Energy Harvesting Sensor Nodes: Benchmarking And Implications On Transmit Power Adaptation

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MTP Stage - 1

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Outline

- Motivation
- Related Work
- Definition
- 3 components
  - Hardware Design
  - Experiments & Measurements
  - Algorithm
- Time Line & Future Work
- References

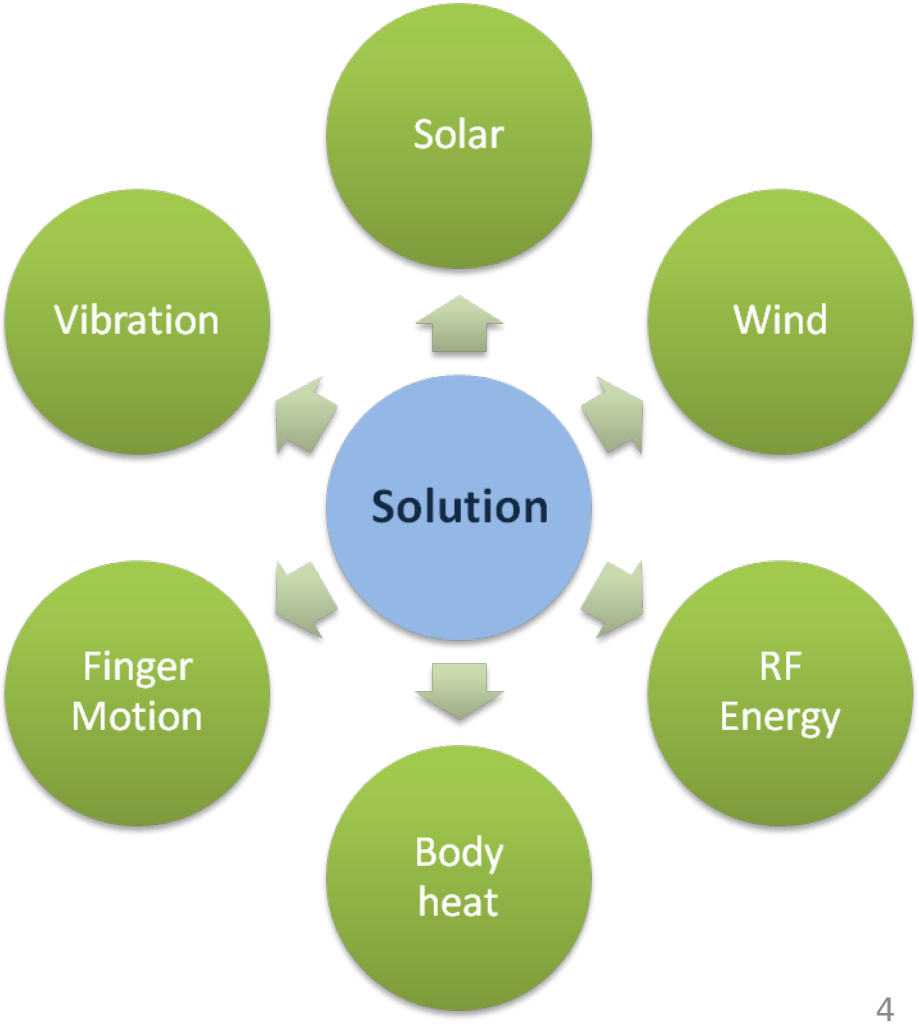
Motivation

- Wide usage of the WSNs.
- Easy deployment in inflexible environment
- Used for various applications
  - Habitat monitoring
    - Great Duck Island
    - eFlux on Turtle
    - ZebraNet
    - Trio
  - Volcano monitoring
  - Structural monitoring

Motivation

Trade off

Life Of Node	Accuracy
Big Battery = longer life	Lower Accuracy = longer life



Definition

Propose an algorithm for adapting the transmit power for better utilization of available energy based on the measurements derived from custom built harvesting aware sensor node.

3 components

- Hardware Design
  - Node architecture
    - Charging circuit
    - Monitor Module
- Experiments & Measurements
  - Charging profiles generation
- Algorithm
  - Transmit Power Adaptation

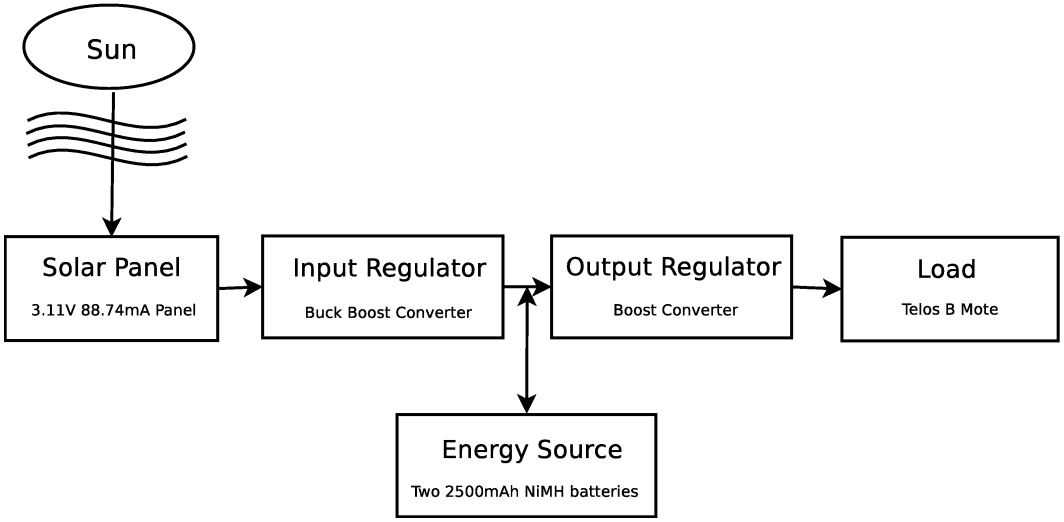
Hardware Design

- Why Solar energy ?
- Which Battery ?

- Related Work
  - **HydroWatch**
    - **Micro climate monitoring in deep forest**
  - Heliomote
  - Prometheus

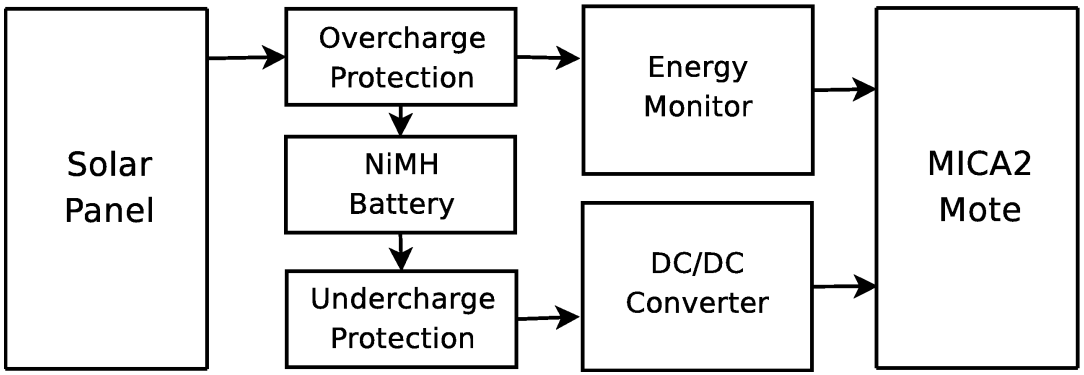
Energy Source	Characteristics
Solar	**Ambient, Predictable**
Wind	Ambient, Uncontrollable, Predictable
RF Energy	Ambient, Partially controllable
Body Heat, Breathing, Blood Pressure	Passive human power, Unpredictable
Finger motion	Active human power, fully controllable
Vibrations	Ambient, Unpredictable

HydroWatch



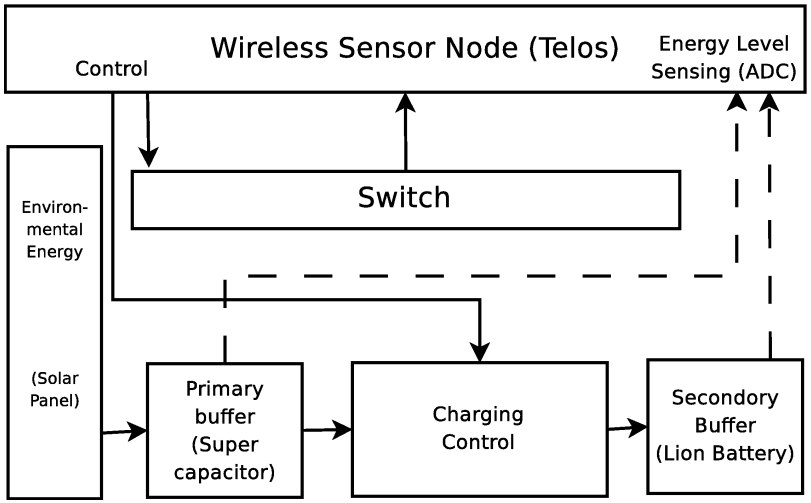
- Using solar panels for harvesting
- 2 NiMH batteries
- Simple circuit
- Telosb for monitoring
- Input and Output regulators
- Trickle charging

Heliomote



- 2 NiMH Batteries
- MICA2 for logic control
- Under charge and Overcharge protection
- Complex circuit

Prometheus

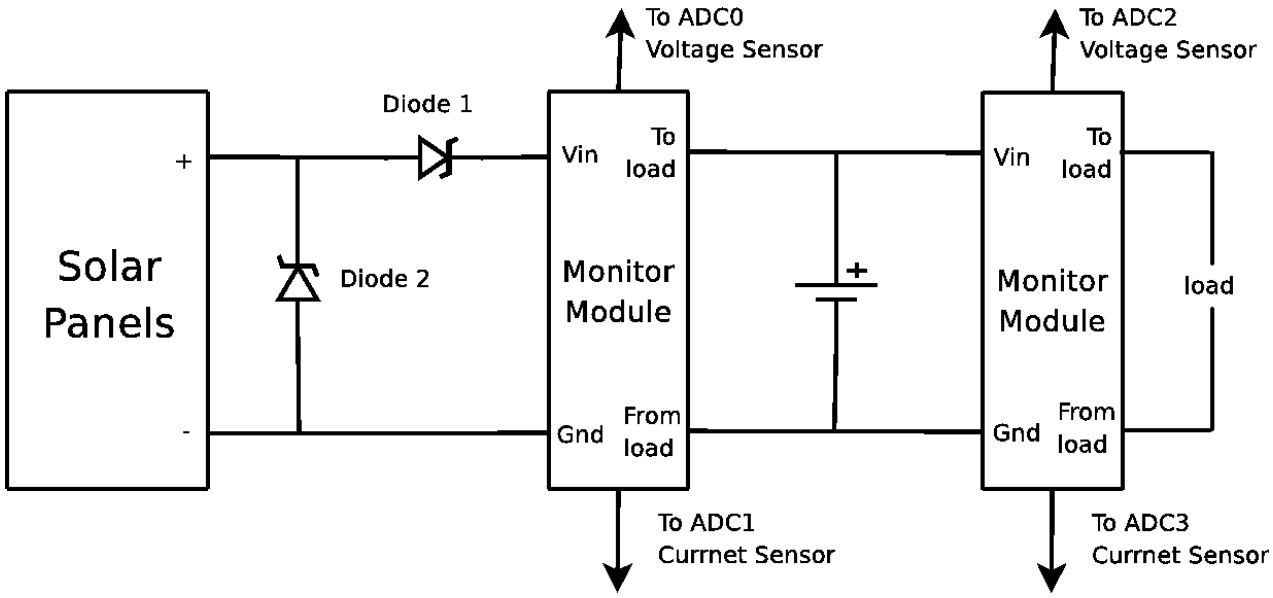


- Lion Battery, super capacitor
- Pulse charging
- Complex circuit.
- Protection for shallow discharge cycles.

Comparison

	Pros	Cons
Hydrowatch	Simple Circuit	Lower life
Heliomote	Overcharging and Undercharging protection	Complex circuit
Prometheus	Log lifetime	Complex Design

Node Architecture

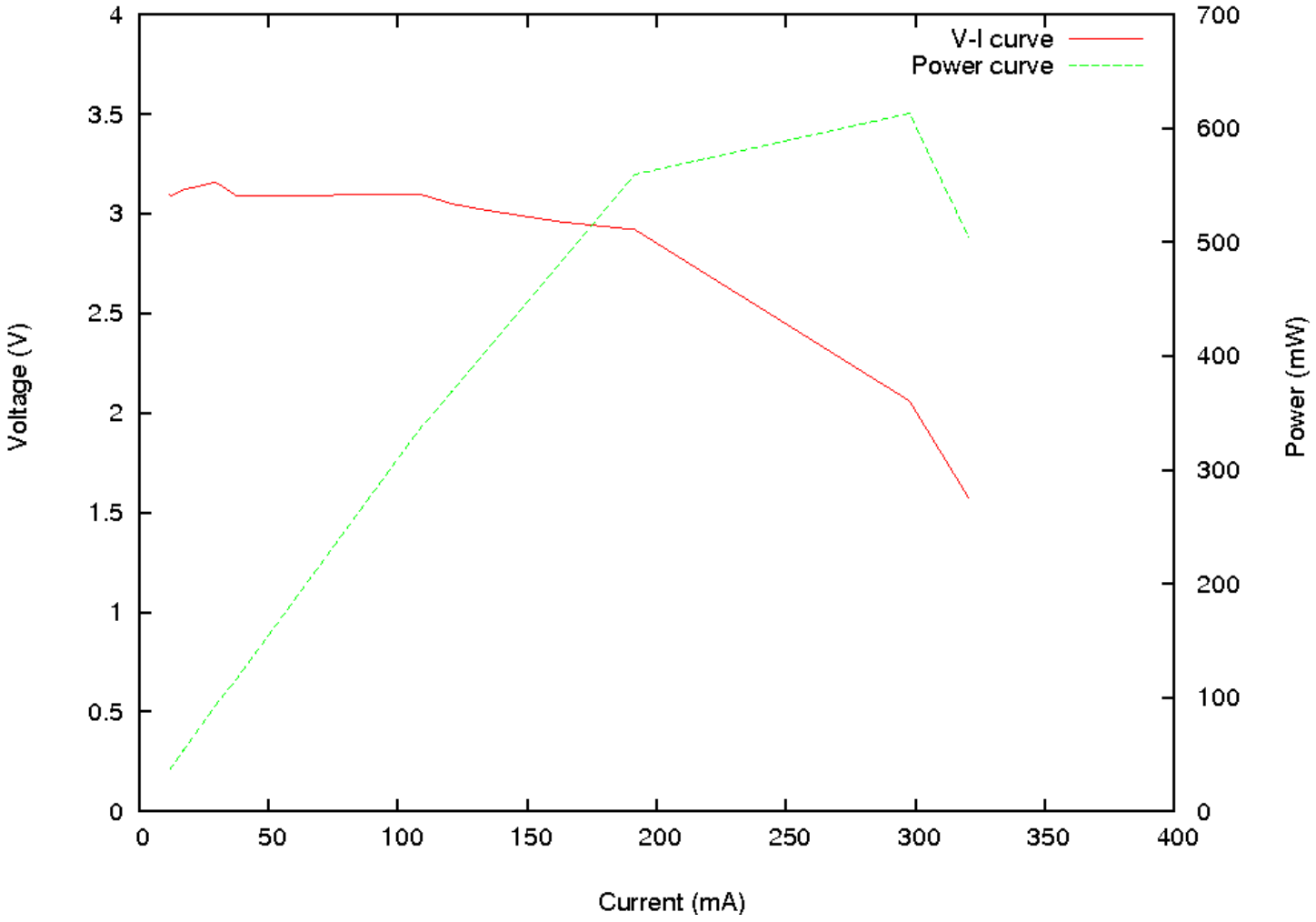


- Battery – NiMH (2 X AA) – Trickle charging
- Solar Panel – 3 V - 165 mA – Amorphous

