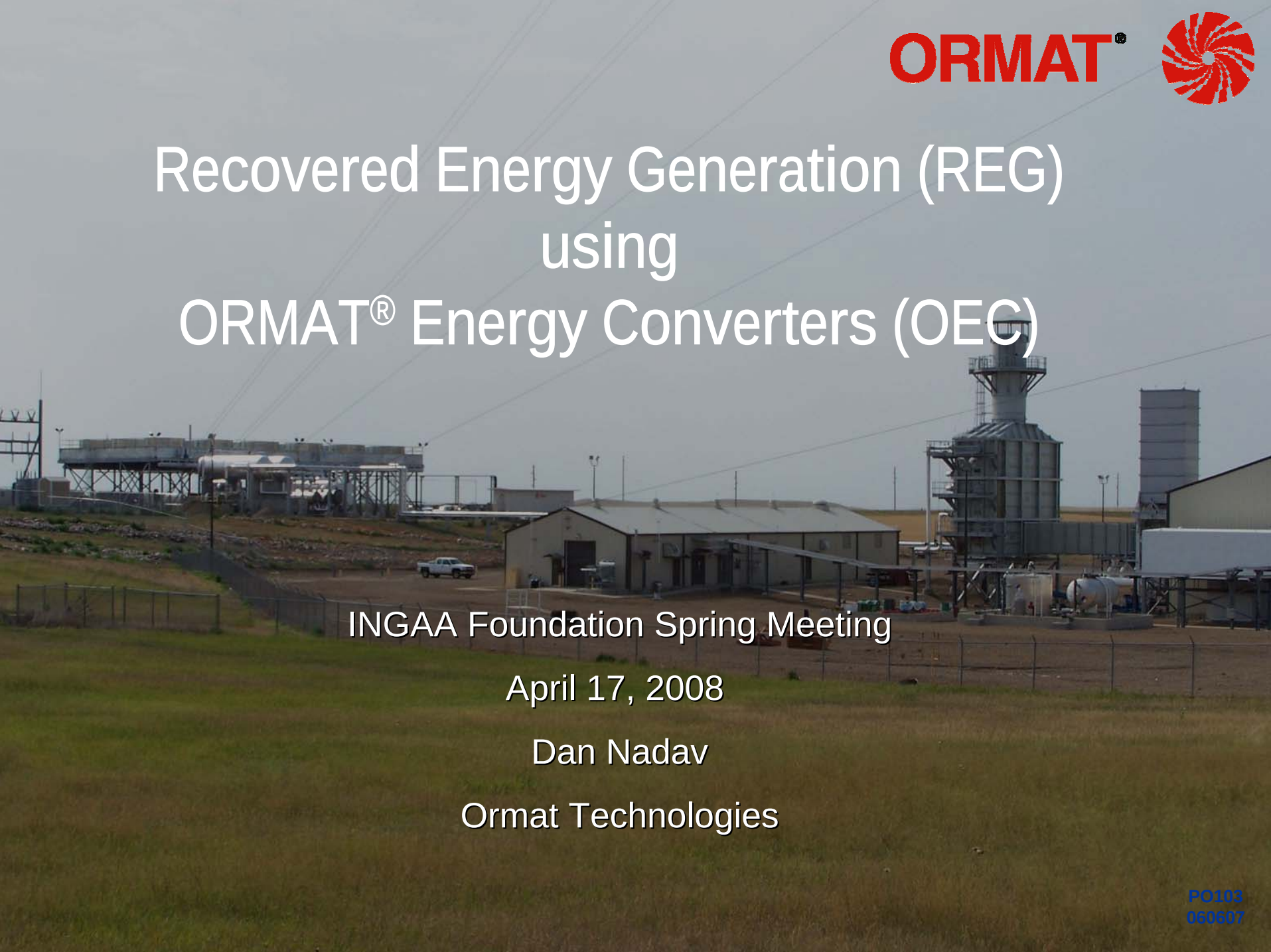


Recovered Energy Generation (REG) using ORMAT® Energy Converters (OEC)

