How Much Does That Lab Equipment Consume Anyways?

Electrical Metering of Large Load Equipment Without The Need For An Electrician

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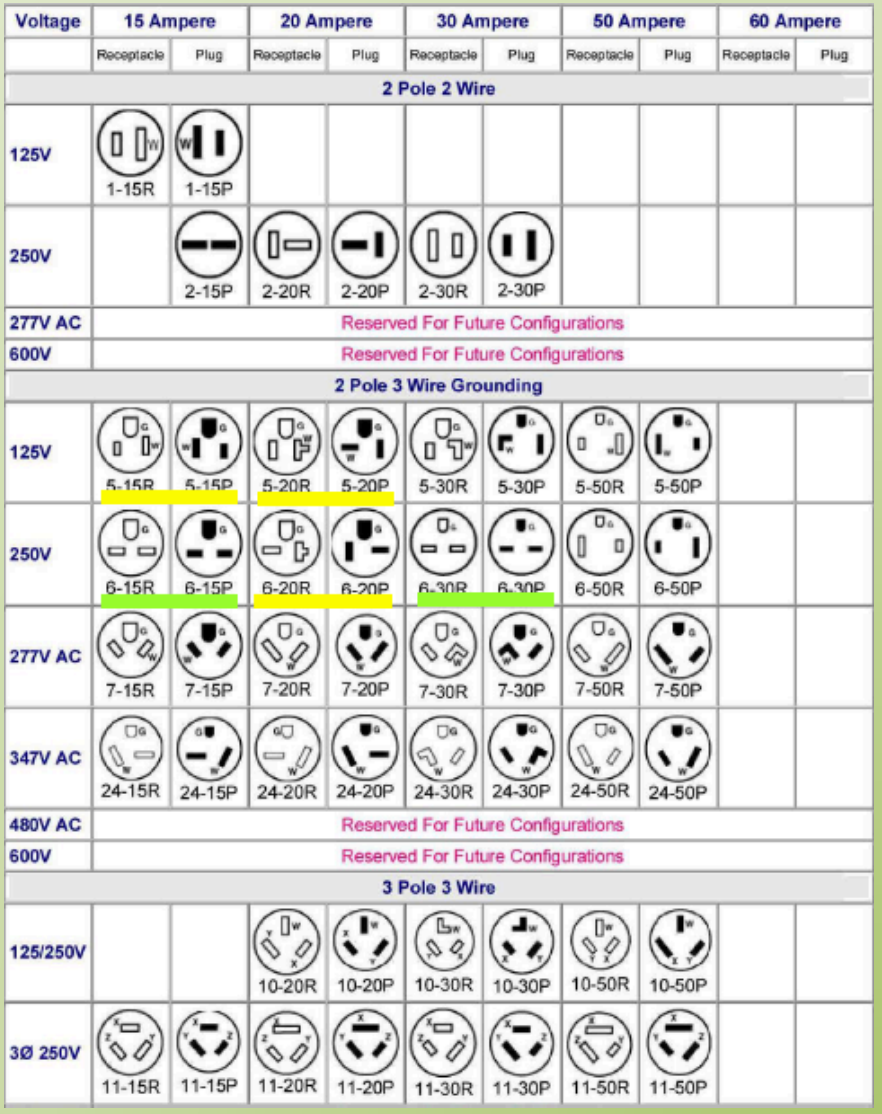
Learning Objectives

