CLEAN COOKING

A2E

ACCESS TO ENERGY INSTITUTE

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DATA RELEASE REPORT

DECEMBER 2020

Are electric cooking appliances the future of clean cooking?

Introduction

At the beginning of 2020, the Access to Energy Institute (A2EI) set out to answer this question with one of the largest electric cooking pilot projects in Tanzania conducted in collaboration with Nexleaf, Modern Energy Cooking Services, and PowerGen. 100 participants at six different mini-grid villages were trained on the usage of electric pressure cookers (EPCs) and given an EPC connected to an electric smart meter to use in their home.

As the pilot participants used their EPCs, these smart meters collected data on their utilization. This data set allows us to answer research questions on the viability of EPCs and electric cooking appliances, such as:

- How did people cook with their new electric cooking appliances?
  How much do they really use them?
- What happened at the community level?
  How will electric cooking appliances affect the grid?
- And how do cooking and cost of electricity relate?
  What happens when the price changes?

Data Release

Nine months into this pilot, A2EI is releasing this smart meter data set to the public so that others can learn from our experience. Alongside the data release, this report presents an analysis of that data set.

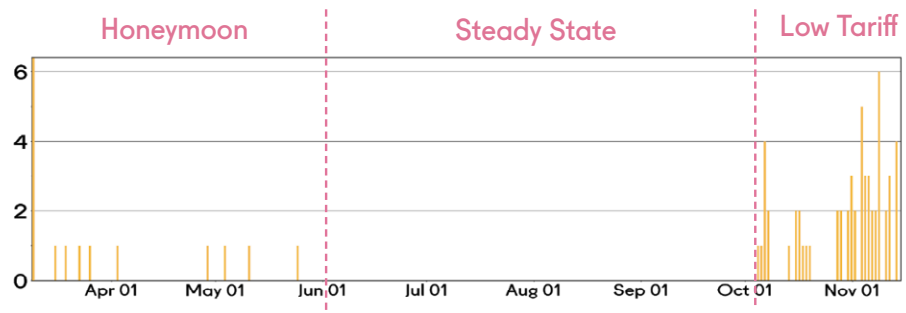
EXECUTIVE SUMMARY

Pilot Overview

100 participants at six different mini-grid villages were trained on the usage of electric pressure cookers (EPCs) and given an EPC connected to an electric smart meter to use in their home. The smart meters recorded energy data on 5-minute intervals for the duration of the pilot. During the first 7 months of the pilot, the users cooked under a cost-reflective tariff of $1 per kilowatt-hour. After that initial period, the tariff was reduced to $0.04 per kilowatt-hour. After 9 months of the pilot, smart meter data from each household was analyzed.

Summary of Findings

Pilot participants used the EPC frequently during the first 3 months of the pilot, attributed to the novelty of owning a new appliance. After this Honeymoon period, usage flat-lined in a Steady State period. Following a reduction in tariff, usage rose sharply, especially in users that had low rates of utilization during the beginning periods.



Conclusions

- Cooking research requires multiple months of data collection to uncover behavioral trends that develop over months
- Users responded positively to the EPCs, but were deterred by the price of cooking
- Price-sensitive users are left behind when electricity prices are high, but lead in usage when prices are low
- To achieve the full impact potential of electric cooking, support from outside of the private sector is needed

Future Work

- Continuation of off-grid pilot and linkage of smart meter data sets with complementary sets
- Commencement of on-grid pilot in 2021 to investigate impact on utilities and high-potential customer segments

PILOT BACKGROUND

This pilot was conducted at 6 remote mini-grid locations in Tanzania, 3 on islands in Lake Victoria and 3 in the mainland region. 100 mini-grid customers selected from across these sites were given 6 liter AC electric pressure cookers (EPCs) and trained on their usage. EPCs were provided free of charge, but pilot users were required to pay for electricity.

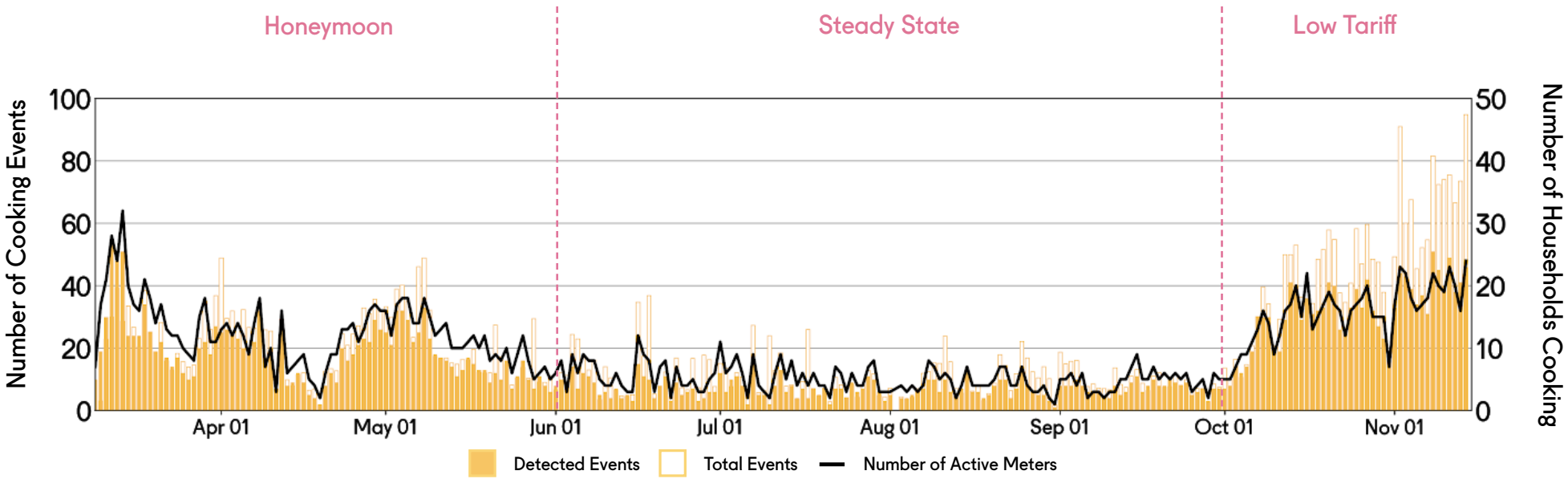
Tariff rates at the pilot sites during the first 7 months of the pilot were cost-reflective and averaged $1 per kilowatt-hour of electricity. After the 7th month of the pilot, national energy policy changes resulted in a reduction of the tariff to $0.04 per kilowatt-hour of energy.