INGAA Foundation Spring Meeting

April 17, 2008

Dan Nadav

Ormat Technologies

PO103
060607

Table of Contents

Company Profile
Main Areas of Activities

Reliable Distributed Power

Geothermal Power Plants

Resource Recovery: Biomass

Heat Recovery - Pipelines

Industrial Waste Heat Recovery

ORMAT

GREEN ENERGY you can depend on

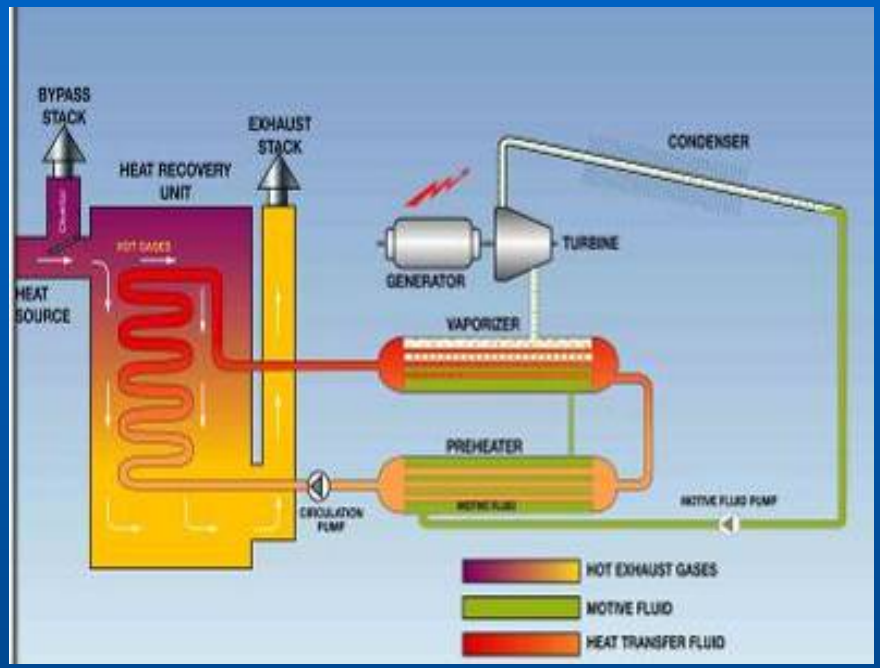
Company Profile

- Focus on Renewable and Sustainable Energy since 1965
- Listed on the New York Stock Exchange (ORA)
  - ✓ The only pure play geothermal/REG company listed (NYSE)
- Vertically integrated
  - ✓ **Design, Engineering, Manufacturing, Supply, Installation & Operation**
- Flexible Business Model
  - ✓ **Equipment only**
  - ✓ **Turnkey (EPC) power plants supply**
  - ✓ **Electricity sales under PPA**
  - ✓ **Project financing**

