Sensor Network Energy Demand

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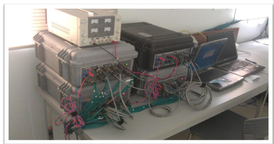
Background

- The Savannah River Site was constructed in the early 1950's to produce basic materials used in the fabrication of nuclear weapons
- 84 facilities in the complex are candidates for ISD closure
- FIU and SRS partnered up to gain a better understanding of the performance of cementitious materials used for ISD
- FIU is supporting in the development of a meso-scale grouted monolith test bed for the deployment and evaluation of sensor systems

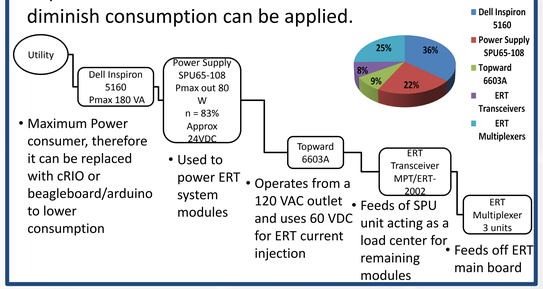
Introduction

- Electrical Resistance Tomography System (ERT) generates a cross-sectional image showing the distribution of electrical conductivity of the grout contents.
- This is done by injecting a current by one electrode, and allowing the rest to act as receivers.
- This conductivity data correlates to the grout hardening process, meaning there is less water, indicating the hydration process is coming to completion.
- The Temperature Probe System uses thermocouple sensors to acquire temperature data of the grout.

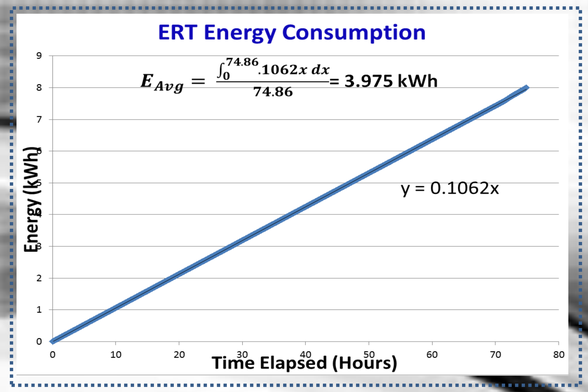


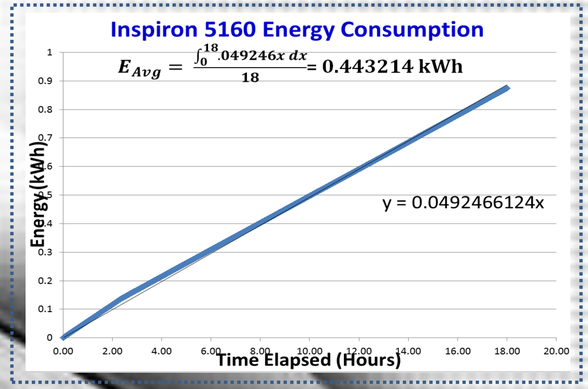
Problem Statement

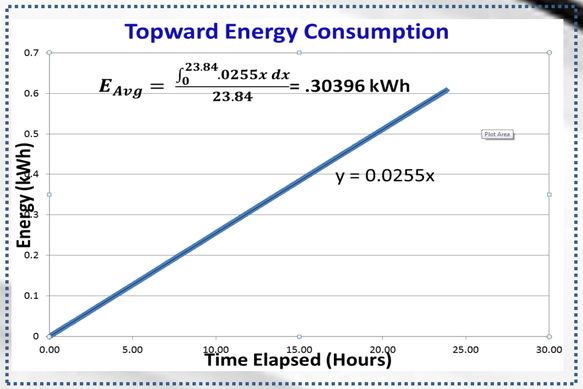
ERT System consumes too much power in the sensor network, therefore other sources of energy need to be implemented to reduce cost or new methods to diminish consumption can be applied.