During the pilot, electricity smart meters were attached to the EPCs and recorded data on the energy consumption on 5-minute intervals. This data collected between March 1 and November 15, 2020 was then processed and analyzed for this report.

This pilot is still ongoing and thus the results presented in this paper are preliminary. Both raw and processed data have been released alongside this report.

HOW DO PEOPLE COOK WITH ELECTRICITY?

Aggregate Cooking Events and Cooking Households from Set of All Users, March to November



When observing the aggregate usage of the EPCs over the 9 month pilot period, we observe a U-shaped trend associated with the number of cooking events and households cooking. At the beginning, people cook relatively often, before this decreases to a low value and then begins to rise again.

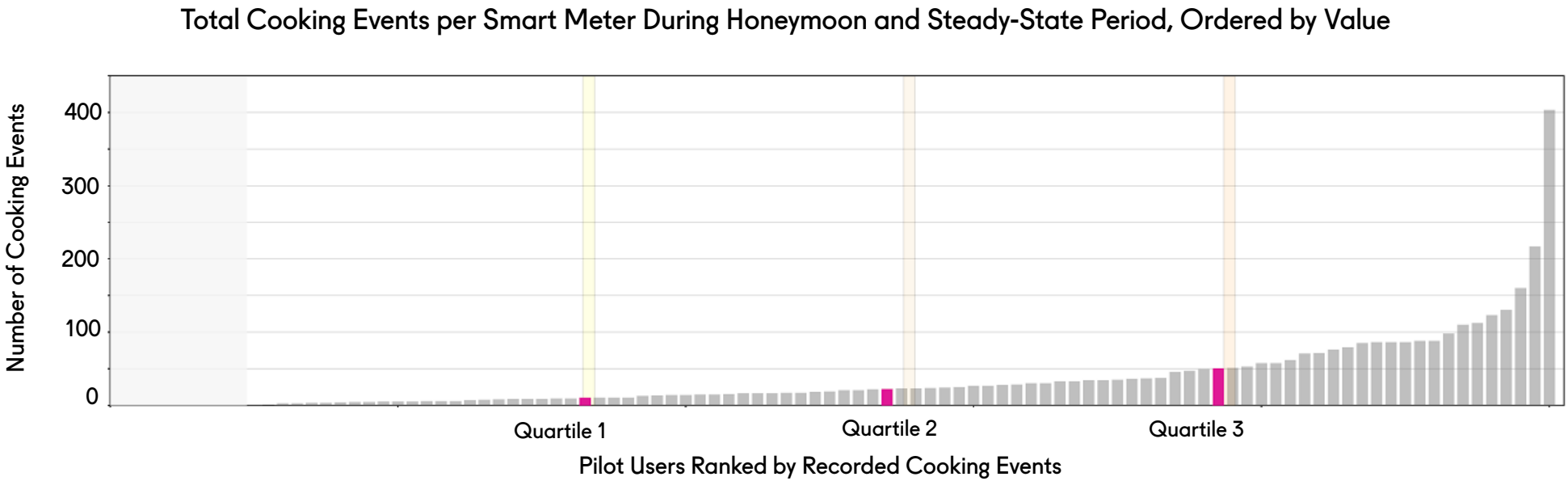
What could cause this behavior? We believe this first period from March 1st to May 31st is characterized by the novelty of owning a new cooking appliance. During this time, people may be excited at having their new appliance and are experimenting with its usage to gain familiarity with its advantages and disadvantages in the kitchen. In this report, we refer to this period as the Honeymoon period.

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.

Starting October 1st, usage begins to rise dramatically. What drives this increase is clear: electricity tariffs at pilot sites began to be reduced after October 1st, from an initial cost-reflective tariff of $1 per kilowatt-hour to a reduced tariff of $0.04 per kilowatt-hour. With the costs of cooking reduced, pilot users begin to use their EPCs with renewed enthusiasm. We refer to this period as the Low Tariff period, spanning from October 1st until present day.

Note: Cooking events were determined based on energy consumption. For more information on defining cooking events and detecting these events, see ReadMe file attached to Data

HOW DO INDIVIDUALS COOK WITH THE EPC?



