Domestic consumption and demand profile estimation: DT PET and DT Profile

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Powering your world

Overview - DT PET

- Introduction
- Model structure
- Sub models
- Performance
- Site assessment
- Demonstration

DT PET Introduction

- DT referred to Distribution Technology where the initiative started
- PET is Pre-Electrification Tool

- Aim is to provide estimates of consumption, demand, LV design parameters and load profiles for residential areas.

- Set of statistical load models implemented in software

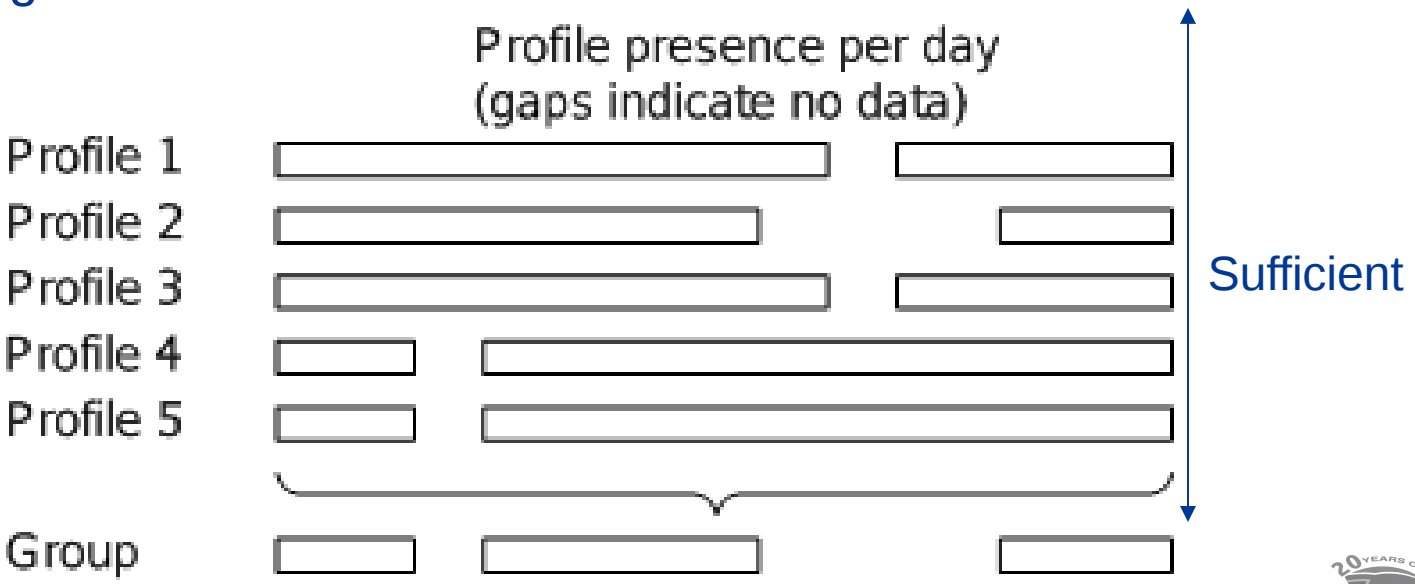
Data sources

- NRS domestic load research programme
- 5 minute profile data
  - Amps
  - Voltage
- Socio demographic information
  - Demographics
  - Appliance ownership
  - Alternative fuels
  - Electricity connection
- Links : Profiles
- Weather
  - Temperature
  - Rainfall
  - Sunrise / sunset