Load Analysis







Temperature Probe System Power Consumption

Load Description	Quantity	Load Current (A)	Load Voltage (V)	DC Load Power (W)	AC Load Power (W)	Daily Duty Cycle (HRS/Day)	Power Conversion Efficiency	DC Bus Voltage (V)	Amp-Hour Load (AH/Day)
Dell Latitude D820	1	N/A	N/A	90	N/A	24	1	14.8	158.38
Power Supply PSC15A-120S	1	N/A	N/A	22	N/A	24	0.7	12	68.21
ADAM-4018	11	N/A	N/A	8.8	N/A	24	1	24	9.55
ADAM-4017+	1	N/A	N/A	1.2	N/A	24	1	24	1.30
ADAM-4520	1	N/A	N/A	1.2	N/A	24	1	24	1.30
				123.2					238.74

This figure shows the Power Analyzer Extech 3803 that was used to measure energy consumption of this equipment. It uses the RS-232 protocol to communicate with the laptop. Additionally, the input load socket is for the power source and the output load socket is for the load being measured.

Renewable Sources of Energy

Solar

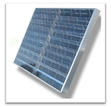
Temperature Probe System PV Array Size

Total DC Power (W)	Daily Duty Cycle (HRS/Day)	Energy Demand (Whr)	20% losses added (Whr)	Bat storage with 2.5-day back up (Whr)	20% Bat Factor added (Whr)	Needed Bat Charge/Day (Whr)	Peak Sun Hours/Day	PV Array Size (W)
123.2	24	2956.8	3548.16	8870.4	10644.48	2128.896	4.5	473.088

Electrical Resistance Tomography System PV Array Size

Energy Demand (Whr)	20% losses added (Whr)	Bat storage with 2.5-day back up (Whr)	20% Bat Factor added (Whr)	Needed Bat Charge/Day (Whr)	Peak Sun Hours/Day	PV Array Size (W)
3975	4770	11925	14310	2862	4.5	636

- Using 215 Watt Kyocera solar panels, three would be required to meet the energy demands of the ERT
- Using 240 Watt Kyocera solar panels, two would be required to meet energy demands of the TPS

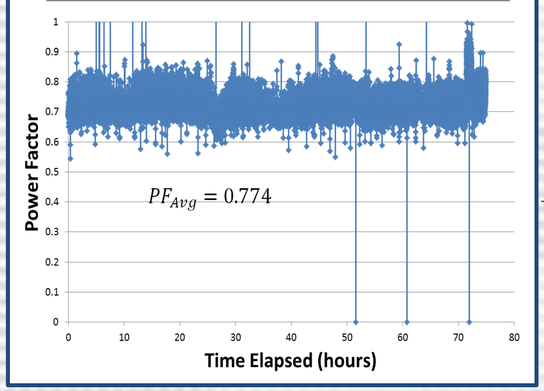


Wind

Wind Turbine Model	Whisper 200	1 kW Talon
Blade Length (m)	1.35	1.4
AVG Miami Wind Speed (m/s)	3.58	3.58
Air Density (kg/m^3)	1.23	1.23
Power Coefficient	0.4	0.4
Blade Radius Squared	1.823	1.96
AVG Miami Wind Speed cubed (m/s)^3	45.883	45.883
Blade Swept Area (m^2)	5.726	6.158
Wind Converted to Rotational Energy (W)	64.63	69.50

- Power converted from the wind into rotational energy is given by: $P_{Ava} = \frac{1}{2}\,\rho A V^3 C_P$
- The results show that not enough energy can be produced from the wind turbines to power ERT or TPS

ERT Power Factor



Alternative Solutions

- Adding a capacitor bank to counteract inductive loading from the ERT making the load appear mostly resistive (power factor correction)
- Removing the Dell Inspiron 5160 from the sensor network and substituting it with an Arduino microcontroller to store the data for it to be transferred to another location
- Diminishing the amount of current used during the current injection process for data acquisition

Future Work/Conclusion

- Solar panels prove to be more efficient and economic in Miami than wind turbines
- The ERT demands 57.4% of energy from the entire sensor network system of which 11.15% comes from the Dell Inspiron 5160
- Use alternative sources of energy to provide some of the power supply
- Research to implement other renewable sources of energy such as hydrogen fuel cell systems or geothermal electricity production

Acknowledgements

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