Realization of Sustainable Energy by Smart Campus

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Mie University
Toward Smart Energy in Campus

Regional Warming Suppression by Smart Campus

1. Overall of Smart Campus
2. Individual Measures and Effectiveness
3. General-Purpose to Other Facility
4. Future
Theses on Promoting Energy Saving at University

Goal: Be Proud of Environmentally Advanced University to the World

- Indistinctness of Actual Energy Usage by each Sector
- Lack of Investment for Energy Saving (First priority is to maintain and repair of energy facility)
- Insufficient Consciousness of Energy Saving

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Aiming at an Environmentally Advanced University

Systems Configuration of MIESC

1. Energy Management System (EMS)
2. Wind turbine
3. Solar power
4. Gas engine co-generation system
5. Waste heat recovery chiller
6. Air conditioning system
7. LED lights
8. Battery

Create Energy

Electricity and Information Flow

Energy Flow

Save Energy

Store Energy

Smart Meter

Event Hall

【Target】
1. CO₂ Reduction Rate 24%
2. Expand Smart System to Others

Overview of Mie University (2015)
- Site Area: 528,040 m²
- Total Floor Area: 314,539 m²
- No. of Students: 7,297 persons
- No. of Faculty and staff: 1,877 persons
- Total members: 9,174 persons

Annual Energy Consumption (2014)
- Electricity: 41.0 GWh
- City Gas: 4,635 km³
- Heavy Oil-A: 424 kℓ
- CO₂ Emission: 23,458 t-CO₂

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Execution of CO₂ Reduction Plan by Means of PDCA Cycle

Clarification of Smart Campus Purpose
(1) Energy Saving
(2) Operating Expenses
(3) BCP

Analysis of Existing and Future Energy Supply/Demand Facilities

Introduction of New Facilities and Evaluation of Energy Saving

Explanation internally and externally

Improving Plan

Optimized and Consensus?

Yes

No

Action and Continuation

Continuous Unfolding
Aim for Realization of Smart Campus and Related Stakeholder

1. A Feasibility Study with Renewable Energy / Energy Saving Facilities
   - Energy Saving Ratio
   - Allotment of large/small independent power

2. Collaboration with Demand and Supply Side
   - Abrupt Fluctuation of Renewable Energy
   - Leveling of Electricity
Proposal of Smart Community

Purposes
1. Utilization of
   - Sustainable Energy (Solar and/or Wind Power)
   - high efficient co-generation
2. CO₂ Reduction emitted from Institute/University
3. Stable Energy Supply
   under Normal Condition and
   Independent Power Supply in case of a natural disaster

**Energy Creation with less CO₂ emission**
- Solar Power Photovoltaic (PV)
- Co-Generation

**Energy Management System (EMS)**
- Peak Shaving
- Stable Supply
  - Demand Forecast
  - Optimum Operation
  - Storage of Electricity

**Energy Saving**
- Air-Conditioning System
- LED Lighting
- Waste Heat Recovery Equipment
Decision of Various Measures

<table>
<thead>
<tr>
<th>Application</th>
<th>Energy</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-Conditioning</td>
<td>Demand Large (in Summer)</td>
<td>Desiccant</td>
</tr>
<tr>
<td>Lighting</td>
<td>Fixed Load, Operating Hour Long</td>
<td>Directly use DC</td>
</tr>
</tbody>
</table>

- **Leading Measure**
  - Energy Saving Air-Conditioning (Desiccant type)
  - LED Lighting with low energy loss (connected with DC of PV)
  - Lighting in CVS

- **Graph**
  - Winter
  - Mild
  - Summer
  - Weekday (Peak) 9,530 (100)
  - Electricity Demand(kW)
  - A ratio of Electricity (%)
  - Air enthalpy

- **Table**
  - Electricity Demand: Weekday and Vacation
  - Heating: Summer
  - Cooling: Summer
  - Ventilation: Winter
  - Lighting: Winter
Electricity demand is affected by each season respectively.

