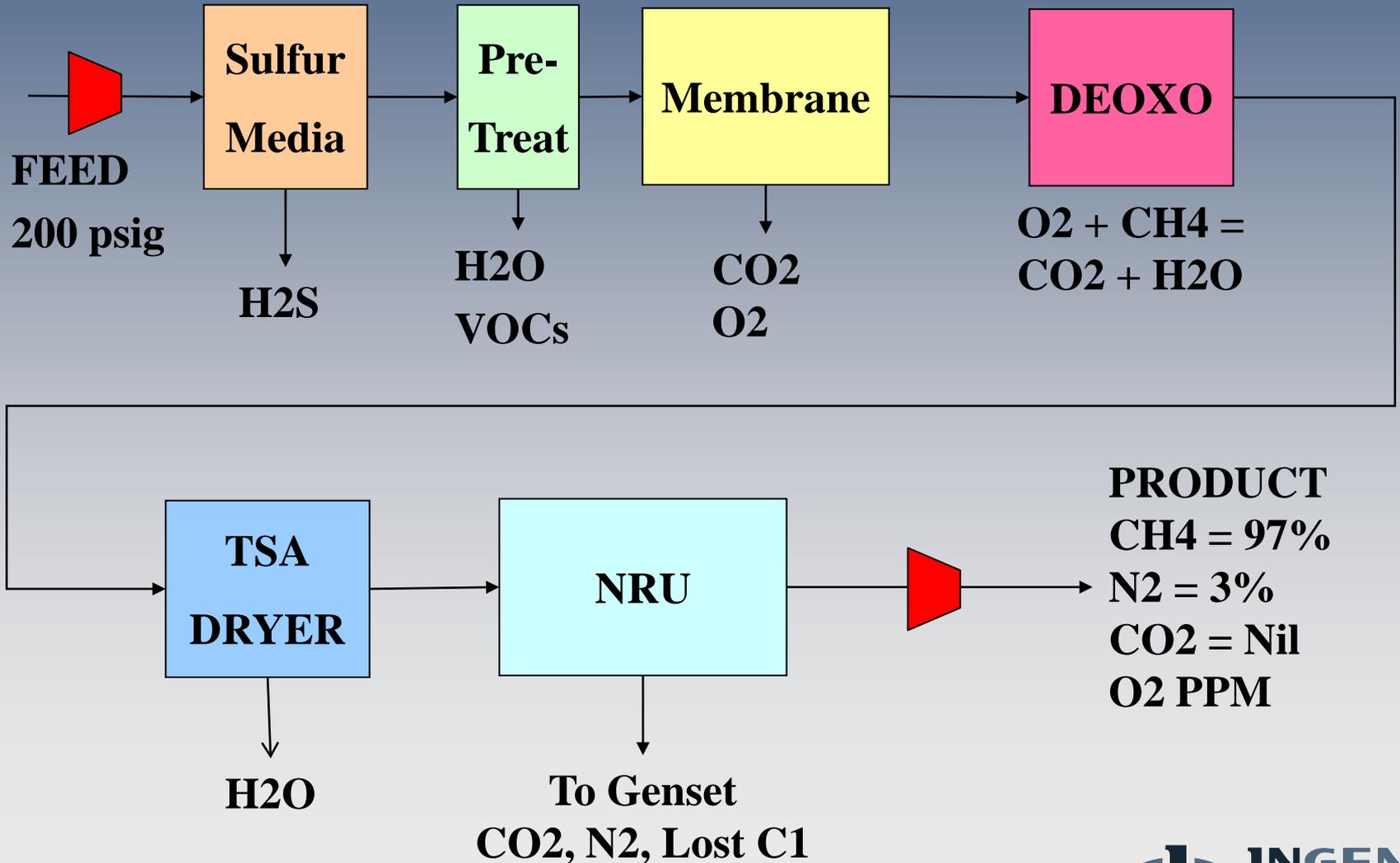
Interstate/LDC Pipeline Quality Issues

- **Northwest Pipeline spec:**
 - 985 BTU/cu ft
 - <3% total Inerts
 - <0.2% Oxygen
- **Typical spec for total Inerts is 33% higher**

High BTU Development Parameters

- **Landfill Gas accepted as normally collected**
- **Maximum equipment redundancy**
- **Use INGENCO dual-fuel electric generators for tail gas**