The above graph shows the total cooking events recorded by the smart meters over the 7 months of Honeymoon and Steady State periods. From the graph, we see many users are utilizing the EPC very little: the 25th percentile of users cooked only 11 times over the Honeymoon and Steady State Periods. Instead, most of the cooking events come from a small subset of users: 25% of the users account for 64% of total cooking events during this time.

This data shows us that in an off-grid context characterized by high costs of electricity, the benefits of electric cooking will be concentrated in a minority of users. This subset of users is also the target market for private sectors organizations looking to supply electric cooking appliances or the electricity that powers them.

Understanding this segmentation is critical. Programs focused on promoting electric cooking appliances in the near-term should target just the subset that is likely to use the appliances heavily, as these users are more likely to realize impact and financial returns. Those that can take the long-term view should instead focus on the majority and address the question of what interventions are needed to ensure that all people access the benefits of electric cooking.

Quartile	Smart Meter	Cooking Events	Share of Cooking Events Up to Quartile (%)
0	#11	1	0%
25	#34	11	3%
50	#56	25	14%
75	#77	51	36%
100	#100	404	100%

Selecting Representative Users

In the following section, we present data from users that we believe represent the range of cooking behaviors from our pilot group. To select our users, we summed the total cooking events of each user during the Honeymoon and Steady State periods and sorted these users by number of cooking events. After removing 10 users due to issues related to data-quality, we found the quartiles (0, 25, 50, 75, and 100th percentile) from the remaining set of users.

Note: 10 smart meters were excluded from this ranking due to issues related to cooking event detection. For more info, see the Readme file.

HOW DO INDIVIDUALS COOK WITH THE EPC?

Cooking Events and Energy Consumption during Honeymoon and Steady State Periods for Three Representative Users

<u>Low-Utilization User</u>

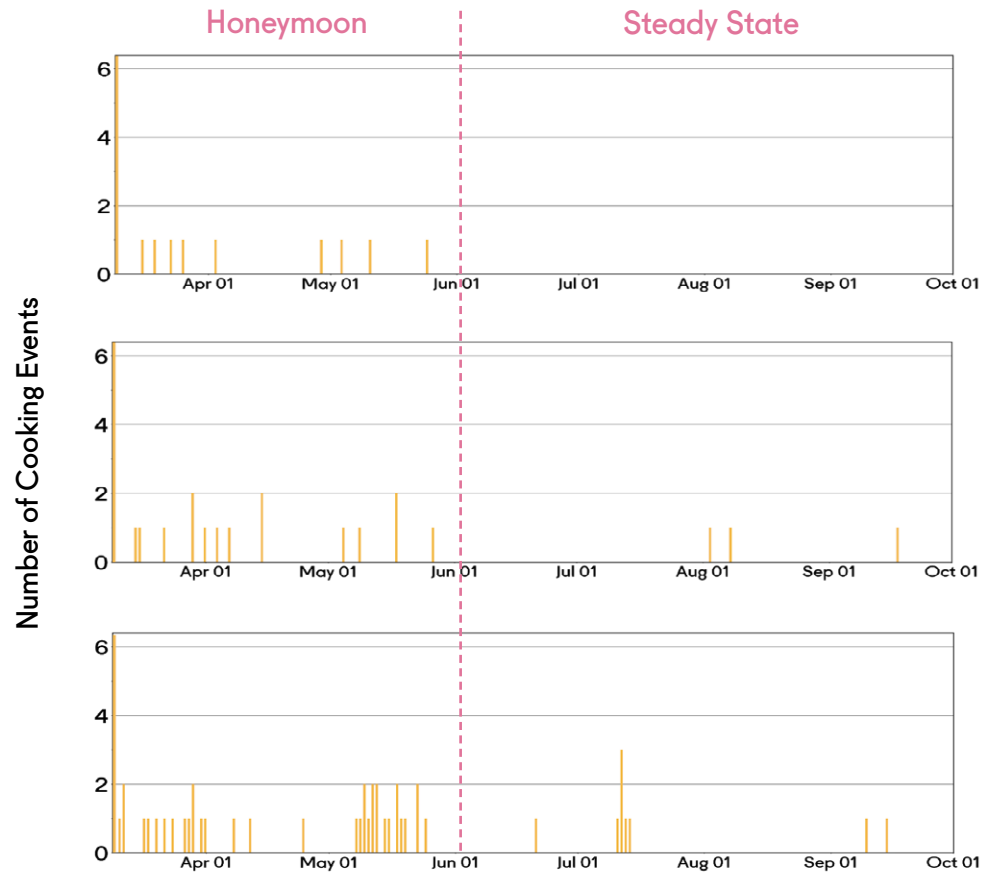
	Honeymoon	Steady State
Average Monthly Cooking Events	3.6	0
Average Monthly Energy Usage (kWh)	1.0	0

<u>Medium-Utilization User</u>

	Honeymoon	Steady State
Average Monthly Cooking Events	5.4	0.8
Average Monthly Energy Usage (kWh)	1.5	0.2

<u>High-Utilization User</u>

	Honeymoon	Steady State
Average Monthly Cooking Events	12.7	2.2
Average Monthly Energy Usage (kWh)	3.2	0.7