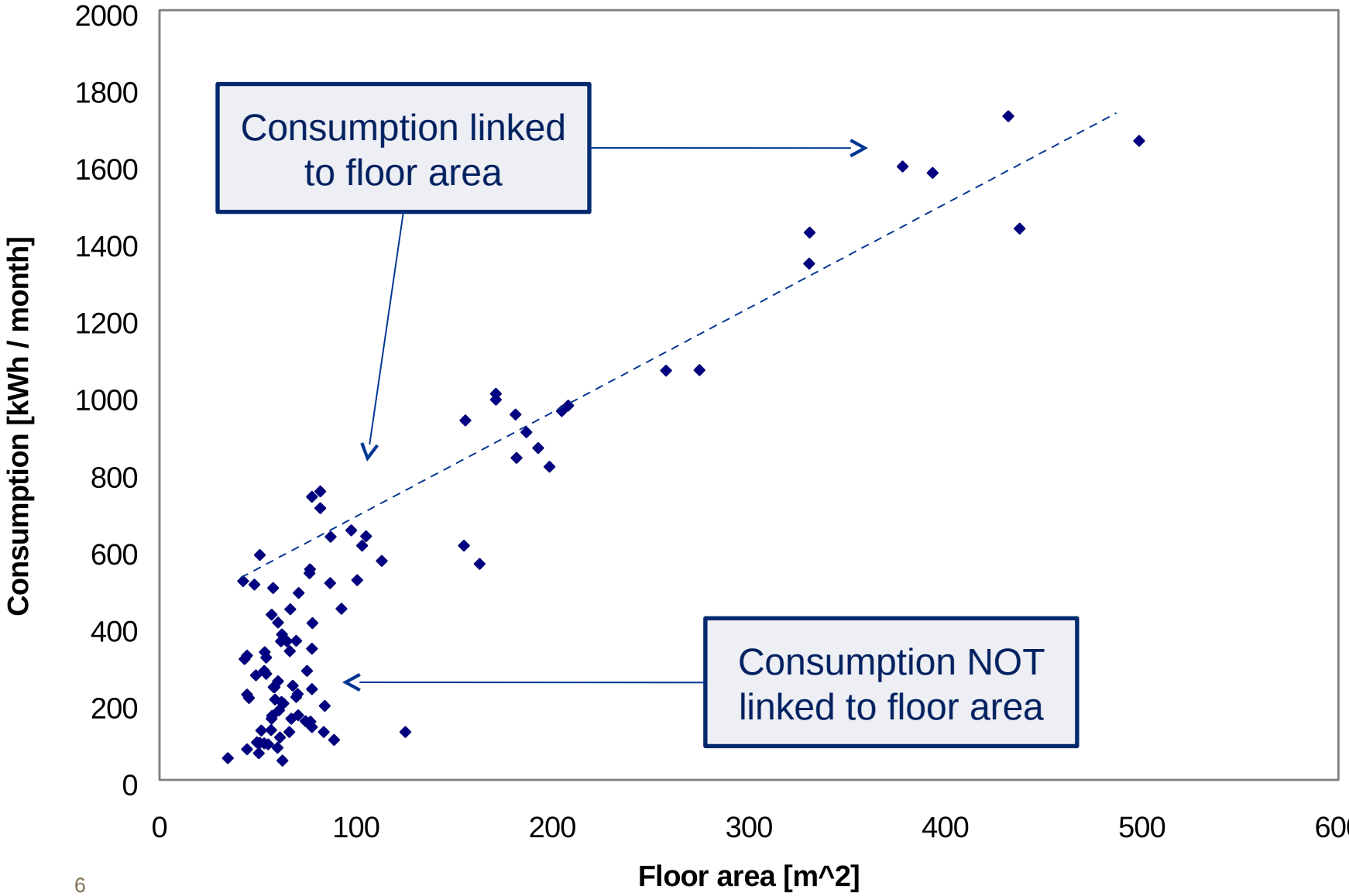
Data filtering

- Data filtered and marked using Seleck rules
  - Filters individual profiles
  - Not sufficient for group behaviour

