README

1 User´s Guide to the README

This document explains the smart meter data, how to use it and which data processing that was done to create the Clean Cooking Data Release Report.

Three (3) dataframes are available for download:

1. a2ei_100_tz_raw.csv
    - Raw data with outliers removed.
2. a2ei_100_tz_info.csv
    - General information about the cooking pilot, e.g. meter location and tariff structure.
3. a2ei_100_tz_events_list.csv
    - Dataframe with information on cooking events

2 What Does The Data Look Like?

2.1 a2ei_100_tz_raw.csv

The households were instructed to plug in the smart meters before they started to cook with the EPC and plug them off when they finished their cooking activities. This meant that most of the meters were turned off when the households weren't cooking. The raw data is presented in csv-format with a recording frequency of 5 minutes, so 1 row represents one data point per household per 5-minutes.

Table 1: Raw Data definitions.

COLUMN NAME	VALUE	DESCRIPTION
account_id	ID	unique database identifier of smart meter
meter_number	ID	unique identifier of smart meter
timestamp_lt	YYYY-MM-DD HH:MM:SS (lt)	timestamp of measurement in local time
region	Country Code Partner (Alpha-2 Name)	two digit country code and partner abbreviation
region_timezone	Continent/City	name of the continent and a city in timezone
energy	Kilowatt hour (kWh)	cumulative energy used by appliance
voltage	Volt (V)	active voltage at time of measurement

current	Ampere (A)	active current at time of measurement
power	Kilowatt (kW)	active real power at time of measurement
power_factor	Ratio (-)	apparent power / real power
frequency	Herz (Hz)	frequency at time of measurement

2.2 a2ei_100_tz_info.csv

This file contains a list of general information about each smart meter. This includes the date of installation, where the meters are located, electricity tariff details and dates of the field trips.

The field trips were conducted to make sure that all stored data is sent to the server. As the meters were installed in areas with bad networks they partly needed to be taken to areas of good networks.

There have been three different tariff structures in place during the fourteen month of pilot. First households had different prices depending on their location. Then, due to governmental regulations the mini-grid operators changed to a daily bundle tariff of 5kWh or 10kWh with a price of 100 TZS/kWh, which is $0.22/day or $0.44/day. After a short time the government prohibited those daily bundles, especially in the island sites, and households were under a flat tariff of 100 TZS/kWh again, but with power limitations in place, as the revenue was not cost covering for the mini-grid operator.

Table 2: Smart Meter's general information.

COLUMN NAME	VALUE	DESCRIPTION
meter number	ID	unique identifier of smart meter
connection_date	YYYY-MM-DD (UTC)	date of meter installation in household
location	mainland OR island	the location of the household
site	ID	unique identifier of the site the meter is on (1-6)
tariff_one	flat [1] OR discount [2] OR block [3]	tariff structure of household before tariff change
tariff_two	daily_bundle	daily bundle with 100 TZS/kWh price after tariff change, 5kWh or 10kWh daily bundles
tariff_three	flat_with_restrictions	price per kWh (100 TZS), but power restrictions

date_tariff_change_one	YYYY-MM-DD (UTC)	date of tariff change from tariff_one to tariff_two
date_tariff_change_two	YYYY-MM-DD (UTC)	date of tariff change from tariff_two to tariff_three
date_disconnect_minigrid	YYYY-MM-DD (UTC)	site 6 got disconnected from the mini-grid, the national grid successively and only partly took over
date_field_trip_one_start	YYYY-MM-DD (UTC)	date for taking meter to good network area
date_field_trip_one_end	YYYY-MM-DD (UTC)	date for bringing meters back to households
date_field trip_two	YYYY-MM-DD (UTC)	date for taking meter to good network area, max 24 hr
date_field_trip_three_start	YYYY-MM-DD (UTC)	date for taking meter to good network area
date_field_trip_three_end	YYYY-MM-DD (UTC)	date for bringing meters back to households
date_field_trip_four_start	YYYY-MM-DD (UTC)	date for taking meter to good network area
date_field_trip_four_end	YYYY-MM-DD (UTC)	date for bringing meters back to households
unexpected_event	epc_broke OR dropped_out OR gave_epc_to_other_household OR passed_away	in the endline survey those households reported unexpected events, like a broken epc or they dropped out of the study or gave the epcs to other households

[1] Flat tariff: Customers are charged a flat rate regardless of how much energy they consume.
[2] Discount tariff: Customers were given a 42% reduction on the flat tariff rate.
[3] Block tariff: Customers are given a 37.5% discount if they use at least 3kWh in a month.

