Decision Support System
for Room-Level Air Conditioners

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Introduction

Energy Consumption Across World

https://yearbook.enerdata.net/electricity/electricity-domestic-consumption-data.html
Introduction

Government to sell energy-efficient ACs, fan at lower price: Piyush Goyal

PTI | Updated: Mar 02, 2016, 08:37 PM IST

NEW DELHI: After the LED bulb distribution scheme, the government is mulling a similar programme under which it will sell on EMI energy-efficient fans and air conditioners at prices much lower than market rates.

"We will soon come out with highly energy-efficient air conditioners on payment plans, so that you can pay for the air conditioner as you save money," Power Minister Piyush Goyal said addressing a press conference here.

Alberta government provides rebates of up to $3,500 for energy efficient homes

By Slav Kornik
Web Producer   Global News

Germany, Italy, and Japan Top World Energy Efficiency Rankings

July 20, 2016

Media Contact(s):
Patrick Kiker, 202-507-4043, Communications Manager

US Moves Up to #8 Spot Behind Spain and China, Rising From #13 Ranking in 2014; 3rd International Scorecard Evaluates 23 Largest Energy-Consuming Countries on 35 Categories.

WASHINGTON, DC – July 20, 2016 – Germany continues to lead the world in energy efficiency, followed by Italy and Japan (tied for second place), France, and the United Kingdom (not reflecting energy-related government changes in 2016), according to the 2016 International Energy Efficiency Scorecard published today by the nonprofit American Council for an Energy-Efficient Economy (ACEEE). New to the rankings this year are eight nations: Indonesia, Netherlands, Poland, Saudi Arabia, South Africa, Taiwan, Thailand, and Turkey.
“Energy conservation is the foundation of energy independence.”

–Tom Allen
Introduction

Appliance-Wise Power Consumption

Kitchen 18%

Lighting 26%

Entertainment 16%

Heating/Cooling 40%
Introduction

Replace the old inefficient appliances with efficient one
Introduction

- **Power Consumption (TWh)**
  - 0
  - 75
  - 150
  - 225
  - 300
  - 2006
  - 2011
  - 2016
  - 2021
  - 2026
  - 2031

- **# of ACs**
  - 50
  - 75
  - 110
  - 164
  - 220
  - 280

- **AC Power Requirements**
Introduction

Make them energy-efficient and SMART!
Problem Statement

\[ T_{\text{set}} = 26^\circ\text{C} \]
Problem Statement
Problem Statement

Informative Feedback
Problem Statement

Informative Feedback
Problem Statement

Informative Feedback

Energy-Efficient Control
Problem Statement

Informative Feedback

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Problem Statement

Informative Feedback

Energy-Efficient Control

Corrective Feedback
Problem Statement

Informative Feedback | Energy-Efficient Control | Corrective Feedback
Informative Feedback

Energy-Efficient Control

Corrective Feedback
Informative Feedback

Weather Data

Ambient Information

Informative Feedback

Weather Data

Model Thermal Behaviour of the Room

Ambient Information

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Informative Feedback

Weather Data | Model Thermal Behavior of the Room | Thermostat

Ambient Information

Informative Feedback

Weather Data

Model Thermal Behaviour of the Room

Thermostat

Ambient Information

AC @25 will save $X

AC @27 will save $Y

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PACMAN

Predicting AC Consumption Minimizing Aggregate Energy Forecast

Enter Your Location
PACMAN

Predicting AC Consumption Minimizing Aggregate Energy Forecast

Enter Your Location
Energy-Efficient Control

Informative Feedback  |  Energy-Efficient Control  |  Corrective Feedback
Portable+ Thermostat
Portable+ Thermostat
Portable+ Thermostat

Thermostat Temperature

16 17 18 19 20 21 22 23 24 25 26 27 28
Portable+ Thermostat

Towards Peak Comfort

Thermostat Temperature
Portable+ Thermostat

Towards Peak Comfort

Thermostat Temperature
Portable+ Thermostat

AC Energy Consumption

Towards Peak Comfort

Thermostat Temperature
Portable+ Thermostat

AC Energy Consumption

Towards Peak Comfort

Thermostat Temperature
**Portable+ Thermostat**

![Graph showing AC Energy Consumption and Thermostat Temperature]

- **AC Energy Consumption**
- **Scope for Energy Savings**
- **Towards Peak Comfort**

Thermostat Temperature

16 17 18 19 20 21 22 23 24 25 26 27 28
Portable+ Thermostat²

Portable+ Thermostat²

Along with
Thermostat
Temperature

Portable+ Thermostat²

Along with Thermostat Temperature

Users Preference

Results

26% Savings in Power Saving Mode
Results

26% Savings in Power Saving Mode

Discomfort Reduced by 23%
Results

26% Savings in Power Saving Mode

Discomfort Reduced by 23%

11% Savings when Enhancing User Experience
Corrective Feedback

Informative Feedback

Energy-Efficient Control

Corrective Feedback
Greina

- Gas Leakage: 34%
- Electrical Fault: 8%
- Ice Formation: 8%
- Water Leakage: 13%
- Compressor Change: 7%
- Wire Repair: 30%
Gas Leakage - A Slow Time-Varying Fault
Design a fault diagnostic engine to **timely** catch the early symptoms of a slow time-varying fault (in an AC) and report to booth managers to avoid any serious damage in future.
Approach

Step 1 - Cluster Booths
Approach

Step 1 - Cluster Booths

Step 2 - Assign Cluster
Approach

Step 1 - Cluster Booths

Step 2 - Assign Cluster

Step 3 - Learn Behaviour
Approach

Step 1 - Cluster Booths

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Step 4 - Observe Deviations
Approach

Step 1 - Cluster Booths

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Step 4 - Observe Deviations

Step 5 - Detect Faulty Appliance
Step 1 - Cluster Booths

- Clustering Parameters (Contextual Similarities):
Step 1 - Cluster Booths

- Clustering Parameters (Contextual Similarities):
  1. Mean external temperature
Step 1 - Cluster Booths

• Clustering Parameters
  (Contextual Similarities):

1. Mean external temperature

2. # of times door was opened / closed
Step 2 - Pick Ideal Booth

- Selection Criteria: Cluster closest (statistical distance) to the booth.
Step 3 - Learn Behaviour

- Designed a two-level bayesian network.
Step 3 - Learn Behaviour

• Designed a two-level bayesian network.

• Reasons:
Step 3 - Learn Behaviour

- Designed a two-level bayesian network.

- Reasons:
  - Weather, user behaviour, AC health
Step 3 - Learn Behaviour

- Designed a two-level bayesian network.

- Reasons:
  - Weather, user behaviour, AC health

- Features:
Step 3 - Learn Behaviour

• Designed a two-level bayesian network.

• Reasons:
  • Weather, user behaviour, AC health

• Features:
  • Trend, peak power consumption, # of compressor cycles, leakage rate, cooling rate, etc.
Step 4 - Observe Deviations

- Given weather, user behaviour, and other sensory information:
Step 4 - Observe Deviations

- Given weather, user behaviour, and other sensory information:
  - infer AC health from the bayesian network
Step 5 - Detect Faulty Appliance

- Consistently low health implies
Step 5 - Detect Faulty Appliance

- Consistently low health implies
- Appliance behaviour degrading over time
Step 5 - Detect Faulty Appliance

- Consistently low health implies
- Appliance behaviour degrading over time
- Transition probabilities learned from the dataset.
Conclusion

Thermostat

Generate Feedback

Smart Control

Informative Feedback

Corrective Feedback
Thank You