1. Metering system and set-up
2. Awareness of large consumers
3. Energy efficient alternatives

How it all began

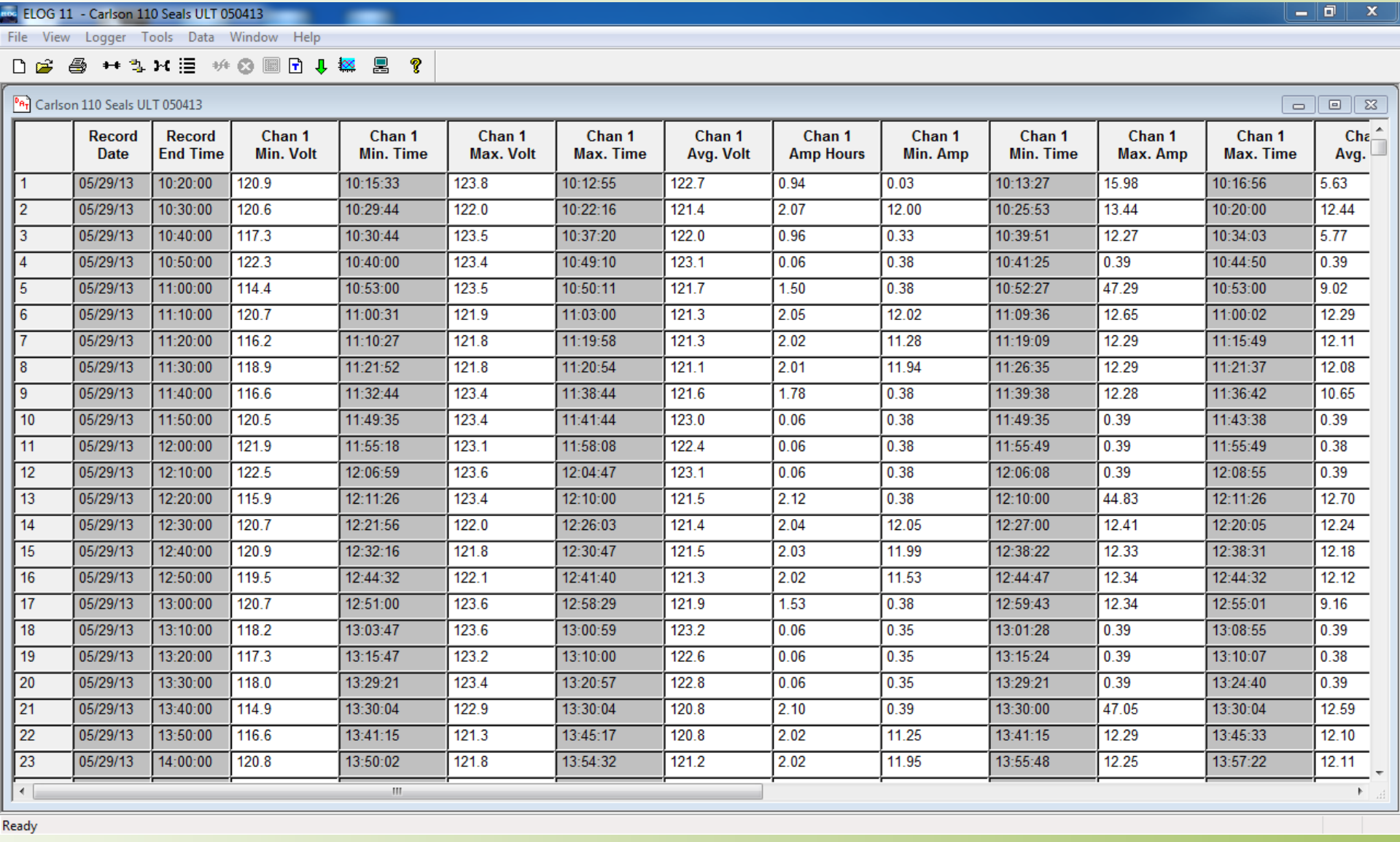
- Grant funding
- Labs21 Survey Protocol
- Cords with different NEMA plugs
- Training by campus tech



Voltage	15 Ampere		20 Ampere		30 Ampere		50 Ampere		60 Ampere	
	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug	Receptacle	Plug
2 Pole 2 Wire										
125V	1-15R	1-15P								
250V		2-15P	2-20R	2-20P	2-30R	2-30P				
277V AC	Reserved For Future Configurations									
600V	Reserved For Future Configurations									
2 Pole 3 Wire Grounding										
125V	5-15R	5-15P	5-20R	5-20P	5-30R	5-30P	5-50R	5-50P		
250V	6-15R	6-15P	6-20R	6-20P	6-30R	6-30P	6-50R	6-50P		
277V AC	7-15R	7-15P	7-20R	7-20P	7-30R	7-30P	7-50R	7-50P		
347V AC	24-15R	24-15P	24-20R	24-20P	24-30R	24-30P	24-50R	24-50P		
480V AC	Reserved For Future Configurations									
600V	Reserved For Future Configurations									
3 Pole 3 Wire										
125/250V			10-20R	10-20P	10-30R	10-30P	10-50R	10-50P		
3Ø 250V	11-15R	11-15P	11-20R	11-20P	11-30R	11-30P	11-50R	11-50P		

