Our Energy

ETH zürich

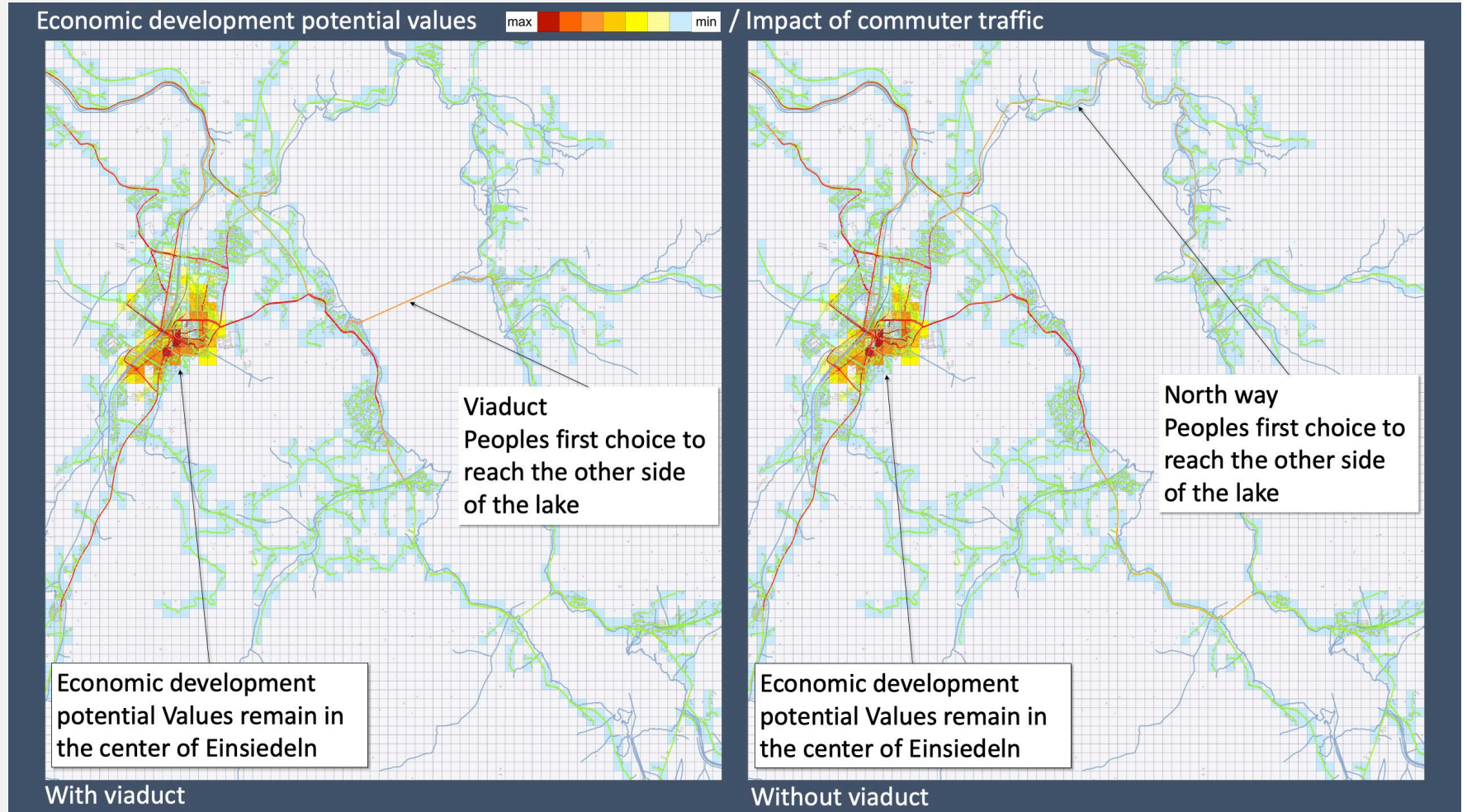## IMG Stiftung Phase 2: The Our Energy Challenge

An exemplary case for Citizen Design Science applied to Community-Scale Solar PV at the Einsiedeln – Willerzell Viadukt

Prof. Dr. Gerhard Schmitt

Danielle Griego, Natasha Catunda, David Dal Busco

Denise Weber, Torsten Häffner
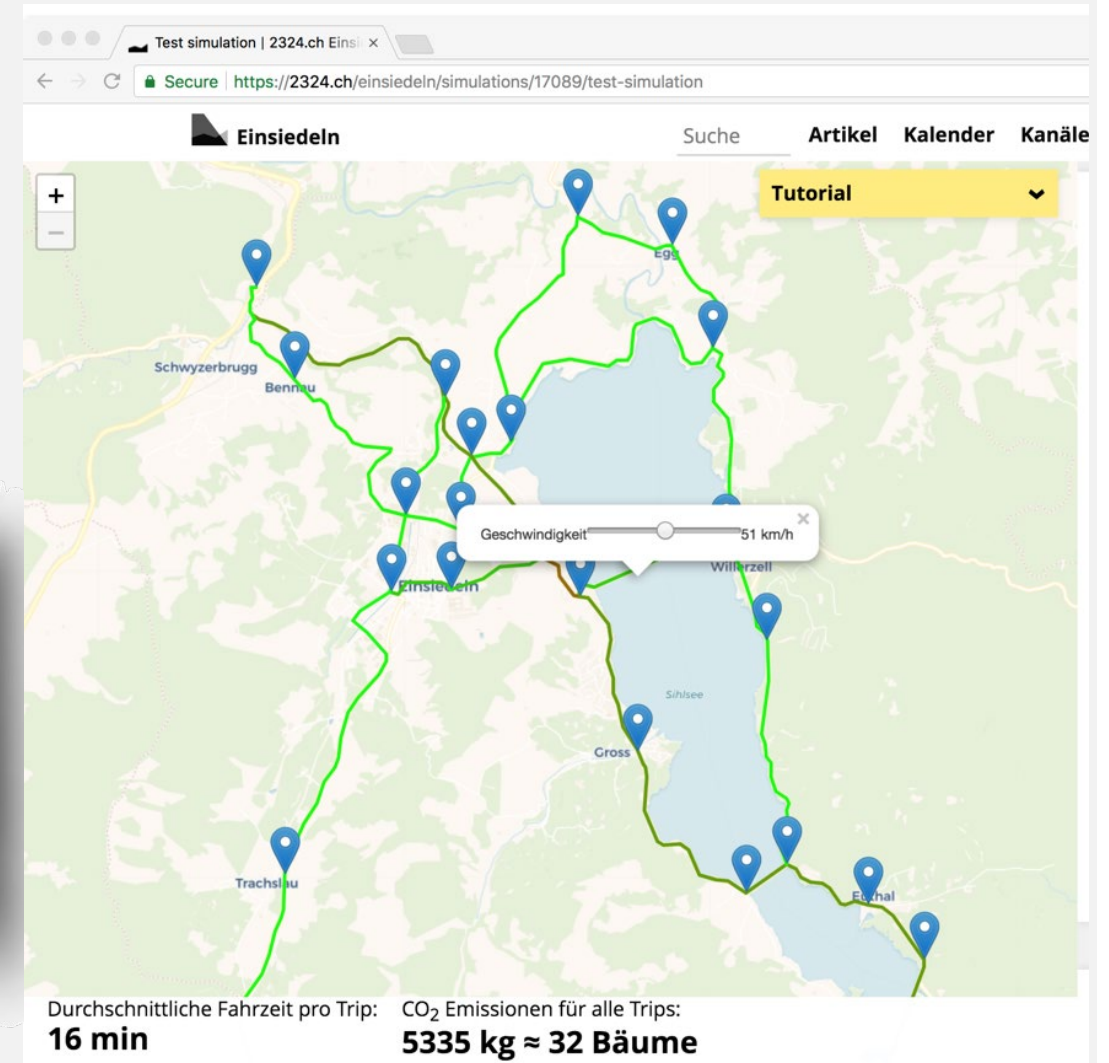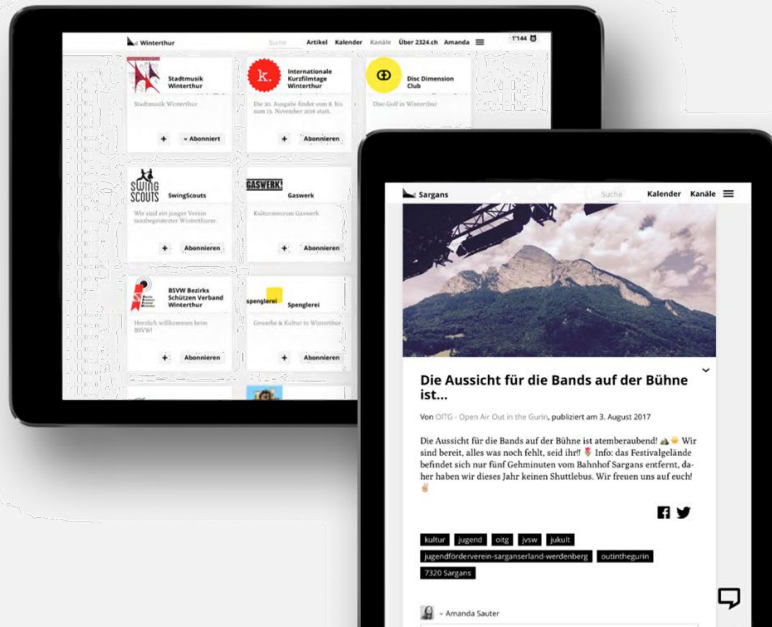
Previous project in Einsiedeln

Impact analysis of bridge removal

Economic development potential values [max ▬▬▬▬▬▬ min] / Impact of commuter traffic

Viaduct
Peoples first choice to reach the other side of the lake

North way
Peoples first choice to reach the other side of the lake

Economic development potential Values remain in the center of Einsiedeln

Economic development potential Values remain in the center of Einsiedeln

With viaduct

Without viaduct

Previous project in Einsiedeln

Citizen Design Science app

⌐ Engagement platform
⌐ Traffic simulator
⌐ CO_2 estimator

Durchschnittliche Fahrzeit pro Trip:
16 min

CO_2 Emissionen für alle Trips:
5335 kg ≈ 32 Bäume

Current project in Einsiedeln: Our Energy

Our Energy

Willkommen zum Sonnenspiel!

In der **ersten Woche** erfahren Sie, wie effizient Sie Ihren Strom nutzen. In der **zweiten Woche** können Sie all Ihren Ehrgeiz auf die Optimierung Ihres Solarstromverbrauchs setzen.

