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IDENTIFYING PREDICTORS OF INTENTION TO USE HOME ENERGY MANAGEMENT SYSTEMS (HEMS) IN THE UK

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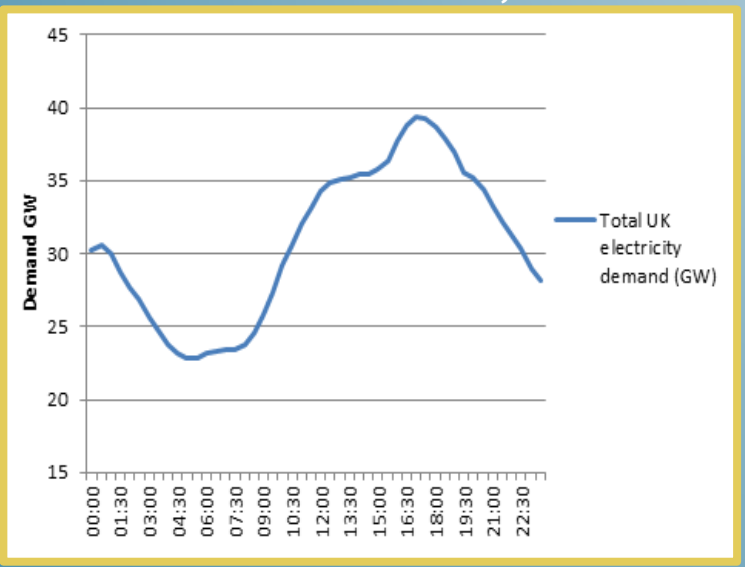
STRIKING A BALANCE

Aim of research:

- *To investigate householder perceptions HEMS as a means of DSM.*



Peak loads are a problem

– *Need to ramp generation up and down to meet with demand.*

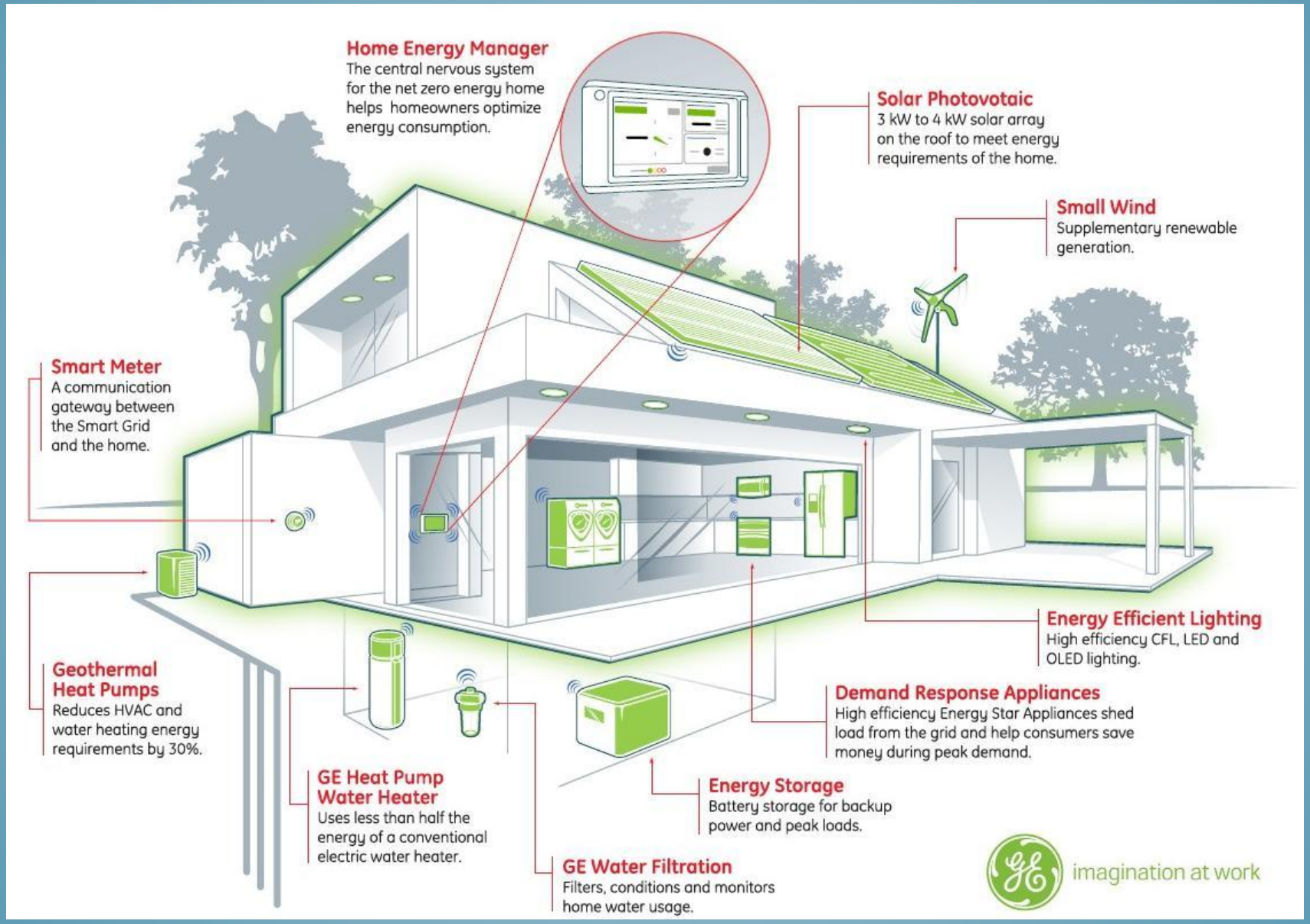
One solution is demand side management (DSM)