ORIGINAL DESIGN



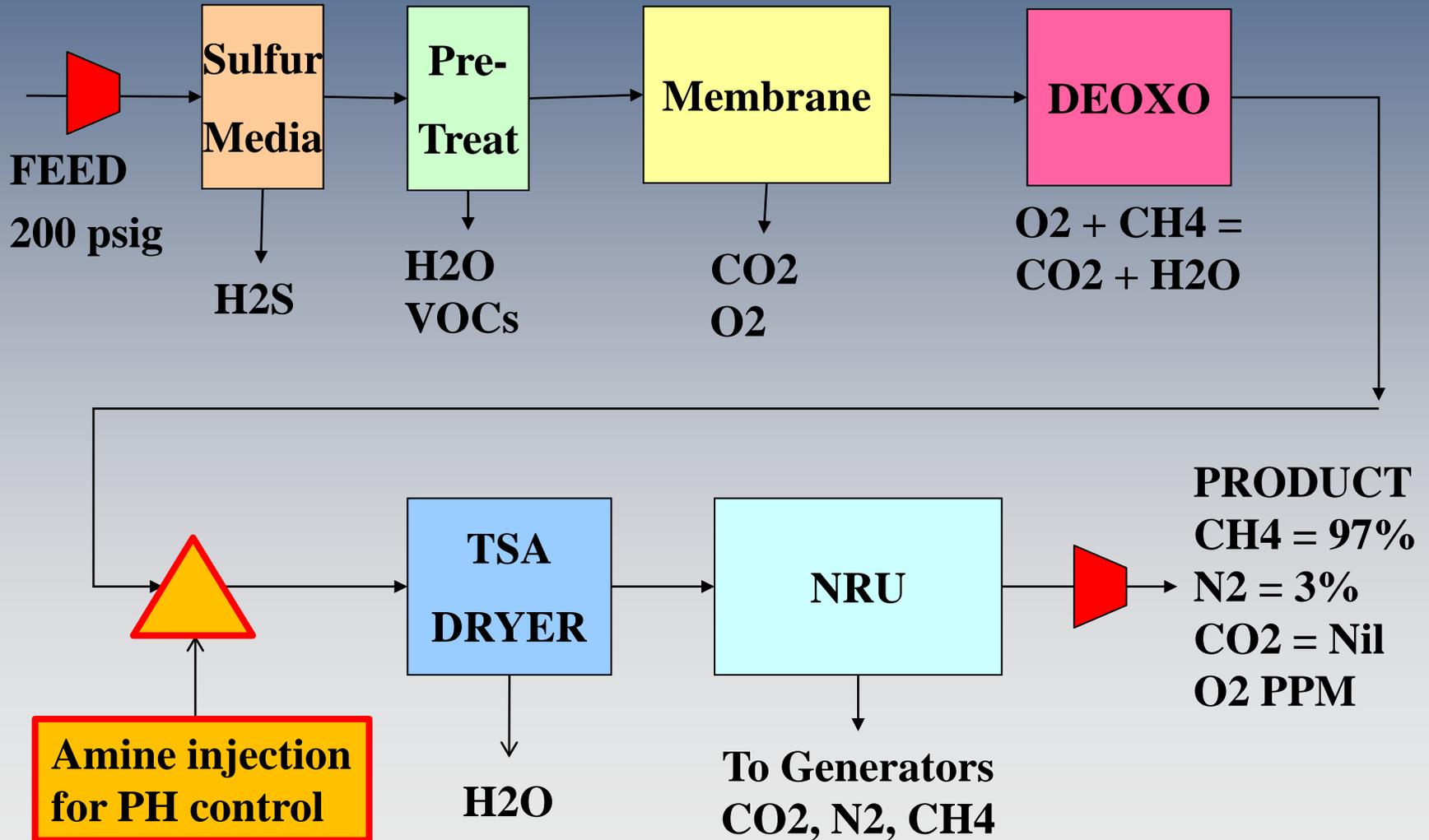
Initial Startup – MAY 2009

- Worked through normal start-up issues
- H₂S removal and compressor issues
- Additional membranes added for CO₂ removal to handle volume

Early Operation

- **Media in NRU began degrading and turning into dust upon startup**
- **Discovered low PH condensate downstream of De-Oxo converter and corroded heat exchanger**
- **Added amine and water injection to control PH**