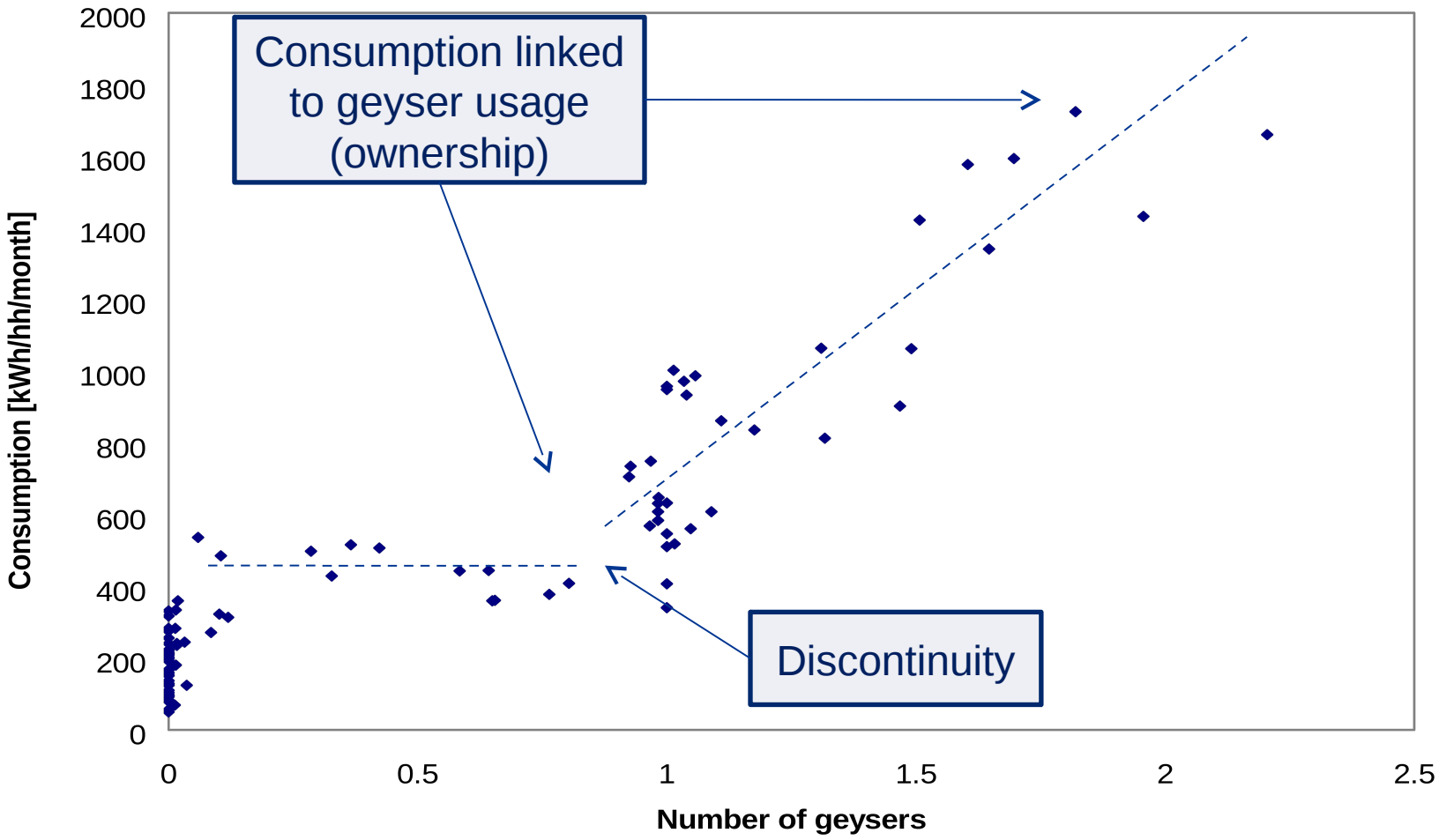
- Group filtering



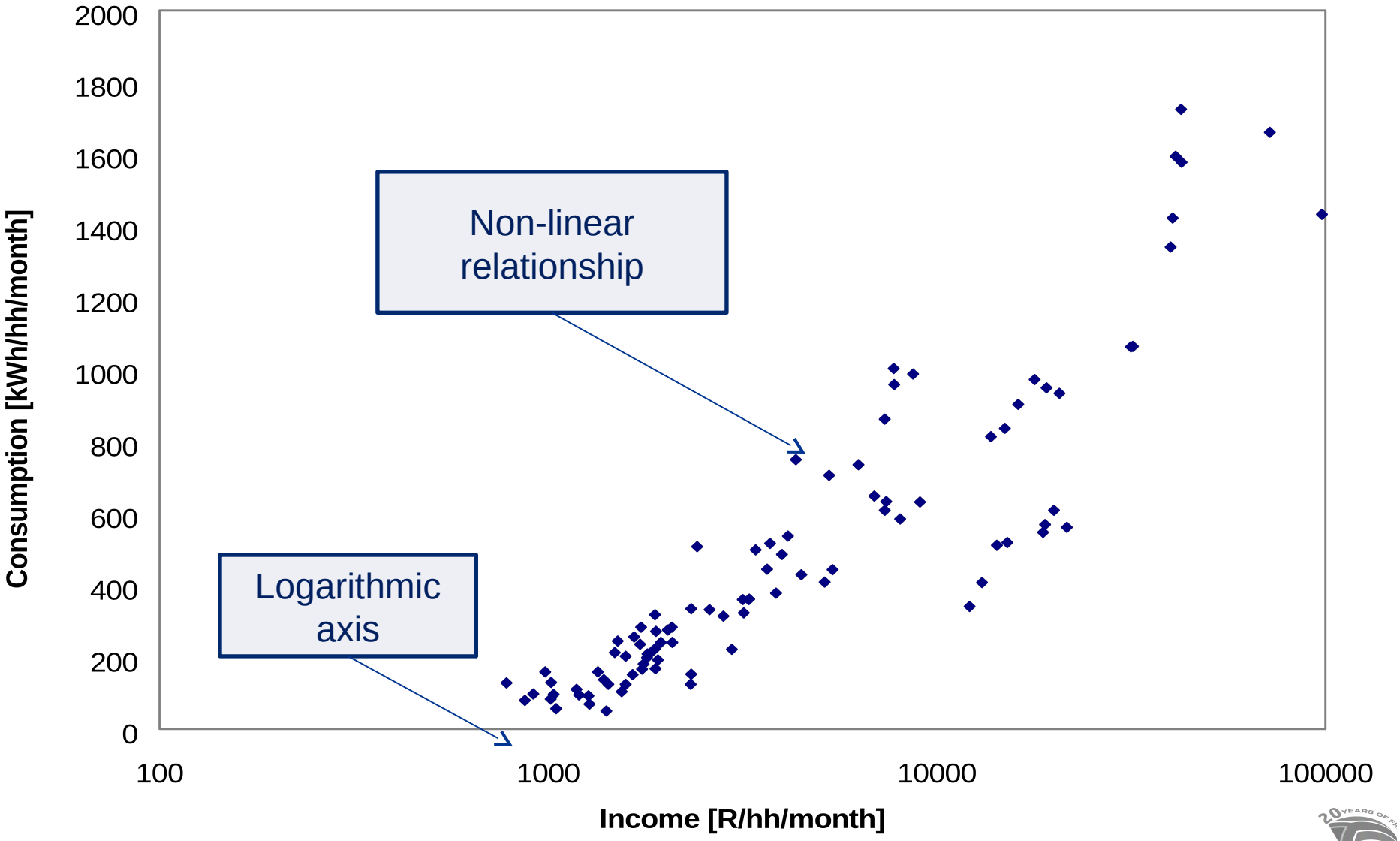
Exploratory Data Analysis – Floor Area



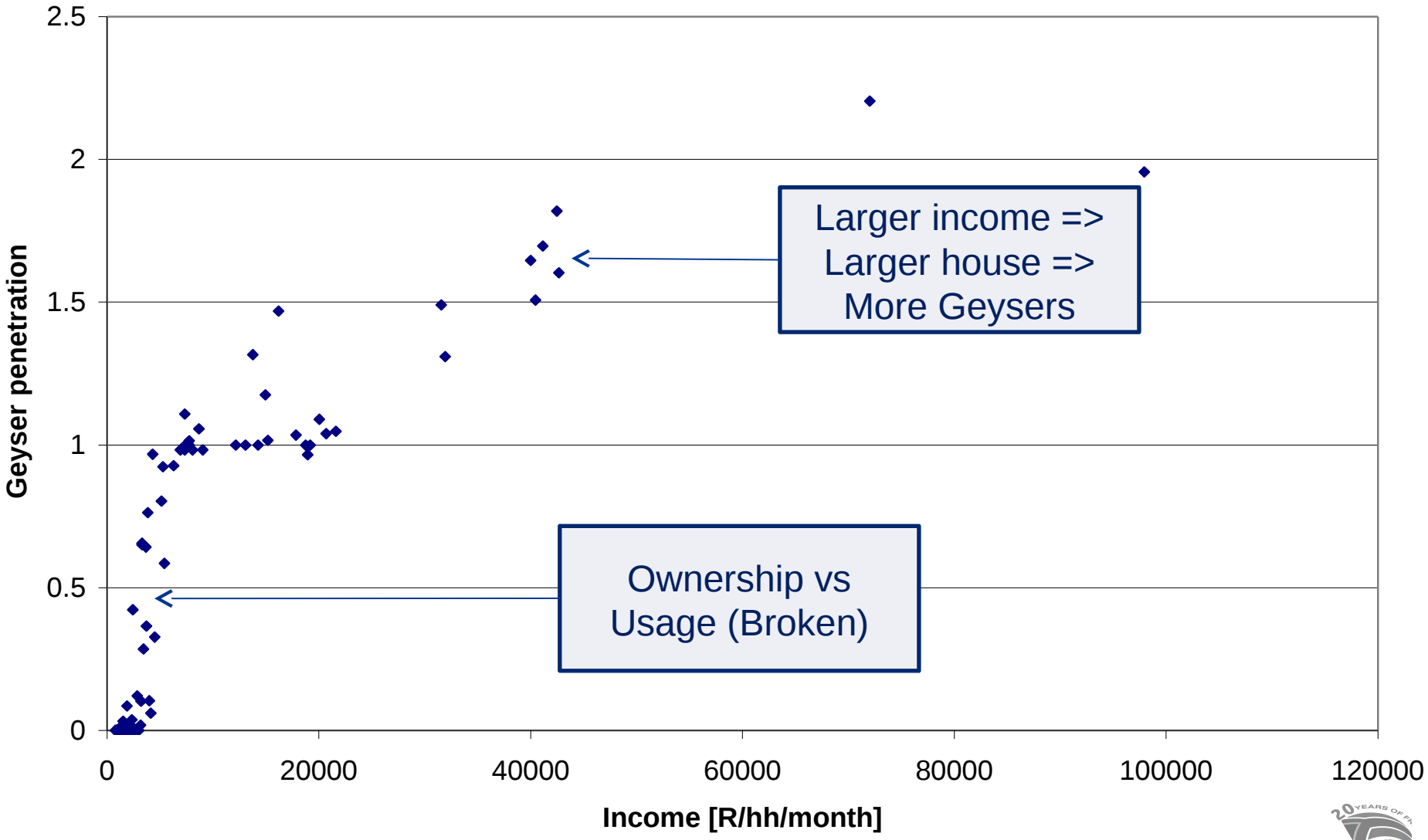