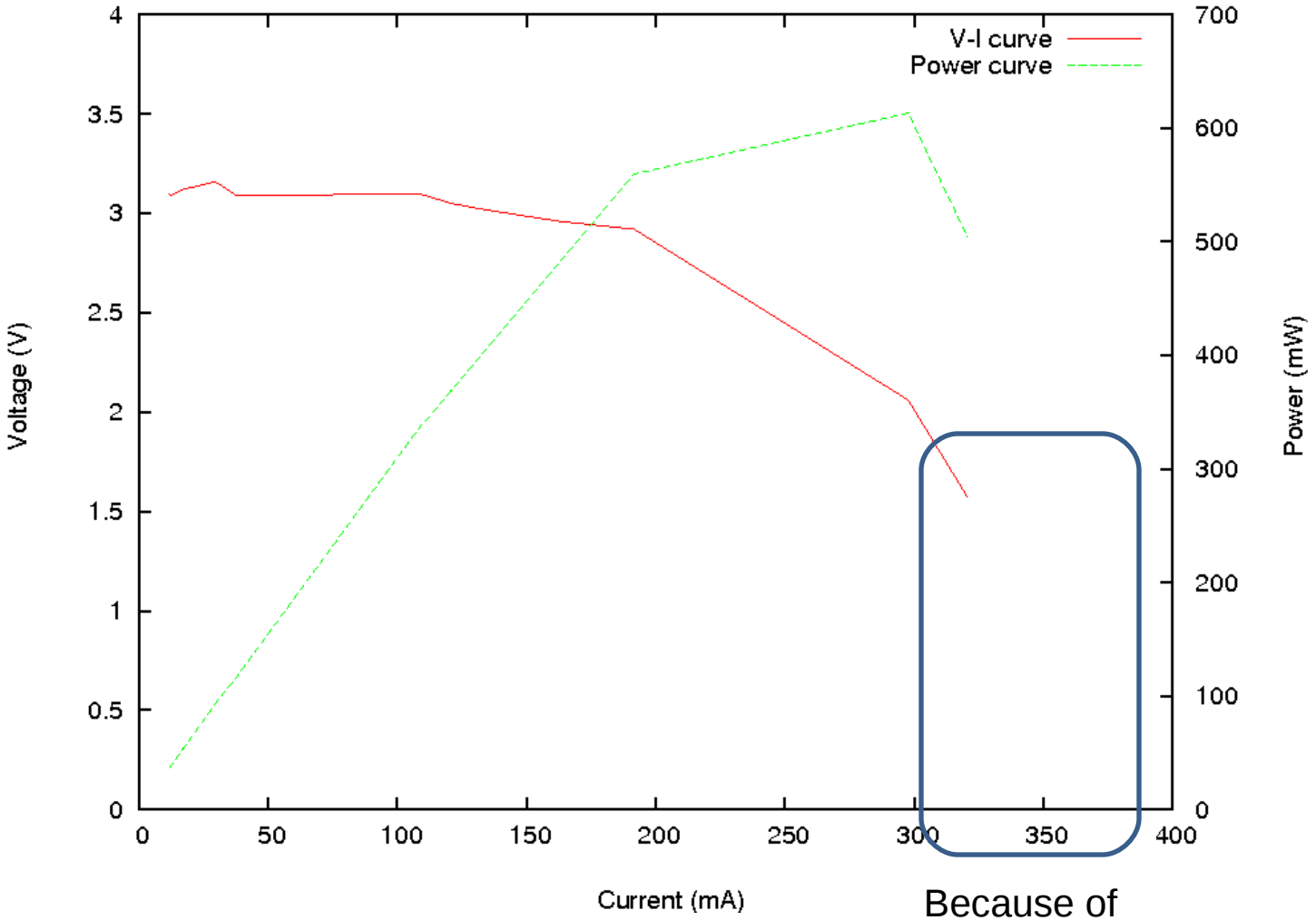
Experiments & Measurements

- Characterizing the solar panel
- Energy calculation
  - Different environments
    - In CSE building terrace
    - On window facing the sunset.
    - On window facing the sunrise.
    - In woods
  - Different solar panels
  - Different weather condition.
  - Same time different days.