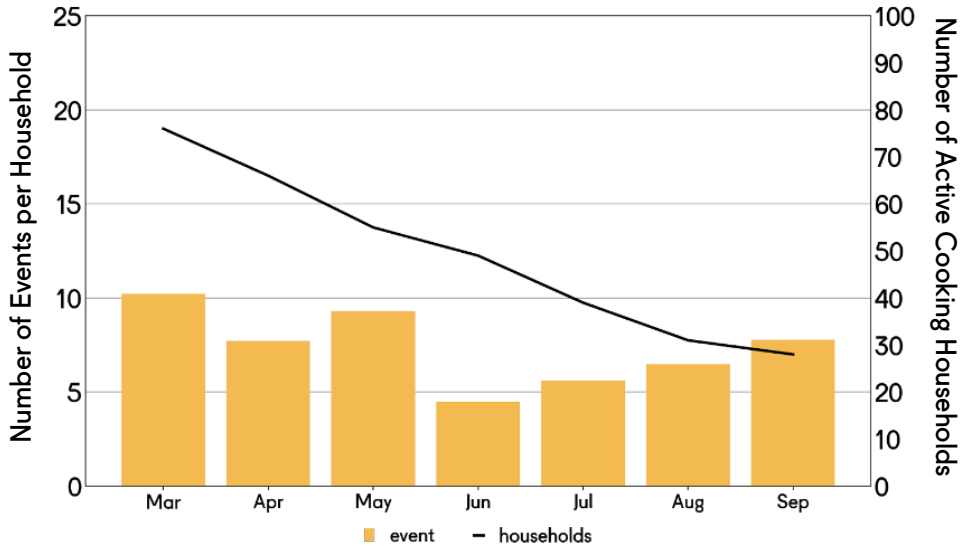
From the graphs above, we see how usage decreased after the Honeymoon period ended. All three users had a sharp decline in the utilization of the EPCs, with the Low-Utilization user ceasing to use the appliance entirely.

If there is a strong relationship between cost of electricity and usage of the EPC as we believe, these graphs would suggest that this influences users differently. A Low-utilization user might be particularly price sensitive and quickly learn to avoid cooking with the EPC. Our High-utilization user might be more willing to spend money for convenience and be more comfortable to sustain their level of usage beyond the initial Honeymoon period.

For all the users, we observed a low level of utilization during the period where the tariff was high: our High-utilization user only used the EPC once every other week.

WHAT DOES EPC COOKING LOOK LIKE AT SCALE?

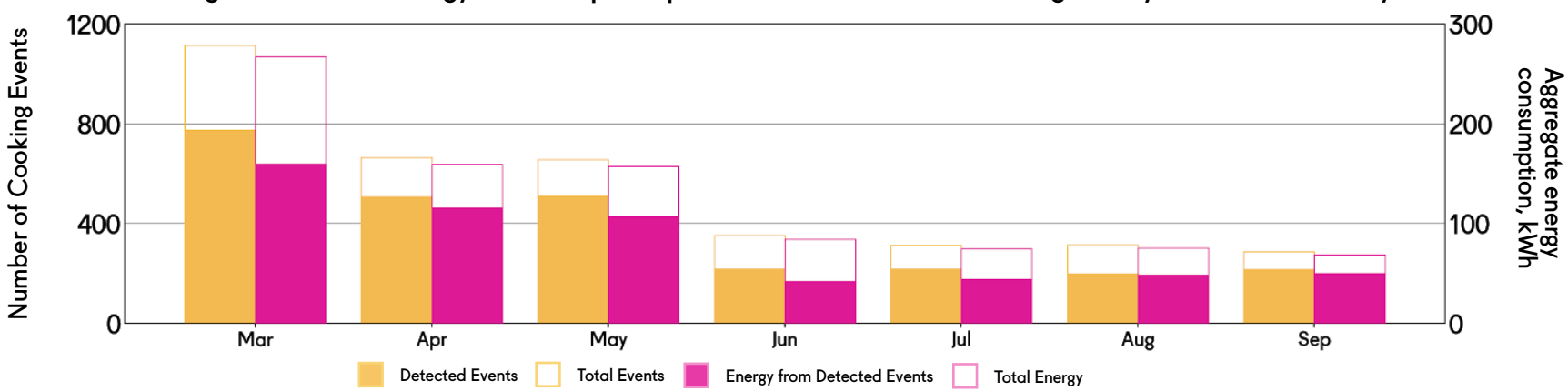
Aggregate Cooking Events and Energy Consumption during Honeymoon and Steady State Periods



The graph on the left shows that during the Honeymoon period, the average cooking events per household stayed relatively constant. At the Steady State period, we see a drop in the number of cooking events per household before the average begins to climb again. All this time, the number of users actively cooking with the EPC declines.

It is unclear what would happen had the pilot extended without any tariff change; it is possible that the active users would continue to decline, but also possible that the behavior would stabilize. That we still observe such changes 7 months into the pilot suggests that short-term studies may be of limited use for those interested to understand sustained usage of these appliances.

Total Cooking Events and Energy Consumption per Month for All Users during Honeymoon and Steady State Periods



The above graph shows how the energy and cooking events declined over the Honeymoon and State periods when viewed in aggregate.

Energy consumption data like this is critically important for private sector companies to understand the business opportunities associated with electric cooking. By translating energy consumption into revenue, it's possible to both size the market opportunity and also understand the ROI for investing in the market. In this case, 28 users were consuming a total of 69 kWh in September at the end of Steady State.