- *Attempt to reduce level of consumption*
- *Load shift to 'clip' peaks and 'fill in' troughs.*

DSM can be facilitated by smart technology

- *HEMS help people to visualise, monitor and manage their gas and electricity use.*
- *Consumers -> Co-shapers*

http://transport-trends.com


Home Energy Manager
The central nervous system for the net zero energy home helps homeowners optimize energy consumption.
Solar Photovotaic
3 kW to 4 kW solar array on the roof to meet energy requirements of the home.
Small Wind
Supplementary renewable generation.
Smart Meter
A communication gateway between the Smart Grid and the home.
Energy Efficient Lighting
High efficiency CFL, LED and OLED lighting.
Geothermal Heat Pumps
Reduces HVAC and water heating energy requirements by 30%.
Demand Response Appliances
High efficiency Energy Star Appliances shed load from the grid and help consumers save money during peak demand.
GE Heat Pump Water Heater
Uses less than half the energy of a conventional electric water heater.
Energy Storage
Battery storage for backup power and peak loads.
GE Water Filtration
Filters, conditions and monitors home water usage.
imagination at work

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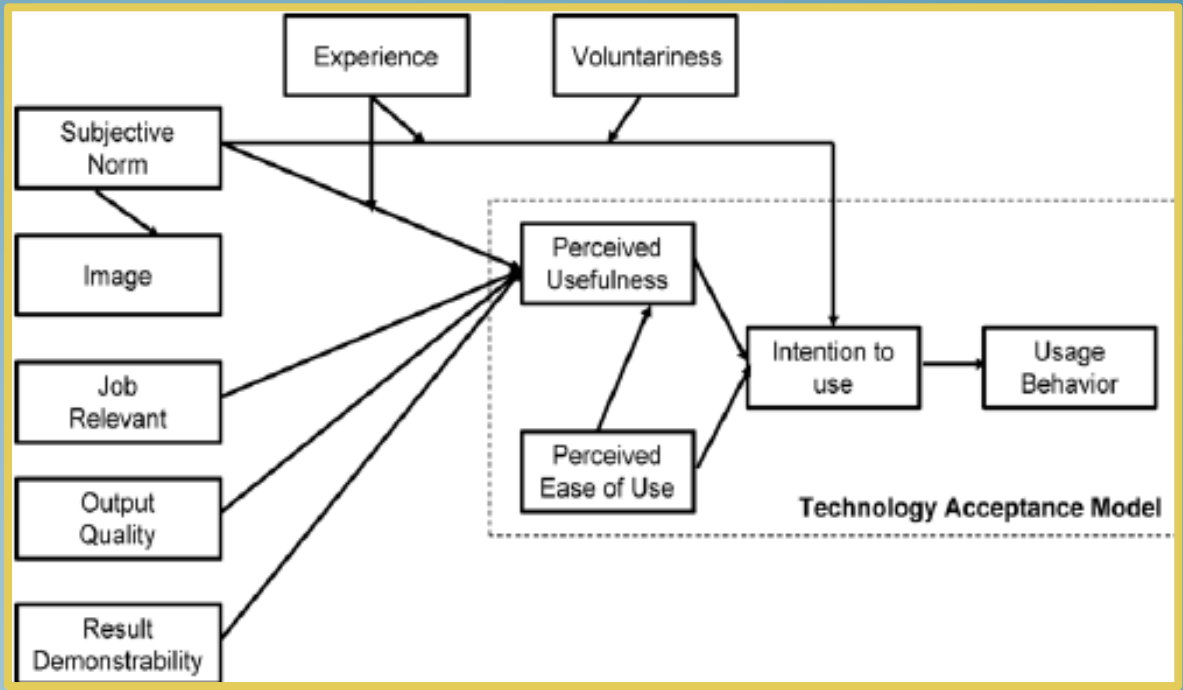
PUBLIC ACCEPTANCE