Solar panel Characterization

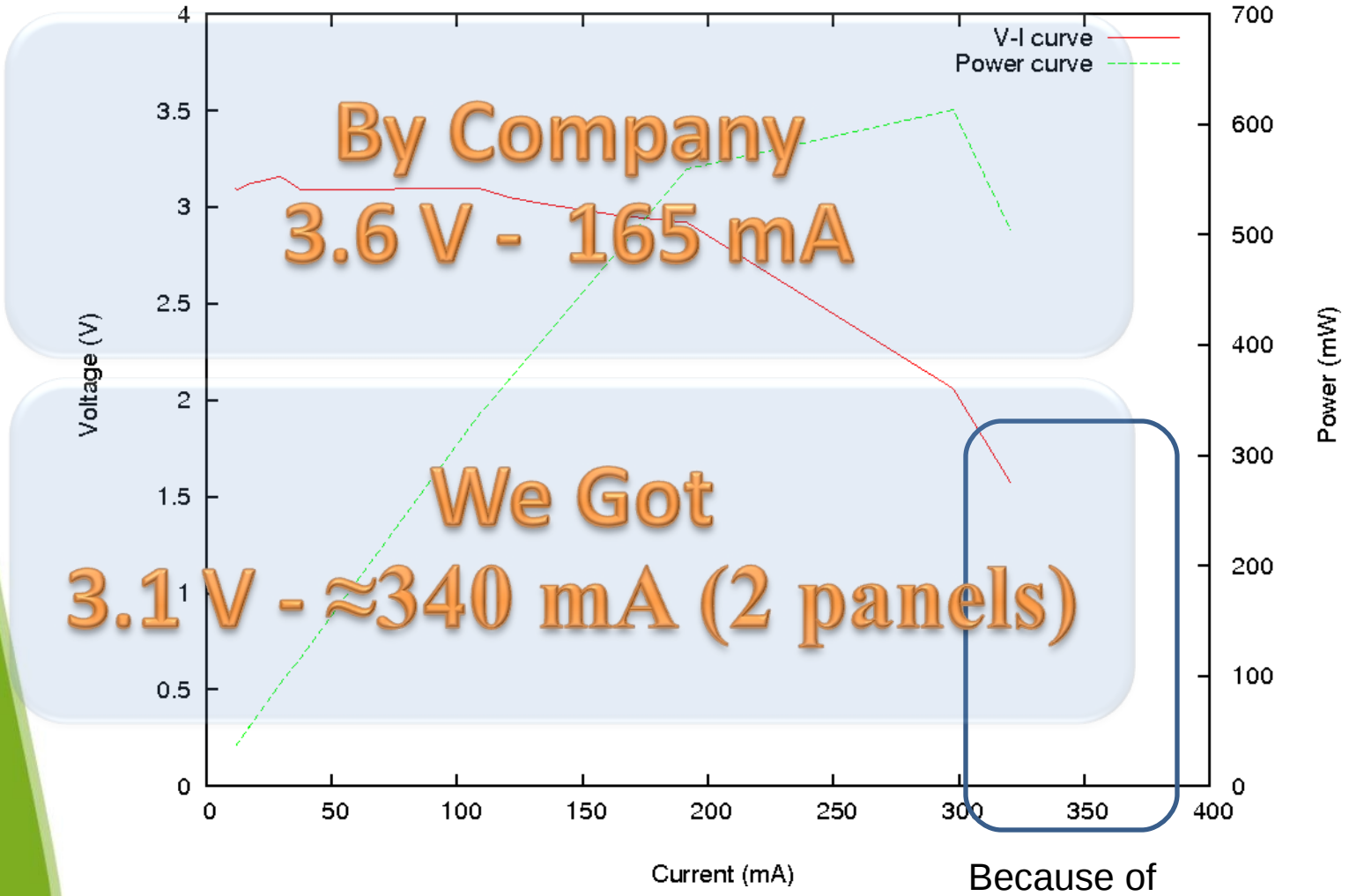


Solar panel Characterization



Because of ZXCT 1010

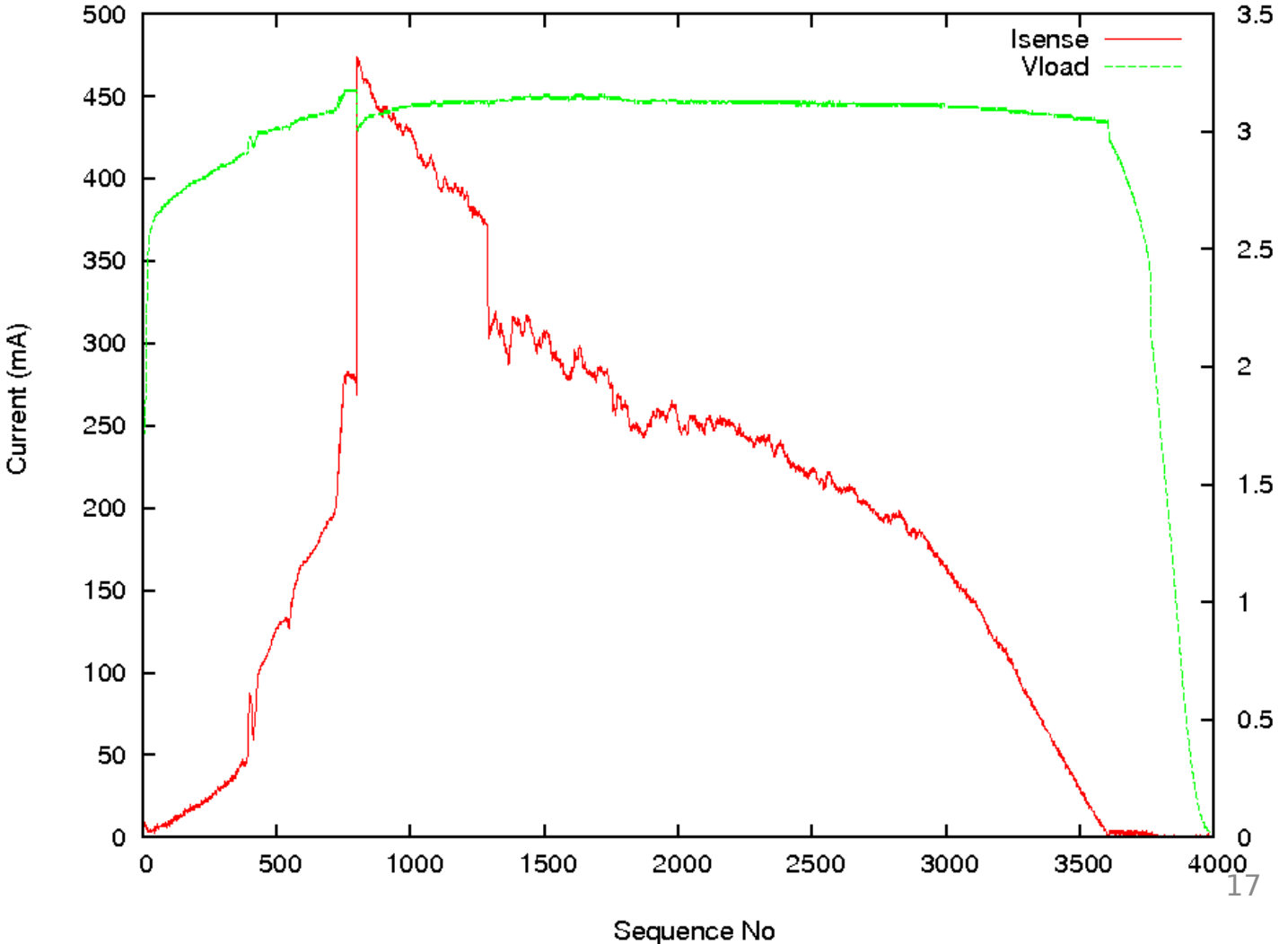
Solar panel Characterization



Because of ZXCT 1010

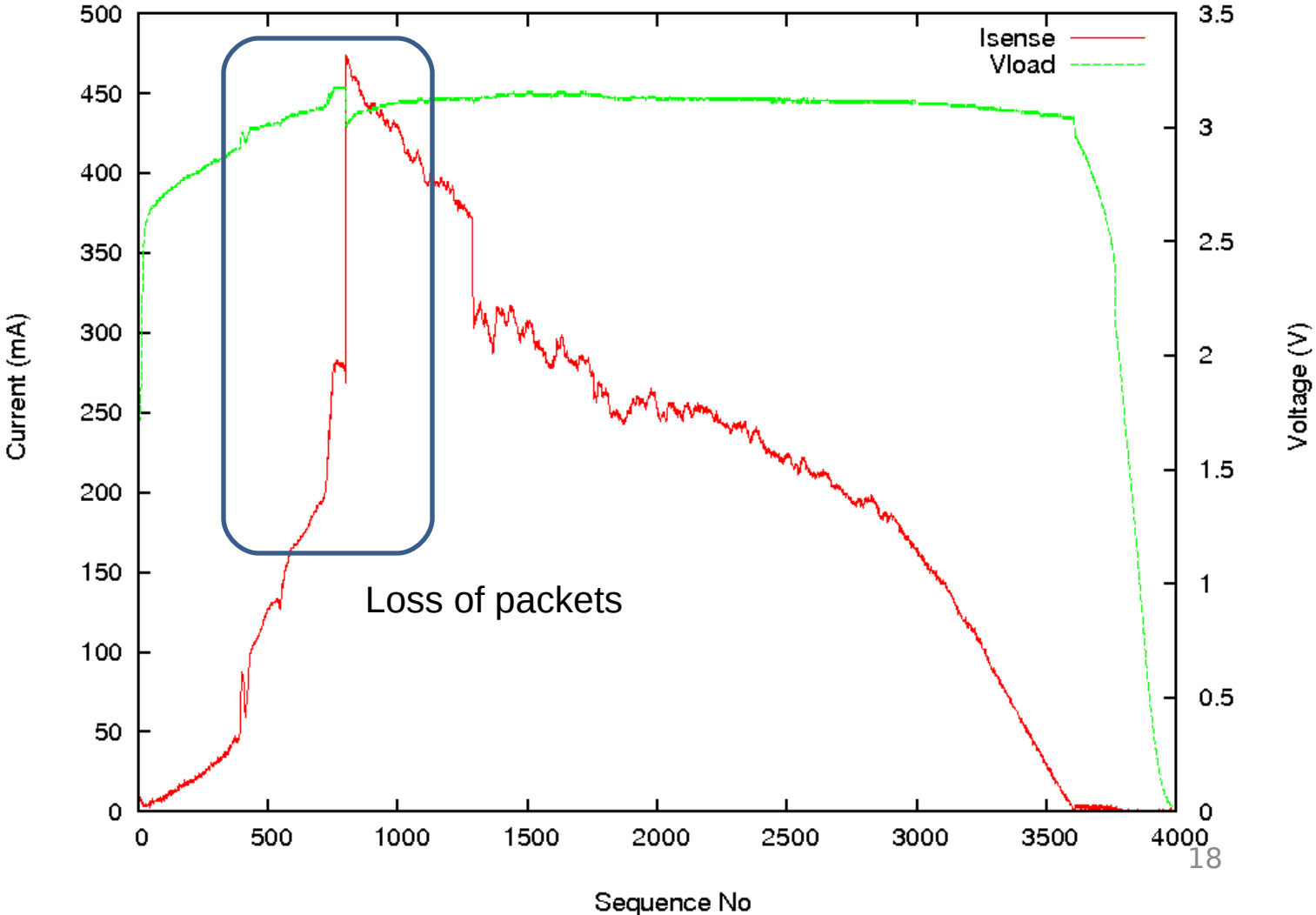
Energy calculation

– On CSE Terrace Full Day



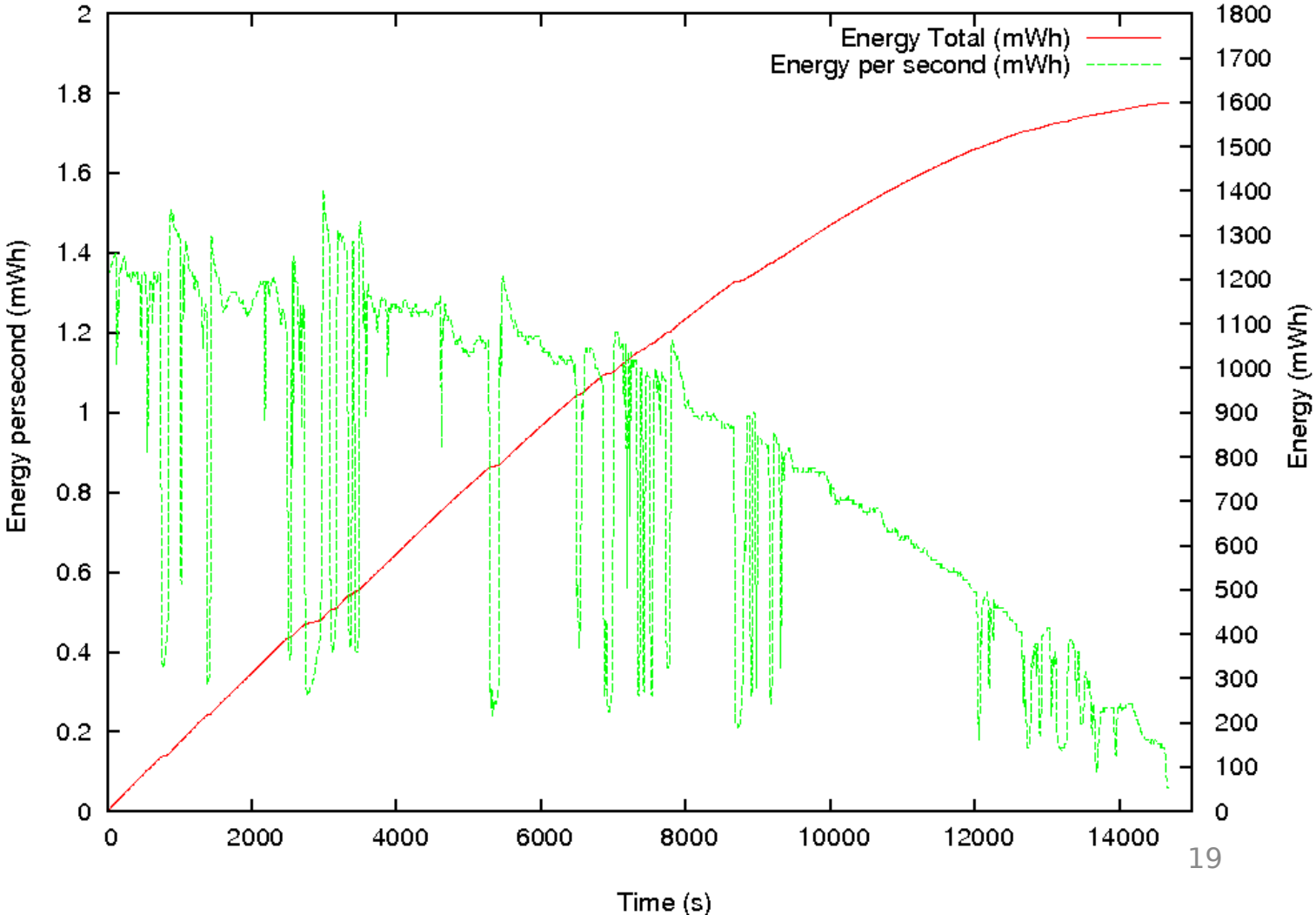
Energy calculation

– On CSE Terrace Full Day



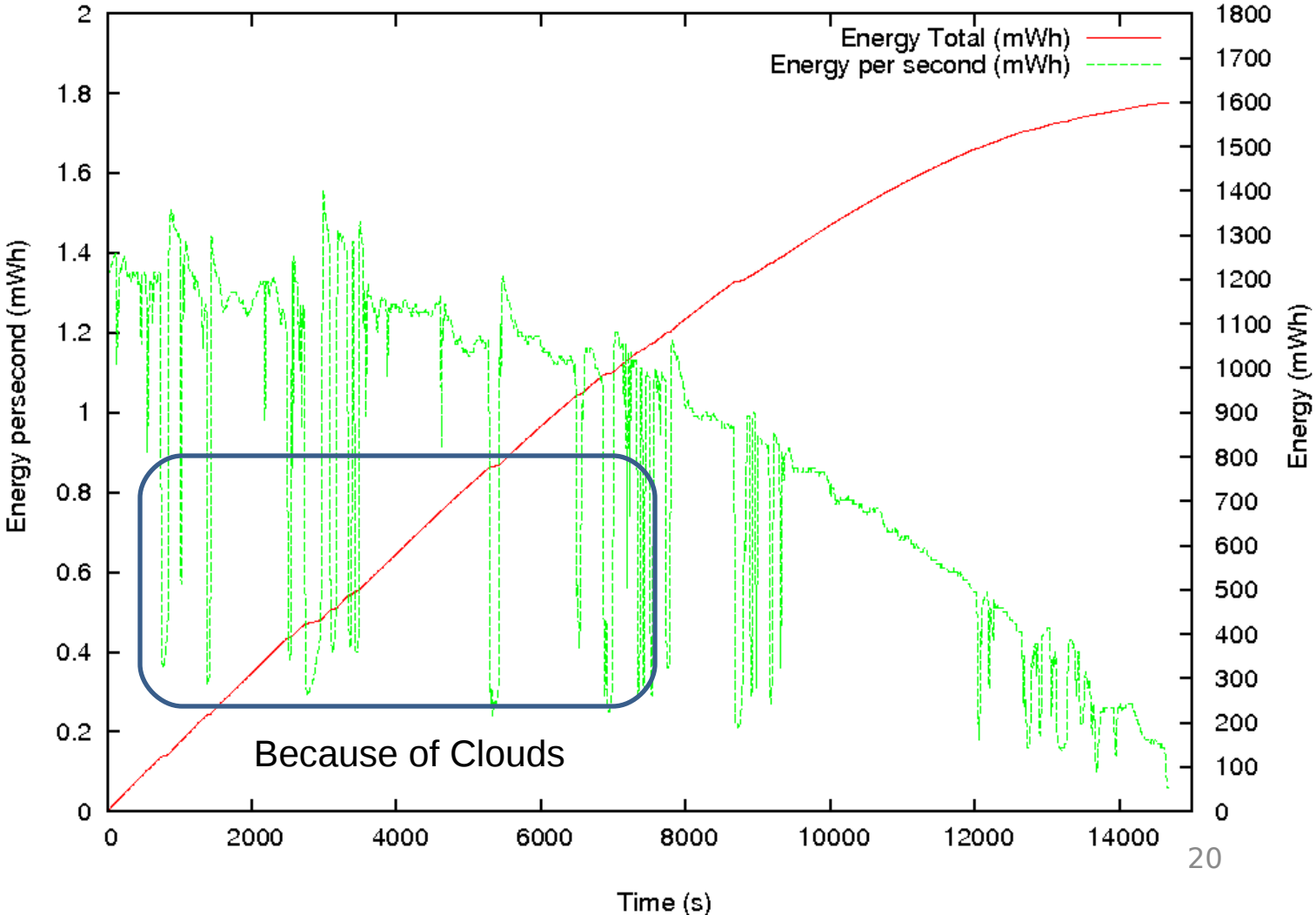
Energy calculation