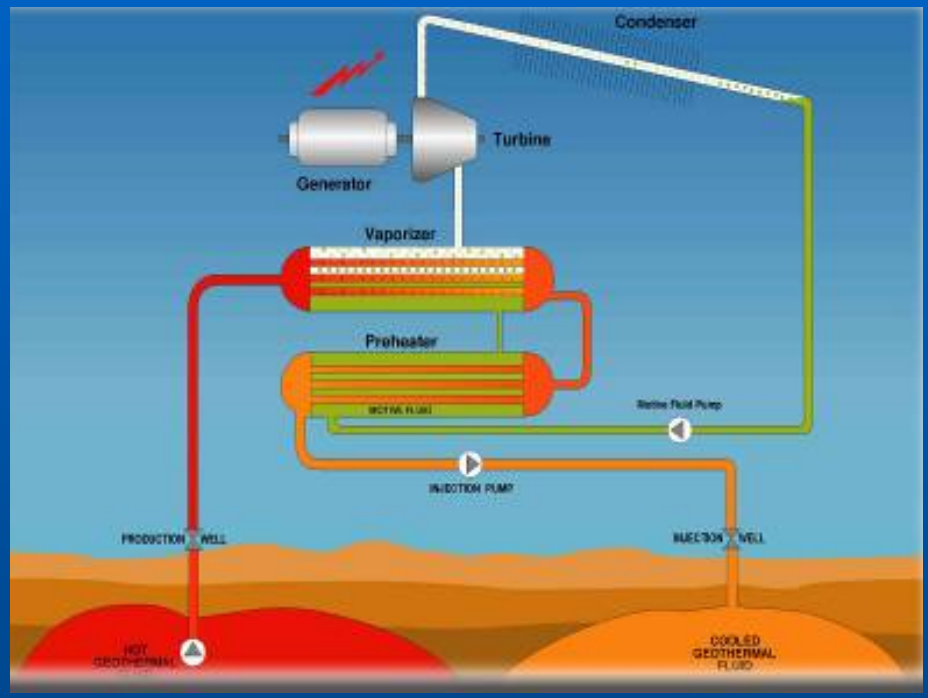
ORMAT

GREEN ENERGY you can depend on

Technology
One Technology / Different Applications



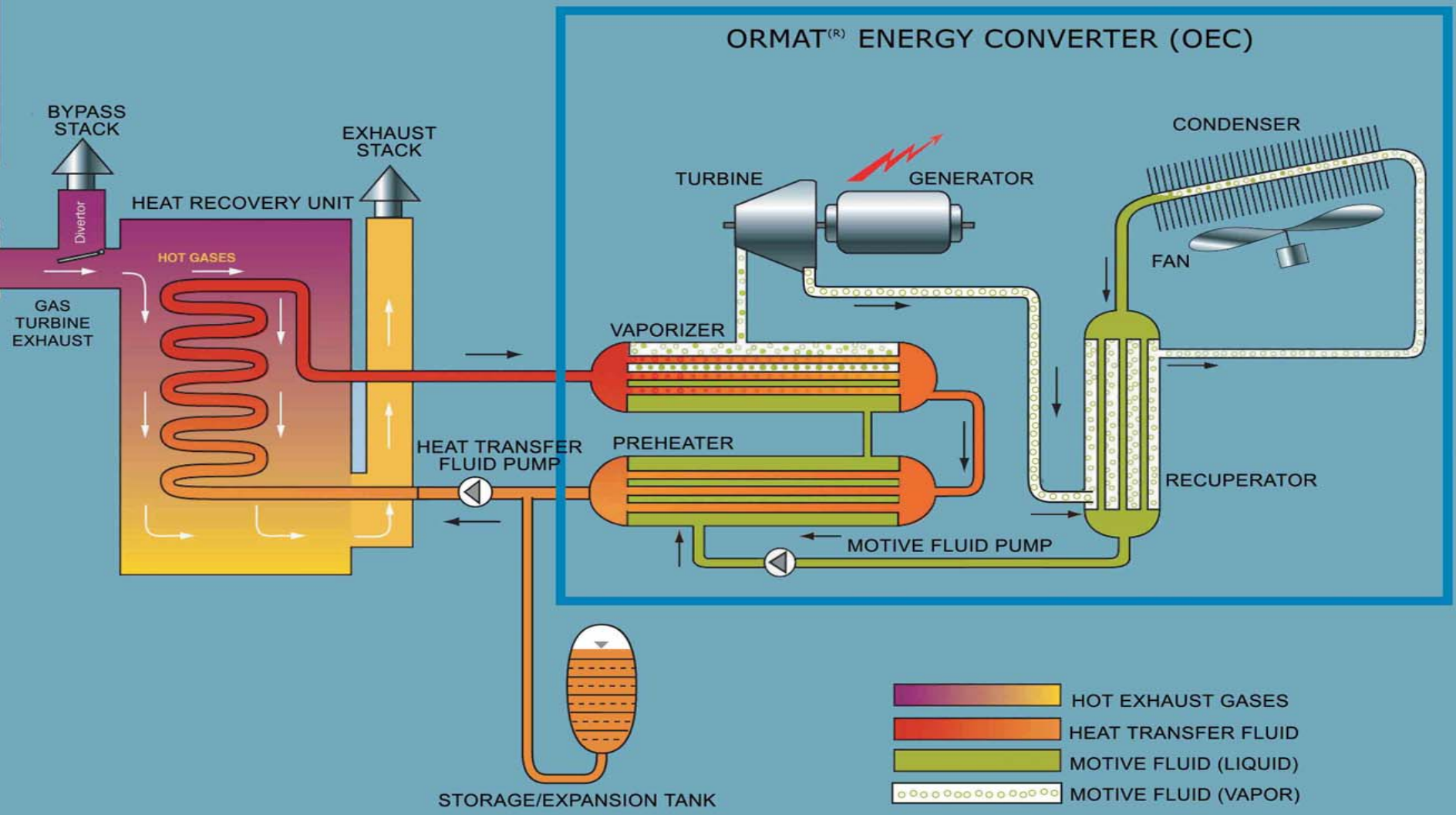
Typical REG application



Typical Geothermal application

ORMAT
GREEN ENERGY you can depend on

RECOVERED ENERGY GENERATION (REG) using OEC



Technology
One Technology / Different Applications

Turbine – Generator set & Air-cooled Condensers

Heat Exchangers – preheater and vaporizer set

OREG 1 – REG Project at NBPL CS 7

Galena – Geothermal plant

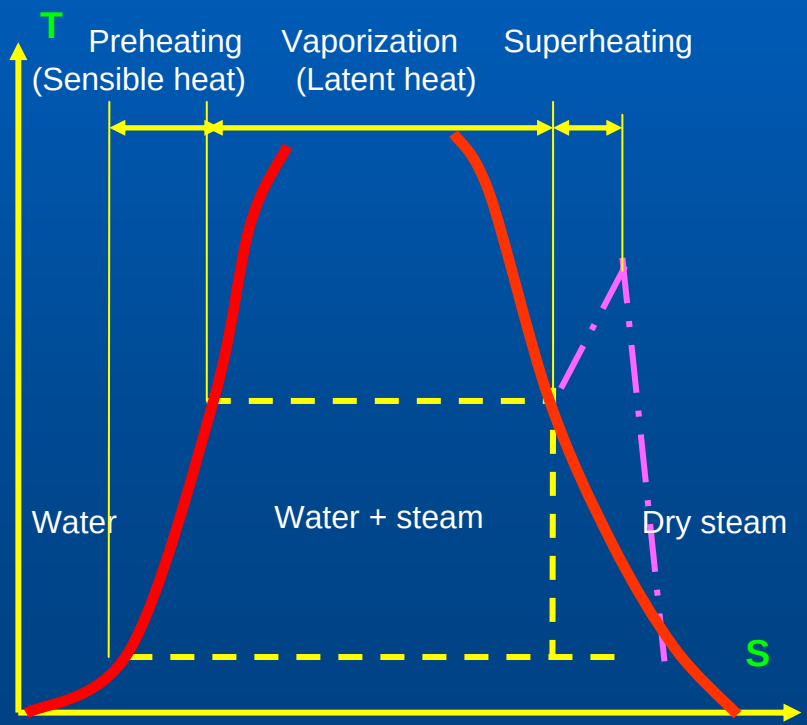
ORMAT

GREEN ENERGY you can depend on

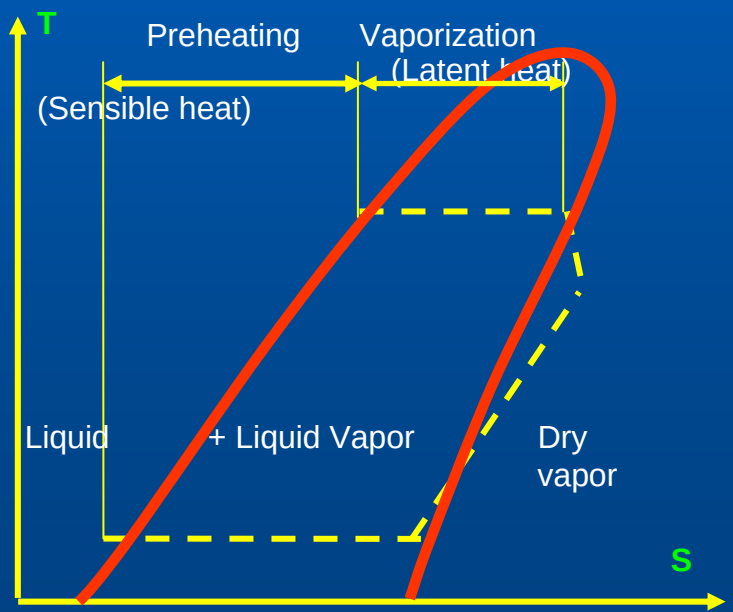
Technology
Moisture-free turbine expansion

Temperature, Entropy Diagrams for organic Rankine cycle

STEAM: Superheater required to avoid wetness



ORC: No superheat required, vapor dries while expanding



ORMAT
GREEN ENERGY you can depend on

Technology - Benefits

- **Simple system**
  - ✓ Air-cooled
  - ✓ No water use, no water treatment
  - ✓ No blow down
  - ✓ No vacuum pumps or steam ejectors
  - ✓ Uses thermal oil as the system's intermediate medium
  - ✓ Load fluctuation tolerance
- **Rugged design**
  - ✓ 1800 RPM turbine, no reduction gear
  - ✓ Outdoor installation typical (even in severe climates)
- **Packaged modular system – fast on-site installation**
  - ✓ 4-6 month onsite construction (20 months from NTP to Completion)