WHAT DOES EPC COOKING LOOK LIKE AT SCALE?

Cooking Events and Energy Consumption of All Users Over Select 24 hour Periods

Low-Utilization Day

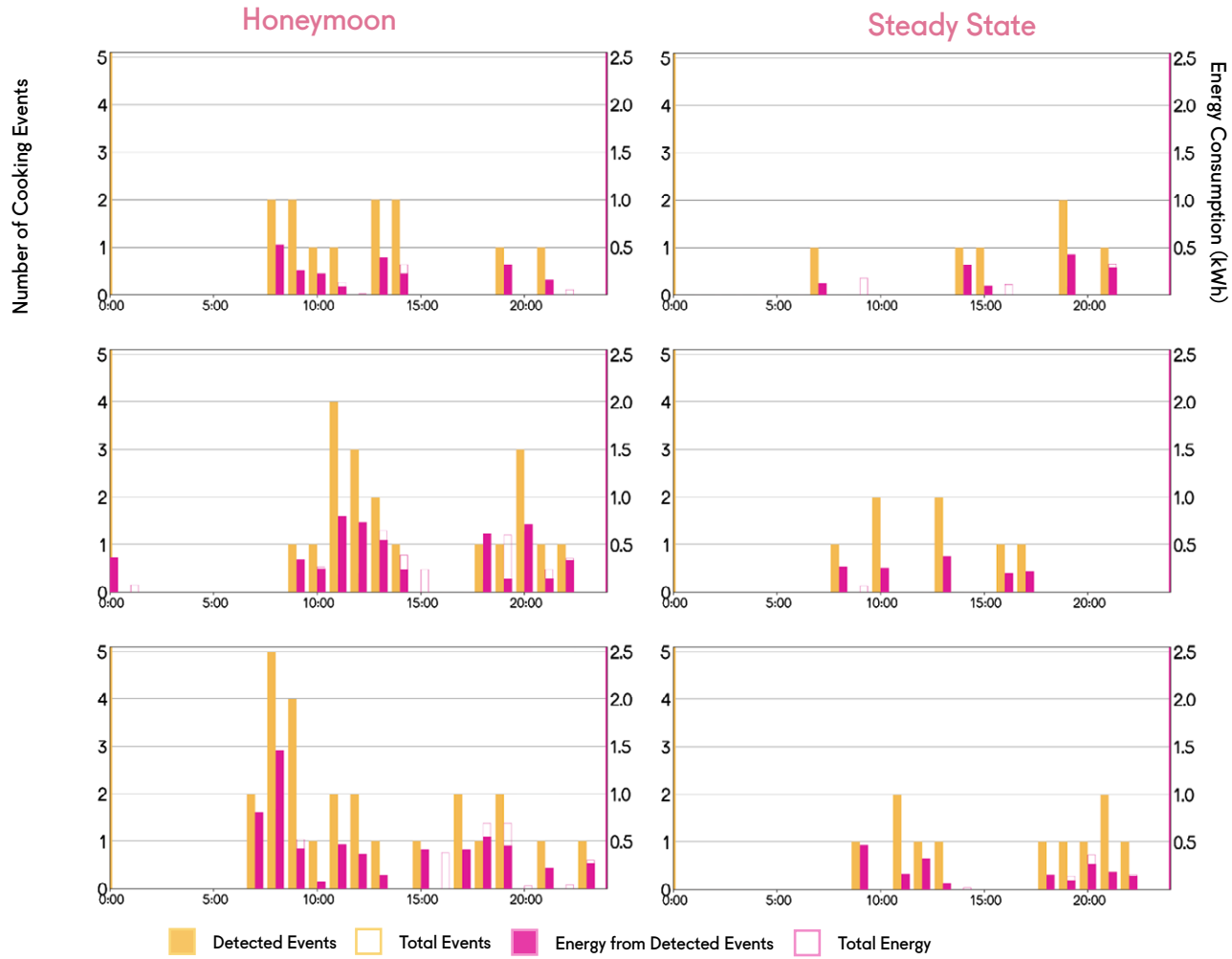
	Honeymoon	Steady State
Cooking Events	12	6
Energy Usage (kWh)	22	1.3

Medium-Utilization Day

	Honeymoon	Steady State
Cooking Events	20	7
Energy Usage (kWh)	5.3	1.3

High-Utilization Day

	Honeymoon	Steady State
Cooking Events	25	11
Energy Usage (kWh)	6.1	1.9



The graphs above show six different days from the Honeymoon and Steady State periods: the 25th, 50th, and 75th percentile found after organizing days by total energy consumption. One of the concerns with the scaling of electric cooking is that simultaneous loads may overload utilities. From these graphs, we understand how this effect may play out.

Above we observe that none of our selected days shows more than 2 cooking events happening in the same hour despite more than 100 people having EPCs. This suggests that under the initial pilot conditions, it would be unlikely that overloading presents a significant problem to the electricity provider.

WHAT HAPPENS WHEN THE PRICE DROPS?