– On Window facing Sunset



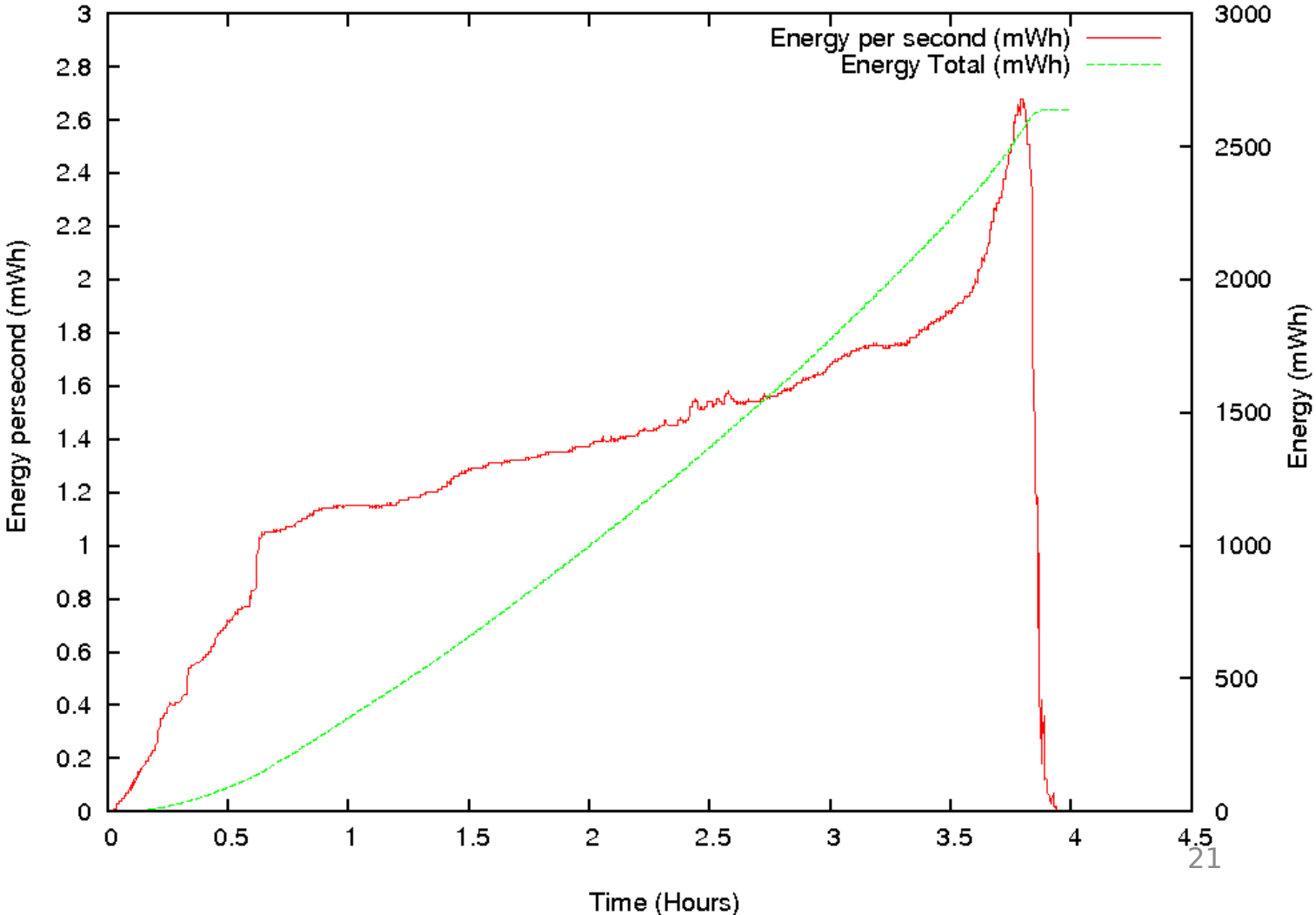
Energy calculation

– On Window facing Sunset



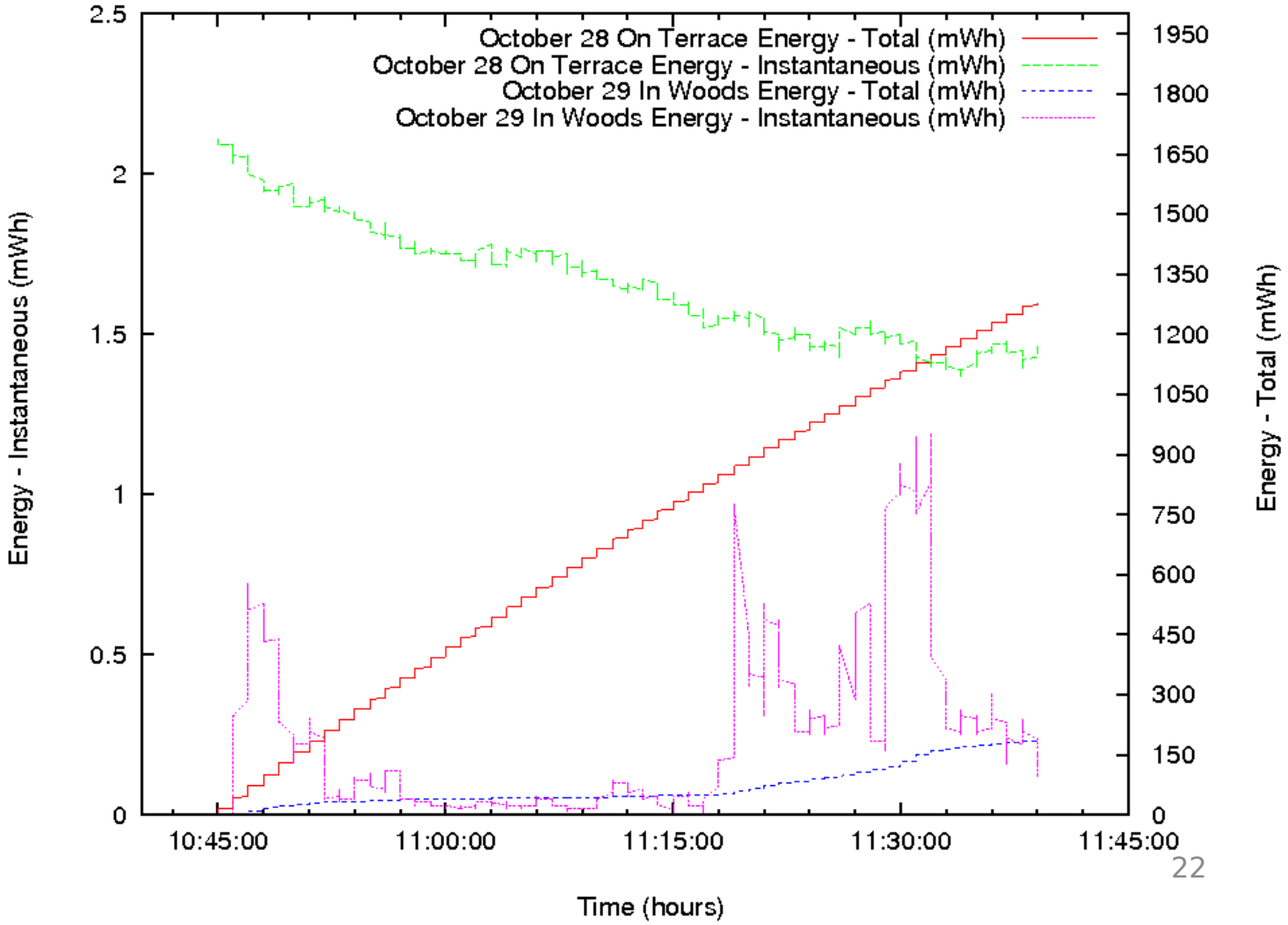
Energy calculation

– On Window facing Sunrise



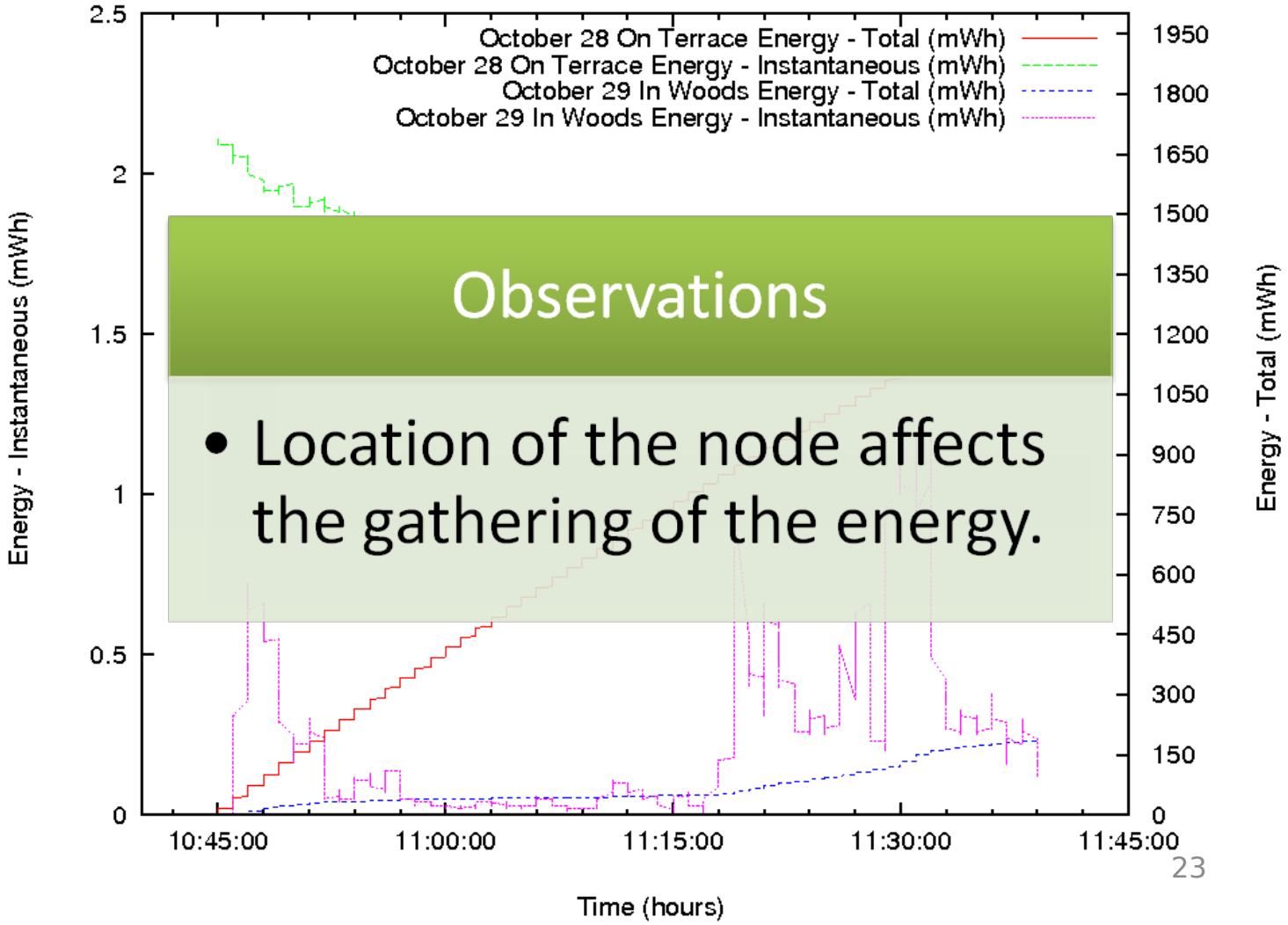
Energy calculation

– In woods



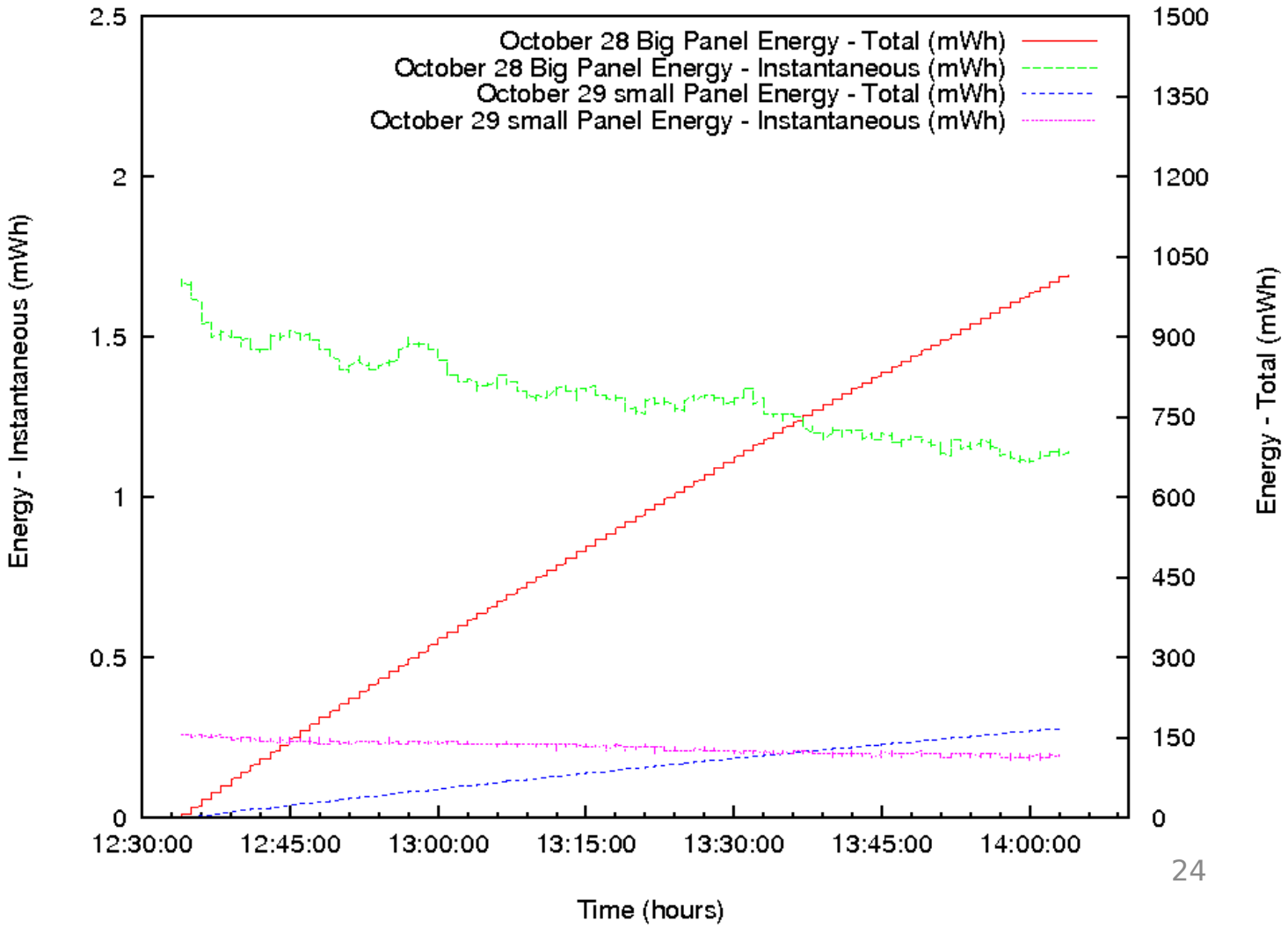
Energy calculation

– In woods



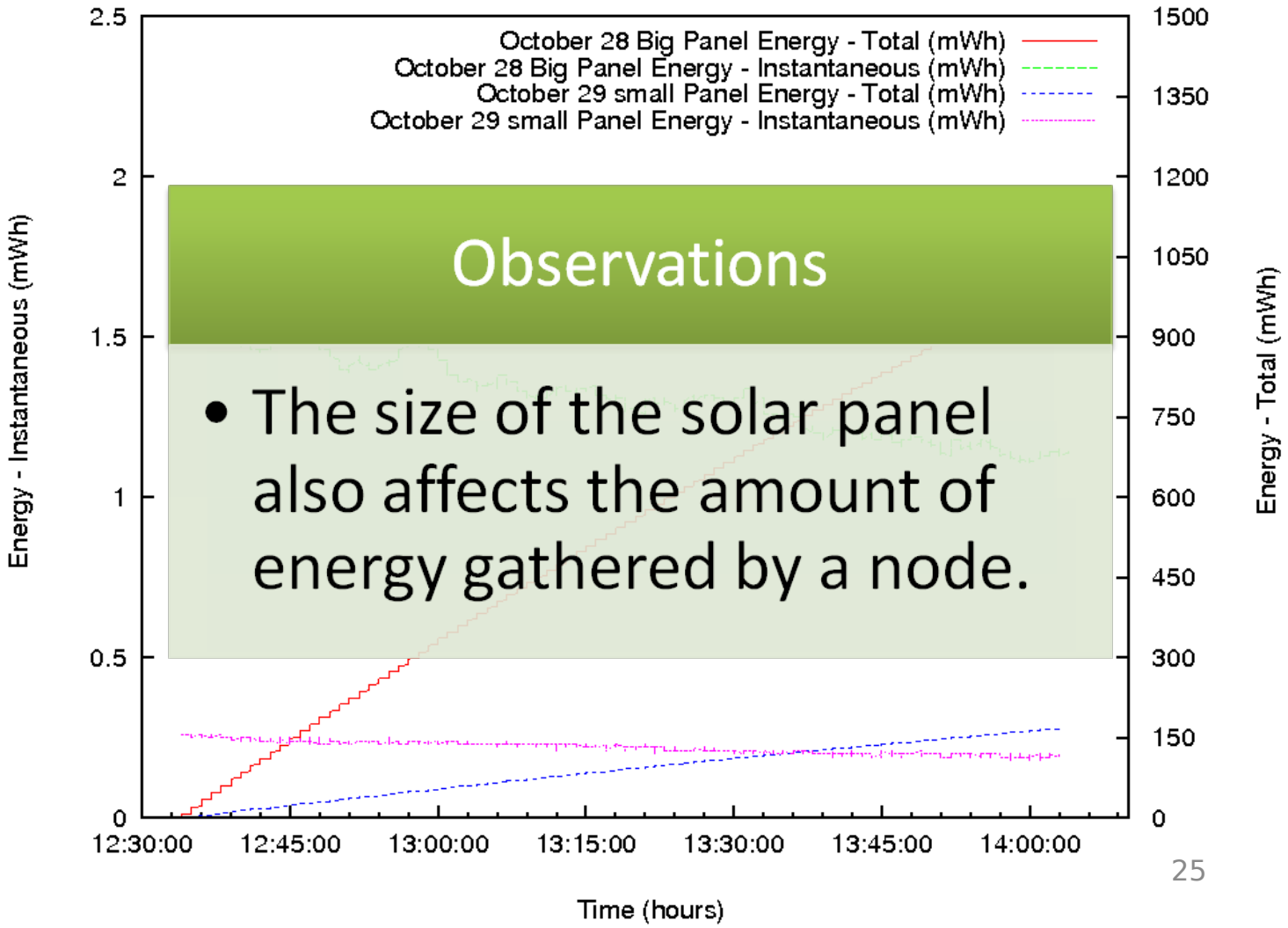
Energy calculation

– Comparison of solar panels



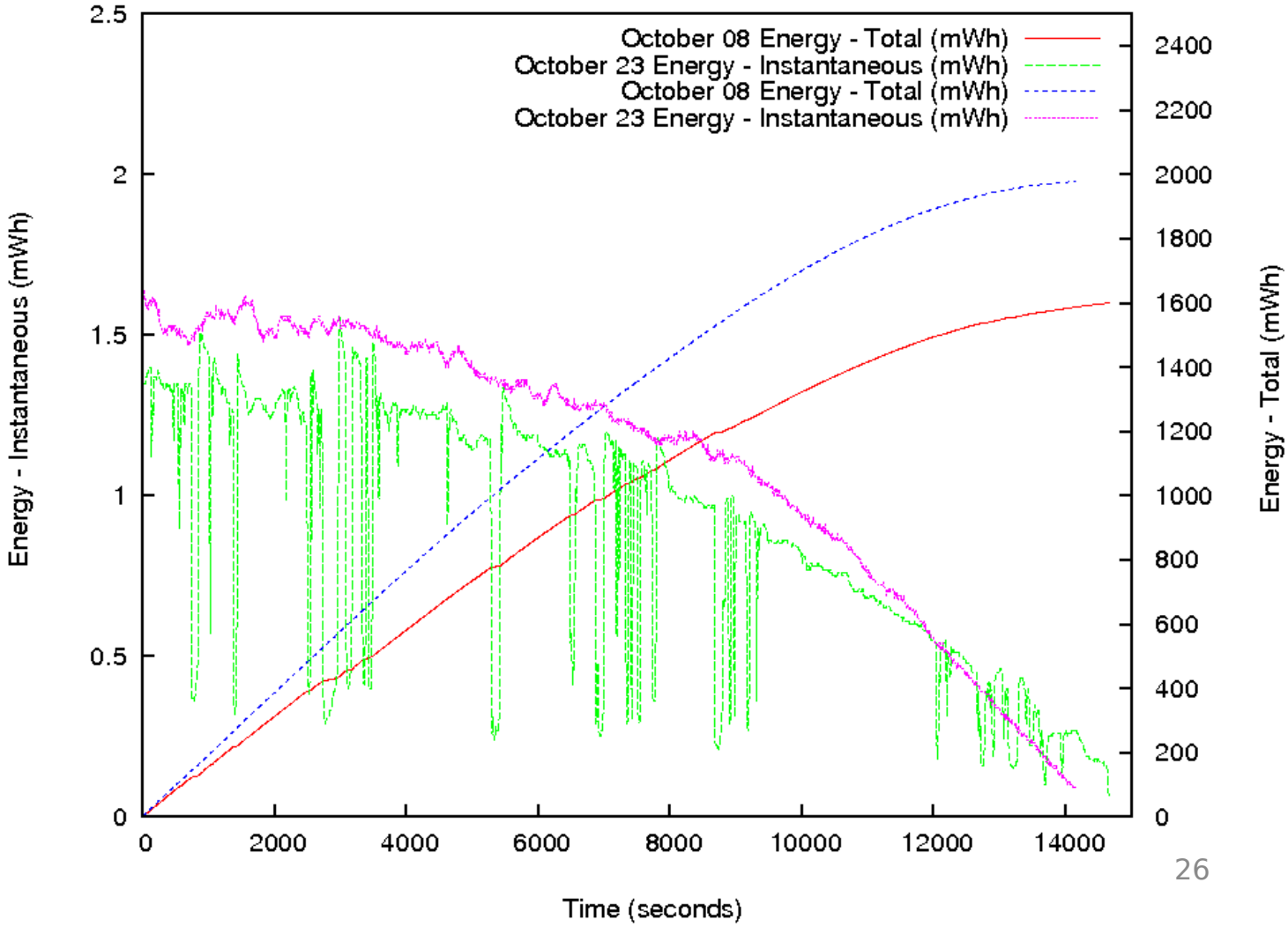