Skip   Next

Die Photovoltaikanlage
am Holzsteg über den Sihlsee

Technische Daten:
Solarfläche: 3'000 m2
Anlagenleistung: 540 kWp
Jahresertrag: 450'000 kWh
                                = Verbrauch von 100 Haushalten

Investitionskosten: 750'000.- Fr.
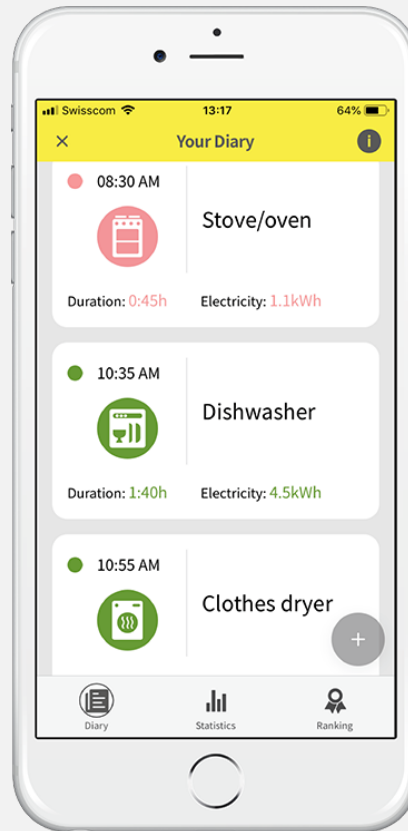Stromgestehungskosten: 10 Rp/kWh

CO2-Einsparung und Speicherung:
Einsparung durch Stromproduktion: 80 Tonnen/Jahr
Dauerhafte Speicherung durch das Bauwerk: 900 Tonnen

Chair of Information Architecture (iA)

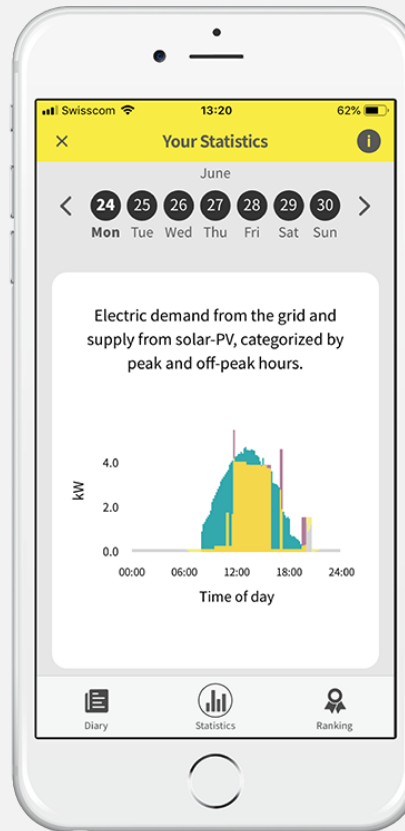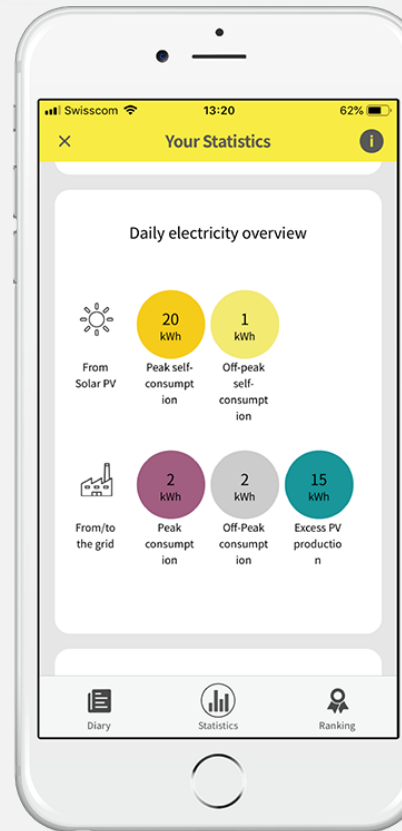Our Energy Project, Einsiedeln 2019, Banner by Edgar Kälin

Our Energy
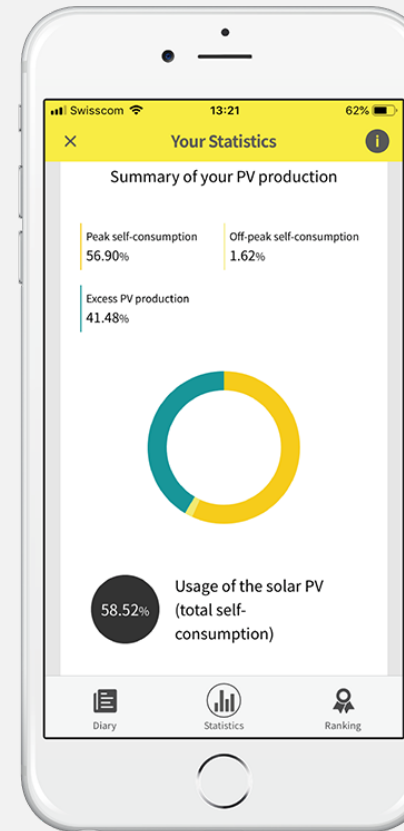ETHzürich

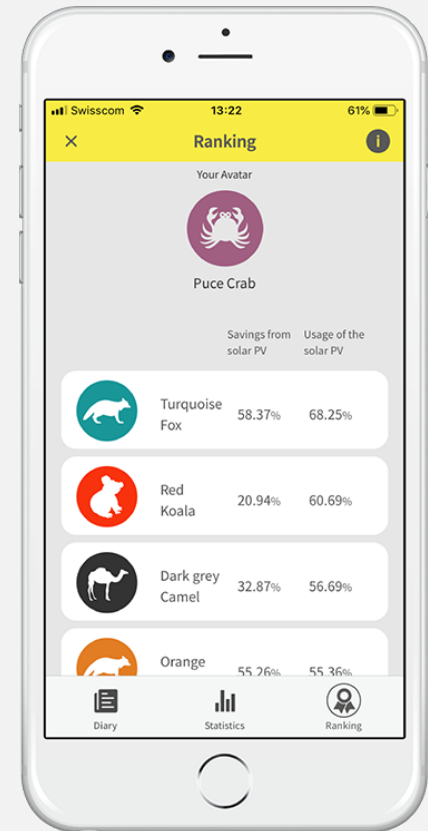## Simulation app to experience solar electricity:
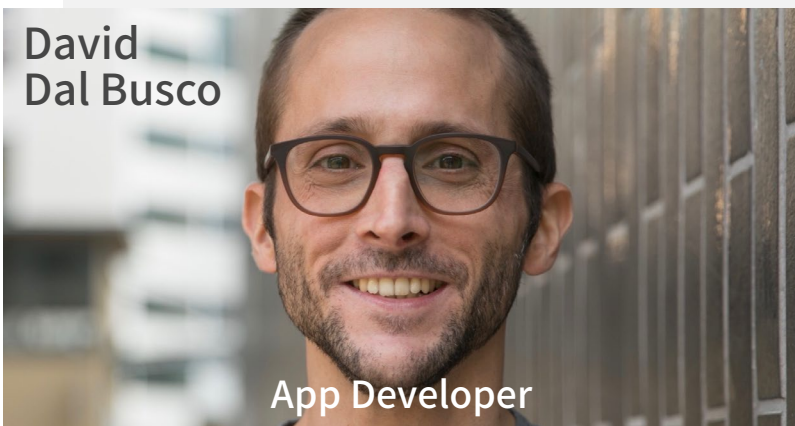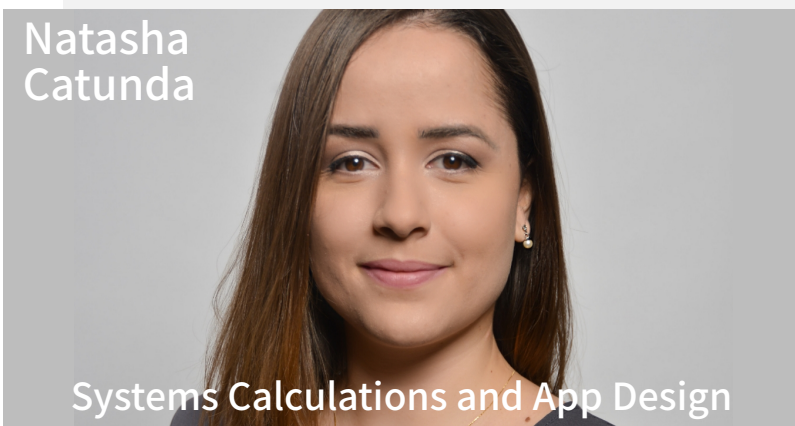
Appliances diary

Statistics graph

Statistics legend

Self-consumption visualization

Ranking

IMG Stiftung Phase 2
The Our Energy Challenge

Danielle Griego — Project lead, PhD Researcher

Prof. Dr. Gerhard Schmitt — Principal Investigator

Denise Weber — Project Coordinator

Natasha Catunda — Systems Calculations and App Design

Torsten Häffner — Communication and Storytelling

David Dal Busco — App Developer
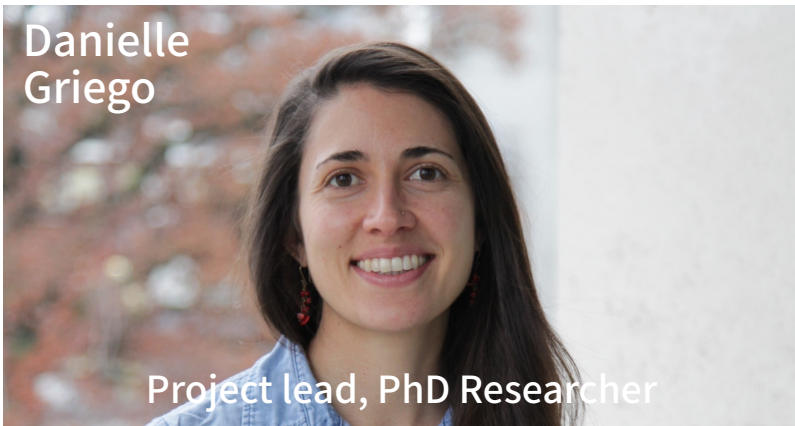
Team Our Energy

Planned and executed timeline

Project status update presentation

First version of App tested and completed

Campaign in Einsiedeln

Project completion

| Sep-Oct | Nov-Dec | Jan-Feb | Mar-Apr | May-Jun | Jul-Aug | Sep |

Launch project + establish conceptual design

Survey development

Beta version of app

Pilot Study for Master's thesis

Update beta version

Full implementation in Einsiedeln

Review findings and prepare final reports

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The Our Energy Challenge

Motivation

Citizens of Willerzell and Einsiedeln want to keep the Viadukt

What future developments can be incorporated into the community around the bridge? Solar Photovoltaics (PV)?

Help contribute to the 2000 Watt-society and Energy Strategy 2050 goals.