Exploratory Data Analysis - Geyser



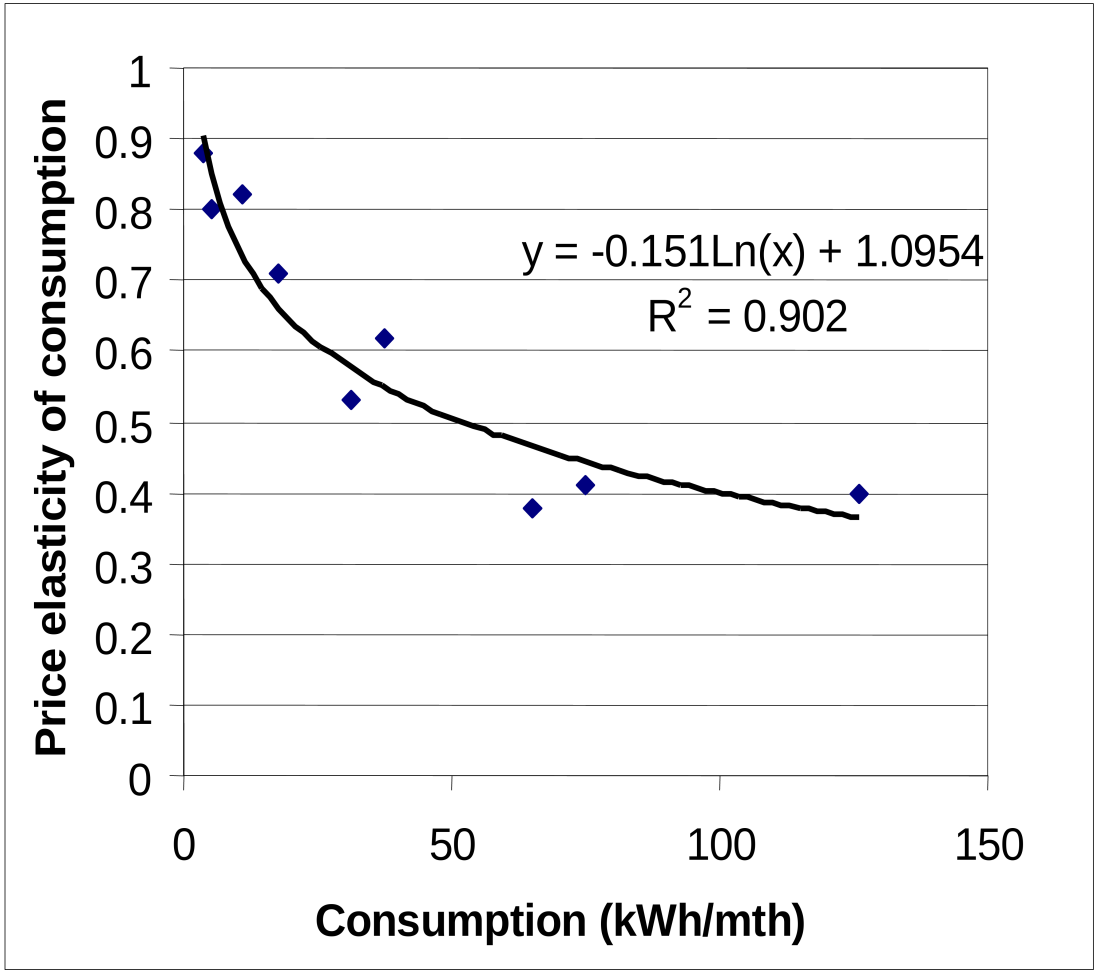
Exploratory Data Analysis - Income



Geyser ~ Income