- *Intended aims of HEMS require 'buy in' from householders.*
- *The TAM2 is a key model of technology acceptance.*
- *Empowerment is also key*

Additional instrumental factors ('Cuprinol' factor)

- *Result demonstrability, output quality, job relevance*

Additional social factors ('Badge of honour' factor)

- *Voluntariness, subjective norms, image*

Goal internalisation, perceived confidence, perceived control (Menon, 2001)

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METHODS

- *Opportunity sample of Uni staff and students + Twitter & Facebook*

- **Condn 1 (*N = 110*)**
  - ***Reduce consumption***
- **Condn 2 (*N = 107*)**
  - ***Load shifting***

Information Choice Questionnaire (ICQ)

Piloting

- *12 x experts in smart grid technologies validate info.*
- *12 x lay-people check readability/understandability*

Measures

1. *Intention to use a HEMS*
2. *Attitudes towards HEMS use*
3. *PEOU, PU & Extd. TAM variables*
4. *Psychological Empowerment*
5. *Environmental Citizenship*
6. *Environmental Concern (NEP)*

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RESULTS
HEMS PERCEPTIONS

Key findings

- *Perceptions of HEMS are generally positive.*
- *People disagree that use of HEMS will increase their social standing.*
- *People uncertain of what is socially expected of them re: use of HEMS.*

TAM2 variable	Demand Redn Mean (SD)	Load Shift Mean (SD)
Intention to use	5.60 (1.44)	5.51 (1.58)
PU	5.45 (1.33)	5.27 (1.46)
PEOU	5.33 (1.07)	5.08 (1.16)
Voluntariness	5.25 (1.12)	4.67 (1.22)
Image	2.55 (1.25	2.74 (1.31)
Home relevance	5.00 (1.35)	4.75 (1.69)
Output equity	5.15 (1.14)	4.87 (1.43)
Result demonstrability	5.38 (0.91)	5.27 (1.10)
Subjective norm	4.08 (1.40)	4.00 (1.39)
Attitude toward use	5.87 (1.16)	5.64 (1.43)

T-tests vs. scale midpoint = 4.00
Green = significant positive; Red = significant negative; Amber = n.s. deviation

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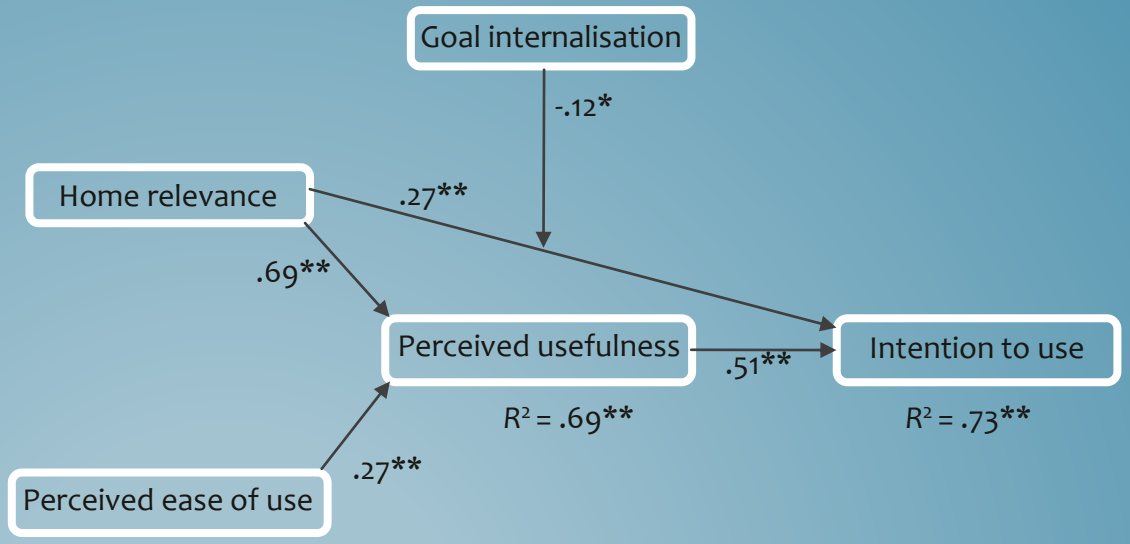
RESULTS
REDUCE CONSUMPTION



Modal Participant

- *26-29 years old*
- *University degree*
- *Own terraced house*

***High** goal internalisation*
***High** competence*
***Low** control of others*
***High** environ. citizenship*
***High** environ. concern*

Goal Internalisation (SD)	*β*	SE	*p*	Lower level CI	Upper level CI
- 1.00	.38	.10	.00	.18	.59
.00	.26	.09	.00	.10	.43
+ 1.00	.14	.10	.14	-.05	.33

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. N.B. As the variables have been standardised, their mean values are 0. β = standardised coefficient.