  - ✓ May use existing utility interconnection
  - ✓ Small installation footprint
- **Cost effective**
  - ✓ Very low O&M requirements
  - ✓ No licensed steam technicians required
  - ✓ Operates in automatic/unmanned mode

Technology - Benefits
Low Operation & Maintenance (O&M) requirements

- Unmanned operation
- Black start and island mode capability
- Single switch operation
- Minimal maintenance requirements.
  - ✓ Ormat is operating four 5.5 MW REG projects using only two operators
  - ✓ Alliance is operating four 5.5 MW REG projects (built by Ormat) with no additional staff requirements

REG – Benefits

Low Operating & Maintenance (O&M) requirements

Category	Frequency per year	Labor Hours per Event	Labor Hours per Year
Weekly Inspection			
Visual & Audio Inspection	52	0.5	26
Vibration Analysis	52	1	52
Air filters – Water draining	52	0.25	13
Rupture disk serviceability inspection	52	0.25	13
Oil pressures & levels check	52	0.25	13
Monthly Maintenance & Checkout			
Repair leaks and general external cleaning	12	12	144
Semi-annual Maintenance & Checkout			
Instruments – Calibration	2	12	24
Generator - Exciter inspection	2	2	4
Condenser Fan system – lubrication & bolts tightening	2	8	16
WHOH – Diverter inspection and calibration	2	3	6
General rust and painting repairs	1	3	6
Generator assembly – Air filter cleaning	2	1	2
Feed pump strainer cleaning	2	2	4
Electrical boards General maintenance	2	8	16