Impact of Free Basic Electricity

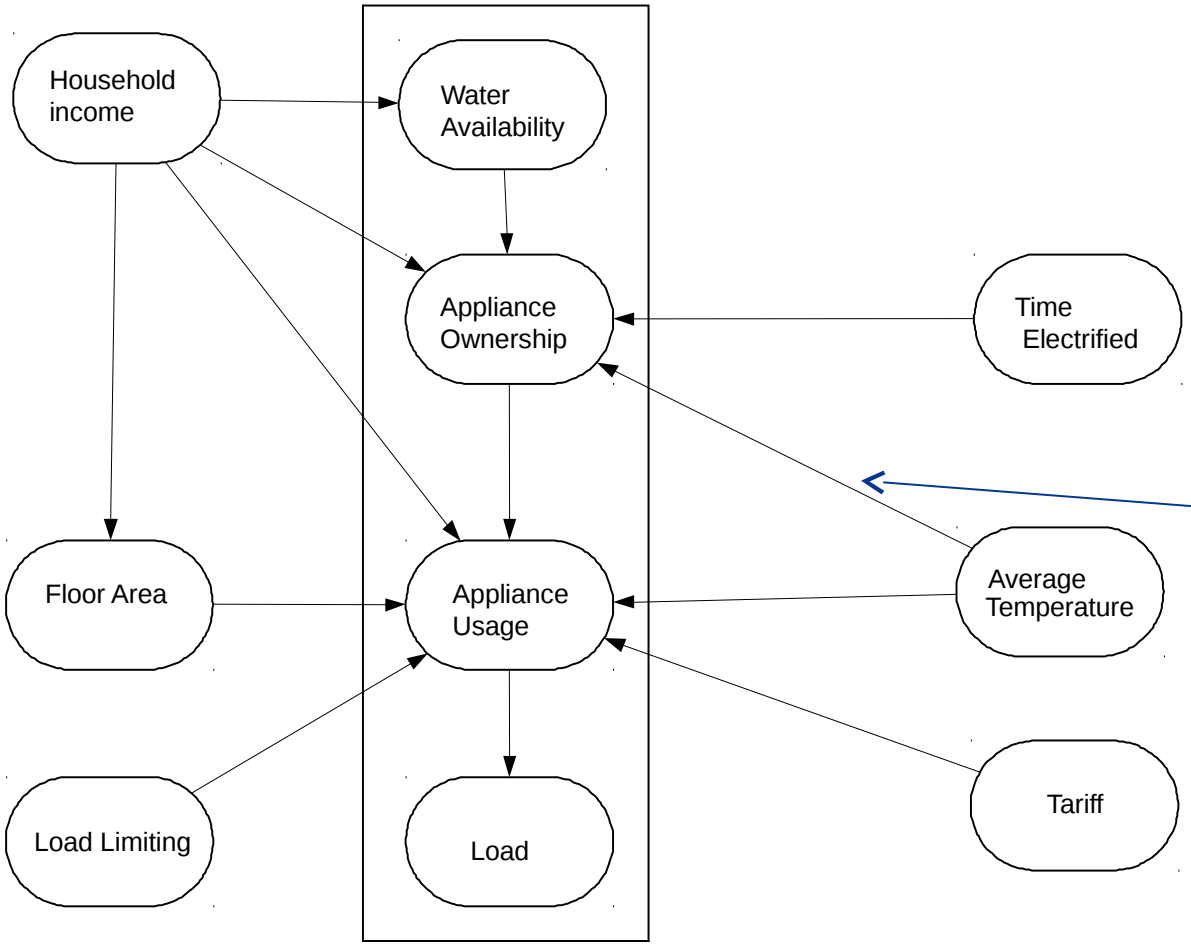


Constructed sample and control groups – measured before, during and after. Based on 50 free units