Demonstration

ELOG software


ELOG 11 - Carlson 110 Seals ULT 050413

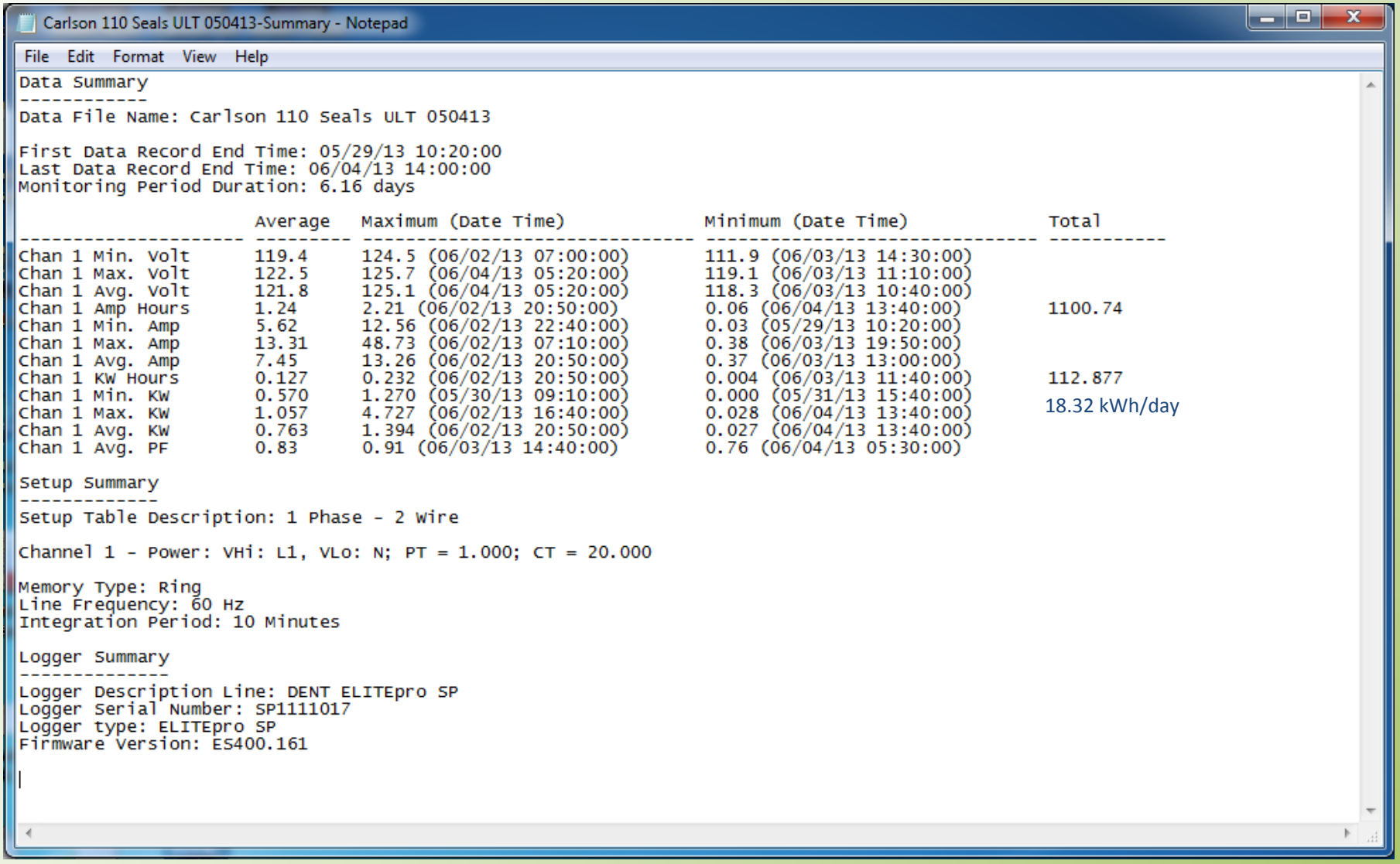
File View Logger Tools Data Window Help

Carlson 110 Seals ULT 050413

	Record Date	Record End Time	Chan 1 Min. Volt	Chan 1 Min. Time	Chan 1 Max. Volt	Chan 1 Max. Time	Chan 1 Avg. Volt	Chan 1 Amp Hours	Chan 1 Min. Amp	Chan 1 Min. Time	Chan 1 Max. Amp	Chan 1 Max. Time	Cha Avg.
1	05/29/13	10:20:00	120.9	10:15:33	123.8	10:12:55	122.7	0.94	0.03	10:13:27	15.98	10:16:56	5.63
2	05/29/13	10:30:00	120.6	10:29:44	122.0	10:22:16	121.4	2.07	12.00	10:25:53	13.44	10:20:00	12.44
3	05/29/13	10:40:00	117.3	10:30:44	123.5	10:37:20	122.0	0.96	0.33	10:39:51	12.27	10:34:03	5.77
4	05/29/13	10:50:00	122.3	10:40:00	123.4	10:49:10	123.1	0.06	0.38	10:41:25	0.39	10:44:50	0.39
5	05/29/13	11:00:00	114.4	10:53:00	123.5	10:50:11	121.7	1.50	0.38	10:52:27	47.29	10:53:00	9.02
6	05/29/13	11:10:00	120.7	11:00:31	121.9	11:03:00	121.3	2.05	12.02	11:09:36	12.65	11:00:02	12.29
7	05/29/13	11:20:00	116.2	11:10:27	121.8	11:19:58	121.3	2.02	11.28	11:19:09	12.29	11:15:49	12.11
8	05/29/13	11:30:00	118.9	11:21:52	121.8	11:20:54	121.1	2.01	11.94	11:26:35	12.29	11:21:37	12.08
9	05/29/13	11:40:00	116.6	11:32:44	123.4	11:38:44	121.6	1.78	0.38	11:39:38	12.28	11:36:42	10.65
10	05/29/13	11:50:00	120.5	11:49:35	123.4	11:41:44	123.0	0.06	0.38	11:49:35	0.39	11:43:38	0.39
11	05/29/13	12:00:00	121.9	11:55:18	123.1	11:58:08	122.4	0.06	0.38	11:55:49	0.39	11:55:49	0.38
12	05/29/13	12:10:00	122.5	12:06:59	123.6	12:04:47	123.1	0.06	0.38	12:06:08	0.39	12:08:55	0.39
13	05/29/13	12:20:00	115.9	12:11:26	123.4	12:10:00	121.5	2.12	0.38	12:10:00	44.83	12:11:26	12.70
14	05/29/13	12:30:00	120.7	12:21:56	122.0	12:26:03	121.4	2.04	12.05	12:27:00	12.41	12:20:05	12.24
15	05/29/13	12:40:00	120.9	12:32:16	121.8	12:30:47	121.5	2.03	11.99	12:38:22	12.33	12:38:31	12.18
16	05/29/13	12:50:00	119.5	12:44:32	122.1	12:41:40	121.3	2.02	11.53	12:44:47	12.34	12:44:32	12.12
17	05/29/13	13:00:00	120.7	12:51:00	123.6	12:58:29	121.9	1.53	0.38	12:59:43	12.34	12:55:01	9.16
18	05/29/13	13:10:00	118.2	13:03:47	123.6	13:00:59	123.2	0.06	0.35	13:01:28	0.39	13:08:55	0.39
19	05/29/13	13:20:00	117.3	13:15:47	123.2	13:10:00	122.6	0.06	0.35	13:15:24	0.39	13:10:07	0.38
20	05/29/13	13:30:00	118.0	13:29:21	123.4	13:20:57	122.8	0.06	0.35	13:29:21	0.39	13:24:40	0.39
21	05/29/13	13:40:00	114.9	13:30:04	122.9	13:30:04	120.8	2.10	0.39	13:30:00	47.05	13:30:04	12.59
22	05/29/13	13:50:00	116.6	13:41:15	121.3	13:45:17	120.8	2.02	11.25	13:41:15	12.29	13:45:33	12.10
23	05/29/13	14:00:00	120.8	13:50:02	121.8	13:54:32	121.2	2.02	11.95	13:55:48	12.25	13:57:22	12.11