Key findings: (1) Basic TAM + Home relevance = good model
(2) Goal internalisation reduces relevance of home relevance!

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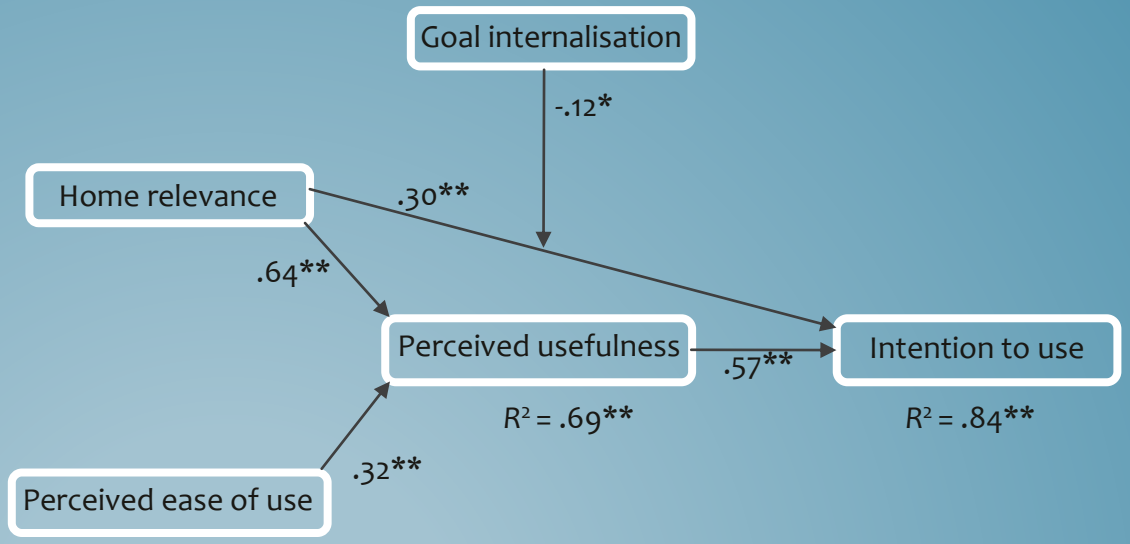
RESULTS

LOAD
SHIFTING



Modal Participant

- *38-41 years old*
- *Doctoral degree*
- *Own semi-det. house*

***High** goal internalisation*
***High** competence*
***Low** control of others*
***High** environ. citizenship*
***High** environ. concern*

Goal Internalisation (SD)	*β*	SE	*p*	Lower level CI	Upper level CI
- 1.00	.41	.07	.00	.27	.55
.00	.30	.06	.00	.17	.42
+ 1.00	.18	.08	.02	.03	.33

Confidence intervals (CI) and Standard Error (SE) estimated from a bias-corrected bootstrap sample of 10,000. N.B. As the variables have been standardised, their mean values are 0. β = standardised coefficient.

Key findings: (1) Basic TAM + Home relevance = good model
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DISCUSSION

Key aim

- Study public perception of HEMS

Key findings

- Perception is positive.
- TAM is good model.
- Pragmatism rules OK…
- …national goals can alter this.

Limitations and future directions

- Self-selected, opportunity sample affects generalizability of the findings.
- Opinions likely to be biased by ICQ information.
- Is hypothetical study context reflective of real world intention to use?
  - e.g. people did not interact with tech., we did not talk about cost.
  - Are intentions predictive of behaviours?
- How will 'social expectations' around HEMS use affect intentions to use?
  - Image and subjective norms

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THANK YOU FOR LISTENING.

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(from Sept. 2017)

Selected References

HEMS

- *Beaudin & Zareipour (2015). Renewable and Sustainable Energy Reviews, 45, 318-335.*

ICQ

- *de Best-Waldhober et al. (2009). Energy Procedia, 1, 4795-4802.*

TAM

- *Venkatesh & Davis (2000). Management Science, 46, 186-204.*

DSM

- *Spence et al. (2015). Nature Climate Change, 5, 550-554.*
- *Warren (2014). Renewable and Sustainable Energy Reviews, 29, 941-951.*

Psychological Empowerment

- *Menon (2001). Applied Psychology, 50, 153-180.*

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CONCLUSIONS

Conclusion

- Energy security attitudes are multi-faceted.
- Cross-national differences.
- Pro-culturalism poor predictor.
- Pro-environ. good predictor.
- Findings need validation.

1. ***Small, opportunity sample***
   - *Need larger, more representative samples to check generalizability.*
2. ***Investigating actual cultural differences***
   - *National cultural values affect pro-environmental values, what about energy security attitudes?*
3. ***Dependent variable***
   - *Is a 6-item scale adequate if you dissect it?*
4. ***Pro-environmental orientation***
   - *NEP would appear to have issues as measure of pro-environmental orientation. Can we employ/develop a better measure?*