Energy calculation

– Comparison of solar panels



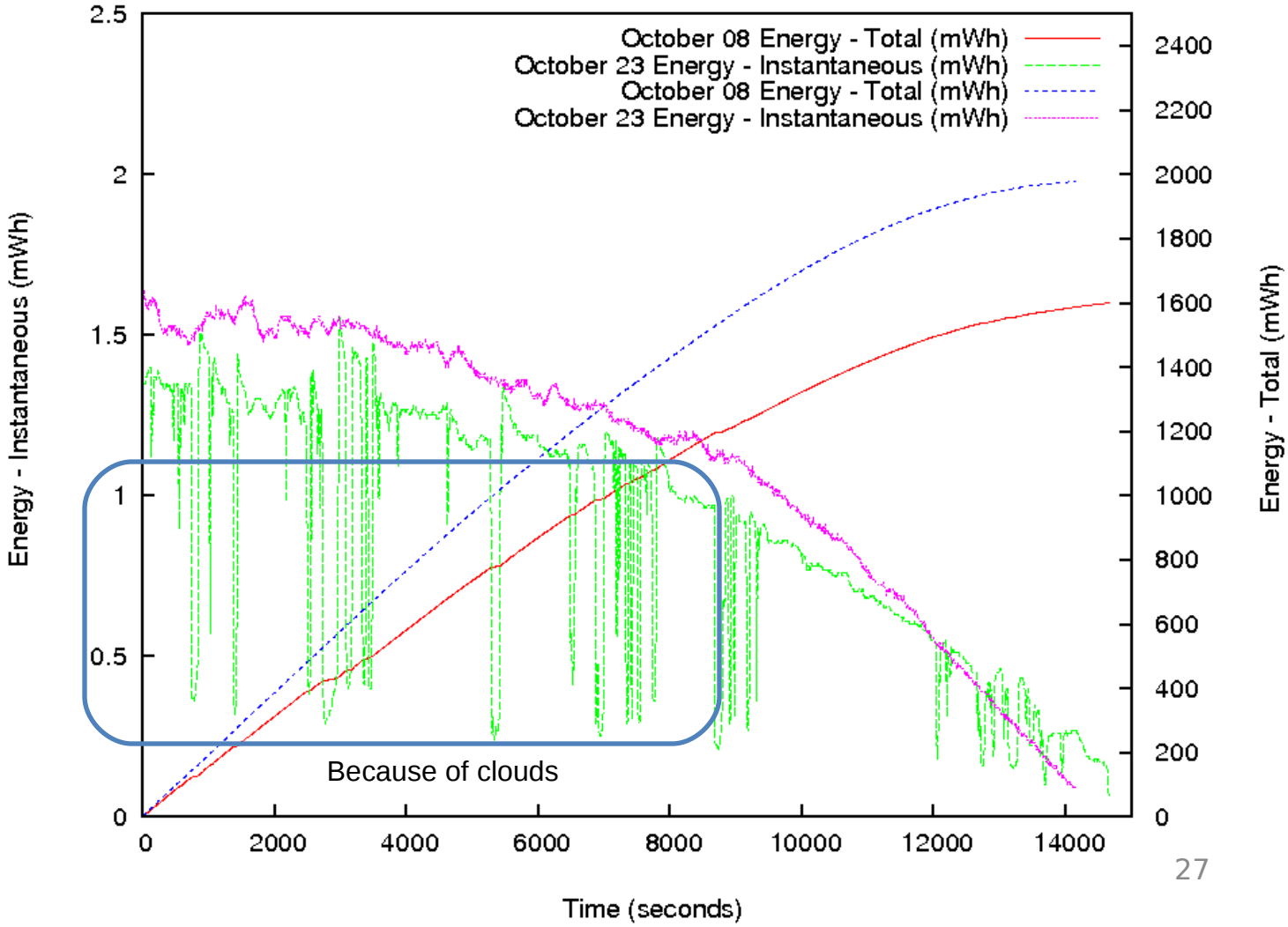
Energy calculation

– Comparison of with clouds and without clouds



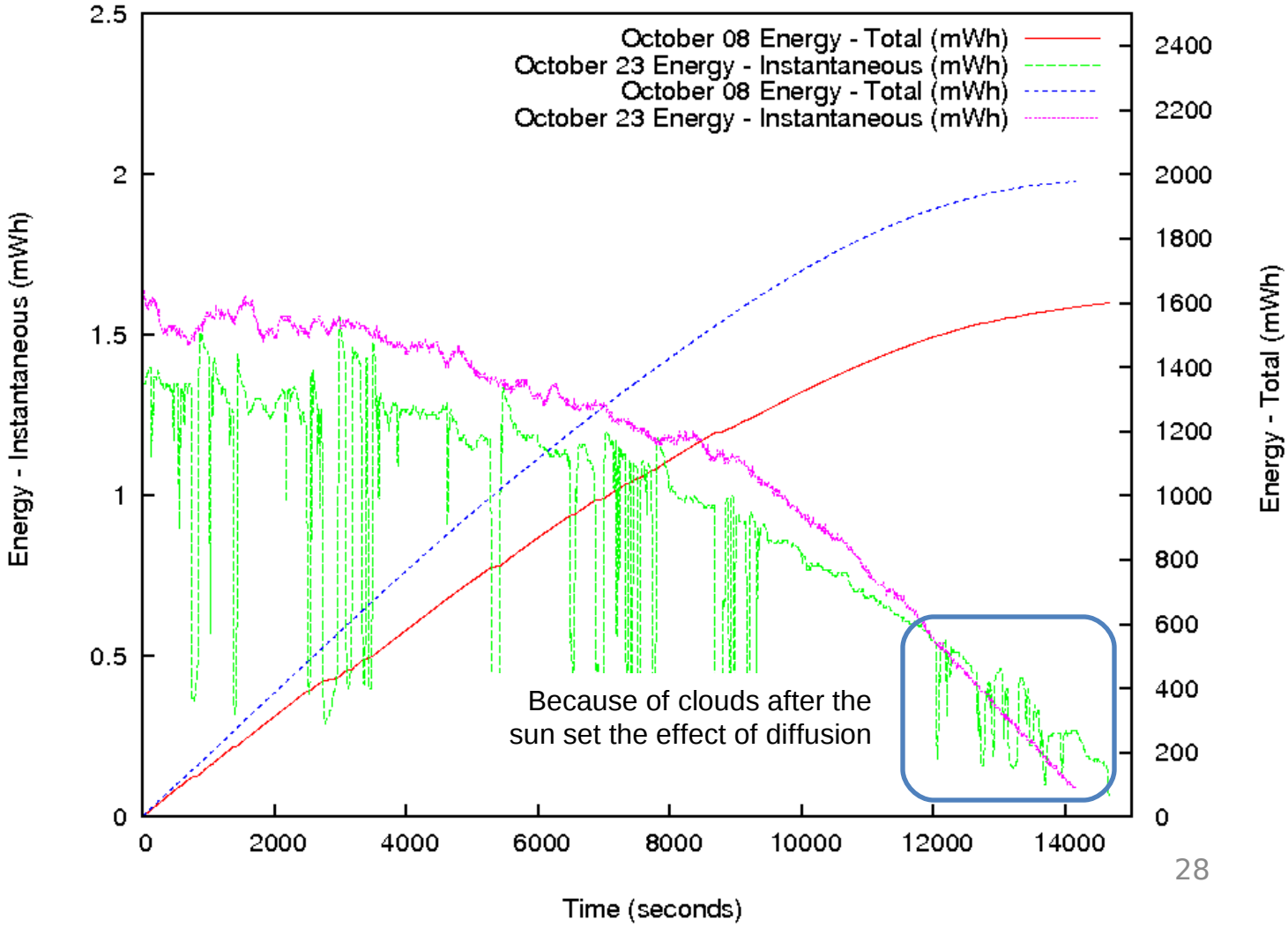
Energy calculation

– Comparison of with clouds and without clouds



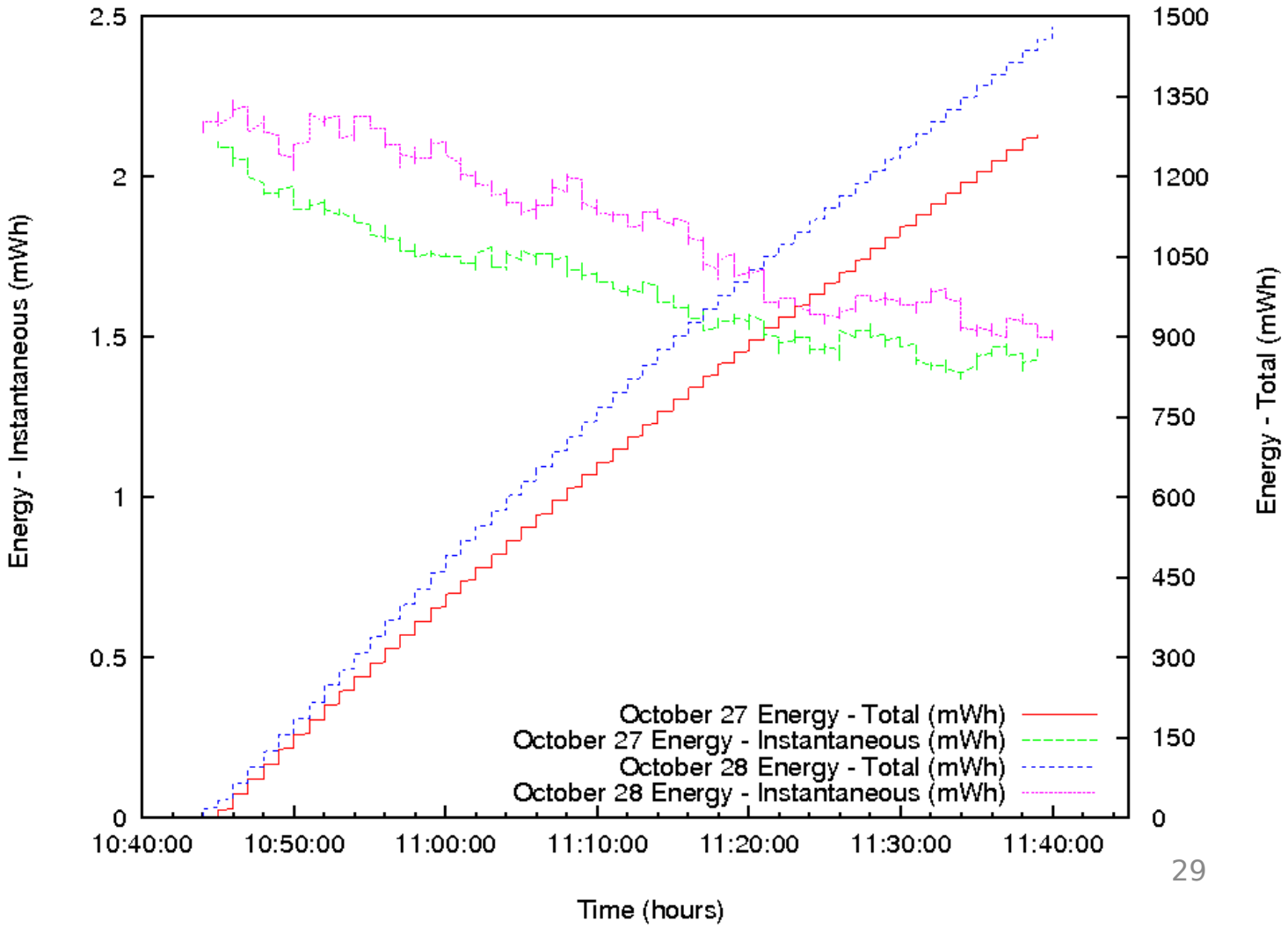
Energy calculation

– Comparison of with clouds and without clouds



Energy calculation

– Comparison of 10:40 – 11:40 of 2 days.