Ready

ELOG software


Carlson 110 Seals ULT 050413-Summary - Notepad

File Edit Format View Help

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Data Summary
------------
Data File Name: Carlson 110 Seals ULT 050413

First Data Record End Time: 05/29/13 10:20:00
Last Data Record End Time: 06/04/13 14:00:00
Monitoring Period Duration: 6.16 days

                     Average   Maximum (Date Time)              Minimum (Date Time)              Total
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Chan 1 Min. Volt     119.4     124.5 (06/02/13 07:00:00)       111.9 (06/03/13 14:30:00)
Chan 1 Max. Volt     122.5     125.7 (06/04/13 05:20:00)       119.1 (06/03/13 11:10:00)
Chan 1 Avg. Volt     121.8     125.1 (06/04/13 05:20:00)       118.3 (06/03/13 10:40:00)
Chan 1 Amp Hours     1.24      2.21 (06/02/13 20:50:00)        0.06 (06/04/13 13:40:00)        1100.74
Chan 1 Min. Amp      5.62      12.56 (06/02/13 22:40:00)       0.03 (05/29/13 10:20:00)
Chan 1 Max. Amp      13.31     48.73 (06/02/13 07:10:00)       0.38 (06/03/13 19:50:00)
Chan 1 Avg. Amp      7.45      13.26 (06/02/13 20:50:00)       0.37 (06/03/13 13:00:00)
Chan 1 KW Hours      0.127     0.232 (06/02/13 20:50:00)       0.004 (06/03/13 11:40:00)       112.877
Chan 1 Min. KW       0.570     1.270 (05/30/13 09:10:00)       0.000 (05/31/13 15:40:00)
Chan 1 Max. KW       1.057     4.727 (06/02/13 16:40:00)       0.028 (06/04/13 13:40:00)       18.32 kWh/day
Chan 1 Avg. KW       0.763     1.394 (06/02/13 20:50:00)       0.027 (06/04/13 13:40:00)
Chan 1 Avg. PF       0.83      0.91 (06/03/13 14:40:00)        0.76 (06/04/13 05:30:00)