Fitted line represents price elasticity

Take-up and pickup of BEST also significant

Cause and effect

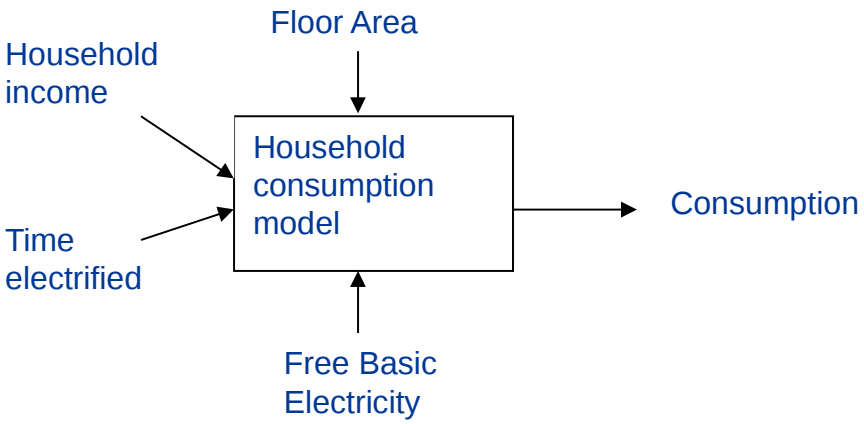


Causal linkages between observed relationships

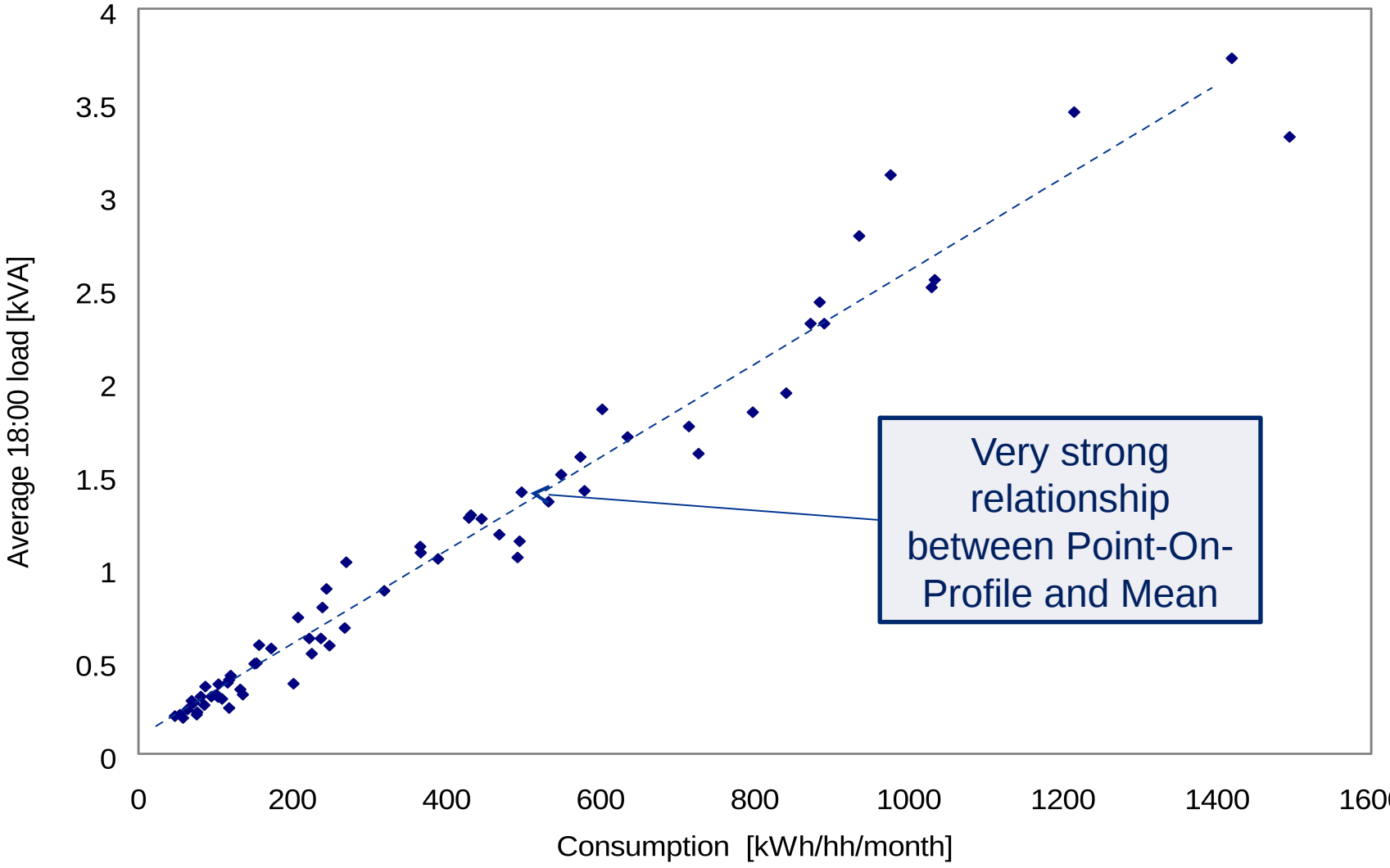
For example, colder temperatures influences heater ownership

Profile model – structure (I)

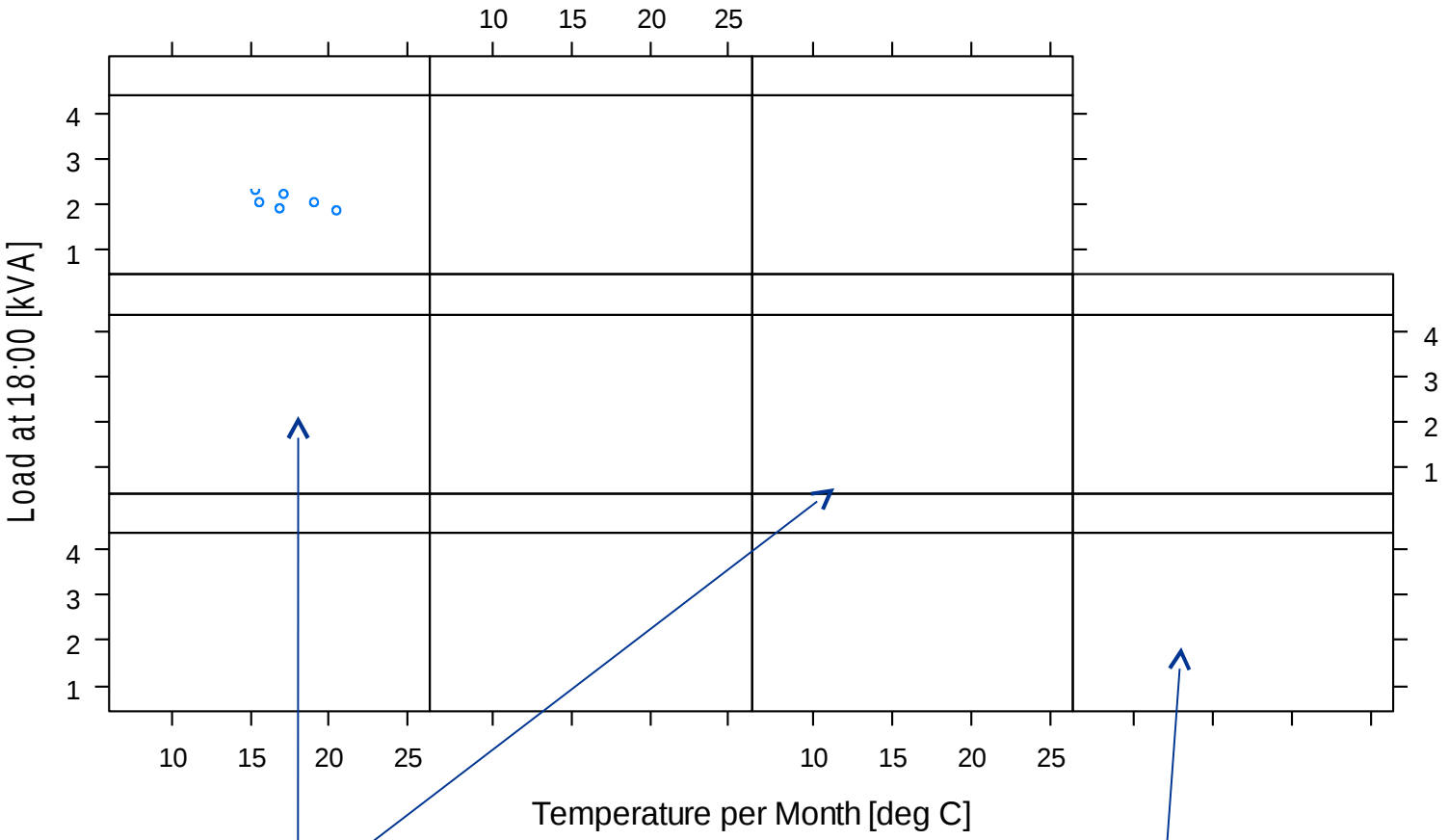
- Consumption model
- Non-linear local regression model
- Fitted using R, loess
- SE = 80 kWh
- $R^2 = 87\%$