INTERIM SOLUTION



NRU FAILURE

- **Extra filtration installed to trap dust**
- **In first 3 months media replenishment required**
- **Consequential failures caused additional dusting and eventual total plant shutdown and replacement of all media**

**Filters changed
again and again
and . . .**

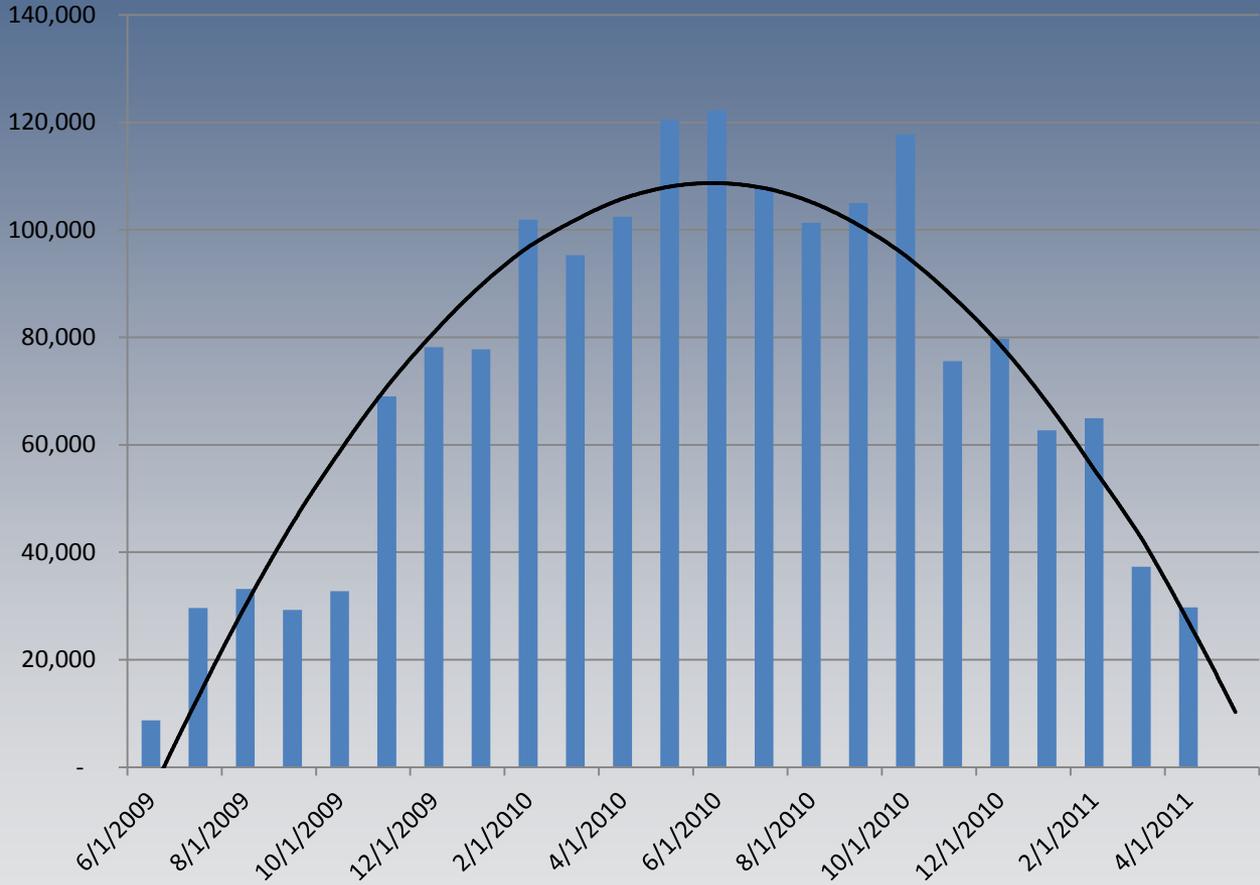


**Bought so many
filters
manufacturer ran
out of components**

Missing media found!