Setup Summary
-------------
Setup Table Description: 1 Phase - 2 Wire

Channel 1 - Power: VHi: L1, VLo: N; PT = 1.000; CT = 20.000

Memory Type: Ring
Line Frequency: 60 Hz
Integration Period: 10 Minutes

Logger Summary
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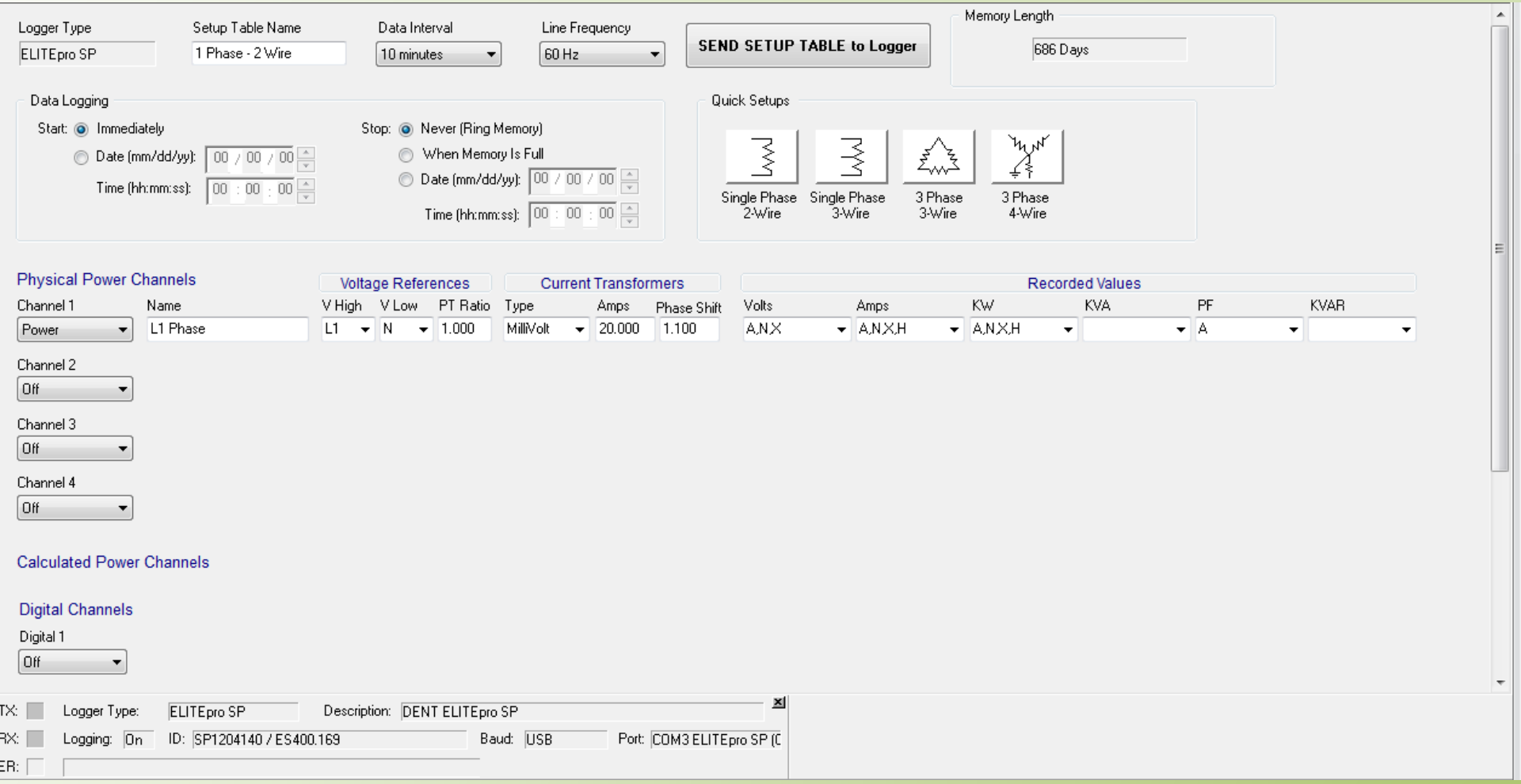
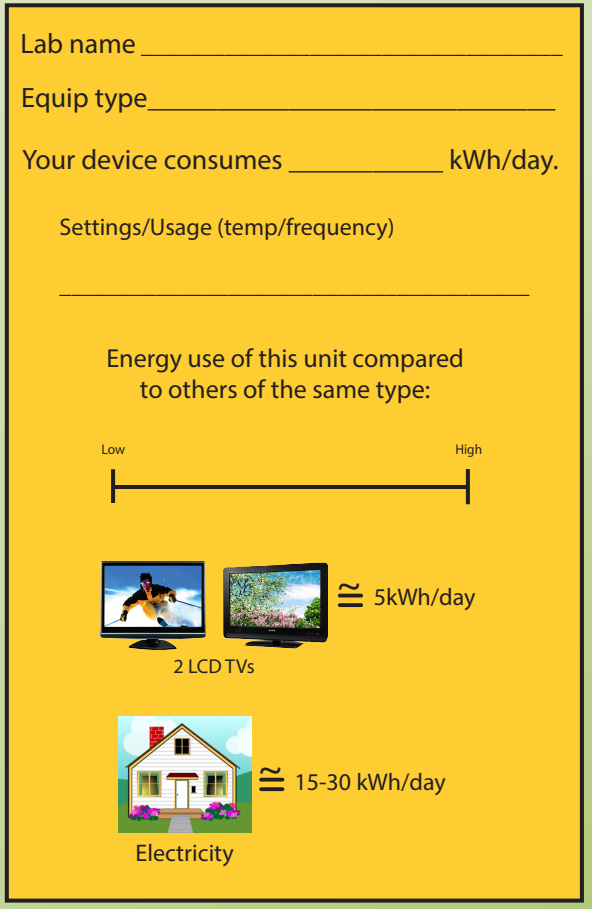
Logger Description Line: DENT ELITEpro SP
Logger Serial Number: SP1111017
Logger type: ELITEpro SP
Firmware Version: ES400.161
```

ELOG software



Benefits of metering equipment

- Unit performance- is it struggling?
- What's the consumption?
- How does it compare?
- FacMan incentives to replace?
- Awareness, Action →Industry response



Ultra Low Temp (ULT) Freezer

- Metered at 27 kWh/day
- Compressor failed
- Green Labs suggestions
  - Energy efficient options
  - Raising temp to -70°C
- FacMan offer of $2140 to replace (9 kWh/day)
- Electricity savings of 66%

Equipment to Keep an Eye Out For

- ULT freezers
- Lab grade freezers (-40^{o}C or -30^{o}C or -20^{o}C)
- Chromatography refrig (glass door refrig)
- Low Temp Incubators
- Drying ovens
- Biosafety Cabinets

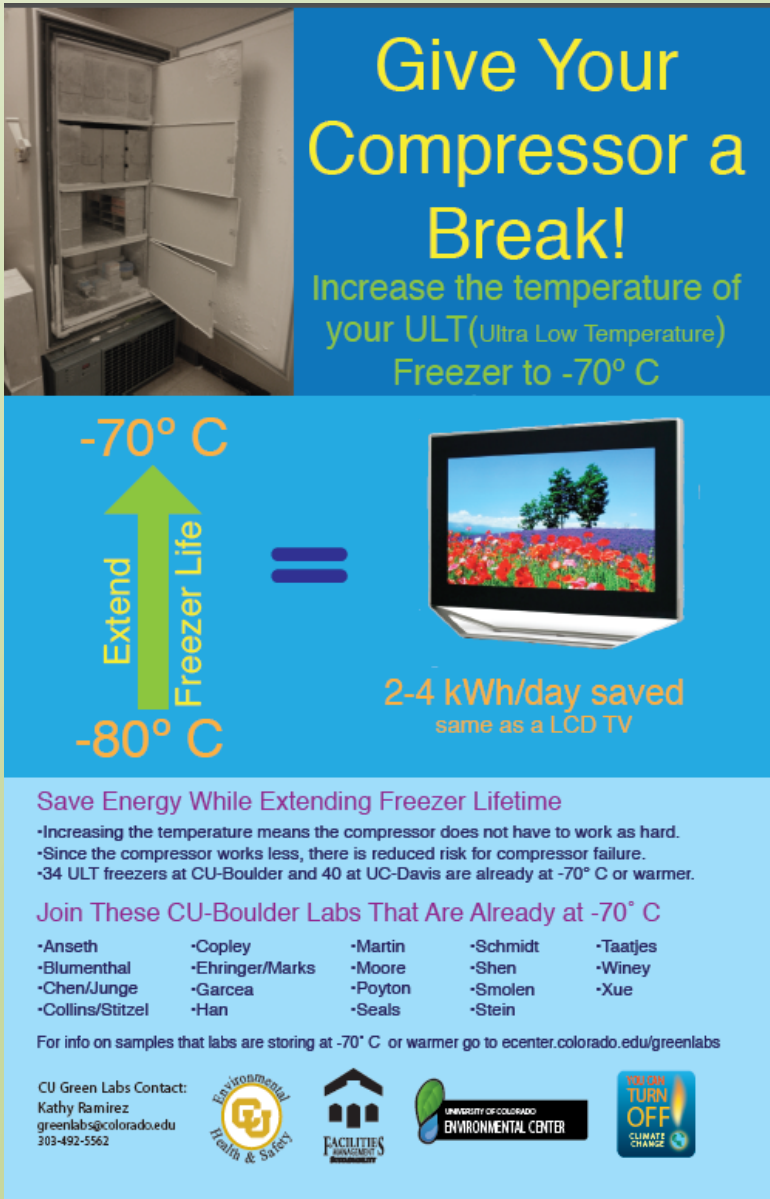
ULT Freezer -80°C to -70°C

- Use 8-30 kWh/day