REG – Benefits

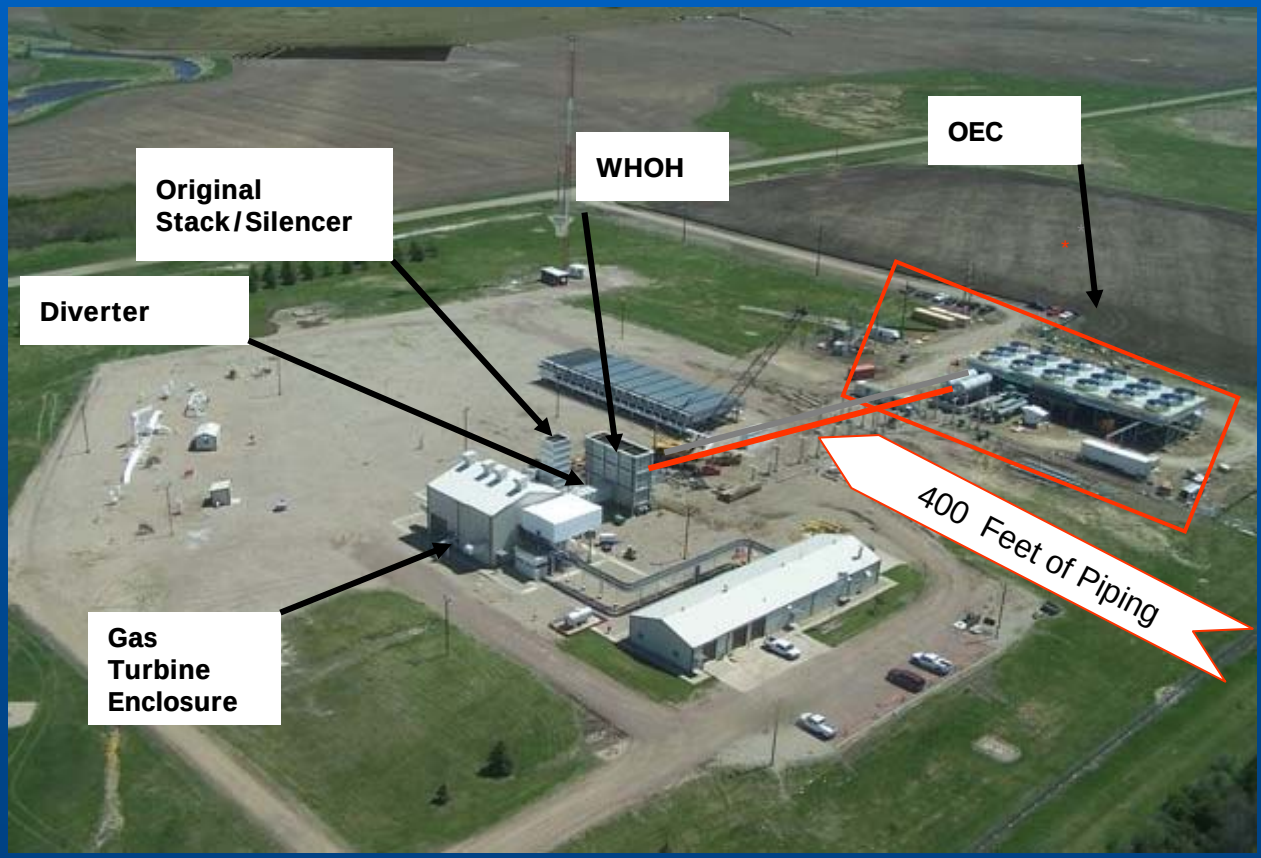
Low Operating & Maintenance (O&M) requirements

Category	Frequency per year	Labor Hours per Event	Labor Hours per Year
Annual Maintenance & Checkout			
Coupling lubrication	1	1	1
Generator insulation test	1	4	4
Motors insulation test	1	4	4
Turbine & Generator – lube oil replacement	1	3	3
Seal oil replacement	1	3	3
Oil systems: Filter replacement	1	1	1
Turbine Overhaul – Every Four Years Maintenance			
One Turbine – Mechanical Seals & Bearings replacement	0.25	120	30
Turbine Bearings			
Turbine Mechanical Seals			
Total labor hours per year 385 Hours			

Technology - Benefits

Flexible installation

- The REG system allows for some large distances between the location of the heat exchanger (Waste Heat Oil Heater) and the OEC.
- This distance does not significantly affect the performance of the OEC.