Energy calculation

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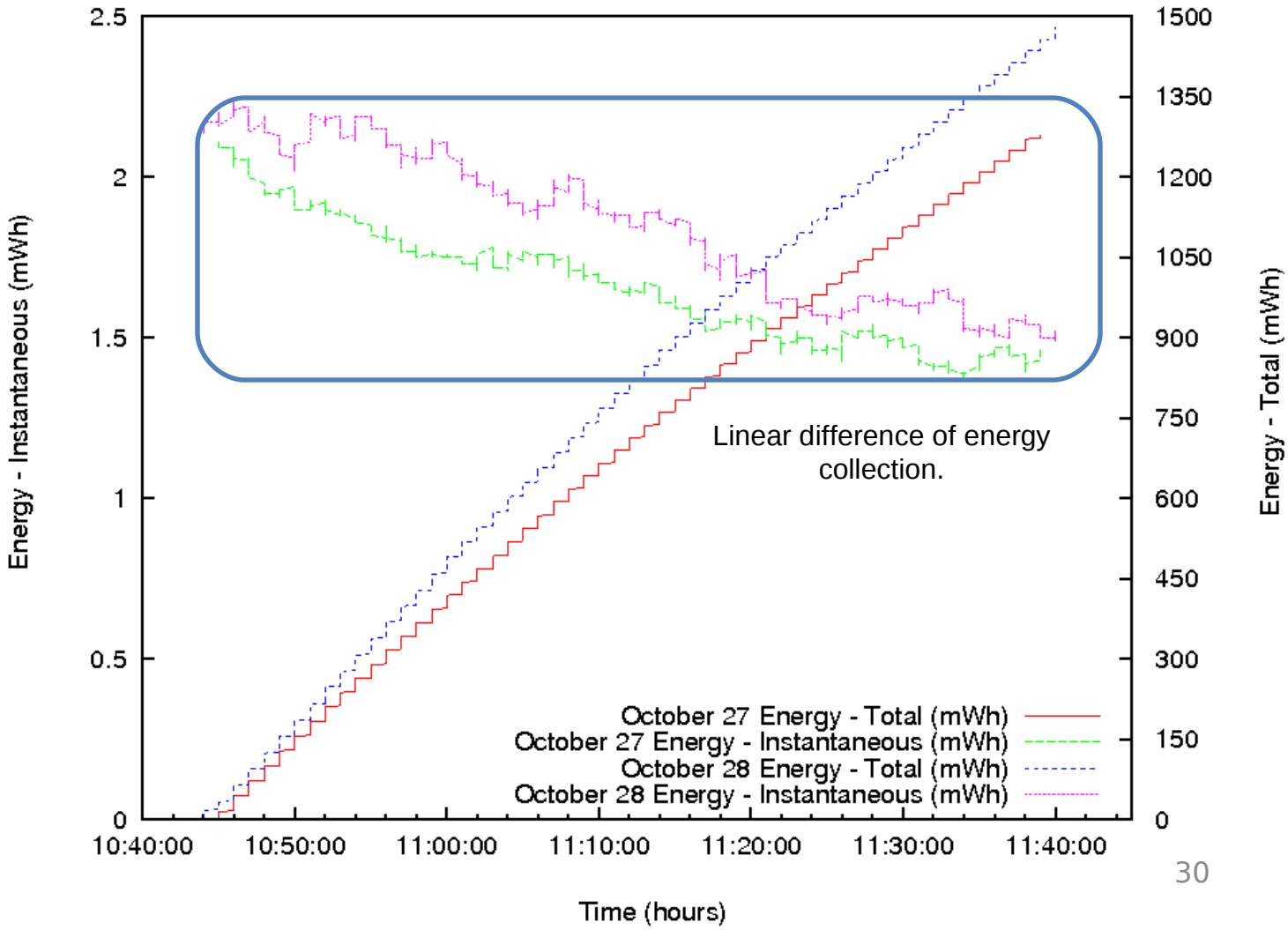
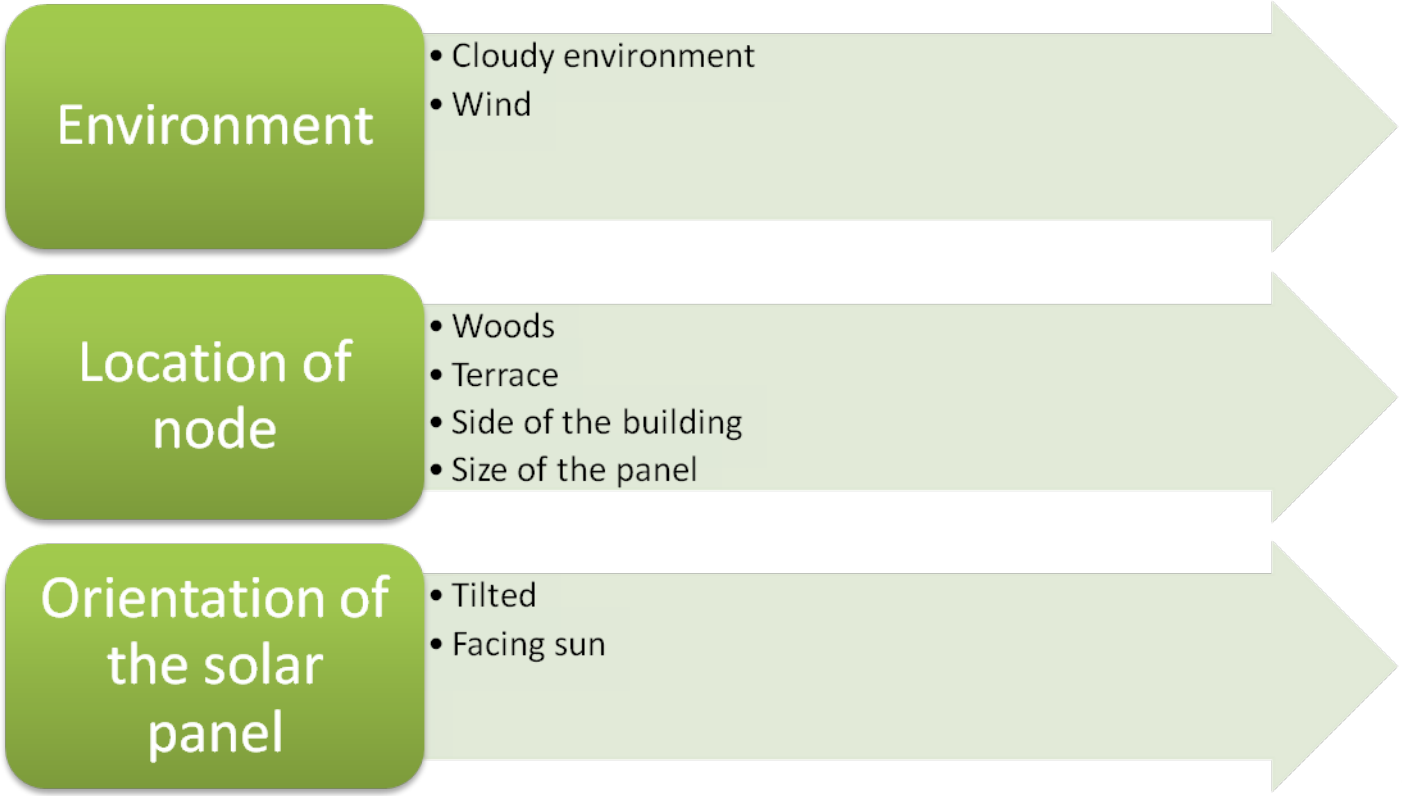


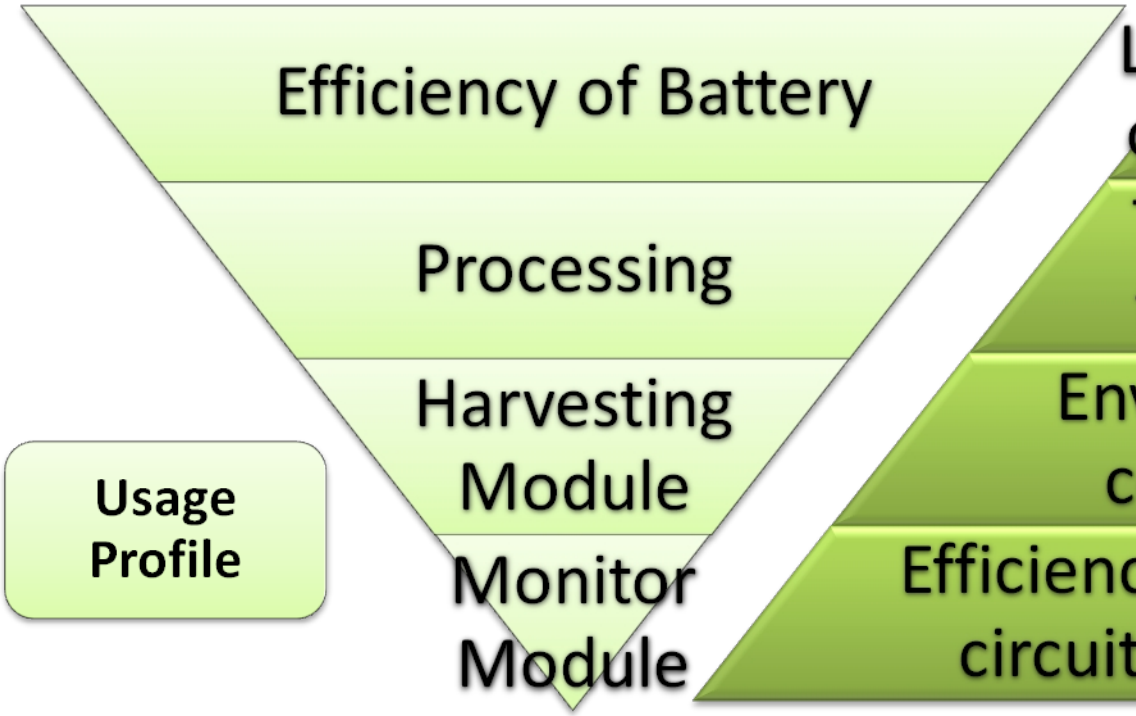
Energy Comparaison

Factors affect the amount of energy gathered by the node.