Focus on solutions that address both increasing renewable energy supply and energy conservation through self consumption or "Eigenverbrauch"

PV is the most promising renewable energy source in CH

IMG Stiftung Phase 2
The Our Energy Challenge

Einsiedeln demographics

Total population: 15,550

Number households: 6,565
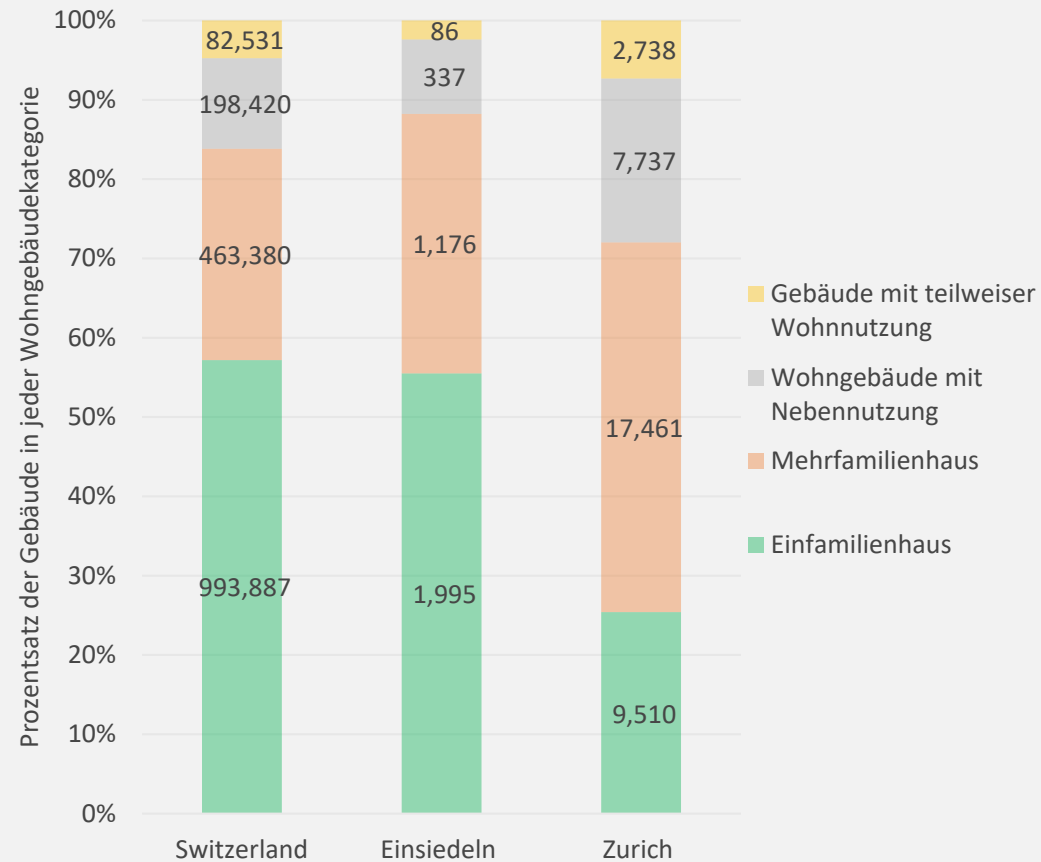
Average residence: 114 m^2

Average number of people per household: 2.3

Swiss Cantonal Statistics: Schweizerischer Städteverband (2017)

IMG Stiftung Phase 2
The Our Energy Challenge

Einsiedeln demographics

Swiss Cantonal Statistics: Schweizerischer Städteverband (2017)

IMG Stiftung Phase 2
The Our Energy Challenge

Outline phase 2

Objectives

Method

Primary project outcomes:
- ✓ Pilot study and evaluation (Master thesis)
- ✓ Final version of 'Our Energy'
- ✓ Our Energy campaign in Einsiedeln
- ✓ Full Implementation results

Conclusions and Future work

Additional outcomes:
- ✓ CISBAT paper + poster
- ✓ Energy Informatics - App Demo
- ✓ Book (Torsten)

Objectives

Evaluate if the **community context**
positively influences the desired behavior of
load-shifting to maximize self-consumption
of a **shared solar PV system**.

1. Develop an energy information platform with both individual and aggregate energy performance data for a community PV system located in Einsiedeln, Switzerland.

2. Test if households achieve higher levels of self-consumption when they are connected to a community scale PV system compared to an individual rooftop PV system. (Pilot study)

3. Test if participants load-shift at the household level to increase their self-consumption compared to an established baseline. (Full implementation)

4. Evaluate if other criteria may also influence the levels of participation such as "energy literacy", sense of community, environmental awareness or interest to invest in renewable energy technology

Method

5-step community-based social marketing approach

1. Selecting Behaviour
   Load-shifting for PV self-consumption

2. Identify Benefit and barriers

3. Develop Strategies

4. Pilot and evaluation

Enhanced app

5. Full implementation

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The Our Energy Challenge

Method

5 step community-based social marketing

Enhanced app

1. Select Behaviour

2. Identify Benefit and barriers

3. Develop Strategies

4. Pilot and evaluation

5. Full implementation

- Focus on load-shifting for self-consumption of solar electricity production
- Categorize appliances to facilitate load-shifting

- Most people do not have access to solar PV at home
- Most people do not receive regular energy consumption information

- Simulate 'what it would be like to have electricity from solar PV'
- Appealing app to show how to load-shift using an 'energy diary'
- Community activities require direct contact with the people

- Test usability of the strategy (APP) with team members
- First pilot study with ETH students
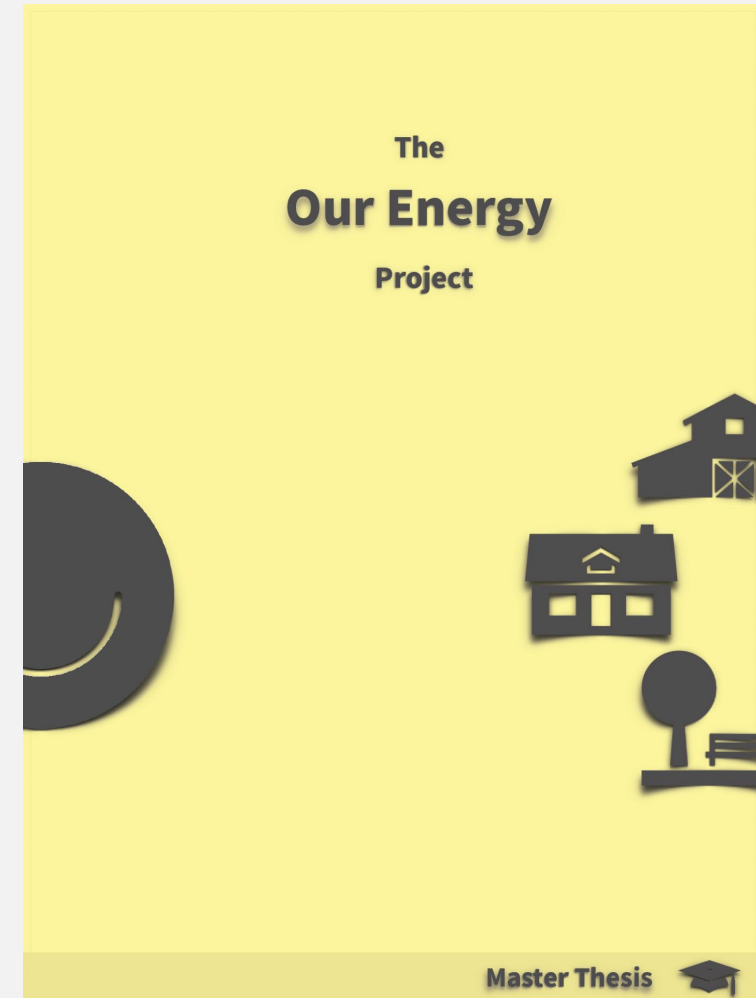- Focus group with representatives from Einsiedeln

- Outcomes from the pilot study to improve the full implementation
- Marketing campaign in Einsiedeln on 22-23 June
- Full study 23 June- 7 July
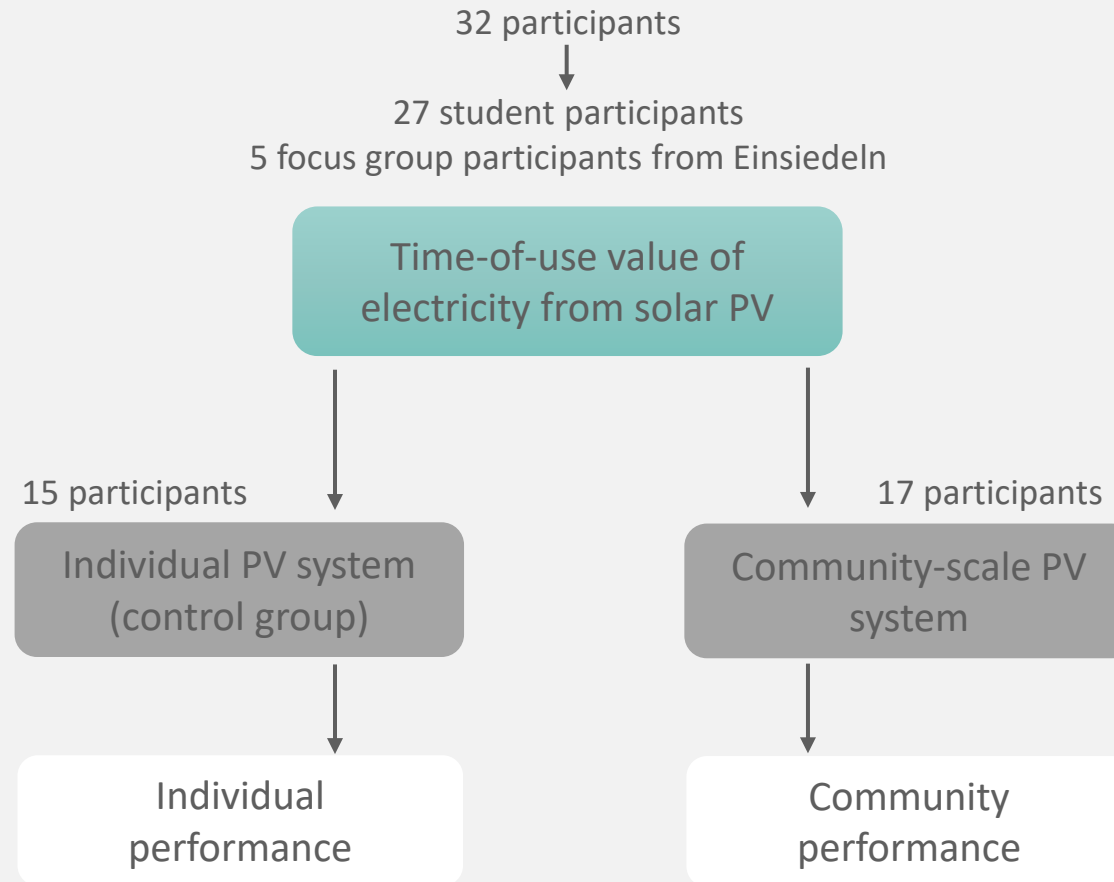
Primary project outcomes