- Spring: 22/4/(Mon)
- Summer: 9/7(Tue)
- Autumn: 1/11(Thu)
- Winter: 11/1(Fri)

- Mainly Hospital
- Students Attending University
- Large number Of people
- Leave University

Electricity Demand Difference caused by Air-Conditioning
Electricity Demand is affected by ambient air enthalpy and solar radiation.

Electricity Demand [kW]

\[ \text{Electricity Demand} = \alpha \cdot h + \beta \cdot SR + \gamma + \sigma \]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>\alpha</td>
<td>Air enthalpy coefficient</td>
<td>kW·kg/kcal</td>
</tr>
<tr>
<td>\beta</td>
<td>Solar radiation coefficient</td>
<td>m²</td>
</tr>
<tr>
<td>h</td>
<td>Air enthalpy</td>
<td>kcal/kg'</td>
</tr>
<tr>
<td>SR</td>
<td>Solar radiation</td>
<td>kW/m²</td>
</tr>
<tr>
<td>\gamma</td>
<td>Fixed value</td>
<td>kW</td>
</tr>
<tr>
<td>\sigma</td>
<td>Compensation (by saving activity)</td>
<td>kW</td>
</tr>
</tbody>
</table>

daytime (10:30 ~ 17:00)

Patent applied on '13
Demand Comparison (Measured and Forecasted)

Comparison between measurement and prediction

Errors

Average RMS Error: Daytime 4.6 %
Nighttime 3.7 %
Preservation of Environment

Countermeasure of Shadow-Flicker and Noise Caused by Wind Turbine (WT)

The shadow-flicker occurs when the wind-turbine blades move across the sun shining. The influence of shadow-flicker is predicted and its result occurs influence to residents. An operation is arranged to shutdown the wind-turbine beforehand when the shadow-flicker is expected in a fine morning.

<table>
<thead>
<tr>
<th>Sound Level dB(A)</th>
<th>Sound similar to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>Normal conversation</td>
</tr>
<tr>
<td>50</td>
<td>Quiet office</td>
</tr>
<tr>
<td>40</td>
<td>Library or midnight in city</td>
</tr>
<tr>
<td>30</td>
<td>Chirp, midnight in suburbs</td>
</tr>
</tbody>
</table>

Noise Propagation caused by Wind Turbine

Distance 830m

Noise level 30dB(A)

30dB(A)

40dB(A)

45dB(A)

50dB(A)
(i) Electricity Peak Restraint

Effect of Electricity Demand Restraint

- Peak Demand 9,530 kW (100%)
- Contracted Value 4,760 kW (49.9%)
- Monthly Peak 4,310 kW (by independent power)

Peak Restraint ▲4,770 kW (▲50.1%)

Operation Improvements
- Storage of Electricity (▲60)
- Improvement of Facilities’ Operation (▲310)
- Waste Heat Use (▲60)
- Improvement of chilled water transportation (▲30)

Methods of Demand Restraint
( ii ) Desiccant Air Conditioning
(New Energy Saving Method)

Evaluation by Discomfort Index

<table>
<thead>
<tr>
<th>Discomfort Index</th>
<th>Feeling</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 – 70</td>
<td>Comfort</td>
<td></td>
</tr>
<tr>
<td>70 – 75</td>
<td>Feel not hot</td>
<td>Our Target</td>
</tr>
<tr>
<td>75 – 80</td>
<td>Slightly hot</td>
<td></td>
</tr>
<tr>
<td>80 – 85</td>
<td>Hot and Sweat</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation

- As ever: Indoor temperature
- New Idea: Indoor temp. and Humidity

Energy Saving Effect: 36.6% reduced

Satisfaction: Size of circle shows satisfaction rate.