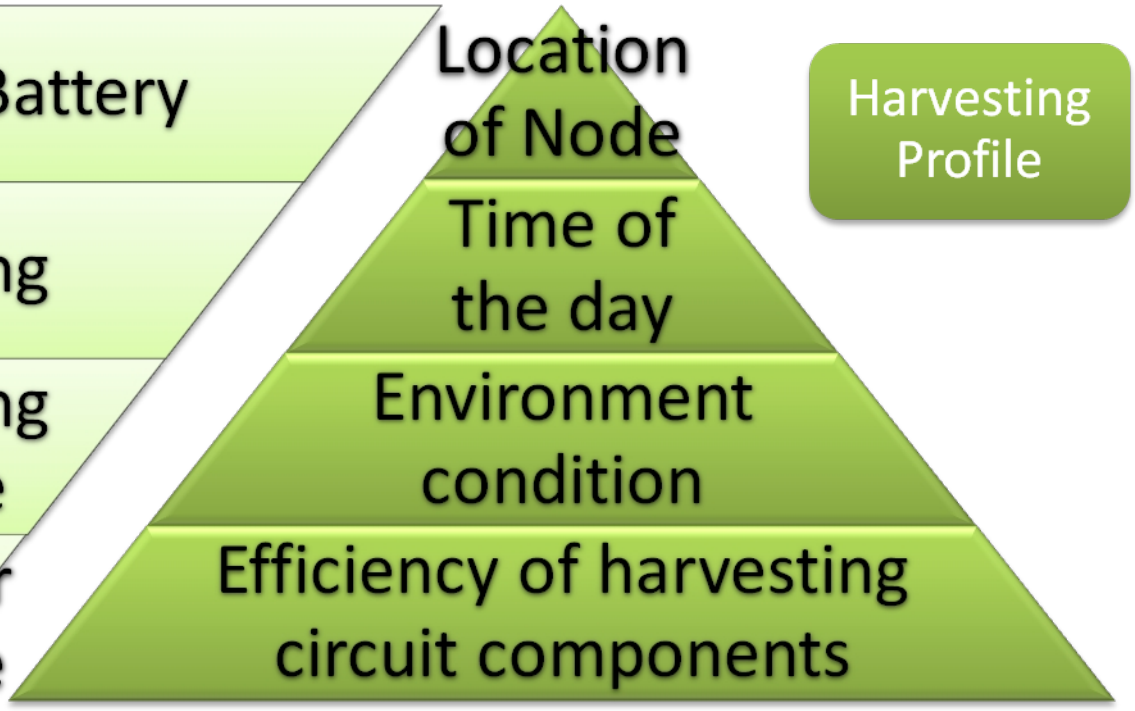


Energy Profiles

For Prediction of energy availability in the algorithm



Usage Profile



Harvesting Profile

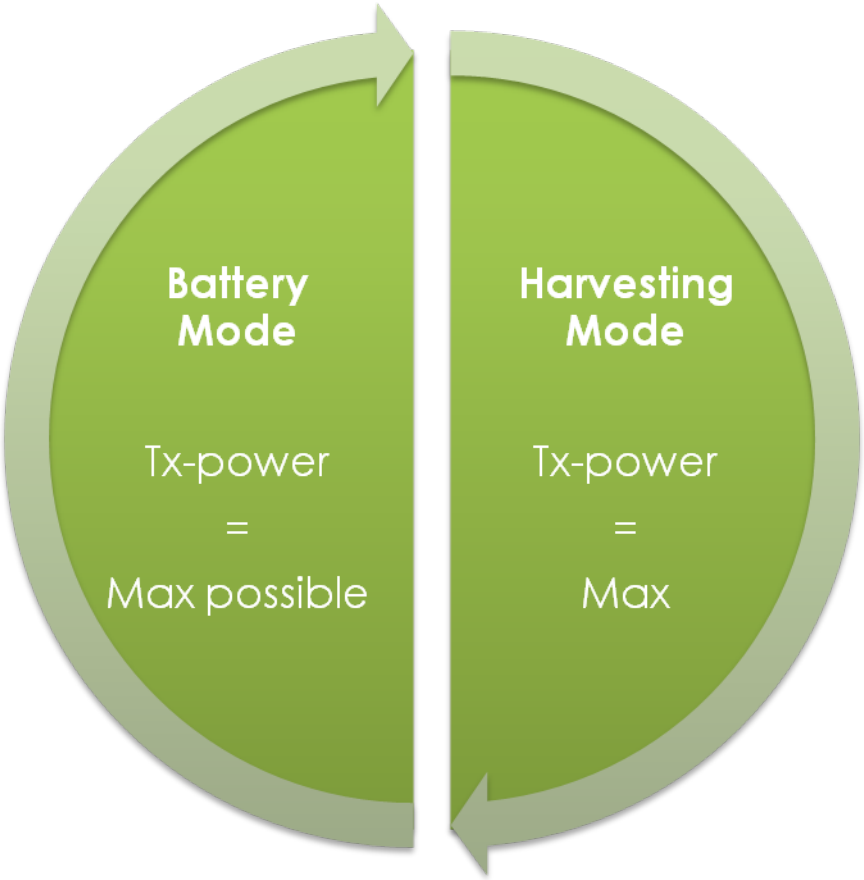
Algorithm Design

- Known parameters (Based on Prediction)
  - Energy profile (harvested energy)
  - Energy profile (usage of energy)
    - Powersave mode
    - Active mode
- Parameters that can be changed
    - Dutycycle
    - **Transmit Power**
    - Processing
    - Clustering

Transmit power

- Most energy consuming component
- Effects of change in Tx-power
  - Routing
  - Goodput
  - Link quality

Algorithm



Max possible

- Next recharge cycle (Harvesting profile)
- Available energy (Battery capacity)
- Usage profile

Algorithm (Cont...)

Harvesting mode

If the amount of energy harvested from the solar panel is greater than the combine battery charging energy and usage energy of load.

Battery mode

If the amount of energy harvested is less then the usage of the load.

Time Line

- Current Status
  - Circuit Design (completed)
  - Measurements (Continue)
- Future Work
  - Algorithm Design and Implementation

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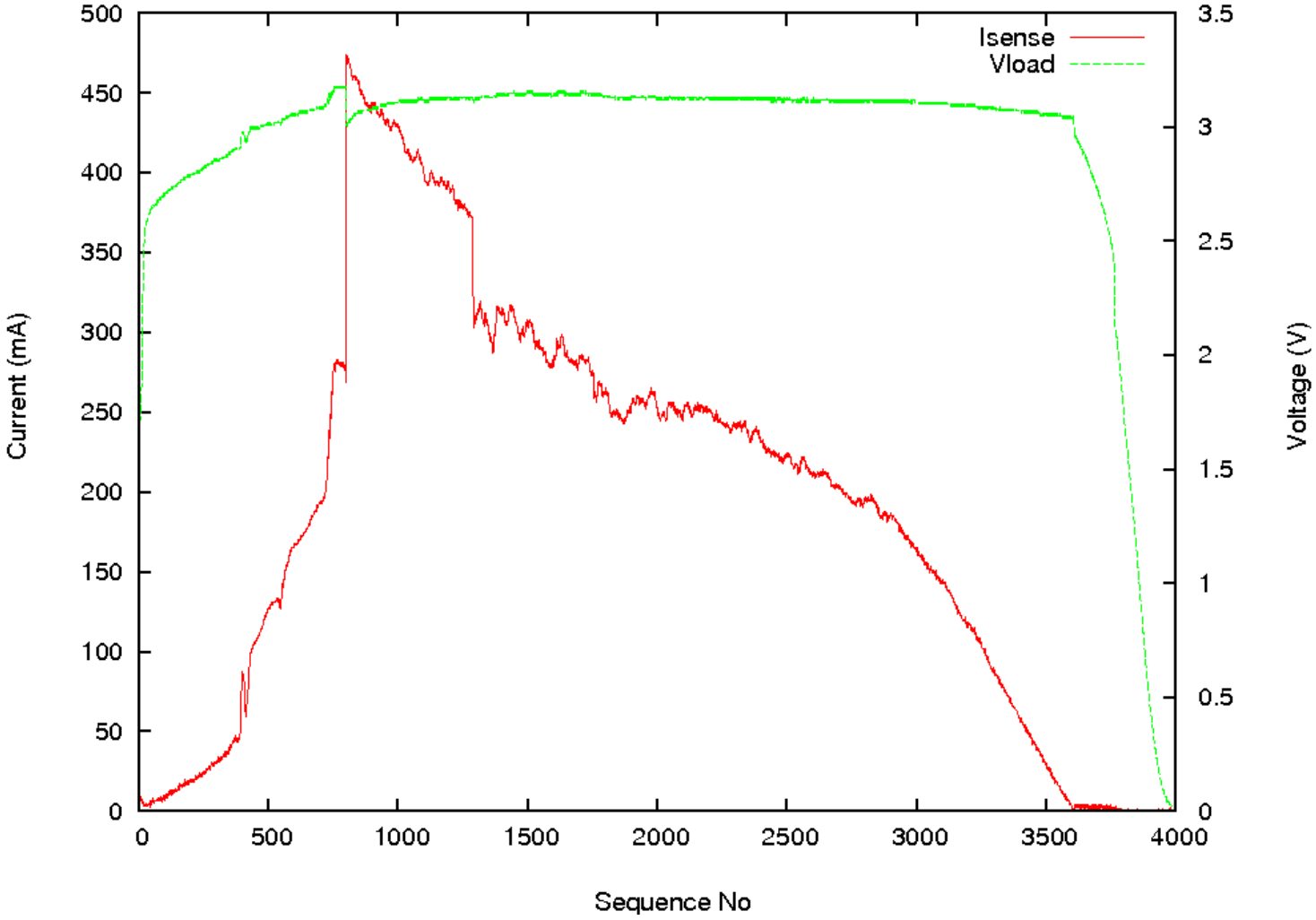
Thank You

Questions ?

Energy calculation – On CSE Terrace



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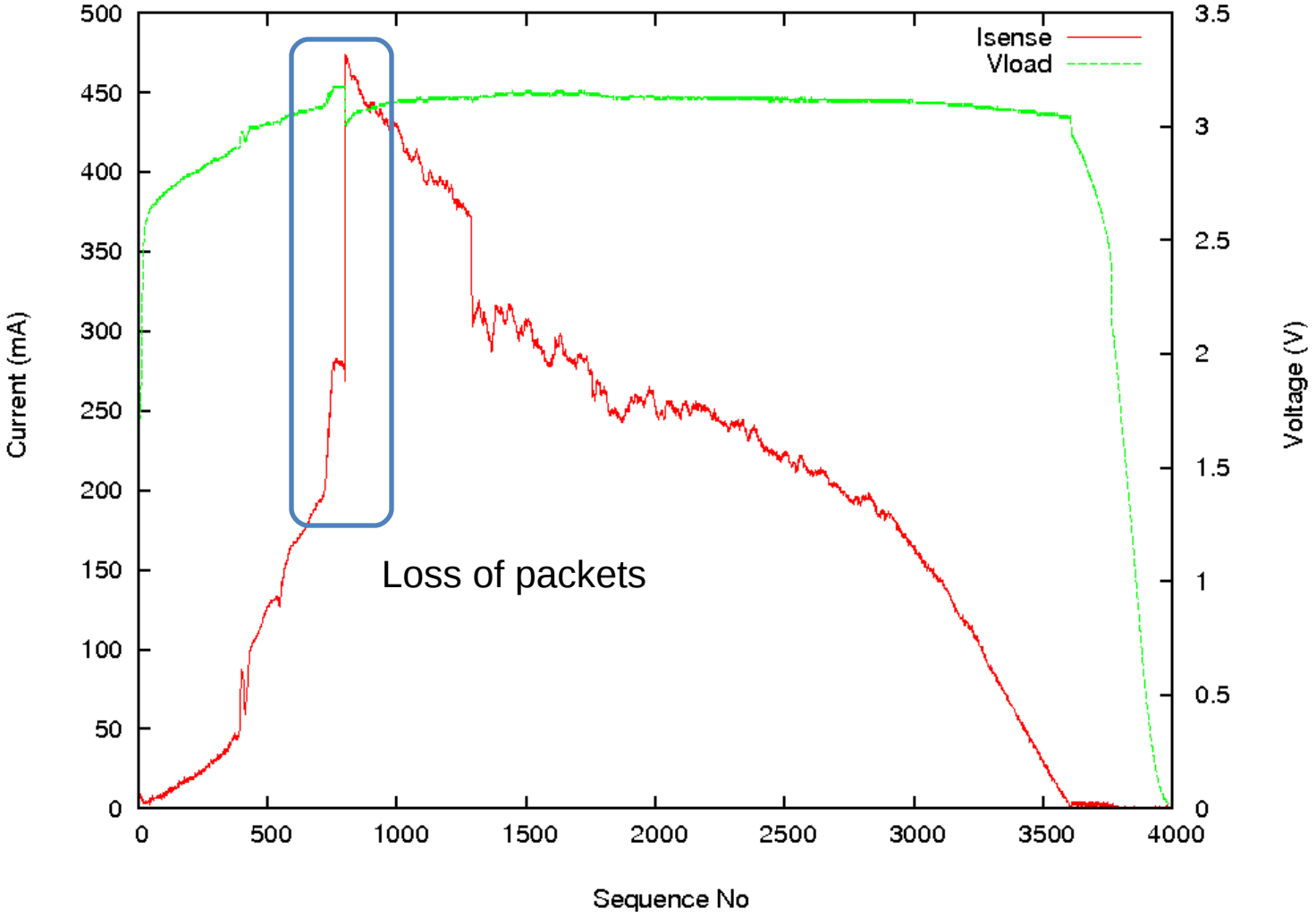