2.3 a2ei_100_tz_events_list.csv

Data which includes information on cooking sessions, 1 line per cooking event and household.
Table 3: Events lists information.

COLUMN NAME	VALUE	DESCRIPTION
account_id	ID	unique database identifier of smart meter
meter_number	ID	unique identifier of smart meter
region	Country Code Partner (Alpha-2 Name)	two digit country code and partner abbreviation
region_timezone	Continent/City	name of the continent and a city in timezone
event_time_utc_start	YYYY-MM-DD HH:MM:SS (utc)	timestamp at start of cooking event in utc

event_time_utc_end	YYYY-MM-DD HH:MM:SS (utc)	timestamp at end of cooking event in utc
event_time_lt_start	YYYY-MM-DD HH:MM:SS (lt)	timestamp at start of cooking event in local time
event_time_lt_end	YYYY-MM-DD HH:MM:SS (lt)	timestamp at end of cooking event in local time
event_duration	Minutes (min)	duration of cooking event in minutes
event_energy_start	Kilowatt hour (kWh)	energy count at start of event
event_energy_end	Kilowatt hour (kWh)	energy count at end of event
event_energy	Kilowatt hour (kWh)	energy consumption of cooking event
event_current_max	Ampere (A)	maximum of current within that cooking event

3 Mini-Grid Insights

Table 4: Minigrid's System information.

Site	Photovoltaic Capacity (kWp)	Battery Capacity (kAh)	Diesel Generator Capacity (kVA)	Number of Connections	Number of Households Cooking	Share of Households with EPC	Photovoltaic power per /household (kWp)
Site 1 – Island	25.9	55.1	22	340	31	9.1%	0.08
Site 2 – Island	16.2	36.7	22	130	12	9.2%	0.12
Site 3 – Island	19.1	55.1	10.5	180	10	5.6%	0.11
Site 4 – Mainland	6.4	18.4	14.5	178	15	8.4%	0.04
Site 5 – Mainland	6.4	18.4	20	132	17	12.9%	0.05
Site 6 - Mainland	12.7	36.7	0	182	15	8.2%	0.07

4 Pilot Periods

Table 5: Different pilot phases.

Period	Start Period	End Period	Number of Days
Honeymoon	March 9th, 20	May, 31th, 2020	84
Steady State	June, 1st, 20	October, 4th, 2020	126
Transition	October, 5th, 20	November, 18th, 2020	45
Low Tariff	November, 19th, 20	December, 31th, 2020	43
Power Restriction	January, 1st, 2021	April, 30th, 2021	120

Honeymoon Period:
We believe this first period from March 1st to May 31st is characterized by the novelty of owning a new cooking appliance. During this time, people may be excited at having their new appliance and are experimenting with its usage to gain familiarity with its advantages and disadvantages in the kitchen. In this report, we refer to this period as the Honeymoon period.
Steady State:
If EPC usage in the Honeymoon period is driven by novelty, then the period after shows what happens when the novelty wears off. Three months after receiving the appliance, EPC usage flatlines. This trend may reflect that users have gained sufficient clarity of the costs and benefits of using the EPC and are able to make rational decisions about its usage. We refer to this period from June 1st until September 30th as the Steady State period.
Transition Phase:
While in both Honeymoon and Steady State periods households were paying high prices of around $1/kWh, in the Transition Phase we see what happens when price reductions are set in place subsequently at all pilot sites. On October 5th the first site (site 2) changed to bundle tariff conditions, where people paid $0.22 or $0.44 per day and received 5kWh or 10kWh. Usage in this period steadily increased, reaching a peak on November 18th, when the low tariff conditions were set in place at the last site.
Low Tariff:
From November 19th on, all sites operated under Low Tariff conditions with daily bundles and without load limitation in place. This period is characterised by a high use of EPCs with up to 100 cooking events per day. This period is especially interesting for mini-grid providers to evaluate effect on the grid and expected revenue.
Restriction Phase:
Starting from January 1st especially the mainland sites were subjected to load limits and partially shut down of whole sites. Usage varies depending on individual conditions and available power on each site. Usage partly stays high, but lower than in the Low Tariff phase.