Cooking Events and Energy Consumption for Three Representative Users

"Low"-Utilization User

	Honeymoon	Steady State	Low Tariff
Average Monthly Cooking Events	3.6	0	38.5
Average Monthly Energy Usage (kWh)	1.0	0	9.8

"Medium"-Utilization User

	Honeymoon	Steady State	Low Tariff
Average Monthly Cooking Events	5.4	0.8	18.3
Average Monthly Energy Usage (kWh)	1.5	0.2	6.5

"High"-Utilization User

	Honeymoon	Steady State	Low Tariff
Average Monthly Cooking Events	12.68	2.24	19.6
Average Monthly Energy Usage (kWh)	3.17	0.65	5.4

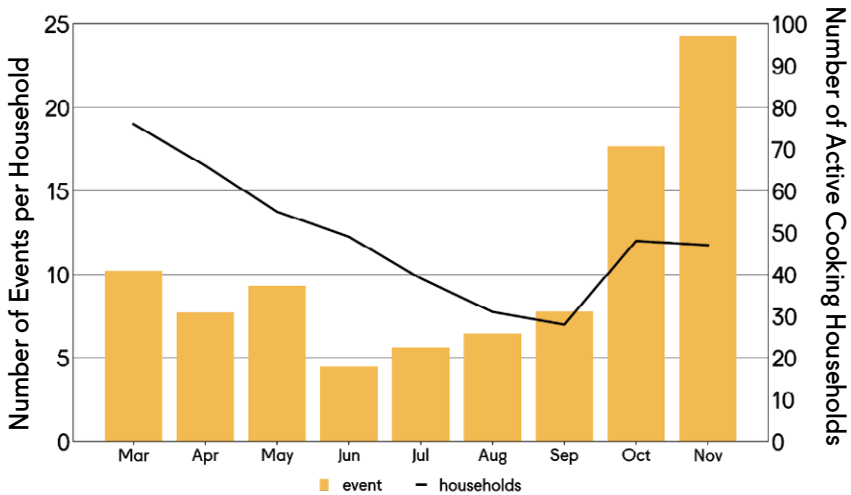
In the graphs above, we show the same three users that we presented previously, based on quartiles from the Honeymoon and Steady State Periods. While it may not be surprising that all three users increased their consumption after the tariff reduction, it is exciting to see that our "Low" Utilization user is now cooking more than both our "Medium" and "High" Utilization users!

This appears to lend evidence to our hypothesis that users who cook infrequently under a cost-reflective tariff are more price-sensitive. When electricity becomes less costly, these users begin using their EPC very heavily, as much as 6 times in a single day.

The implications of this are significant. When the costs of electricity are high, the positive impacts of electric cooking are accessed only by a small, wealthier market segment; when the cost of electricity is low, the positive impacts are more equitably distributed and may even benefit lower-income users more than any others.

WHAT HAPPENS WHEN THE PRICE DROPS?

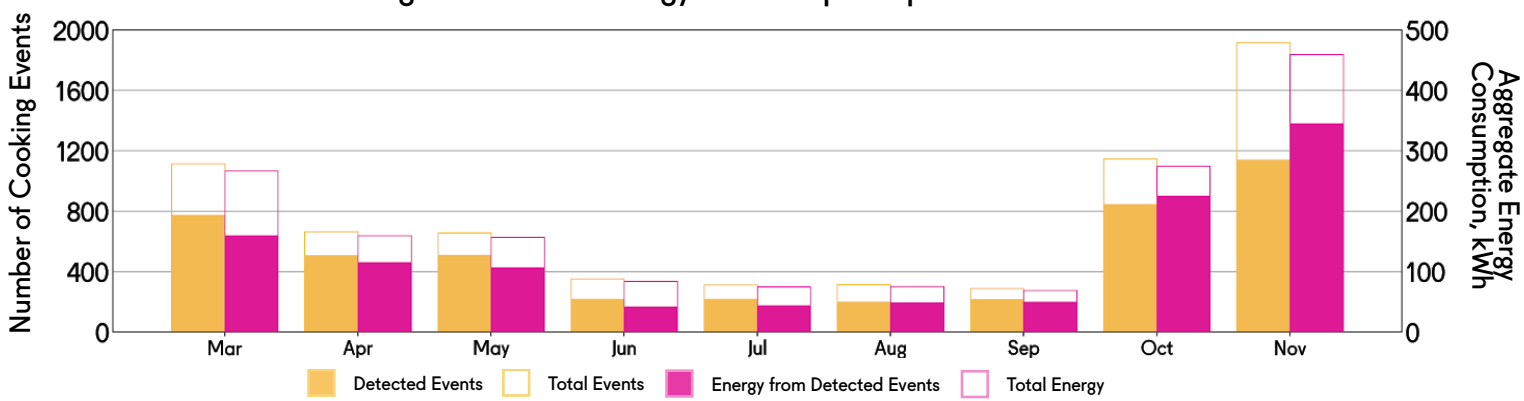
Aggregate Cooking Events and Energy Consumption during Honeymoon and Steady State Periods



Following a tariff drop, we see both a rise in the number of active users and in the frequency of cooking. The average cooking events per household have tripled from September to November, and the number of active users has almost doubled over the same time period.

As before, we can only guess how cooking behaviors will develop in the coming months: perhaps usage will continue to increase until a new Steady State is reached, or perhaps this is a second Honeymoon period while people adjust themselves to the new costs of cooking.

Total Cooking Events and Energy Consumption per Month for All Users



From the above graph, we see the dramatic increase in energy consumption on each month-long period. The total energy consumption from the pilot users reached almost 500 kWh between November 1 and November 15, the cut-off date for data included in this data release, and was projected to reach 1000 kWh by the end of November. In comparison, energy usage for September was only 80 kWh.