Exploratory Data Analysis – 18:00 load



Temperature vs Load at 18:00

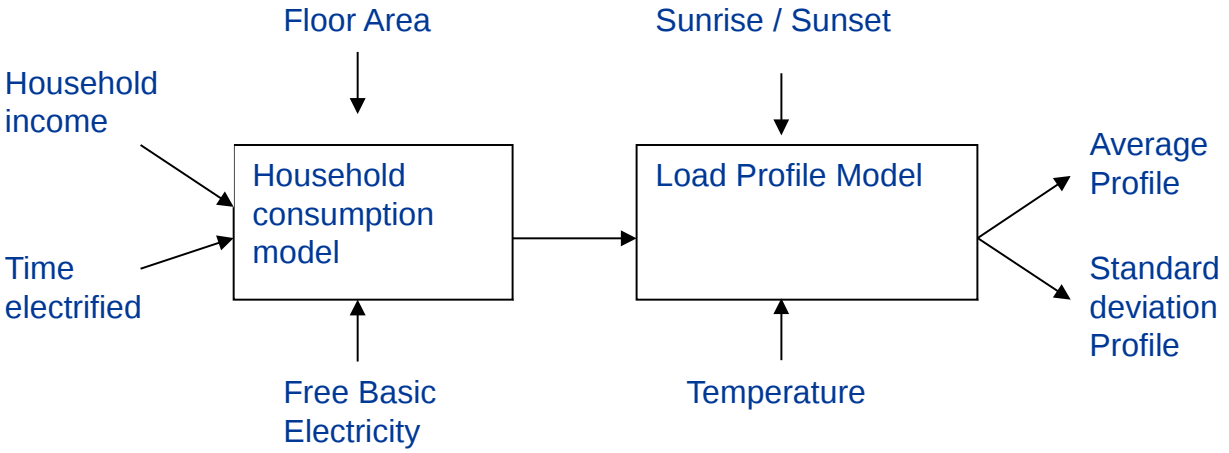


Gradient varies per community

Temperature effect Less pronounced in Durban

Profile model – structure (II)

- Generalized additive model
- Fitted using R, gam
- Average profile: SE = 120 W, R^2 = 95%
- Stdev profile: SE = 150 W, R^2 = 87%



Design parameters survey

- Survey
  - Size of dwellings, number per erf, layout, building styles
  - Recent aerial photograph (use of drones?)

- Household Survey
  - Treat different LSMs separately
  - Divide into blocks and survey at least 100 dwellings – capture diversity
  - More households maybe required for larger / more diverse areas

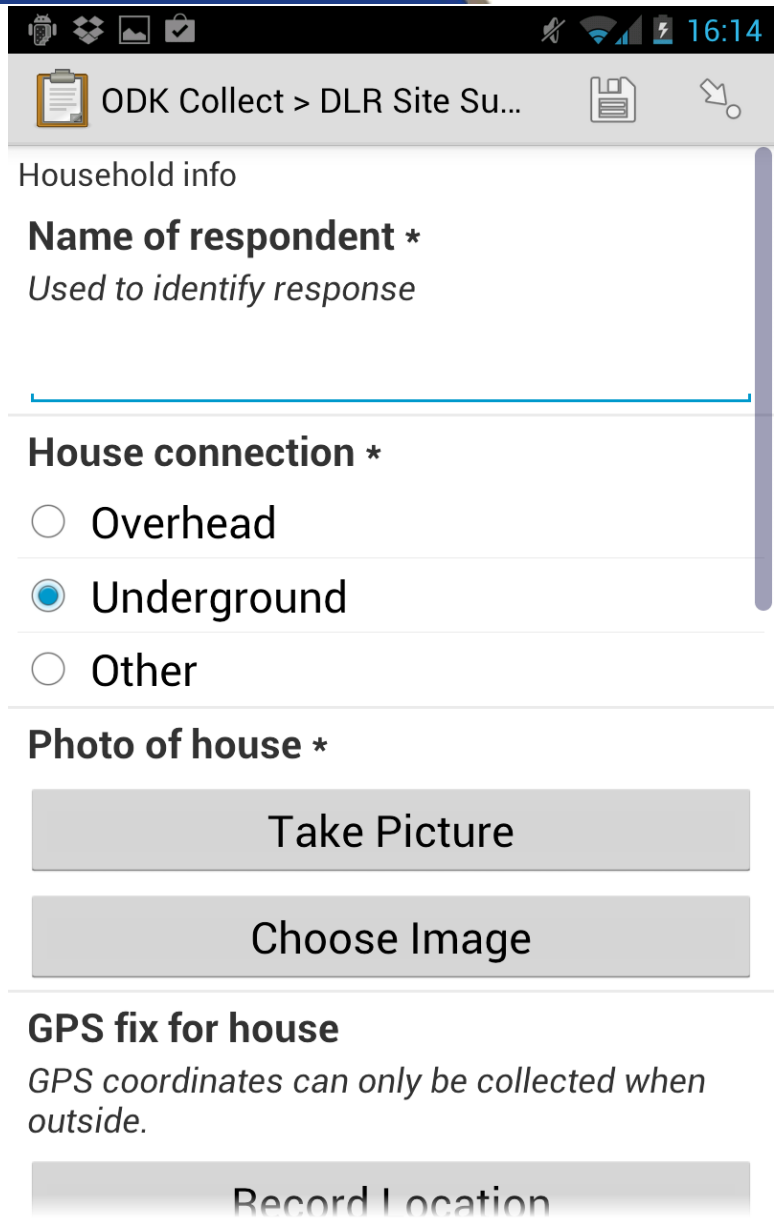
Design parameters survey

- GPS location of household
- Household income, sub-divided into different sources, e.g. Small business, agriculture etc.
- Floor area of the primary
- Source of hot water