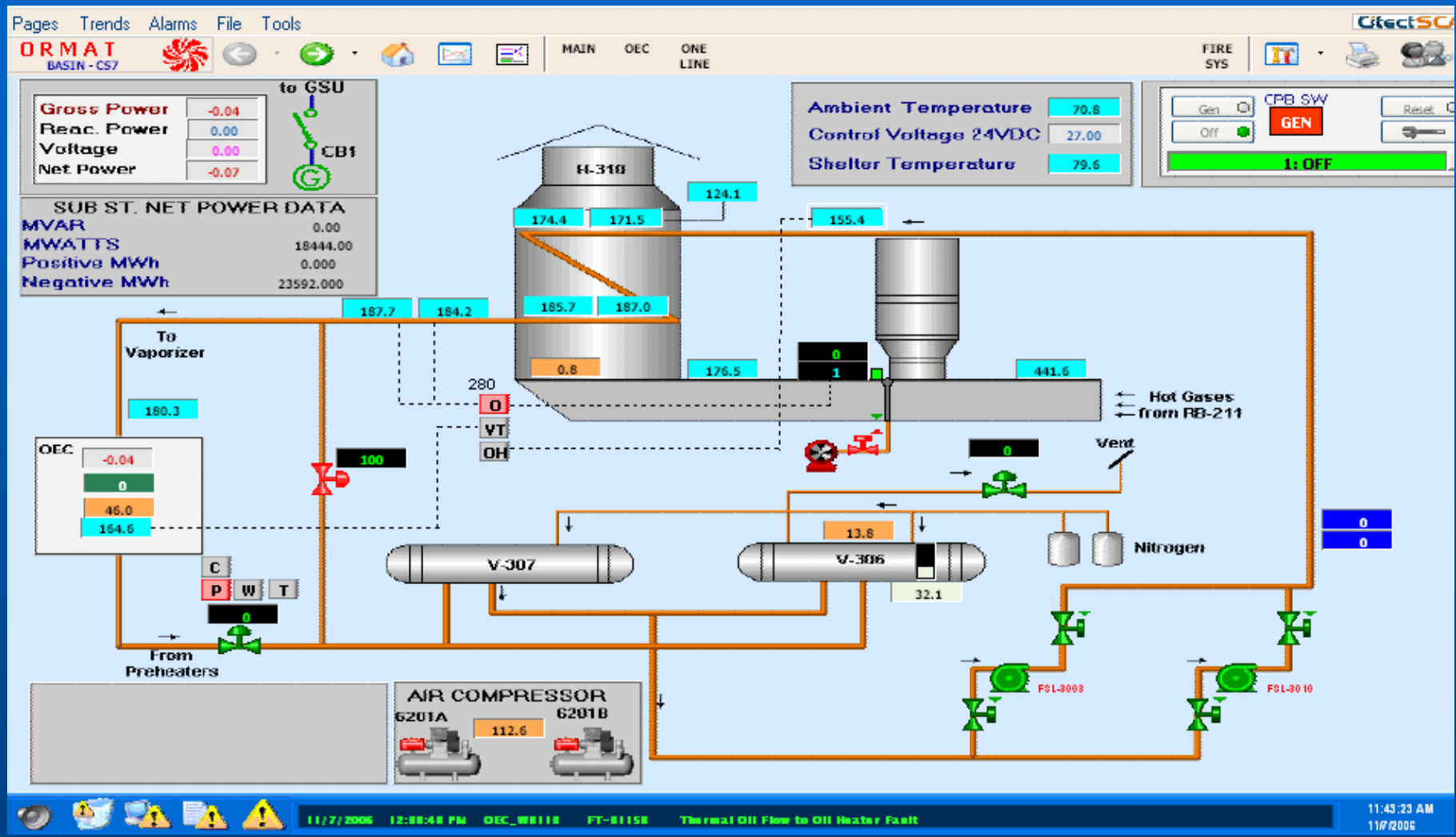


Technology - Benefits
Minimum interruption

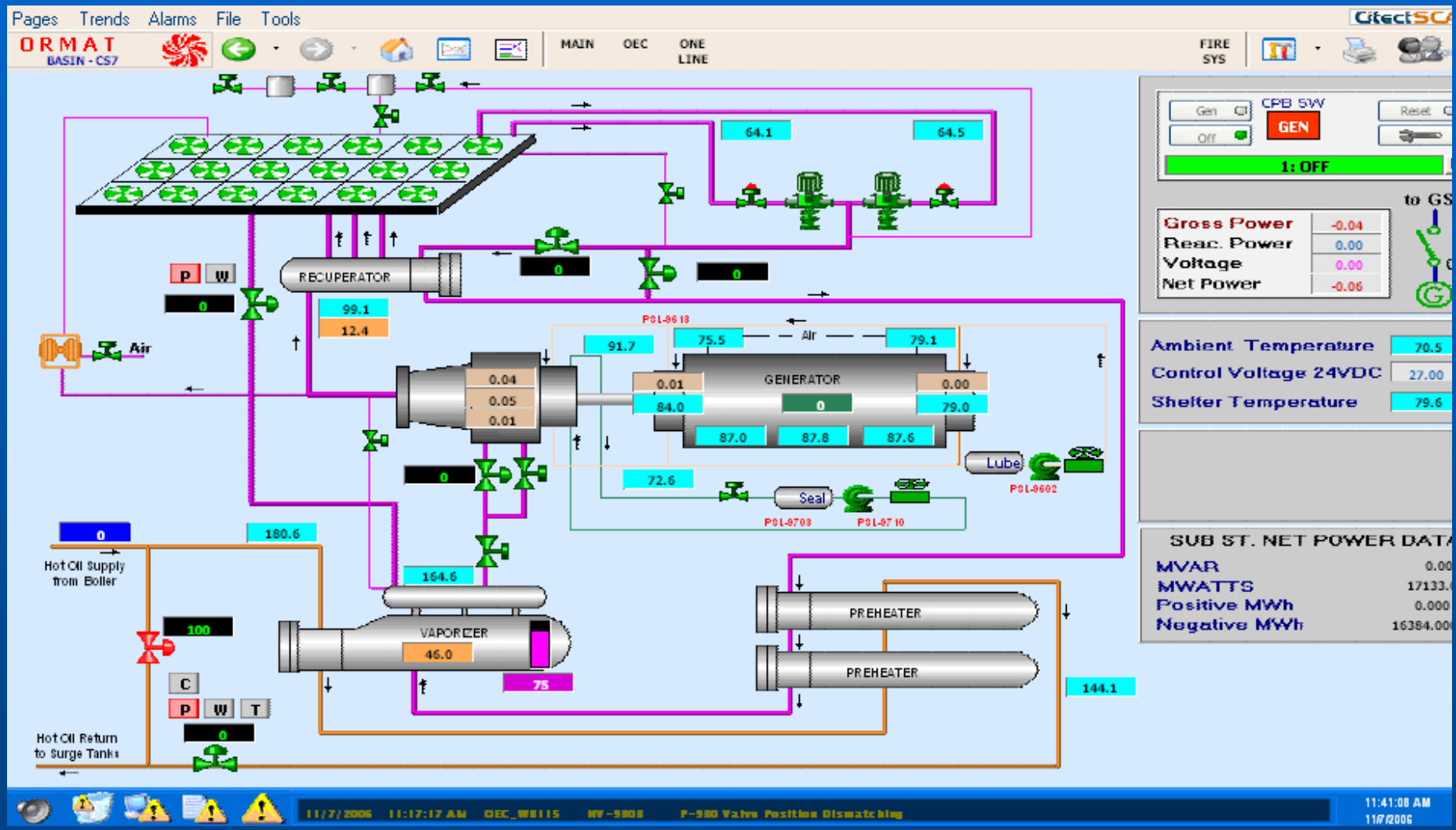
Installation completed in less than 48 hours

ORMAT®
GREEN ENERGY you can depend on

HMI system - computer and dedicated software – WHOH and oil system



HMI system - computer and dedicated software – OEC



Control and Operation

- The REG unit requires minimum maintenance and allows for virtually unmanned operation and remote monitoring
- Remote Monitoring and Operation - 24/7 remote monitoring of all unit elements
  - ✓ Turbine and Generator
  - ✓ Heat Exchangers
  - ✓ Condensers
  - ✓ Pentane Loop
  - ✓ Oil Loop

ORMAT
GREEN ENERGY you can depend on

Technology - Benefits
Short time-to-implementation

- 20 month completion time from NTP

Milestone Date (from NTP)	EPC Milestones
Execution date	- Execution of the EPC Contract
3-4 months	- Process design drawings by Ormat - Issue mechanical and electrical purchase orders/Mobilization of civil works construction
6 months	- Issue civil, mechanical, electrical detail design purchase orders - Foundations complete
8 months	- Release of bid award for major raw materials
11 months	- Shipment of the OEC & WHOH from Ormat or vendor's dock
12 months	- OEC equipment delivered to the site - Mobilization of mechanical and civil subcontractors to site
14 months	- OEC equipment placed on foundations
19 months	- Substantial completion
20 months	- Acceptance date

Ormat's Experience
Neptune Gas Processing Plant

- Heat source - two Solar Mars 100 Gas Turbines
- REG application – 4.6 MW
- Allows island-mode operation
- Historical availability factor near 100%
- O&M performed by the plant operating team
- 24/7 monitoring using Ormat's remote monitoring software package