FIRST 22 MONTHS OUTPUT



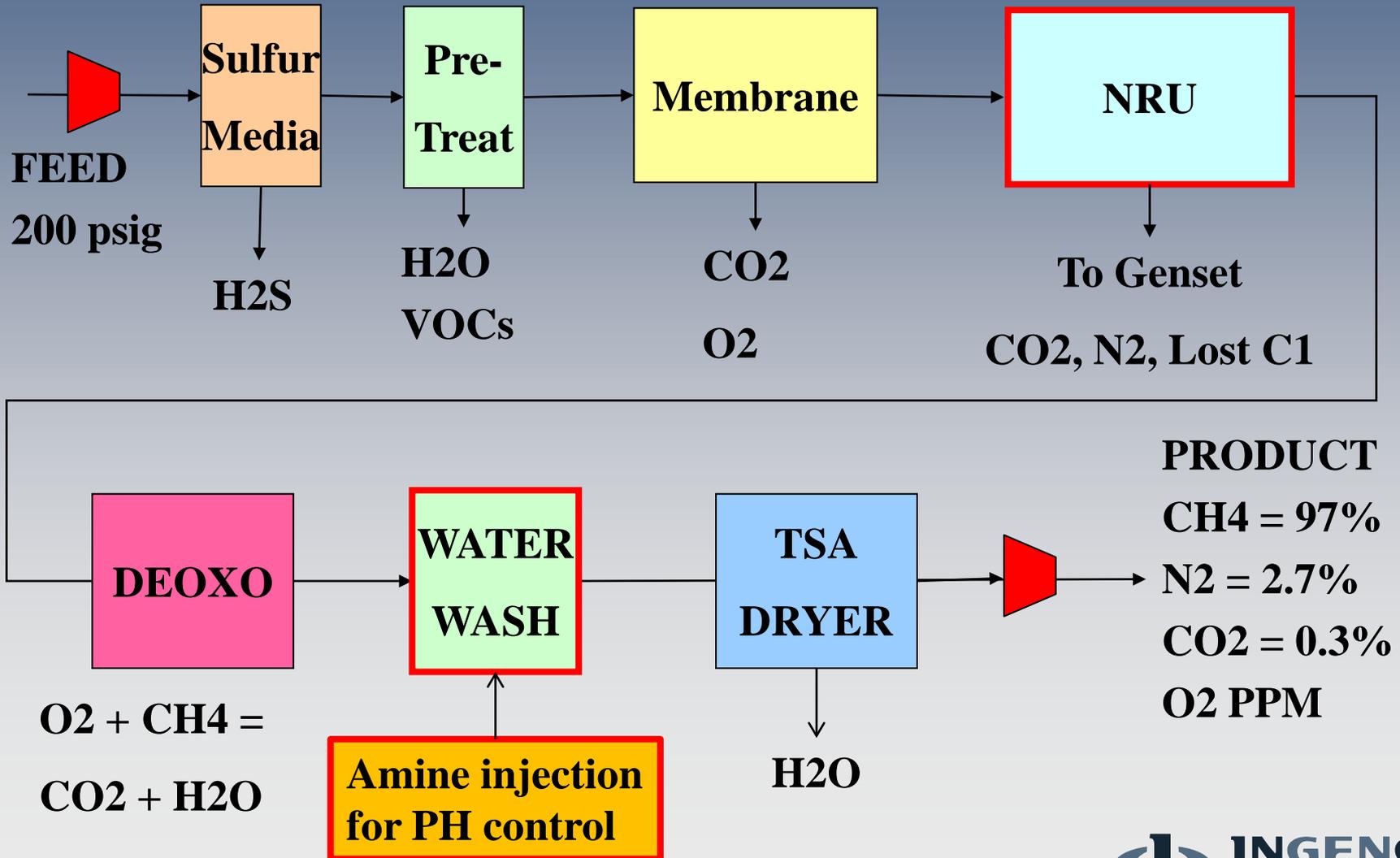
Failure analysis and repair plan

- **Outside expert evaluations**
- **Re-evaluated media alternatives**
- **Existing NRU vendor guaranteed media performance contingent on reconfiguration**

Implementation

- Relocated oxygen removal catalyst and TSA dryer downstream of NRU at request of NRU vendor to preclude any possibility of acid-gas damage to media
- Disassembled and cleaned entire plant back end
- NRU vendor implemented software and hardware modifications to reduce possibility of media fluidization

