

Geothermal Power Plays

High Temperature Electronics for Downhole Environments

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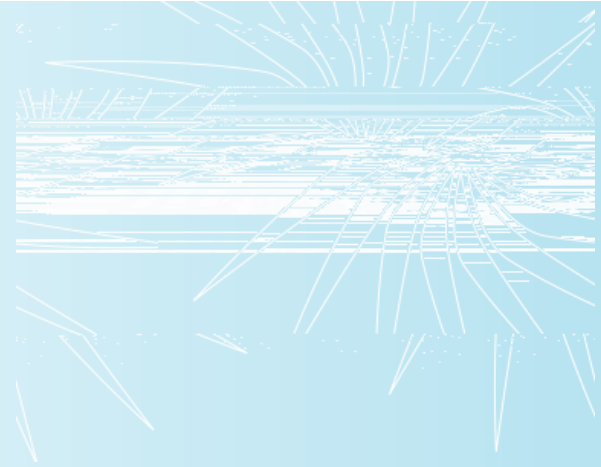
Southern Methodist University

Dallas, Texas

May 20th, 2015



Joule's Niche:



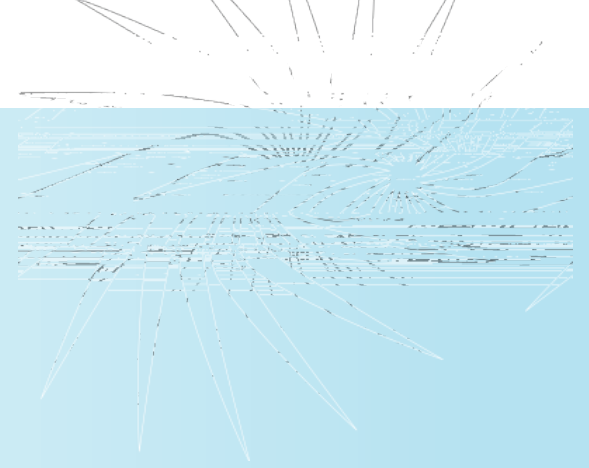
Markets Served:

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Geothermal Power Plays

Given:

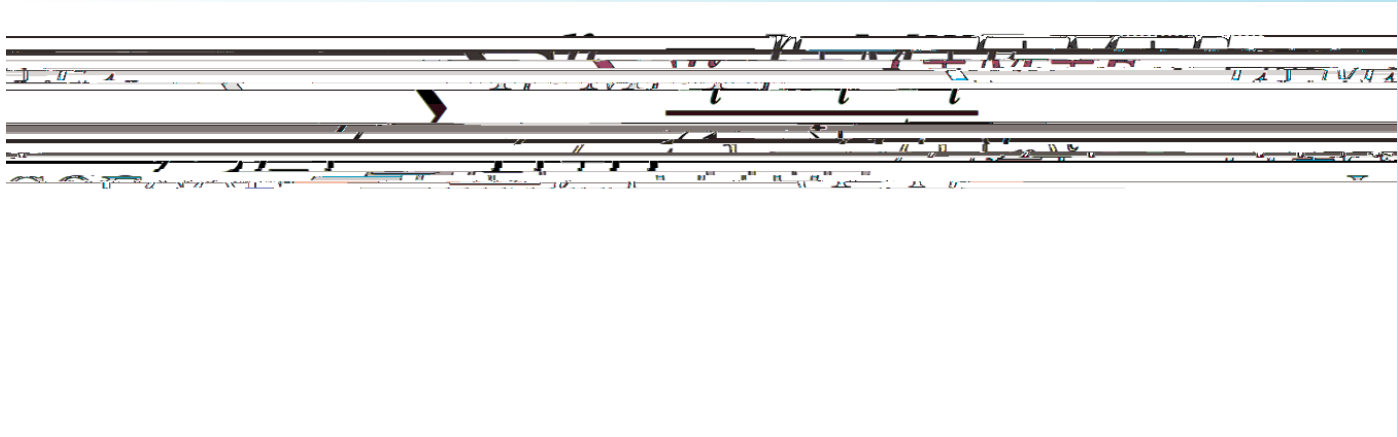


Geothermal drilling, formation evaluation, and downhole monitoring is the most challenging with hottest and hardest demanding conditions.