- -70°C metered to save 2-7 kWh/day
- ~60% of 110 units are at -70°C
- Database of practices

10 X 

electricity

(25 kWh/day/house)



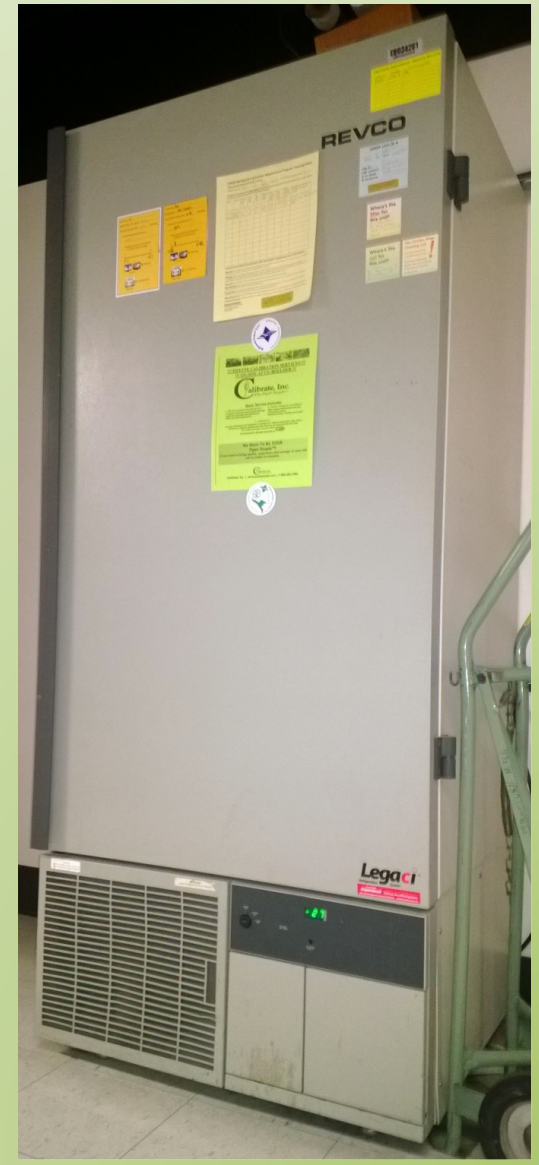
Database of cold storage practices

Biosamples stored long term at -70°C or warmer

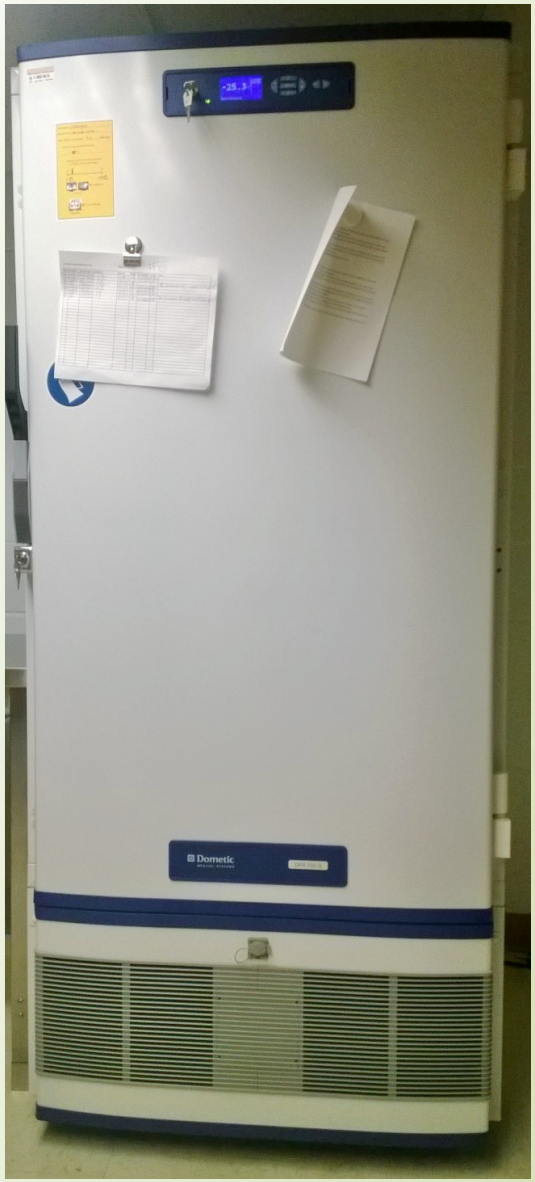
Sample Type	Temp (degrees C)	Duration sample stored in freezer	Duration freezer at indicated temp	University	Dept	Lab PI
plant tissue	4	3-6 years	since purchase	CU-Boulder	Ecology and Evolutionary Biology	Pamela Diggle
water samples for nutrient analysis	-20	0.5-1 year	since purchase	CU-Boulder	Ecology and Evolutionary Biology	Pieter Johnson
frozen worms	-70	0.5-1 year	since 1995	CU-Boulder	Molecular, Cellular, Developmental Biology	Tom Blumenthal
competent cells	-70	1-3 years	since 1995	CU-Boulder	Molecular, Cellular, Developmental Biology	Tom Blumenthal
RNA, DNA, cellular extracts, purified proteins	-70	>10 years	since 1995	CU-Boulder	Molecular, Cellular, Developmental Biology	Tom Blumenthal
competent cells, worm strains, antibodies, DNA, RNA	-70	3-6 years	since summer 2010	CU-Boulder	Molecular, Cellular, Developmental Biology	Min Han