1. Pilot study and evaluation

2. Final version of 'Our Energy'

3. 'Our Energy' campaign

4. Full Implementation

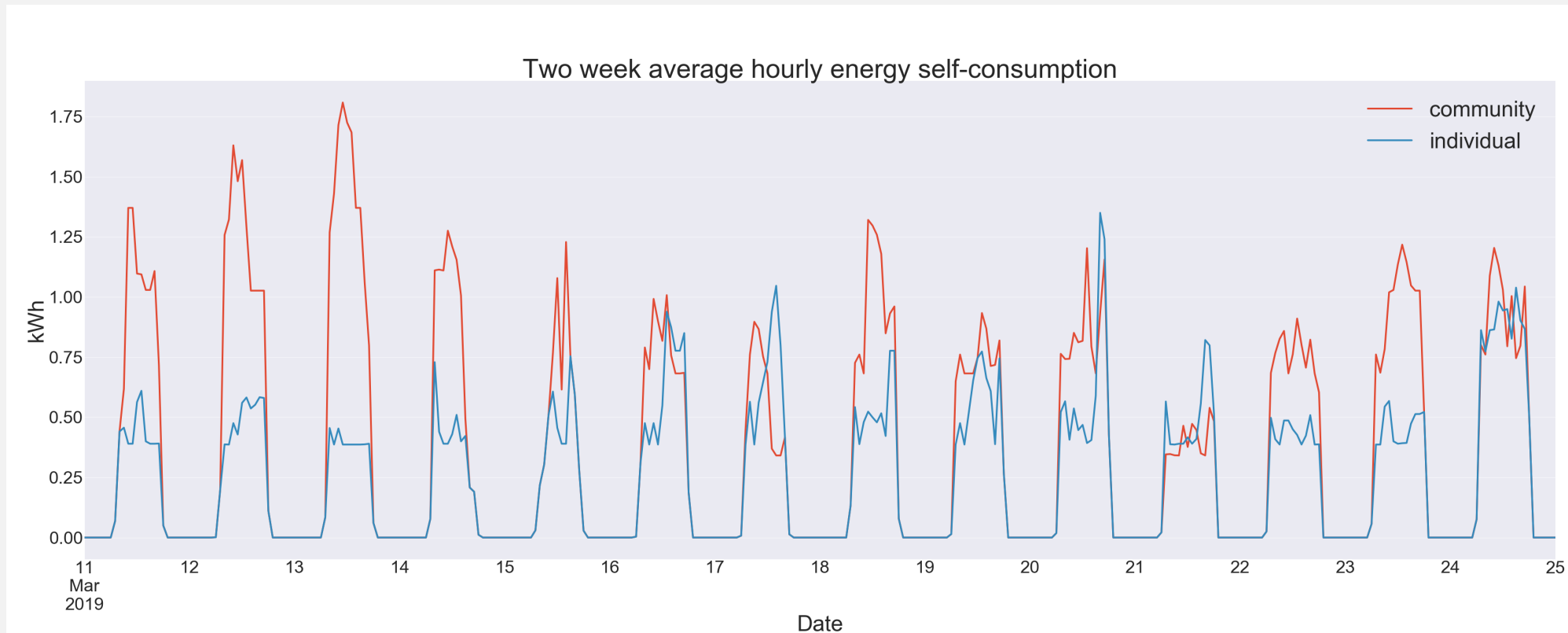a. Experimental Set-up

b. Summary of findings

c. Design improvements
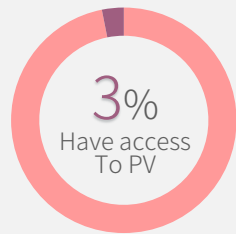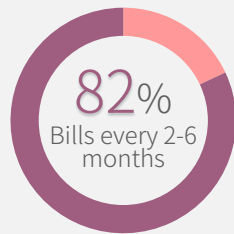
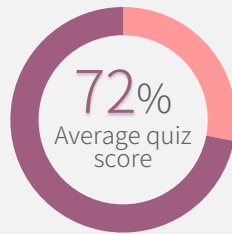# Experimental set-up

Two-week study: 11-25 March 2019

32 participants

27 student participants
5 focus group participants from Einsiedeln

Time-of-use value of electricity from solar PV

15 participants

Individual PV system (control group)

17 participants

Community-scale PV system

Individual performance

Community performance

Summary of findings

Two week average hourly energy self-consumption

Summary of findings

Pre-participation survey results:

3% Have access To PV — Access to PV

82% Bills every 2-6 months — Access to electricity data

72% Average quiz score — Energy literacy

82% Have shared facilities — Shared facilities

71% In community systems

45% In individual systems

Likelihood to invest in PV

61% No resources wasting

35% conserve electricity

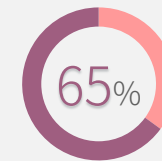**28%** Direct access to PV
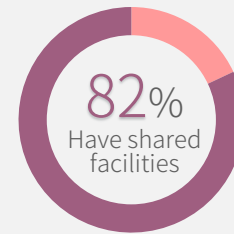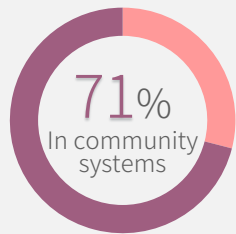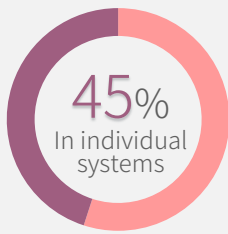
Environmental awareness
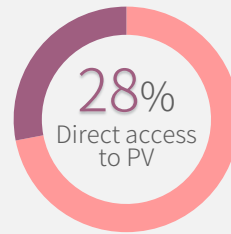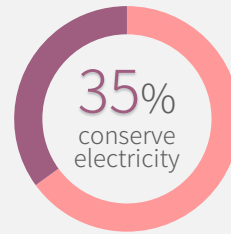
Post-participation survey results:

65% Household electricity consumption
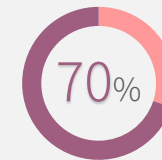
70% Time-of-use of electricity
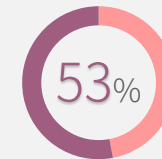
53% Load-shifting

Reported learning effects

Summary of findings

What worked:

Visual representation and ease of use of the app

Knowledge about personal use of electricity

Raised awareness and experience with the time-of-use of electricity

Sense of other people participation with the ranking function

What did not work:

Initial point scheme was too simplistic
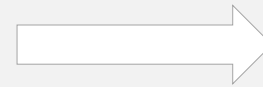
Not enough knowledge on how to shift appliances

Version without the ranking was not as interesting

List of appliances not representative and no possibility of adding multiple entries

Design improvements

Info panel

Ranking panel

Main screens

Electricity production panel

Household panel

Grid panel

Activities panel

Activities pop-up

Points pop-up

Points panel

Electricity production panel

Household panel

Electricity production panel

Appliances diary

Statistics chart

Consumption information

Weekly visualization

Ranking panel

Design improvements

Appliances diary

Statistics graph

Statistics legend

Self-consumption visualization

Ranking

Available on Apple store and Google Play
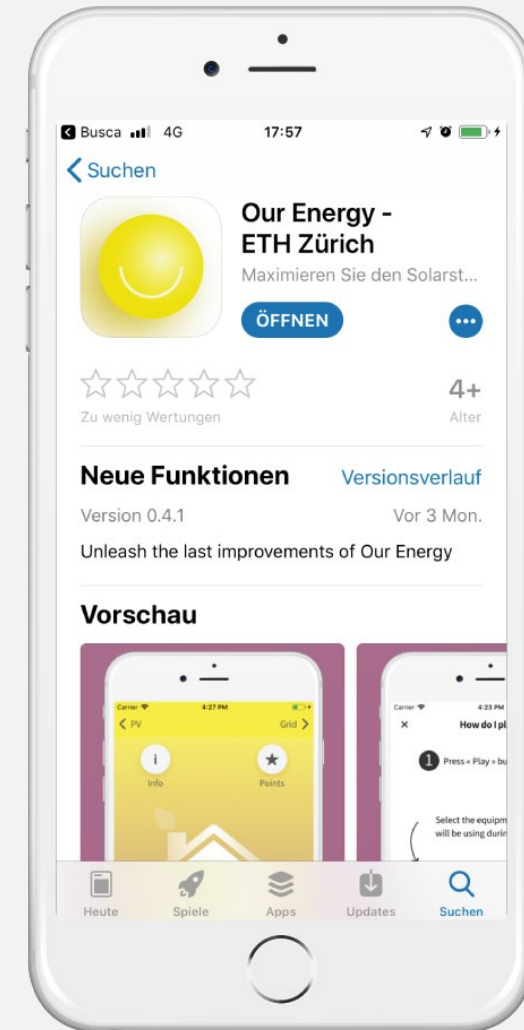
Current features:
- Solar information available only for Einsiedeln
- Appliances are based on typical Swiss and European power ratings
- Lighting, heating and cooling calculations are for a typical Swiss residence (size, number of people, typology)
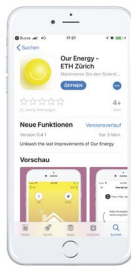
Two-day Campaign 22-23 June 2019

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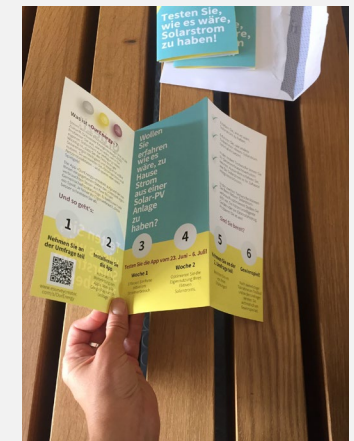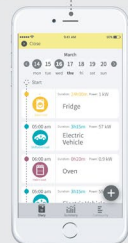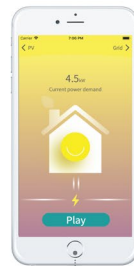
Our Energy in the news

a. Updated experimental Set-up

b. Participation summary

c. Summary of findings

d. Novelty

Updated Experimental set-up

Two-week study: 23 June- 7 July 2019

Week 1 objective: Baseline actual energy consumption

Week 2 objective: to increase self-consumption (compared to week 1 baseline)

1

Nehmen Sie an der Umfrage teil

www.esurveycreator. com/s/OurEnergy

2

Installieren Sie die App

Automatische Weiterleitung zum Apple Store oder Google Play nach der Umfrage.

3

Testen Sie die App vom 23. Juni – 6. Juli!

Woche 1

Erfassen Sie Ihren aktuellen Stromverbrauch.

4

Woche 2

Optimieren Sie die Eigennutzung Ihres fiktiven Solarstroms.

5

Nehmen Sie an der 2. Umfrage teil

Berichten Sie uns von Ihren Erfahrungen!

6

Gewinnspiel!

Nach zweiwöchiger Teilnahme am Testlauf und an den Umfragen nehmen Sie automatisch am Gewinnspiel teil.