Ultimately, the increase in energy consumption caused by the tariff reduction results in a loss of monthly revenue, from an estimated $80 in revenue from cooking events in September to $40 in November. However, there is more to explore on the topic of balancing social impact and financial sustainability of utility providers. Whether through donor subsidies, carbon offset credits, or different pricing schemes, it may be possible to bring down the costs of electricity to the benefit of both users and the private sector.

Note: Because data collection was paused on November 15, projected total energy cooking events, and number of active households are expected to rise in November.

WHAT HAPPENS WHEN THE PRICE DROPS?

Cooking Events and Energy Consumption of All Users Over Select 24 hour Periods

Low-Utilization Day

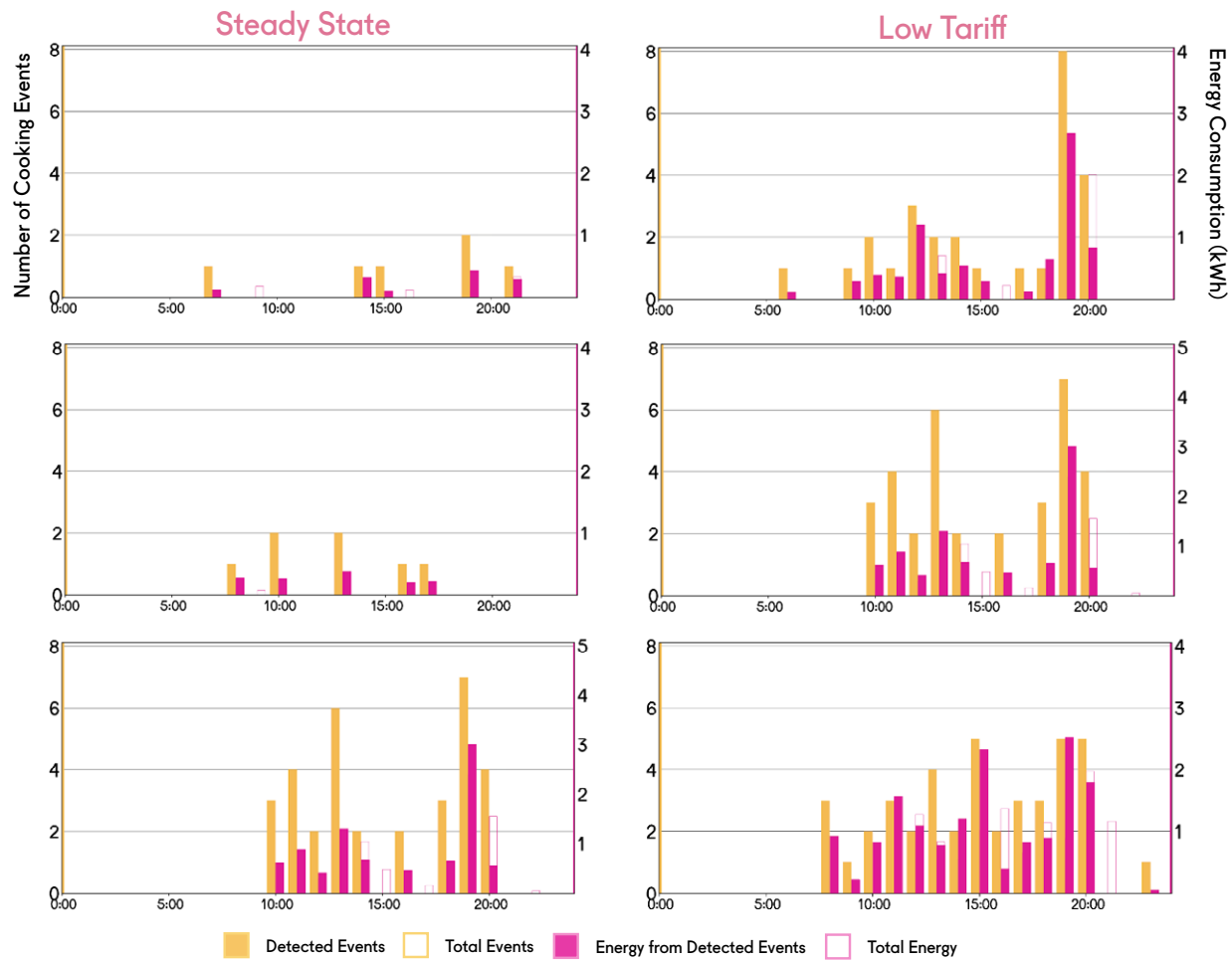
	Honeymoon	Steady State
Cooking Events	6	27
Energy Usage (kWh)	1.26	7.87

Medium-Utilization Day

	Honeymoon	Steady State
Cooking Events	7	33
Energy Usage (kWh)	1.33	8.58

High-Utilization Day

	Honeymoon	Steady State
Cooking Events	11	41
Energy Usage (kWh)	1.9	15.44



Again we observe a large difference between the Steady State and Low Tariff periods, such that the 25th percentile day in the Low Tariff period has substantially more cooking events than the 75th percentile day during Steady State.