competent cells, samples for mass spec, pellicles	-60 and -70	0.5-1 year	since spring 2010	CU-Boulder	Molecular, Cellular, Developmental Biology	Mark Winey
cell lysates, protein samples	-60 and -70	1-3 years	since spring 2010	CU-Boulder	Molecular, Cellular, Developmental Biology	Mark Winey
antibodies	-60 and -70	3-6 years	since spring 2010	CU-Boulder	Molecular, Cellular, Developmental Biology	Mark Winey
yeast and bacterial stock strains	-60 and -70	>10 years	since spring 2010	CU-Boulder	Molecular, Cellular, Developmental Biology	Mark Winey

Lab Grade Freezer (-40, -30, -20°C)

- Typically 5 - 12 kWh/day
- This unit: 14.9 kWh/day at -40°C
- Raised temp to -25°C, 6.3 kWh/day
- 8.6 kWh/day saved; 60% reduction



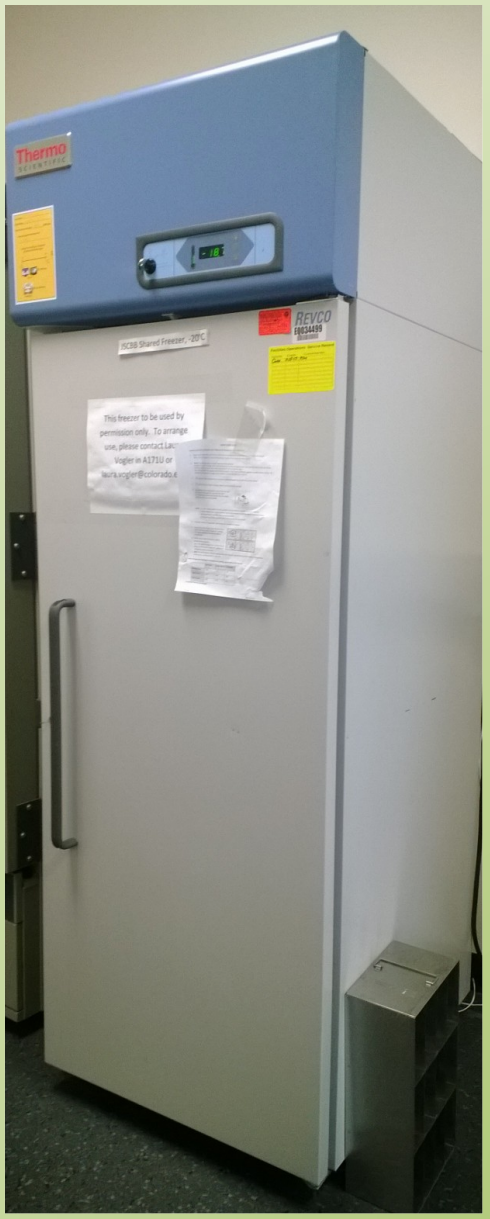
Lab Grade Freezer (-40 to -25ºC)



- 7.1 kWh/day at -40ºC by manufacturer
- Unit at -25ºC, using 3.6 kWh/ day
- 50% savings

Lab Grade -20°C Freezer

- New, yet uses 13.3 kWh/ day!
- More than some ULT freezers at -80°C
- Need to pressure industry to change
- Energy Star -20°C use 2 kWh/day, works for most labs



Chromatography Refrigerators

- Use 5-10 kWh/day
- Many not used for chromatography
- Residential refrig 1.2 kWh/day, works for most labs

Low Temperature Incubators

- Use 5-20 kWh/day,