This environment severely limits the life and performance of electronic components, sub-systems, and turn-key designs.

Given:

LEVELIZED COST OF ELECTRICITY LCOE Formula



I_0 = investment expenditures in the year t ; M_t = O&M expenditures in the year t ; E_t = fuel expenditures in the year



Presentation Goals:

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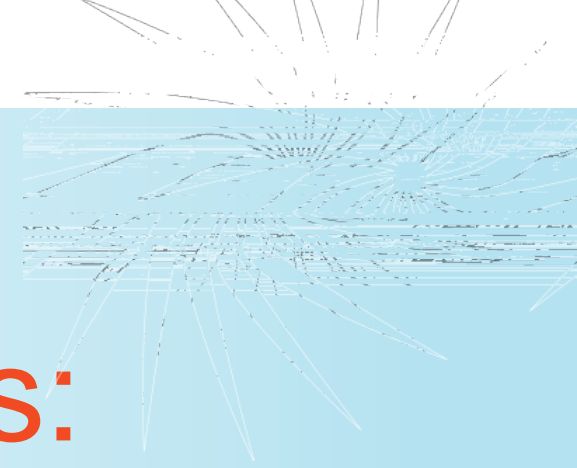
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The definition of high temperD6tDe TJ-.D6to-.c

Applications

High Temperature Downhole Disciplines:



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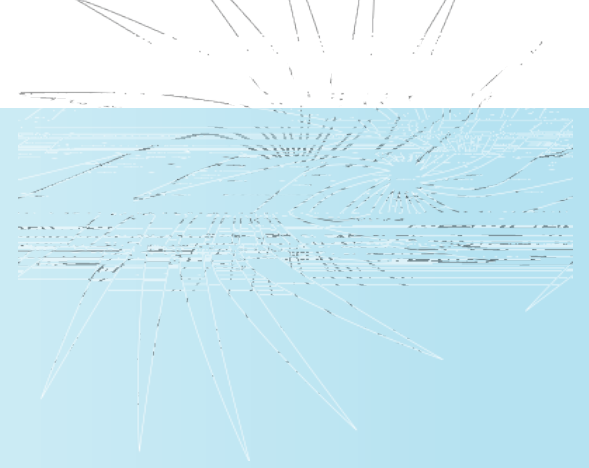
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High Temperature Electronics for Downhole Environments Applications

High Temperature Silicon Components

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200°C with appropriate high temperature

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X-Rel Semiconductor

SOI Reliability Assessment

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High Temp Components:

EVANS CAPACITOR 200°C

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APEI 225°C

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SPJ Thick Film RESISTORS 300°C

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UNITED SILICON CARBIDE 260°C

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VECTRON INTERNATIONAL 230°C

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VANGUARD ELECTRONICS 220°C

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X-REL SEMICONDUCTOR 230°C

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CRITERIA LABS HT DIE PACKAGING 230°C

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High Temperature Sub-Systems And Design Services

Very Little "Off the Shelf" solutions exist above 175°C

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200°C

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Joule Design Services:

CAPACITOR MODULES 200°C

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POWER SUPPLIES 200°C

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SOI DATA ACQUISITION 225°C

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SILICON CARBIDE POWER MODULES 260°C

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REAL-TIME CLOCK MODULES 180°C

CUSTOM MAGNETICS 220°C

HIGH TEMPERATURE CHARACTERIZATION/AGING 230°C

DIE, MCM AND HYBRID PACKAGING 240°C

DOWNHOLE & SURFACE ELECTRICAL AND MECHANICAL
ENGINEERING SERVICES -40°C to 230°C

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Conclusion

Cost-competitive energy

requires technology development

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