Energy Consumption

Resident 40 persons

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DC (Direct Current) Power is directly supplied from PV to LED Lighting

**Energy Saving Effect: 18%**

- **Conventional**
  - AC Supply: 1,619 W (100%)
  - DC Supply: 1,326 W (81.9%)
  - Saving: 293 W (18.1%)

- **New Supply Method**
  - AC Supply: 1,571 W
  - DC Supply: 1,414 W
  - Saving: 293 W (18.1%)

**Comparison between DC vs AC**

- **LED Lighting**
- **PV Panel**
- **Utility**
- **AC Line Transformer**
- **PCS**
- **LED Lighting**
- **Same Brightness**
- **LED Lighting in the CVS**

AC: Alternating Current
DC: Direct Current

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(iv) Effective Usage of Small size Battery

Hybrid Storage (Fast Capacitor and Lead Battery)

- **Electricity demand restraint** at Power Peak Period
- **Mitigation of Abrupt Fluctuation** for WP and PV

**Improvement of Battery Operation**

**Electricity Demand Peak-cut**

- Peak-cut mode
- **Contract Value**
- **Threshold Value**

**Electricity Generation**

- **Store**
- **Under control**
- **Discharge**
- **WP·PV Output** (with no control)

Time (h)

Electricity (kW)

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Electricity Supply to Campus in Case of Disaster (BCP)

Electricity from Power Company

City Gas
Gas Engine
Storage Battery Capacitor
Wind Power
Solar Power

In Case of Disaster
Power Failure

Electricity, Gas: Shut down
Wind Power, Solar Power: Normal Condition

Electricity Supplied by Renewable Energy

Important Load 1 (against Disaster)

Stabilization of electricity (Store/Discharge)

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Generalization of the methods implemented in the Smart Campus Program and future expansion

Apply versatile technologies and actions for energy saving and power saving to other universities in and outside Japan

Promotion of PR and expansion

Tohoku and Hokkaido
Temperate
High energy peak rate

Inland
High temperature

Southeast Asia, Kanto and southern
Hot and humid (marine climate)

Kyushu and Okinawa
Promotion of “cool biz”

Hybrid battery technology

Demand response, dynamic pricing

LED lighting system using DC power supply

Voluntary management-type environmental activities
(MIEU Point)

Considering a feasibility study with an Indian University and graduate school

- Power demand forecast
- Evaluation of environmental impact to the community
- Autonomous power supply in case of a disaster

【Common technologies】

- Power demand forecast
- Evaluation of environmental impact to the community
- Autonomous power supply in case of a disaster
Selection of optimum heat source for air conditioning by region

<table>
<thead>
<tr>
<th>Climate conditions</th>
<th>Use exhaust heat</th>
<th>Electricity</th>
<th>Heat source for cooling and heating</th>
<th>Air Conditioning</th>
<th>Heating</th>
<th>None</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperate</td>
<td>Absorption</td>
<td>Turbo</td>
<td>Desiccant (Low COP)</td>
<td>① Inland</td>
<td>教堂</td>
<td>教堂</td>
<td>教堂</td>
</tr>
<tr>
<td></td>
<td>Steam/hot water</td>
<td></td>
<td>Heat pump (Low COP)</td>
<td>② Close to the sea</td>
<td>教堂</td>
<td>教堂</td>
<td>教堂</td>
</tr>
<tr>
<td>Cold</td>
<td>Absorption</td>
<td>Gas</td>
<td>Absorption (Low COP)</td>
<td>③ Inland</td>
<td>教堂</td>
<td>教堂</td>
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</table>

Evaluation of energy efficiency

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Results and Future

【Progress of Energy and CO₂ Emission】

We will continue our smart activity to prevent global environment.
Our Future Activity

- **Establishment of Vision and Goal**
  
  Aim at "One of the Advanced Environmental University in the World"

- **Encourage the Energy Saving Activity**
  
  Visualization of energy usage conditions and Guide to all the member

- **Optimization by Removal of Uselessness**
  
  High accurate demand forecast
  
  High priority operation of efficient equipment

- **Continuous Practice of ECO Activity**
  
  Continuity of energy saving activity in a body
  
  Demand response, Incentive Activity

**What is Smart?:**

Everyone continues to respect "Nature, Object and Region".

**Thank for your Attention!**