Here we see that in situations where electricity prices are low, electric cooking would be more likely to overload a grid. From the plots above, we observe one instance where there are 8 cooking events in a single hour. However, across all three sampled days, there is no more than 3 kWh of energy used in a single hour – a relatively small amount given the 100 household pilot size. This supports the idea that the effects of electric cooking on grids may be minor, but more data is needed to confirm this idea.

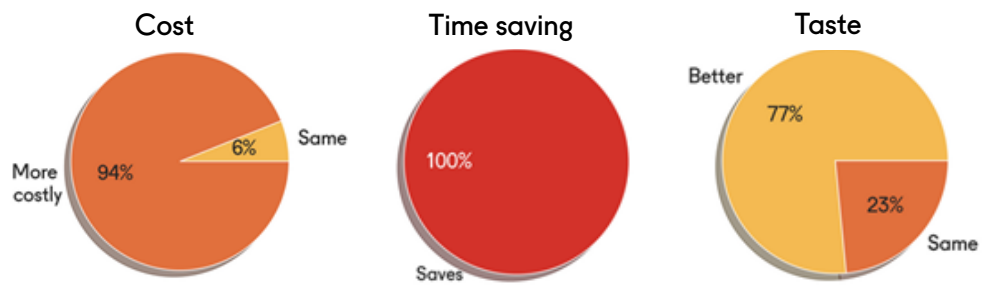
CONCLUSIONS

Cooking Research Needs Substantial Time

One conclusion from this research is that clean cooking research needs sufficient time to allow for users to acclimate to changes in their cooking. It took 3 months for our pilot users to exit the Honeymoon period and reach a relatively stable cooking behavior with their EPCs; observations made on shorter time frames might not be indicative of a longer-term behavior.

People Love Cooking with Electricity (But Not Paying for It)

We observed clearly that cooking and the price of electricity had an inverse relationship: people cook more with electricity when it is affordable, as shown by the distinct difference between the Steady State and Low Tariff periods. But we also observed that some people continued to cook when the price was high. In follow-ups with our pilot users, we asked them about their EPCs and what they thought about them in comparison to other cooking methods: the response was universally positive in terms of time savings and very positive in terms of taste. When asked about the price under the cost-reflective tariffs, the response was very negative. This demonstrates an important point: the main barrier to adoption of electric cooking is the price, not cultural preferences.



Price-Sensitive Users Are Left Behind when Electricity Prices are High, but they Lead when Electricity Prices are Low

When the price of electricity dropped, all pilot users began to cook more with electricity. But we saw many (if not the majority) of those increases coming from users that were priced out of using their EPC prior to the tariff reduction. From this we can conclude that investments that bring down the cost of electricity will primarily benefit price-sensitive households, and for that reason might be an attractive means for accelerating equitable access to clean cooking.

Electric Cooking Goes Beyond the Private Sector and Will Require Support to Reach Its Full Potential

Our research showed that there was a demand for electric cooking and that this represents a market opportunity, but SDG7 will not be achieved only through the efforts of the private sector. More work needs to be done to de-risk that market opportunity such that companies will be comfortable to invest in it. At the same time, more work needs to be done to complement those private sector efforts and ensure that the benefits of electric cooking are widespread and equitable.

CONCLUSIONS

Is Electricity The Future of Clean Cooking?

At Access to Energy Institute, we believe the answer to this question is yes. Emission-free, zero-carbon cooking is not only an ideal vision of clean cooking, it is also one that was well-received by the cooks whose opinions matter most.

But when will electric cooking become the norm? How long could it take to get there? These are much more difficult questions. While our pilot showed demand for electric cooking appliances, it also showed how this demand was strictly governed by price, for better or for worse. How we as a sector address the questions of cost, whether it be appliance or electricity or otherwise, will determine the outcome.

Future Work

Continuation of Off-Grid Pilot

This pilot will continue to run into 2021, which presents an opportunity to dive deeper into the data already collected as well as gain new insights into the response of users to this Low Tariff period.

Beyond the smart meter data, we plan to analyze our data in conjunction with data collected from our pilot partners, including cooking diary data and data on biomass cookstoves at pilot user households. Combining these datasets will provide rich new insights into our users and their cooking habits.

On-Grid Electric Cooking Pilot

Starting in 2021, A2EI will begin piloting electric cooking appliances in on-grid contexts at scale, targeting data collection from 1000 users. Compared to rural off-grid areas, we expect on-grid areas to have relatively high rates of electricity access, low costs of electricity, and reduced availability of charcoal and/or firewood. These factors work in the favor of electric cooking, meaning these locations are where we would expect to see the quickest adoption of electric cooking.

The body of research for these on-grids pilots will focus on understanding user behavior but also geared toward gathering data that guides national grids on how to engage with electric cooking.

NEED COOKING DATA?

We want to support your projects to get better data by putting 1,000 smart meters on electric cooking appliances globally. Contact cleancooking@a2ei.org for more information.

DOWNLOAD THE FULL DATA RELEASE

Interested to get the raw data? Dowload it here:
www.a2ei.org/news/clean-cooking-data-release

Are you interested in future data releases? Do you have input, thoughts or ideas you would like to share with us? Please email us at cleancooking@a2ei.org.

Our clean cooking research was conducted in collaboration with Nexleaf, Modern Energy Cooking Services, and PowerGen.

NEXLEAF ANALYTICS

MECS Modern Energy Cooking Services

PowerGen

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