Participation summary

- **61** pre-survey's
- **24** post-participation survey's completed

- **87** App downloads
- **51** App users (with appliance data input for 1 or more days)

Daily participation for two-week study

Summary of findings

Average hourly self-consumption per day for all 51 participants

Week 1: Baseline period

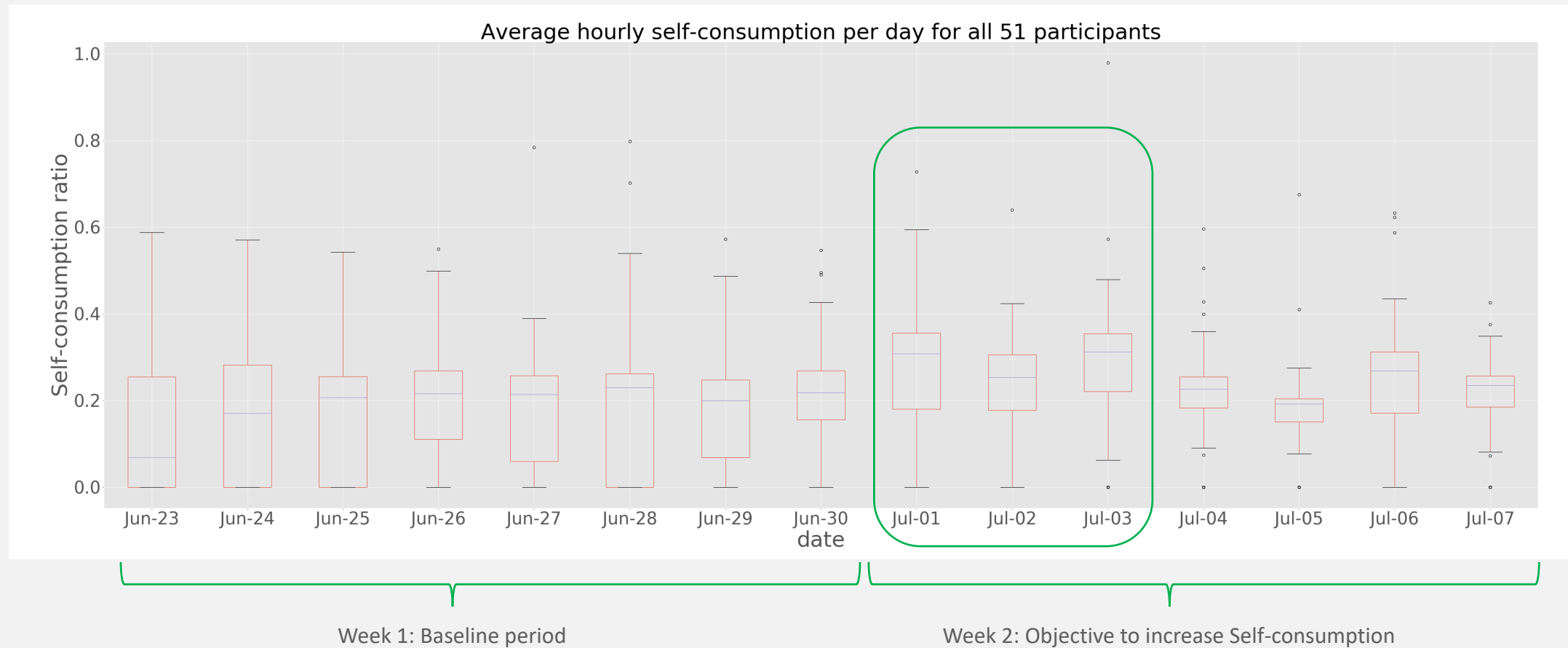Week 2: Objective to increase Self-consumption
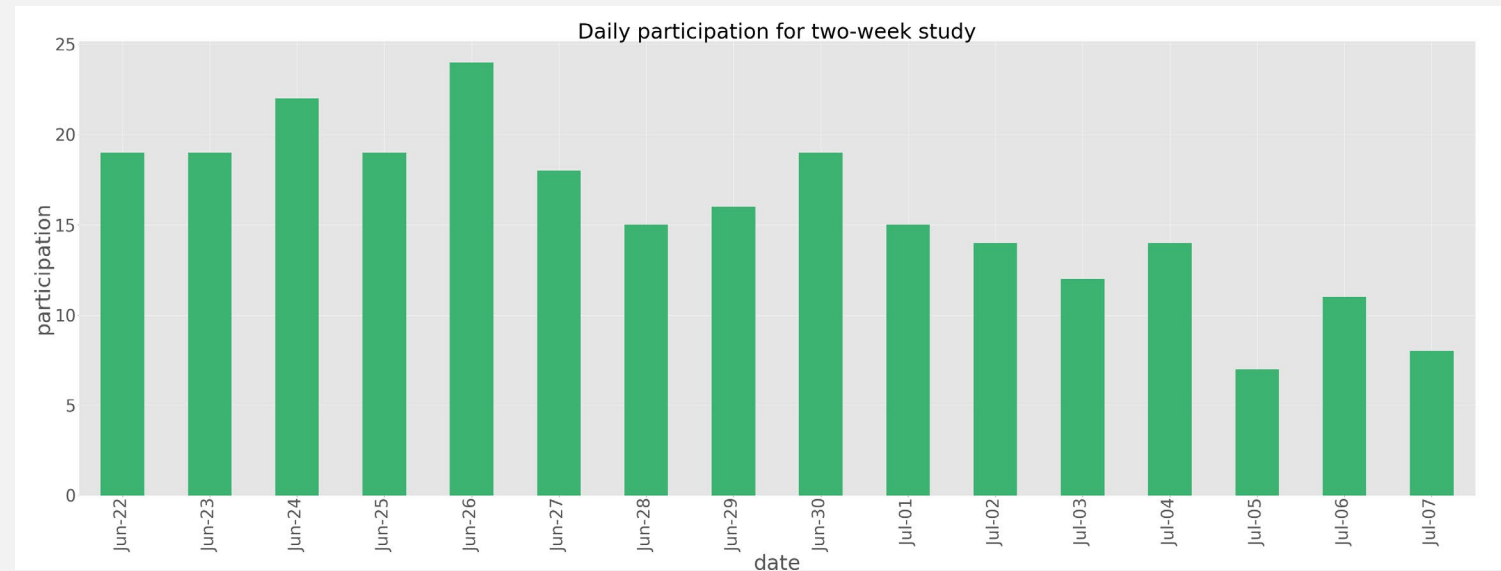
Summary of findings

Example of an individual participant
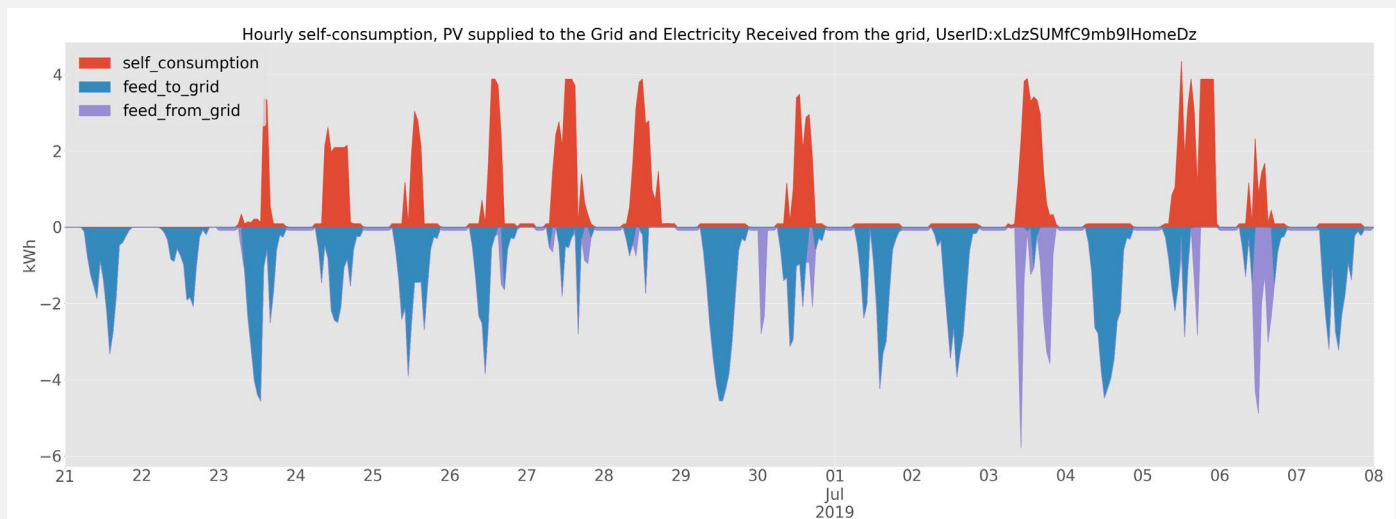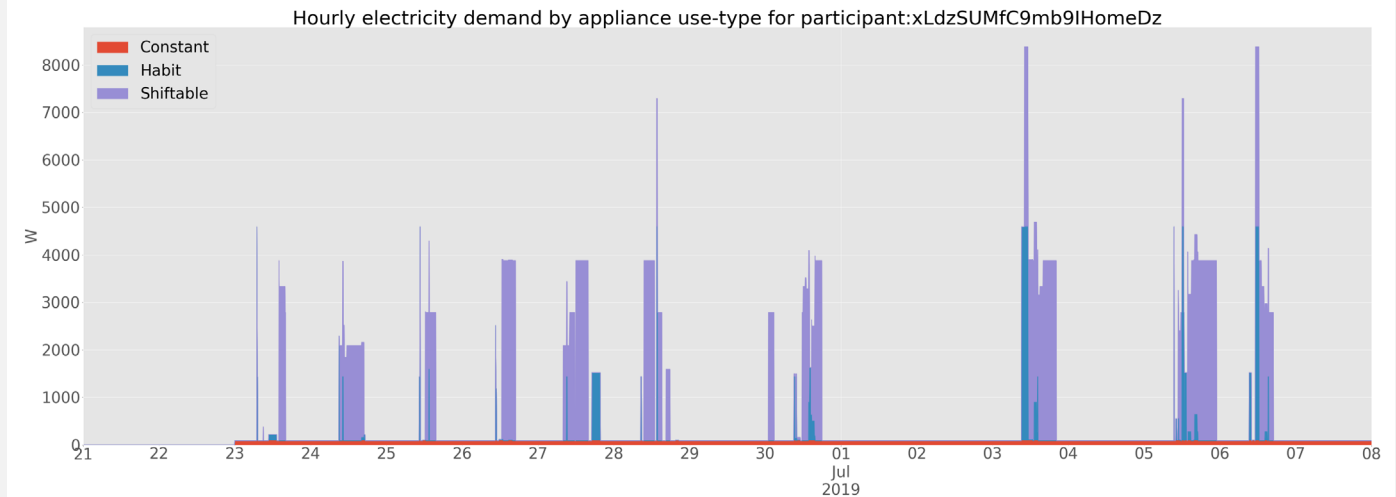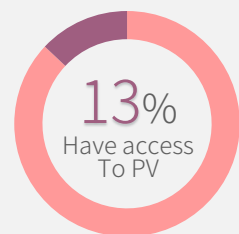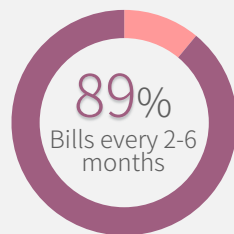
Hourly electricity demand by appliance use-type for participant:xLdzSUMfC9mb9IHomeDz

