



GRANEX™ - Overview for CCBC
Utilising Low-to-Medium Temperature Heat for Power Generation
August 2010

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GRANEX™ Introduction



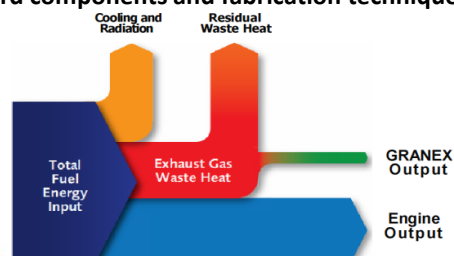
- New 'heat cycle' or 'heat engine': Converts heat into electricity
- ~40% more efficient than conventional Organic Rankine Cycle technology
 - ~30% reduction in cost per MW
- Developed by Newcastle Innovation/University of Newcastle in conjunction with Granite Power
 - With REDI Grant assistance from AusIndustry (Federal Government)
- R&D: 3 years
- Commercial Roll-out: commenced February 2010
- Targets:
 - Recovered Waste Heat
 - Geothermal
 - Solar Thermal

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Overview of GRANEX™



- GRANEX™ combines the concepts of supercritical power generation and heat regeneration into a single platform
- GRANEX™ leads to much higher conversion efficiencies than those currently provided by conventional ORC power cycles
- Simple technology, so it offers a greater degree of flexibility and robustness, which further improves project economics
- Uses standard components and fabrication techniques



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REDI Project



The \$2.5M REDI Project that developed GRANEX™ technology was jointly funded by Granite Power and AusIndustry.

Included a 1 kW Proof-of-Concept Plant, and a 100 kW Prototype Plant

The **1 kW Proof-of-Concept Plant** operates at pressures of up to 30 MPa and temperatures up to 300°C ** under GRANEX™ or ORC configurations

- Measures pressure, temperature, and flow rate made at 20 different points using a sophisticated data acquisition system.
- Studied many working fluids over a range of source and sink temperatures ($150^{\circ}\text{C} < T_{so} < 250^{\circ}\text{C}$ & $15^{\circ}\text{C} < T_{sf} < 35^{\circ}\text{C}$).
- So far, about 650 individual configurations have been studied

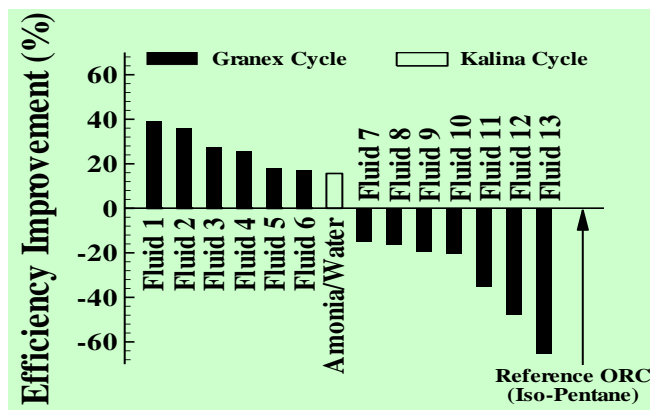
The **100kW Prototype Plant** is a pure GRANEX™ unit, focussed on 150-250°C, a narrower pressure range and fabricated to 'normal manufacturing standards'.

- Performance confirmed exactly to expectations
- Provided scaling rules

** Currently being increased to ~480°C

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Test Plant Results



Efficiency improvements with reference to ORC (at 200°C).

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100 kW Prototype Plant (Nov 2009)



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GRANEX™ transforms geothermal project returns



REFERENCE ECONOMICS FOR GEOTHERMAL UNITS - WITH GRANEX

Assumptions/Outcomes	Standard ORC plant	With GRANEX	
ASSUMPTIONS			
Wells per unit average	6.4	6.4	Drilling costs and field parameters unchanged
Drilling Costs \$m	\$65M	\$65M	
Average Temperature	198°C	198°C	
Achieved flow rate per circuit	40 kg/sec	40 kg/sec	Reflects higher efficiency after auxiliary load
Achieved net power output	17MW	25MW	
Plant Costs \$m	\$65M	\$80M	Plant costs reflect costs of higher capacity generator plant required
Total Capex \$m	\$130M	\$145M	
FINANCIAL OUTCOMES			
EBITDA \$m/yr	\$18M	\$27M	
Project Value at 9x EBITDA	\$165M	\$245M	
Development Profit	\$35M	\$100M	Development profit is nearly 3x ORC Reference
Capex/EBITDA Payback	7.2x	5.4x	

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Varies with each RWH opportunity

Example: Mining Project

- If ~25% of total costs are related to power supply, and
- If genset power cost are ~15 cents per kWh

Then

- Average power costs reduce to ~13.65 cents per kWh
 - ~9% saving, and
- Overall power costs reduce to ~23% of total costs
 - **PLUS: Reduced exposure to energy costs and to carbon price/tax**
- Return on “investing” in GRANEX™ = 25 – 30%

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- Initial Focus is Recovered Waste Heat
 - Intention is to commercially prove at the 1MW-2MW scale
 - Then upscale to 5-10MW
 - A number of partners and sites are under negotiation
 - Gensets
 - Kilns
 - Marine Engines
 - Next: small gas turbines
 - Includes a range of temperatures
- A geothermal target could be added to the portfolio

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Funding Challenges



- R&D: initially complete
- Applications Development
 - RWH: Varies with opportunity <\$0.5M - \$10M
 - Geothermal: up to ~\$90M
- Overriding framework:
 - Continuing GFC
 - Uncertainty re carbon price/tax & related legislation/regulation
- Raising money is a significant challenge

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Funding Sources



- Institutions: insist on demonstrated proof and earnings
 - Subsequent roll-out
 - Market development
- Venture Capital
 - Funding for growth, not for development
- Retail Investors
 - Currently very cautious & analogous to institutions
- Professional & Sophisticated
 - Some will support R&D
 - More will support applications development and subsequent roll-out
- Industrial Partners: possible for applications development
- Customers: possible for applications development
- Government: default option, required to address market failure
 - R&D
 - Applications Development

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- Multitude of implementation issues teased out since February
- Marketing issues attended to
 - Leaflets/Pitch documents
 - Formal budget proposal documents
 - Preliminary independent market study
 - Better understanding of customer perspectives and issues
- >12 opportunities provided with budget proposals
 - Much larger number approached:
 - Most businesses not interested unless multiple demo plants exist
 - Most businesses not prepared to invest in saving money
 - Most businesses lack time/expertise to assess novel technology
- Current advanced prospects
 - Gensets x 4
 - Brick kilns x 2
 - Small gas turbine x 1

Issue	Response
Small company	<ul style="list-style-type: none"> •Initially target small sales (1 – 2MW) •Cornerstone shareholder(s)
Reference sites	<ul style="list-style-type: none"> •Identify customers capable of analysis •Price incentives for initial customers •Target quality ‘names’
Lack of Funds	<ul style="list-style-type: none"> •Seek grants etc •Majority of senior management time is devoted to fund raising •Careful management of new proposals (so as to not exceed ability to respond)
Lack of Demand due to Various Uncertainties	<ul style="list-style-type: none"> •Lobby government •Attend conferences etc •Deliver results