- Years electrified
- Monthly electricity bill
- Current meter no

Open Data Kit

- Android based free and open source data collection kit
- Take pictures
- GPS coordinates
- Automatic loading to a (cloud) server



Visualize captured data

Using DT PET

- Demonstration

Adjusting for Risk

- Theft
- Income growth or decline
- Densification
- Renewable

Overview – DT Profile

- Introduction
- Principles of profile addition
- Demonstration

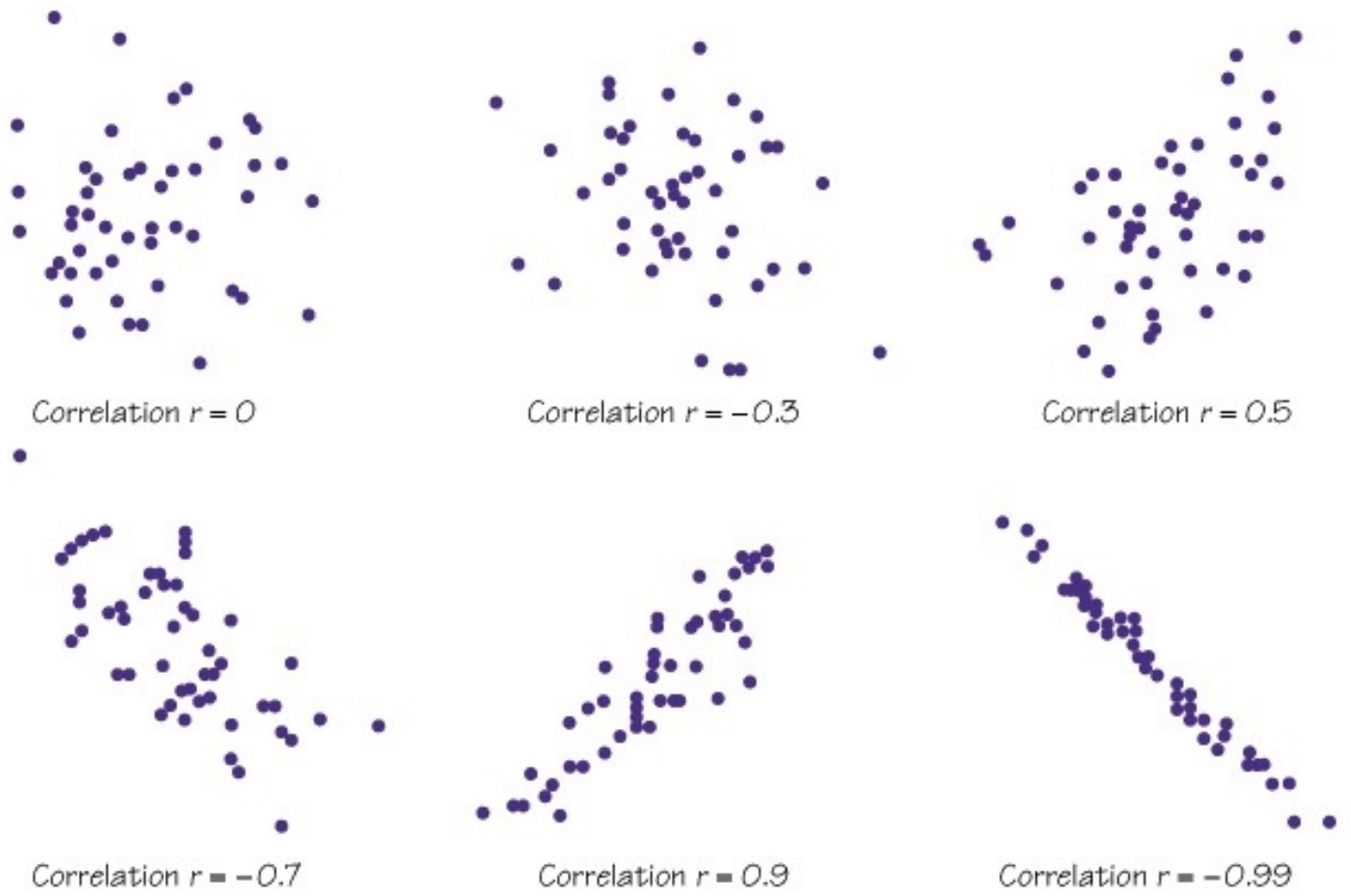
Introduction – DT Profile

- Estimating combined load characteristics
  - Different income groups
  - Number of consumers per income group
- Provides
  - Load profile
  - Estimated consumption
  - Time of Use components (Peak, Standard, Off-Peak)

Principle of load profile addition

- Basic statistical properties
- Average load profile
  - Mean per season, weekday type and hour
  - Standard deviation
- Means are added
- Standard deviation a bit more tricky, need to deal with correlation

Correlation



Some shortcuts

- If correlation = 0:

$$\sigma^2_{\text{total}} = \sigma^2_{1} + \sigma^2_{2}$$

Different classes, then correlation = 0

- If correlation = 1

$$\sigma_{\text{total}} = \sigma_1 + \sigma_2$$

Same class, then correlation = 1

DT-Profile

- Demonstration

Conclusion

- Tools available to assist with
  - Consumption
  - Demand
  - Load profiles

- Represents latest knowledge of South African domestic load behaviour