Hourly self-consumption, PV supplied to the Grid and Electricity Received from the grid, UserID:xLdzSUMfC9mb9IHomeDz

Summary of findings

Pre-participation survey results:

13% Have access To PV

Access to PV

89% Bills every 2-6 months

Access to electricity data

79% Average quiz score

Energy literacy

64% Have shared facilities

Shared facilities

16% In community systems

23% In individual systems

Likelihood to invest in PV

49% No resources wasting

28% conserve electricity

18% Direct access to PV
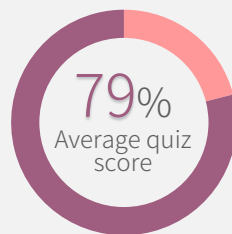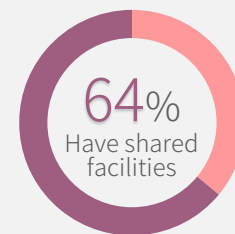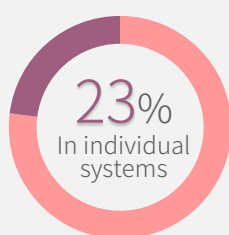
Environmental awareness
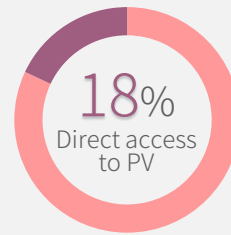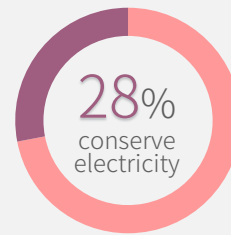
Post-participation survey results:
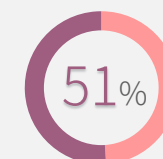
51% Household electricity consumption
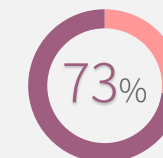
73% Time-of-use of electricity
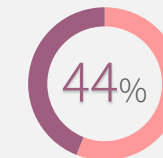
44% Load-shifting

Reported learning effects

Novelty: Testability of solar PV systems was not previously available

Reasons for participating in the two-week study

I am considering installing Solar PV at home: 5 (23.8%)

I am curious to test the daily experience of having a Solar PV system: 10 (47.6%)

I want to compare my actual PV system and energy consumption to the app: 2 (9.5%)

I know other's who also participated: 8 (38.1%)

I wanted to support a research project at ETH: 15 (71.4%)

I have a chance to win a prize: 5 (23.8%)

I didn't use the App, I just downloaded it to check it out: 1 (4.8%)

Other: 3 (14.3%)

Conclusions and future work

For research?

- Adapt the app for case study areas that already have Solar PV systems

- Study the effects of community for behaviour of users who already have solar PV

- Simulate how users can share/sell the excess electricity from their system to neighbors in their community

- Study the preferences of different user categories

- Include energy storage scenarios

For market?

- Automatic input of data / connection with real electricity consumption

- Possibility to remotely control appliances using the app

- Provide PV sizing options for the users to choose & test anytime

- Include weather forecasting to inform users when and what to shift

- Share control of a household between the same household users

⊕ Additional outcomes

1. CISBAT paper + poster

2. Energy Informatics - App demo

3. Book (Torsten)

IMG Stiftung Phase 2
The Our Energy Challenge

🔍 Additional outcomes

- Published paper in Energy Procedia conference proceedings
- Theme: Human and building interaction
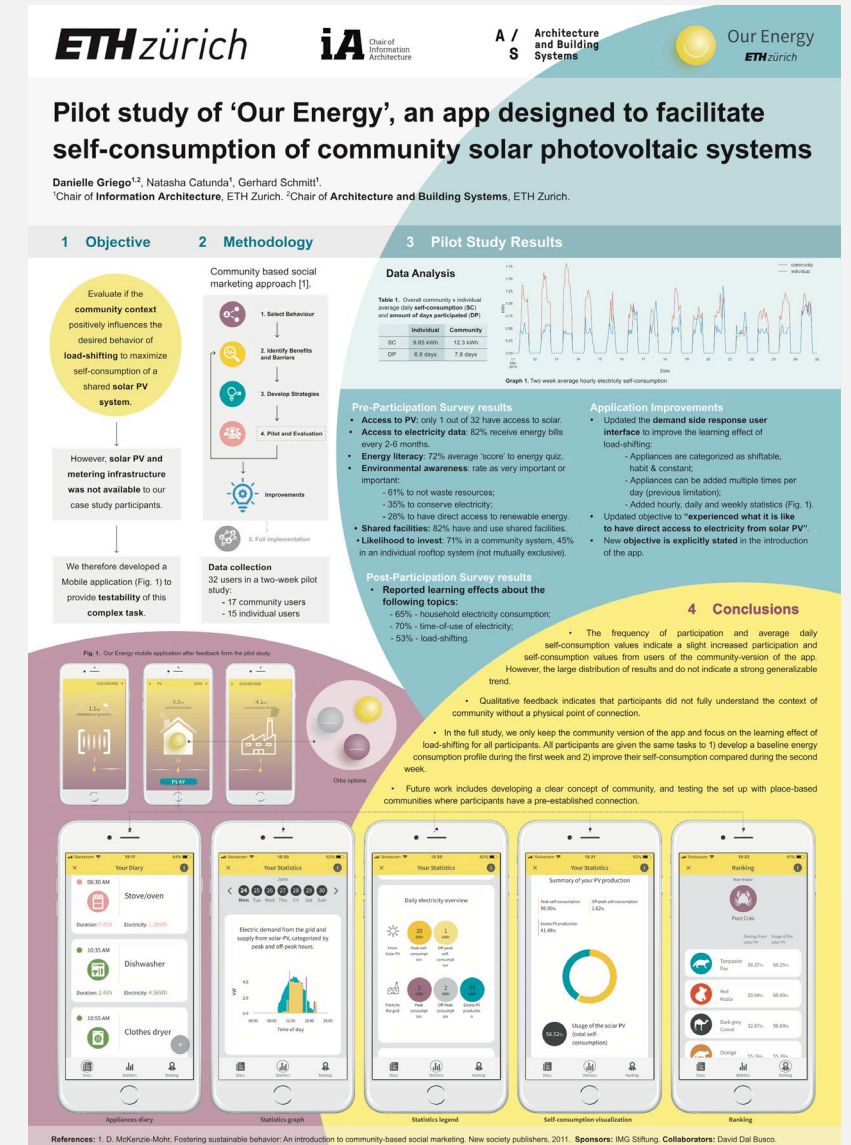
🔍 Additional outcomes

- Demo presentation of the App

- Information and communication technologies in the energy domain the German-Austrian-Swiss region and its neighboring countries (DACH+)

Energy Informatics 2019
The 8th DACH+ Conference on Energy Informatics, Salzburg, Austria, September 26-27, 2019

Our Energy
ETHzürich

Simulation app to experience solar electricity:

| Appliances diary | Statistics graph | Statistics legend | Self-consumption visualization | Ranking |
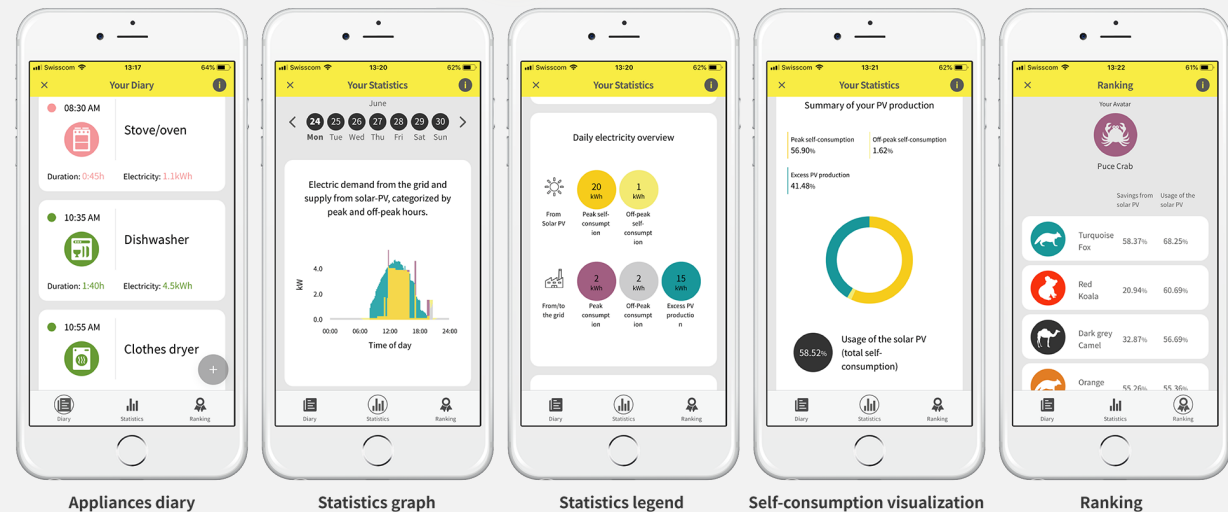
Thank you for your attention!