5 EPC Technical Characteristics

Table 6: EPCs technical specifications.

Specification	Value
Power	1000 W
Make	Nikai
Capacity	6 L
Voltage	220–240 VAC

Figure 1: EPCs used in the pilot.

5 Assumptions and Calculations

Translating cooking sessions into CO_2 output

From [1] page 9, Table 4 we see that 15.9MJ of wood translates into 1kg. When looking into [2] page 143, table 7.2 we find that 1kg of wood translates into 1370-1688g of CO_2 emissions. We assume one meal prepared with food is assuming 8MJ, as we find in [3] page 130, table C.2. that on average 23.9MJ are used on average per household and we assume people cook on average 3 meals per day. Consequently, 8MJ translates into 0.5kg of firewood per meal translating into 765g of CO_2 emissions.

6 Cooking Session Definition

All code is written in Python with Pandas. The cooking events are created by applying several event conditions for maximum resemblance to the actual cooking events. In essence, a cooking event is any change to the energy counter within 15 minutes.

Below is an overview of the conditions that are used for defining a cooking event:

1. Treatment of empty cells
    1.1. Fill current value (A) from row above

1.2. Fill energy counter value (kWh) from row above

Explanation: The smart meters in this project are only sending data when a value changes, e.g. from 4 A to 4.1 A. Hence, the current value and energy counter value are filled out to match the value of the previous row.

2. Calculate instantaneous power (kW): current * voltage / 1000

Explanation: The power of the EPC is calculated by multiplying the current and voltage. This is more exact than the power value on the smart meter display, which is calculated as an average of the recording interval [read: 5 minutes].

3. Apply conditions for event start and end
   3.1. Indicate when EPC is turned on/off
   3.2. Calculate event end time
   3.3. Calculate event start time

Explanation: Several conditions are applied on the data to indicate if the EPC is turned on or off. This includes looking at the minimum energy consumption of an event (0.02 kWh), checking any irregularities in the time recording intervals and assigning changes in the energy counter to either an ongoing cooking event or a start or an end of a cooking event.

4. Disqualify events that are not qualifying as EPC events according to the threshold values

Explanation: If an event is longer than the maximum event duration (400 minutes) or has a maximum current below the rated current of the EPC (3.0 A), then these are removed from the list of cooking events. In case a cooking event is lacking a current value i.e. is so short [read: 5 to 10 minutes] that it only has empty cells as current values, then this event is not removed.

5. Merge events that are very close to each other into one

Explanation: Check if events start within 10 minutes to each other to produce longer and fewer events. These events are merged, because the events have typically been separated because of the fact that an appliance is maintaining the heat for 5 to 10 minutes without consuming any electricity.

6. Get event energy and event time

Explanation: Extract the energy consumption and event time of each session to produce the event list file

7. Calculate cooking events from data gaps

Explanation: Assign the energy and time between two subsequent recordings that are longer than 15 minutes and have a change in the energy counter value. The data gap is either allocated to the start section or end section of an existing event or it makes up a completely new cooking

event if the energy gap is larger than the average event. Completely new events are marked with a 1 in the column called event_calc [read: calculated event].

Please reach out to us at cleancooking@a2ei.org to get more advanced details and the cooking definition code for you to play around.