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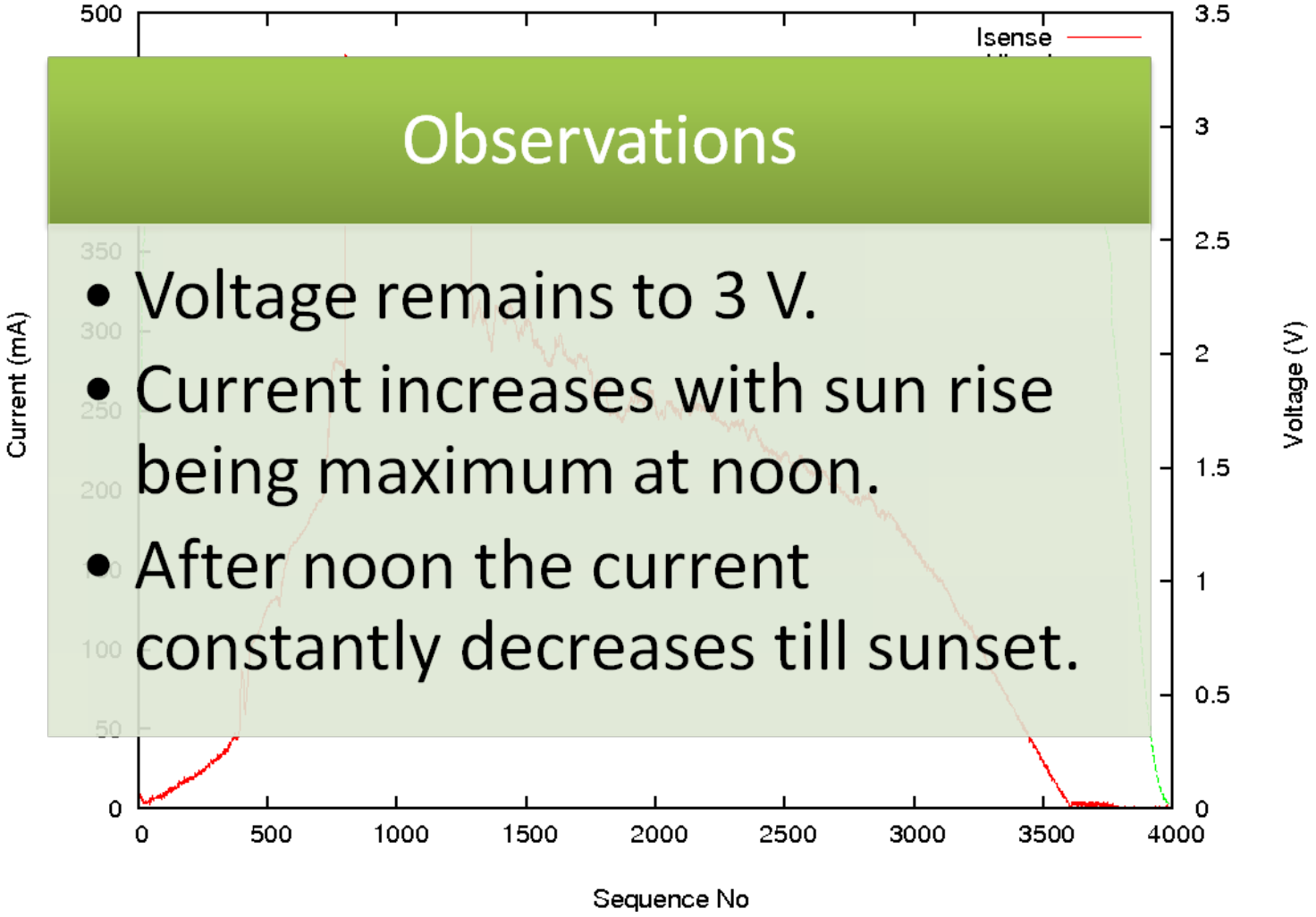
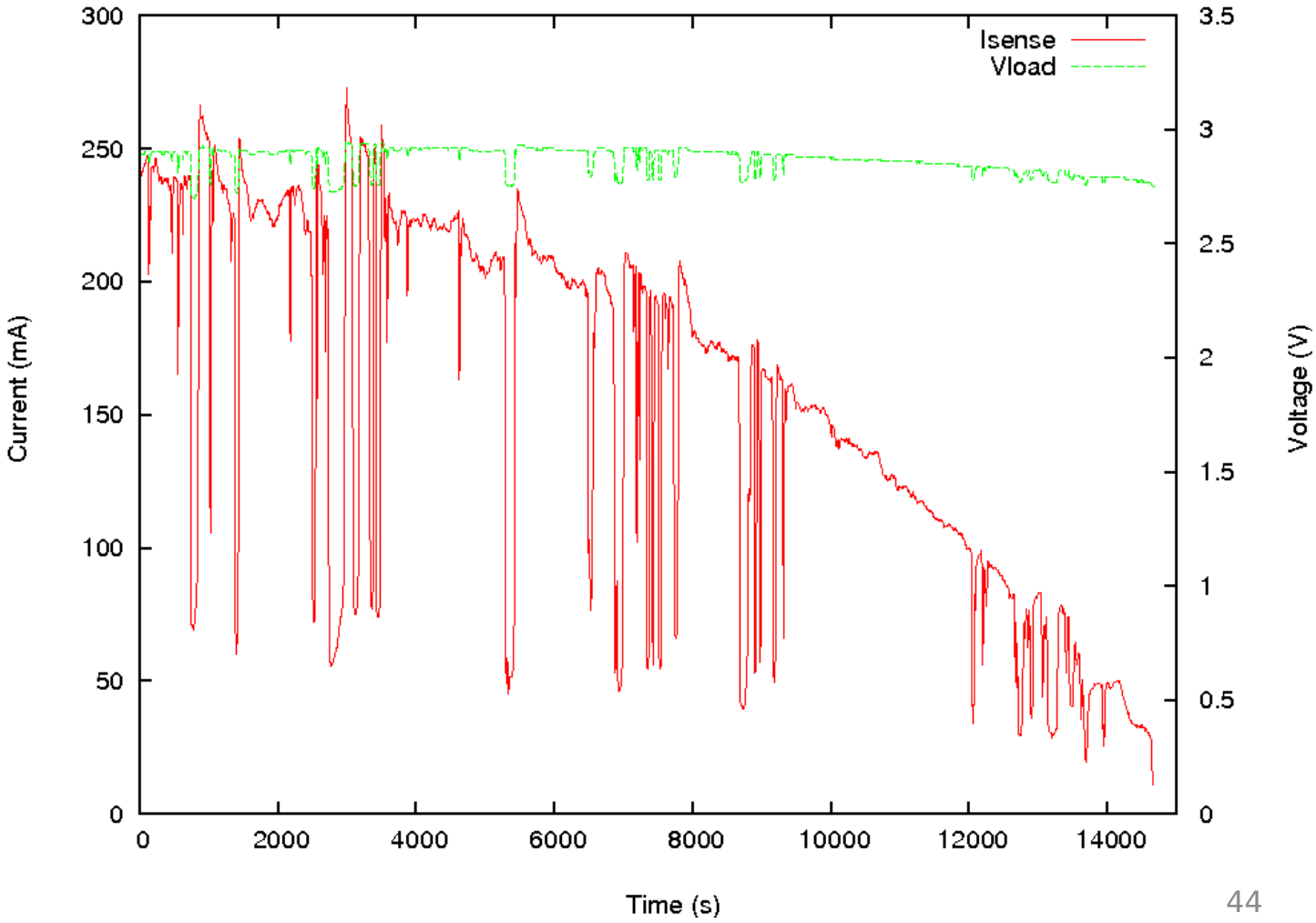


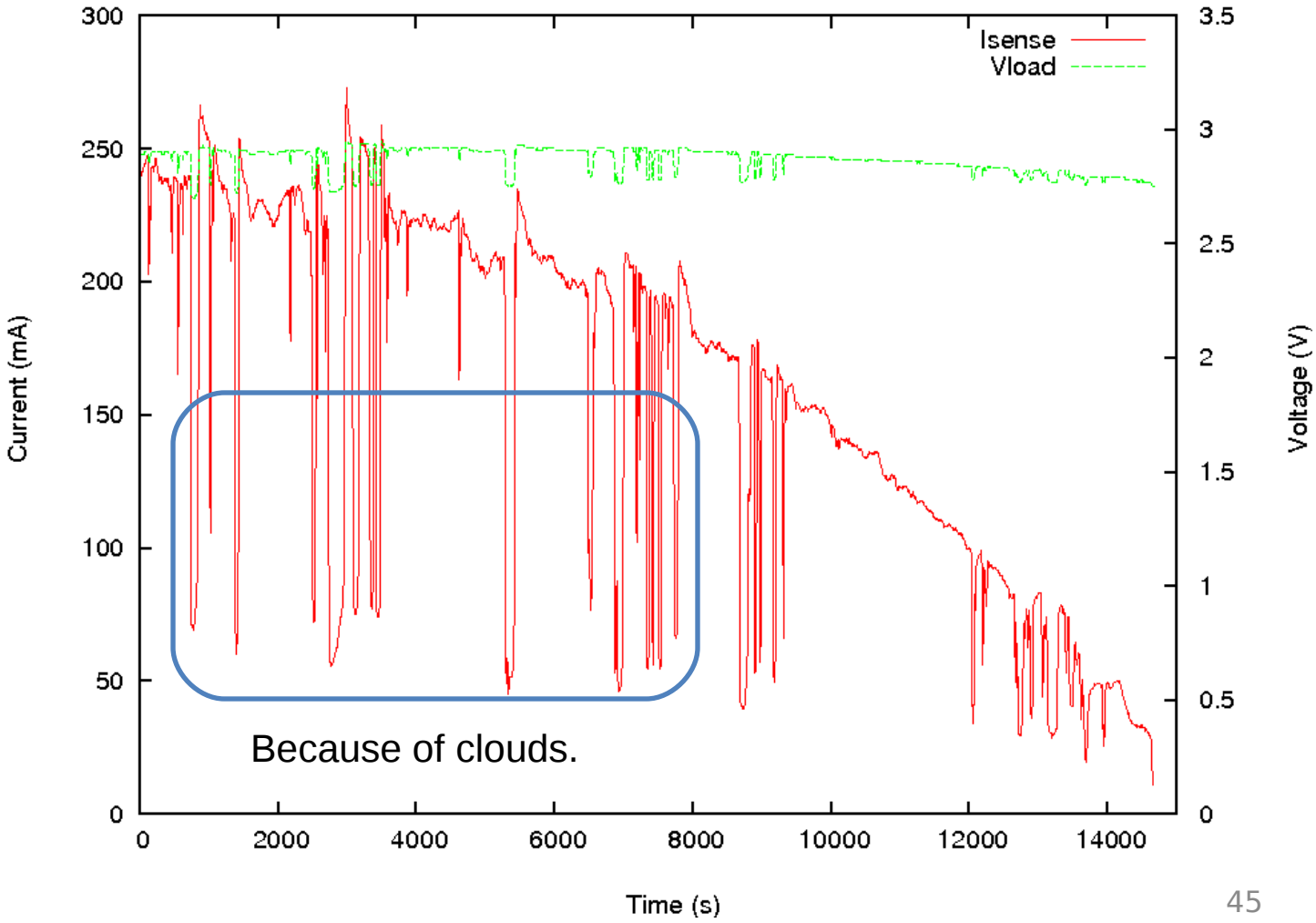
Observations

- Voltage remains to 3 V.
- Current increases with sun rise being maximum at noon.
- After noon the current constantly decreases till sunset.

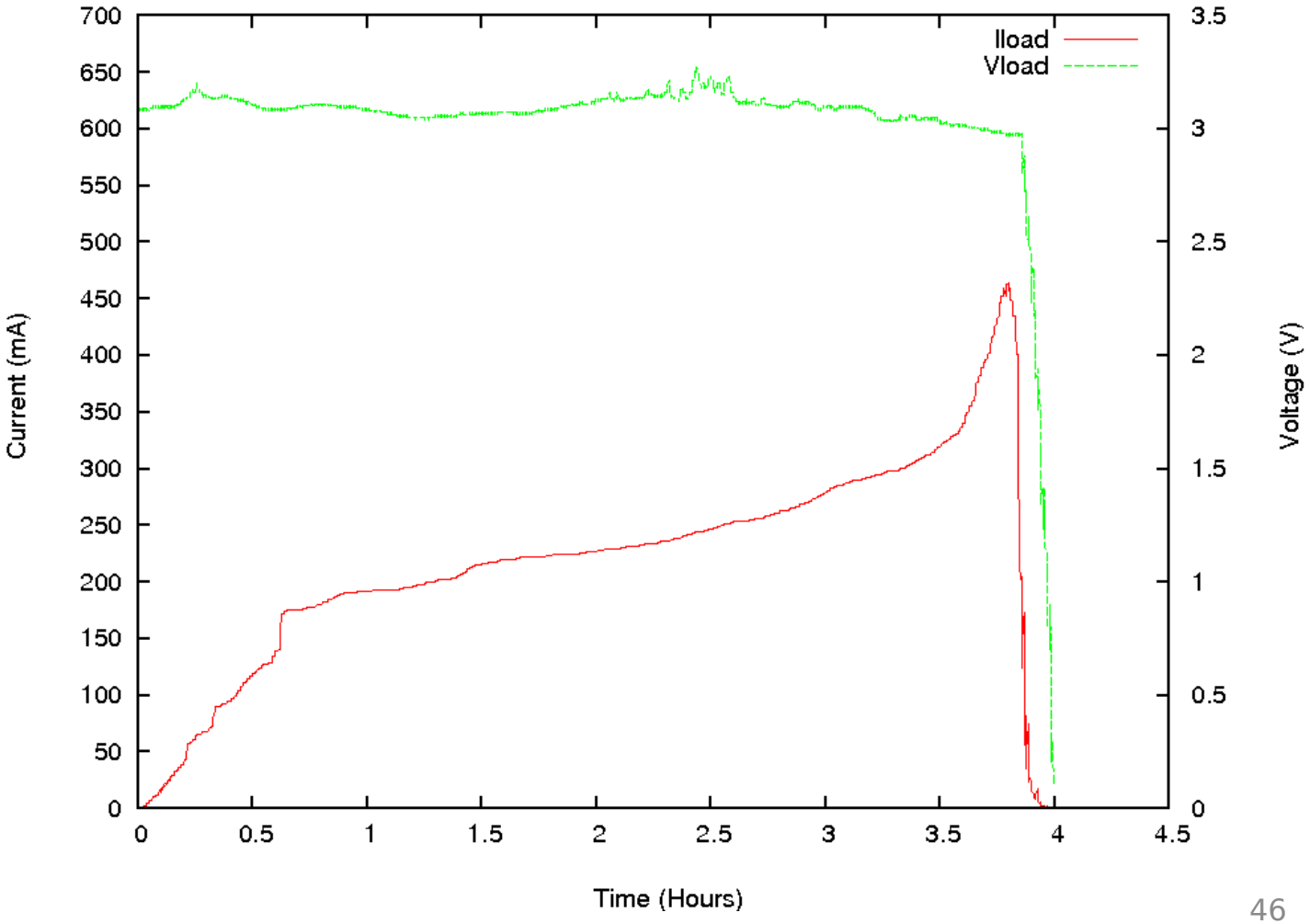
Energy calculation – Window facing sunset



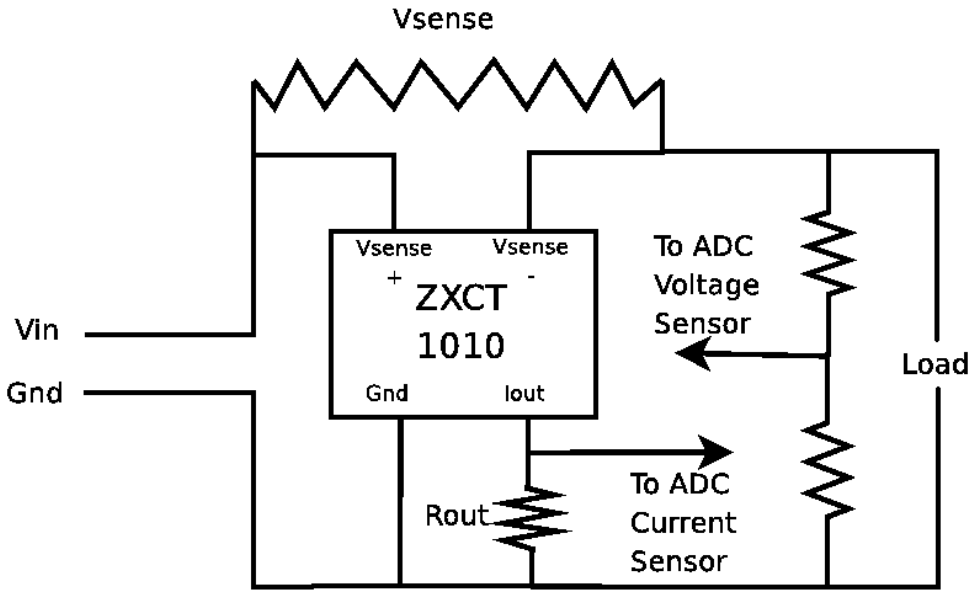
Energy calculation – Window facing sunset



Energy calculation – Window facing sunrise



Charging Circuit



Monitor Module

- ZXCT 1010 – Current Monitor
- Measures current in voltages

Usage and harvesting of energy