Our Energy

ETH *zürich*

Pilot study and evaluation

Calculations framework

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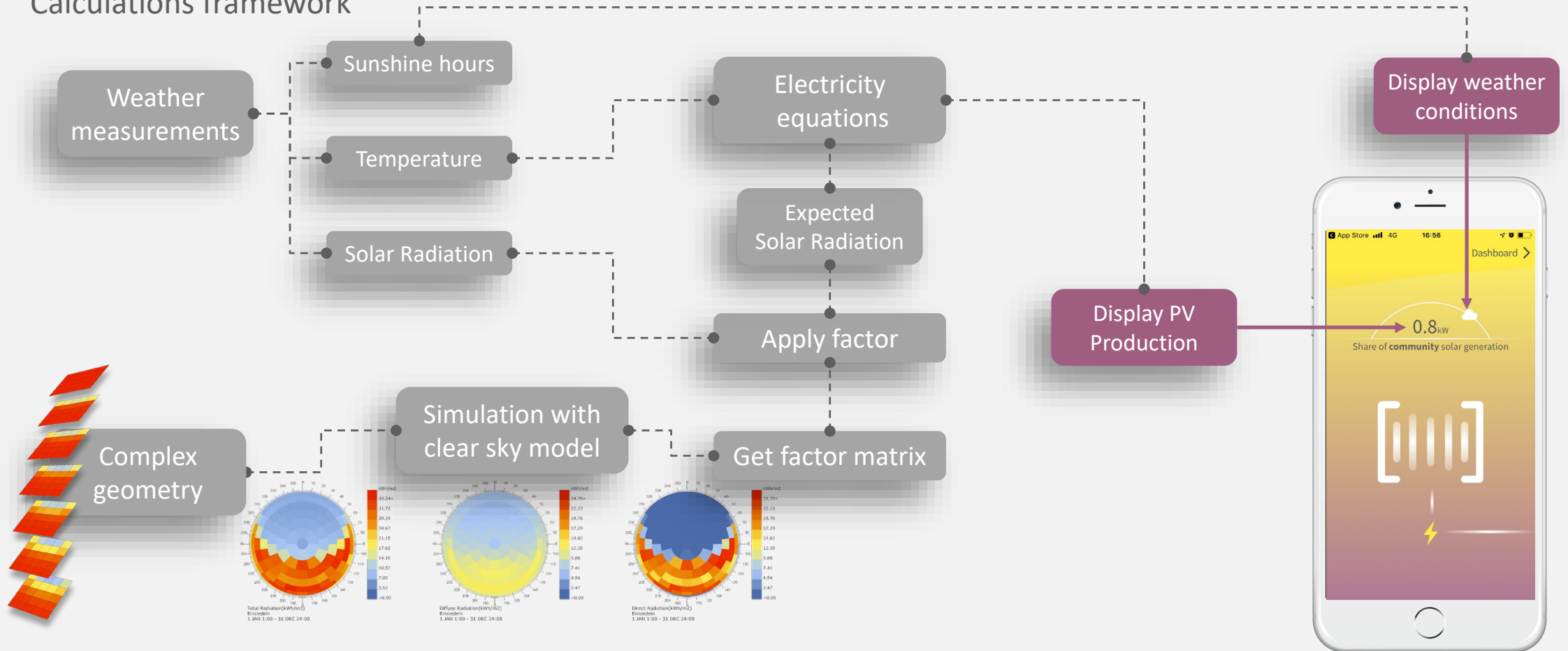
Pilot study and evaluation

Community x individual versions (PILOT)
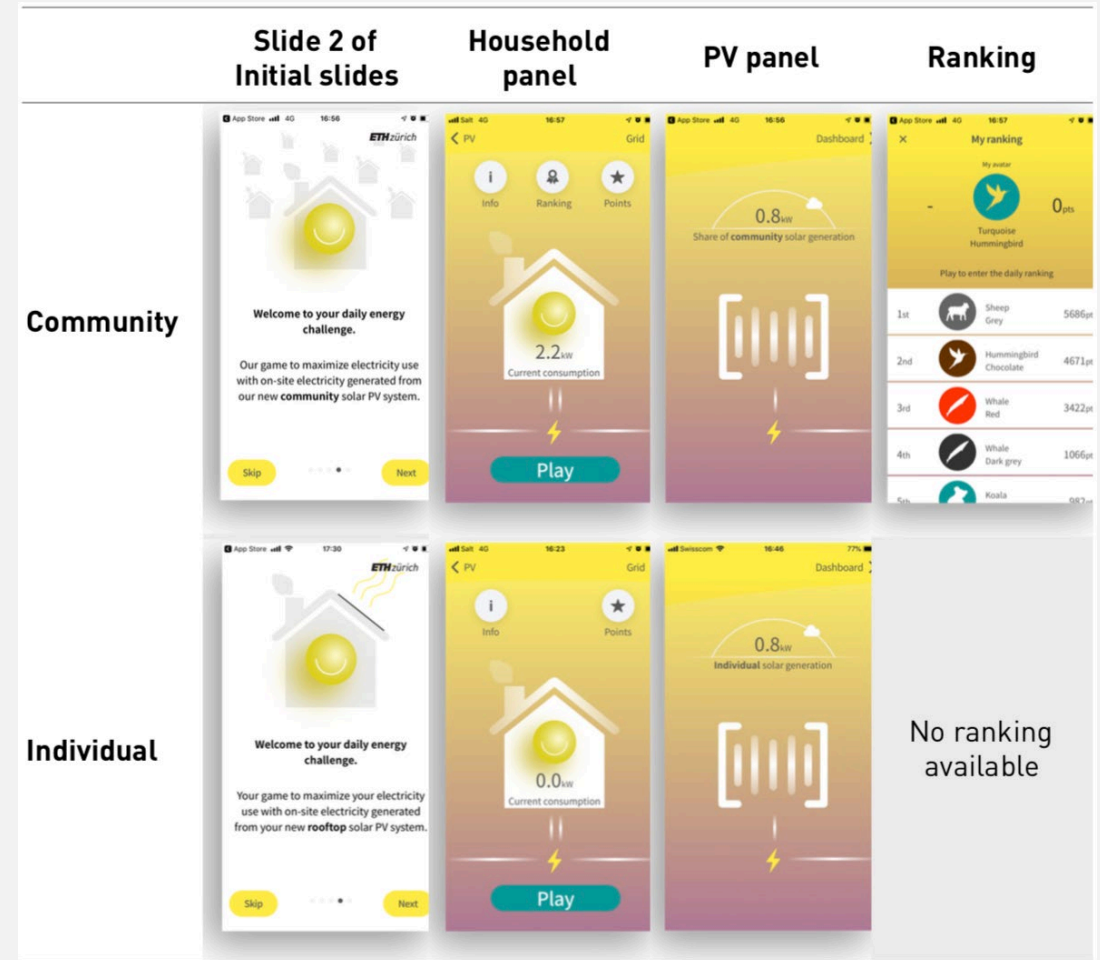
Pilot study and evaluation

Survey learnings

Users were more interested in not wasting resources

There is a slightly more interest in sharing a PV system in a community
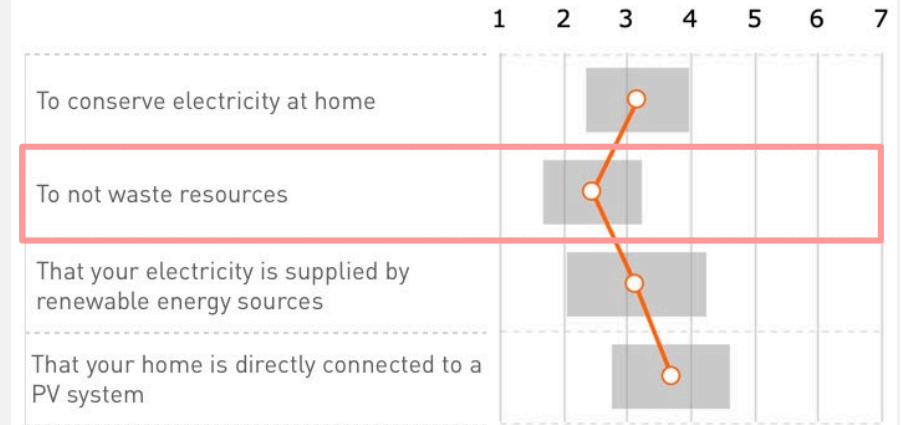
Figure 3.1 - Student's answers from the question of how important are each of these statements. Answers ranges from 1 (extremely important) to 7 (extremely unimportant). Orange circle shows the arithmetic average and the grey area shows the standard deviation.
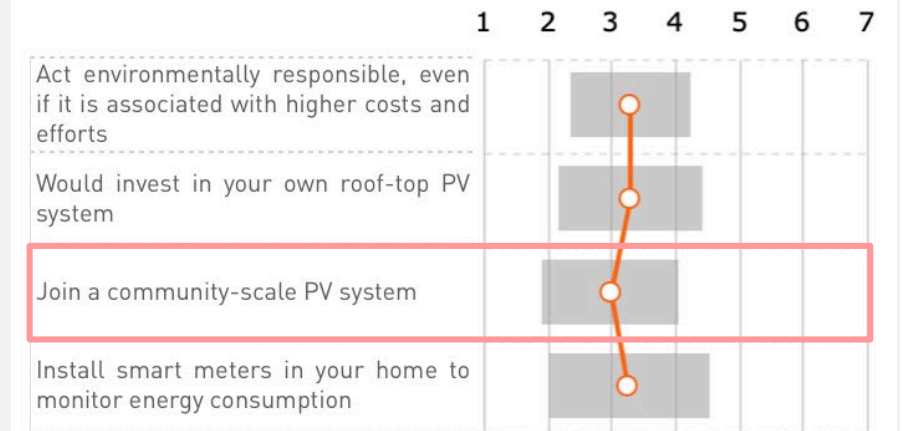
Figure 3.2 - Student's answers from the question of how likely are that users behave according to each of these statements. Answers ranges from 1 (extremely important) to 7 (extremely unimportant). Orange circle shows the arithmetic average and the grey area shows the standard deviation.

Pilot study and evaluation

Accuracy of clear sky weather file

Normal distribution of errors

- Historical, μ=-0.72, σ=3.59
- Ineichen 1, μ=-7.74, σ=25.86
- Ineichen 2, μ=-8.05, σ=12.45
- Ineichen 3, μ=-0.83, σ=22.90
- Ineichen 4, μ=-1.10, σ=5.24
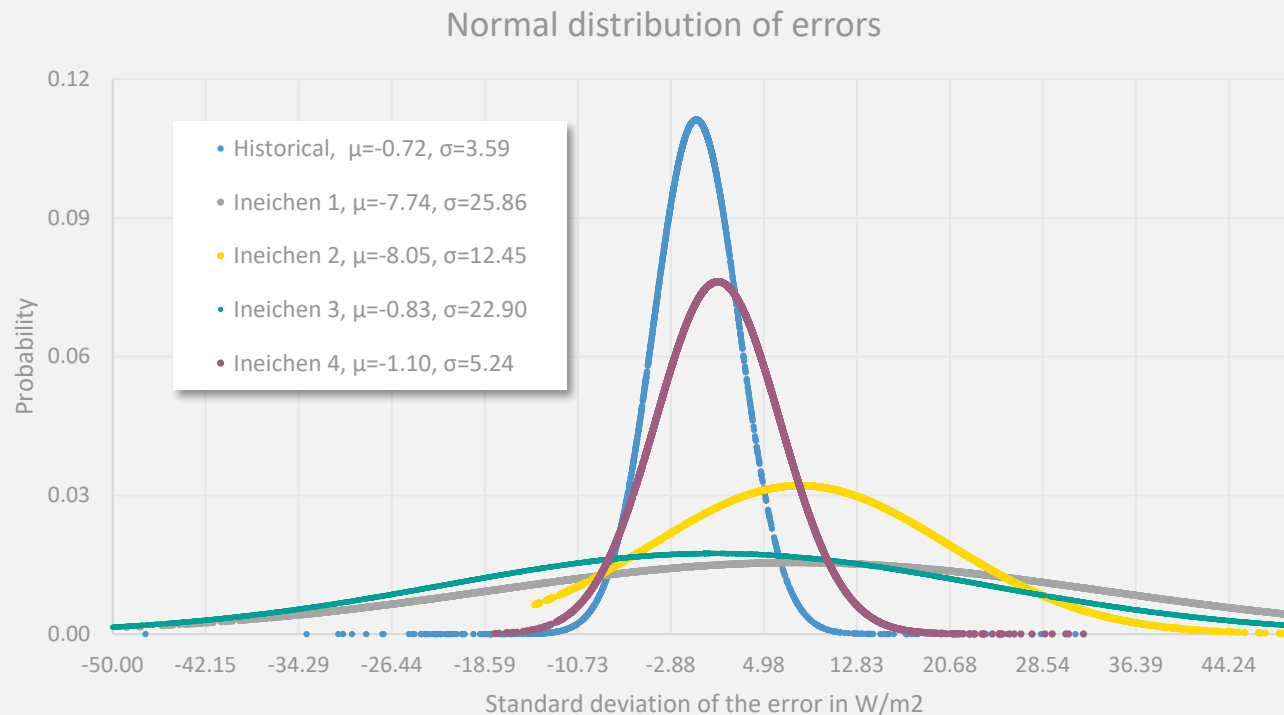
The accuracy of output simulation values when compared with input values.