- Heating only units use as low as 0.1 kWh/day

30°C, 14.6 kWh/day
(+ 8.2 kWh/day small unit)

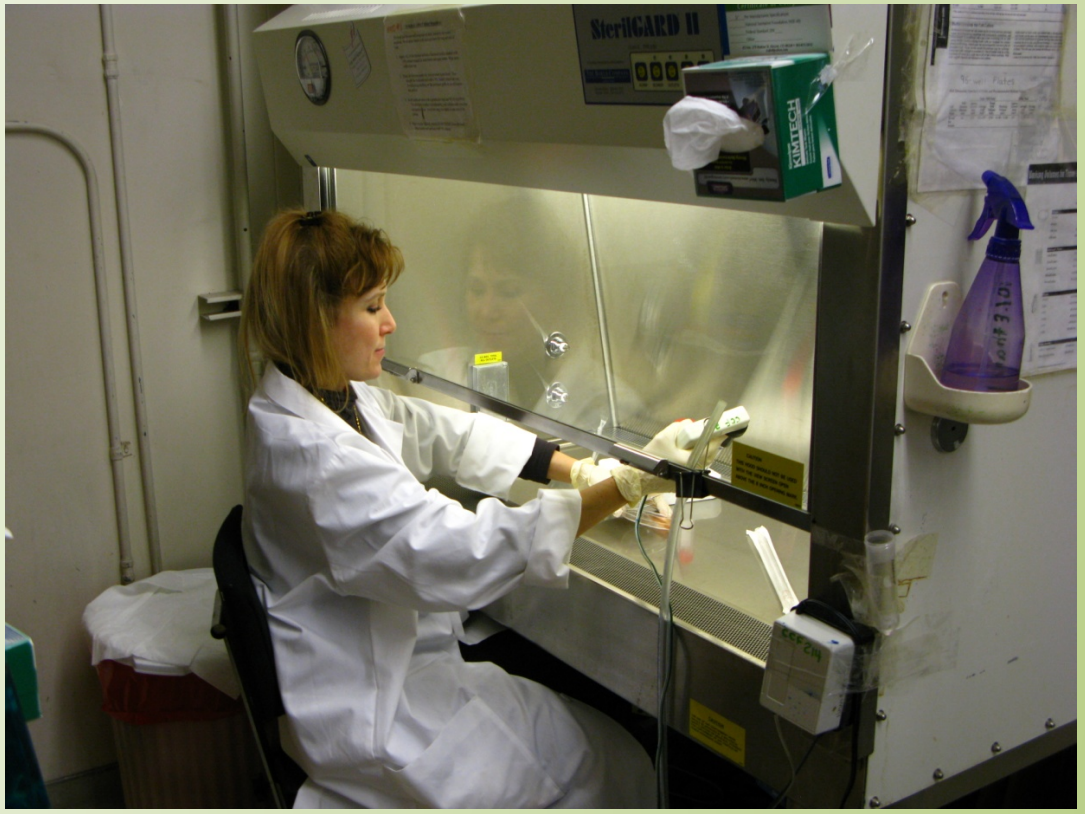
30°C, 0.23 kWh/day
Binder BD 400

Drying Ovens

- 0.1 to 28 kWh/day
- Eject heat into the lab space
- Sharing, timers, off when not in use

Biosafety Cabinets (BSCs)

- Metered 11.1 kWh/day (4 ft) & 18.8 kWh/day (6 ft)
- Blowers off overnight, ~40% savings
- UV light not recommended by NIH, CDC, NSF
- Working with EH&S on signage



Suggestions

- Energy efficient ULT freezers
- Temp choice: -70^{o}C and room temp sample storage
- Avoid lab grade freezers & chromatography refrig
  - Energy Star, residential units work for most labs
- Watch for Low Temp incubator use for refrig or warmer than room temp →replace with heating only unit
- BSCs off when not in use→energy savings & longer filter life
- Drying ovens: consolidate, timers, off when not in use

Acknowledgements

- Colorado Dept of Public Health and Environment
- I2SL and Labs21
- University of Colorado Boulder (CU-Boulder) Facilities Management
- CU Boulder Environmental Center
- CU Boulder Environmental Health and Safety
- CU Green Labs Program & Kathy Ramirez-Aguilar

Questions

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