FINAL SOLUTION

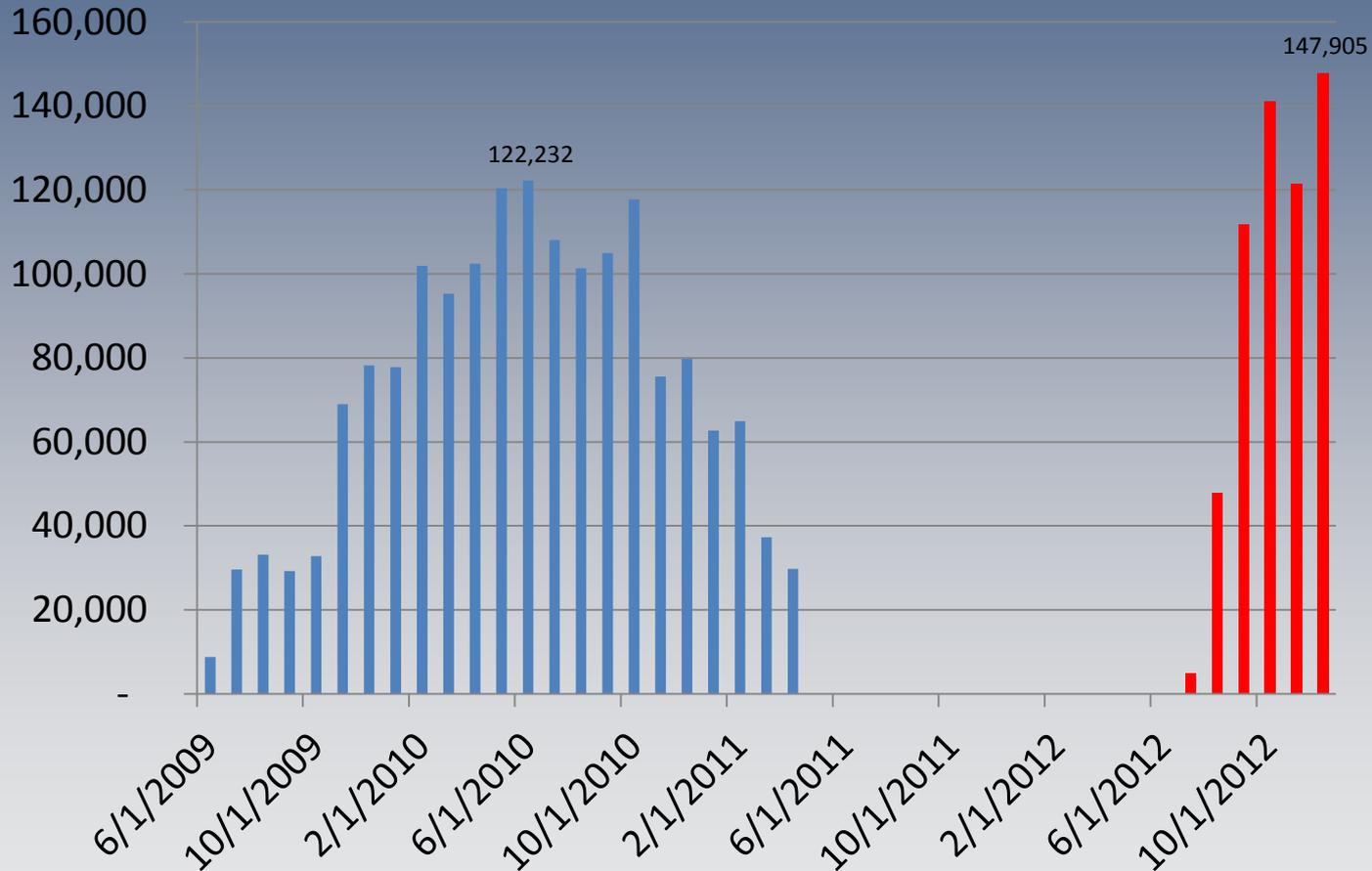


August 2012 Restart

- **NRU vendor provided good support for re-commissioning and improved control system for easier operation**
- **Overall monthly performance much better than initial operating period**

Results Much Improved

21% greater monthly output



Restart Results

- Methane recovery appears consistent but below expected original pro forma
- No degradation of media has been observed to date but will be monitored closely

Conclusions

- Turnkey EPC contract no guarantee of success
- Cause of original media failure not fully resolved
- Strong vendor commitment critical
- Reconfigured plant working well