Weather file	Mean Absolute Error
Historical	0.6 %
Ineichen 1	11.9%
Ineichen 2	6.7%
Ineichen 3	7.6%
Ineichen 4	3.4%

Pilot study and evaluation

Cloud scheme

Classification of cloud cover from sunshine duration from [68] and adaptation for the Our Energy app.

Cloud classification from (REF)			Cloud scheme utilized in Our Energy app		
Code	**Description**	**Sunshine Duration**	**Sunshine duration**	**Description**	**Icon**
Type CC	Clear, cloudless	93-95%	8-10	Sunny	
Type QC	Quasi clear, non-homogeneous	70-95%			
Type CD	Cloudy, dynamic	40-75%	4-7	Partially cloudy	
Type CN	Cloudy, non-homogeneous	0-45%			
Type OQ	Overcast, quasi-homogeneous	0-20%	0-3	Cloudy	
Type OH	Overcast, homogeneous	0%			

Pilot study and evaluation

Enhance list of available appliances

Add multiple entries feature for appliances

Extra graphs

Something fun

Summary of set appliances

References

Table 3.2 - Students suggestions.

|	Suggestion description	Applicability	Usefulness	Dupli-cate?
Appliances	Include additional devices or possibility to include own appliance. Add power rating description.	PA	PR	Yes
	Include appliances categories.	PA	PR	No
	Adjust appliances tag names visualization.	AP	PR	No
	Possibility of editing appliances' information after a day passed.	NA	ND	No
	Add a feature that make it possible to use the previous day as a template for the next day.	NA	DE	No
Points	Add something fun to show achievements (Ex. Hive growing).	PA	DE	No
	Show a summary of all the points in a graph.	PA	PR	Yes
Ranking	Add a time limit for the ranking. Restart ranking when time cross the time limit.	AP	PR	No
Notifications	Add reminders to enter the appliances according to ideal behavior.	PA	DE	Yes
	Add tips according to the time of the day.	PA	DE	Yes
	Add daily reminders.	AP	PR	No
PV screen	Add graphical representation of the daily incident solar radiation.	AP	PR	Yes
	Add information of where the data came from.	AP	PR	No
Others	Language picker within the app.	PA	DE	No
	Allow users to interact with other users in the community setting. Share and compare results also.	PA	PR	Yes
	Summary of the set up appliances.	AP	DE	Yes
	Possibility of choosing their own avatar.	NA	DE	No

Full Implementation

Hourly overview for two-week study

IMG Stiftung Phase 2
The Our Energy Challenge
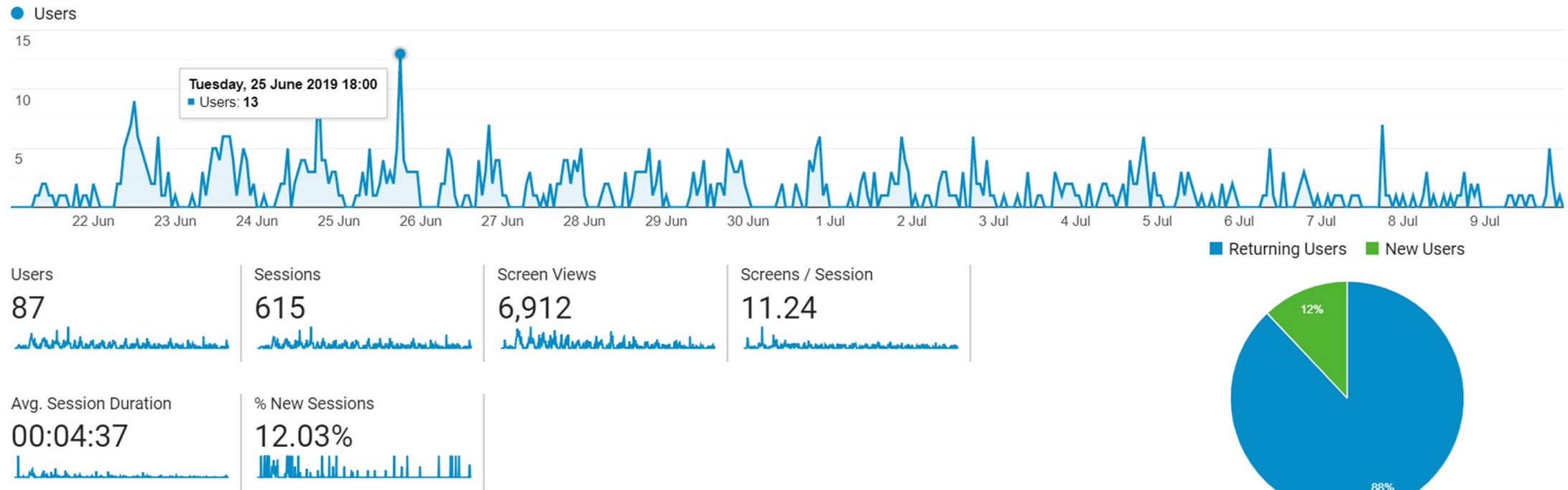
Full Implementation

Daily notifications
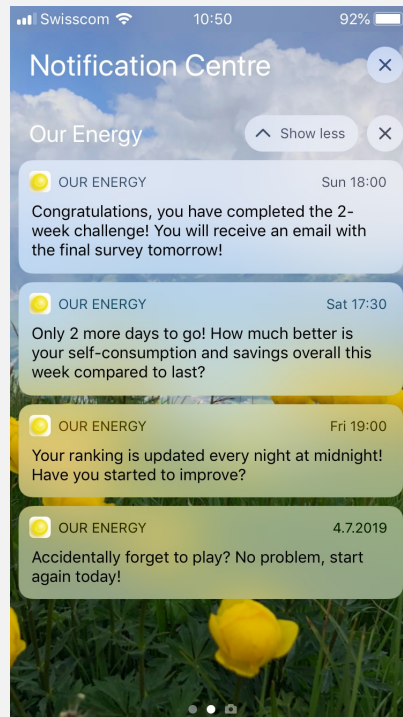
Date	English Notification	German Notification	Type
Mon 24-Jun-19	Welcome to Week-1! Add the appliances you actually use at home this week. Check your savings. Have fun!	Willkommen in Woche 1! Fügen Sie die Geräte hinzu, die Sie diese Woche zu Hause verwenden. Schauen Sie sich Ihre Ersparnisse an. Viel Spass!	Informative
Tues 25-Jun-19	It's not too late to participate, start logging your data today!	Es ist noch nicht zu spät, um teilzunehmen, beginnen Sie noch heute mit der Erfassung Ihrer Daten!	Reminder/ Incentive
Wed 26-Jun-19	Have you noticed that you cannot enter past data? Make sure to play each day!	Haben Sie bemerkt, dass Sie vergangene Daten nicht in Ihr Geräte-Tagebuch eintragen können? Versuchen Sie, jeden Tag zu spielen!	Informative/ Reminder
Thurs 27-Jun-19	Households with solar-PV typically have a self-consumption around 30%, what is yours so far?	Haushalte mit Solar-PV haben in der Regel einen Eigenverbrauch von rund 30%. Was ist Ihrer bisher?	Informative
Fri 28-Jun-19	Only 3 more days to record your actual appliance usage, keep it up!	Nur noch 3 Tage, um Ihren tatsächlichen Geräteverbrauch zu erfassen, weiter so!	Informative/ Incentive
Sat 29-Jun-19	Notice anything new or interesting while keeping a daily appliance diary?	Haben Sie bei der täglichen Gerätetagebuchführung etwas Neues oder Interessantes bemerkt?	Incentive
Sun 30-Jun-19	Today is the last day in week-1! Great job! What was your average self-consumption and savings from PV?	Heute ist der letzte Tag in Woche 1! Prima! Wie hoch war Ihr durchschnittlicher Eigenverbrauch und Ihre Einsparungen durch Solar-PV?	Informative / incentive
Mon 1-Jul-19	Today is the start of Week-2! Now try different options to maximize your electricity from solar PV.	Heute ist der Anfang der Woche 2! Probieren Sie nun verschiedene Möglichkeiten aus, um Ihren Strom aus der Solar-PV zu maximieren.	Informative
Tues 2-Jul-19	What is your goal this week? How much can you improve your self-consumption and savings from solar PV?	Was ist Ihr Ziel diese Woche? Wie viel können Sie Ihren Eigenverbrauch und Ihre Einsparungen durch Solar-PV verbessern?	Incentive
Wed 3-Jul-19	Have you tried matching your 'shiftable' appliances with available solar electricity this week?	Haben Sie diese Woche versucht, die 'flexibel' Geräte mit verfügbarem Solarstrom zu kombinieren?	Informative
Thurs 4-Jul-19	Accidentally forget to play? No problem, start again today!	Haben Sie versehentlich vergessen, zu spielen? Kein Problem, fangen Sie noch heute wieder an!	Reminder
Fri 5-Jul-19	Your ranking is updated every night at midnight! Have you started to improve?	Ihr Ranking wird jede Nacht um Mitternacht aktualisiert! Haben Sie angefangen, sich zu verbessern?	Reminder/ Informative
Sat 6-Jul-19	Only 2 more days to go! How much better is your self-consumption and savings overall this week compared to last?	Nur noch 2 Tage bis zum Ziel! Wie viel besser ist Ihr Eigenverbrauch und Ihre Einsparungen insgesamt diese Woche im Vergleich zur letzten?	Reminder
Sun 7-July-19	Congratulations, you have completed the 2-week challenge! You will receive an email with the final survey tomorrow!	Herzlichen Glückwunsch, Sie haben die 2-wöchige Testphase abgeschlossen! Sie erhalten morgen eine E-Mail mit der letzten Umfrage!	Informative

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Participation summary

Rate of participation per individual during the two week study

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