ORMAT
GREEN ENERGY you can depend on

Ormat's Experience
Northern Border Pipeline

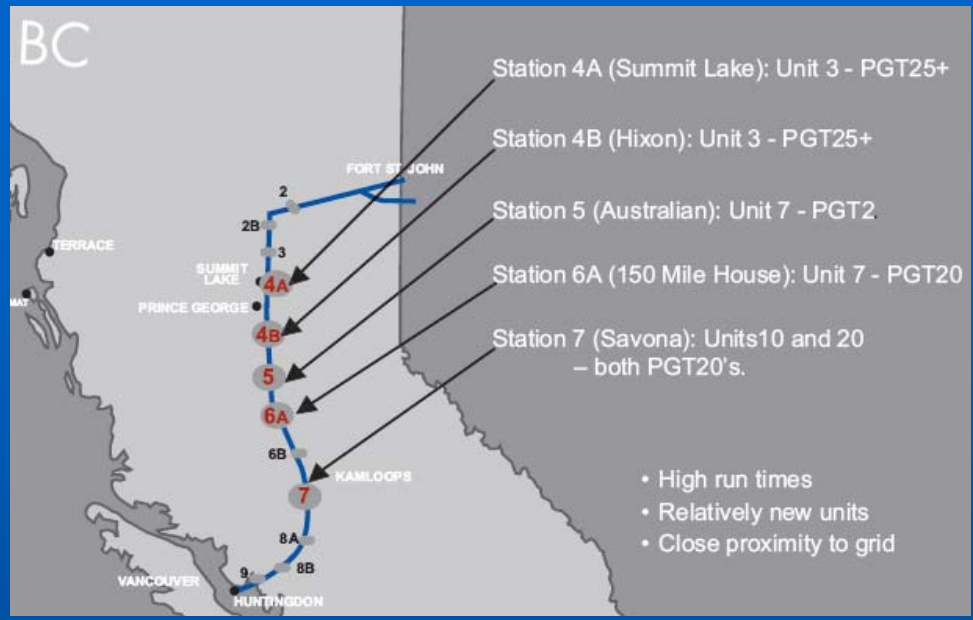
- Heat source – 4 RR RB211 Gas Turbines
- Owned and operated by Ormat
- Capacity: 6.5 MW x 4 (locations) = 26 MW (total)
- Technology advances
  - ✓Automated diverter
  - ✓Remote operation from main and backup locations
  - ✓Minimum impact on day to day station operation

Ormat's Experience – The Alliance Pipeline

- Heat source – one 33,000 HP General Electric LM2500 Gas Turbine
- The Kerrobert Recovered Energy Generation Power Plant is owned and operated by NRGreen Power Limited Partnership
- Capacity: 6.5 MW
- The electricity generated by the power plant is sold to SaskPower
- NRGreen is currently commissioning three more similar projects at its compressor stations in Saskatchewan

Ormat's Experience – The Duke Energy Pipeline

- Developer: EnPower, an independent power producer (IPP) owned by Pristine Power and Enmax
- An agreement to develop five 5-MW REG projects on five compressor stations at the T-south mainline
- Currently two projects (Station 6A 150 Mile House and Savona) are under construction based on a long term PPA with BC Hydro as part of the utility's "Clean Energy Program"



ORMAT
GREEN ENERGY you can depend on

Ormat's Experience –
Kinder Morgan's Trailblazer Pipeline (the Peetz Compressor Station)

- Heat source – two 12,000 Solar Mars Gas Turbines
- Owned and operated by Ormat
- Capacity: 4 MW
- Generates Green Credits qualified under the Colorado RPS

ORMAT
GREEN ENERGY you can depend on

REG Experience – Small, Pre Packaged, Standard Units.

- Three small standard 350 kW units using Jenbacher gas engines in landfills and other industrial applications
  - ✓Pre Packed
  - ✓Modular
  - ✓Easy to install
  - ✓Highly reliable

ORMAT
GREEN ENERGY you can depend on

The Environmental Impact

- Each MWh derived from recovered energy generation will save approximately:
  - ✓ 1 ton of CO_2
  - ✓ 2 kilograms of SO_2
  - ✓ 5.5 kilograms of NOx
- The potential to use the REG to support electrical motors substituting gas turbines or reciprocating engines in compressor stations
  - ✓ Qualified for GHG credits

Soft Benefits – the PR Impact

- The current PR landscape provides a perfect opportunity for large emitters and other energy companies to leverage on green energy projects:
  - ✓Environmentally-conscious public (and investors)
  - ✓Hungry-for-news Media
  - ✓Proactive regulator/legislator

MSNBC – covering the OREG1 (South Dakota) REG plant dedication ceremony

ORMAT®

GREEN ENERGY you can depend on

Alliance – the Kerrobert dedication ceremony with SK premier and minister of energy

ORMAT

GREEN ENERGY you can depend on

Thank you

Contact:
Dan Nadav
Business Development Manager
email: dnadav@ormat.com