Smart Parking for Sustainable Communities

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Introduction

- **Sustainable communities** refers to communities planned, built, or modified to promote **sustainable living** with a tendency to focus on environmental and economic sustainability, urban infrastructure, social equity, and municipal government.

- **Smart Parking** is a parking strategy that combines technology and human innovation in an effort to use as few resources as possible—such as fuel, time and space—to achieve faster, easier and denser parking of vehicles for the majority of time they remain idle. (Paul Wessel@Parksmart)

- **Green parking** is a form of parking lot designed to be environmentally more sustainable.
A **smart city** is a municipality that uses information and communication technologies to increase operational efficiency, share information with the public and improve both the quality of government services and citizen welfare.
Smart City: Main Components

1) Sustainability
2) Efficiency
3) People, communities
4) Security
OUTLINE

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- Smart Parking – Design and Building Perspective
  - Sustainability and Environmental Impact
  - Smart and integrated design
  - Different parking facility design approach
- Smart Parking – Transportation Perspective
  - Parking Guidance and Information System (PGIS)
    - E-Parking
    - PGIS with Transit
    - Automated Parking
    - V2H & V2G
- Concluding Remarks
Smart Parking – Design and Building Perspective

- Sustainability and Environmental Impact
- Smart and integrated design
- Different parking facility design approach
Sustainability and Parking Facility

- Building owners spend more than $6 billion to light their parking lots and garages
- E.g: University of Minnesota, Minneapolis campus
  - All 18 of its parking facilities use energy-efficient LED lighting and implemented lighting controls
  - University achieved a 90% energy savings and 29% return on investment in the first year
- Solar Panel Power Generation
- Green Wall
Sustainability and Material Use

- Develop new sustainable building materials, construction methods, and energy efficient improvements
Examples of Sustainable Paving Materials

<table>
<thead>
<tr>
<th>Paving</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pervious concrete</td>
<td>Special structural concrete having no fine particles (appearance is like a rice cake), and having a void content of 15 to 25 percent. Will support traffic and allow water to pass through (3 to 5 gallons per minute) to gravel bed beneath. Strength is about 85 percent of conventional concrete.</td>
</tr>
<tr>
<td>Pervious pavers</td>
<td>System composed of interlocking paving blocks placed on a bed of fine gravel. The configuration of the pavement blocks creates small voids that allow stormwater to infiltrate.</td>
</tr>
<tr>
<td>Structural grass pavers</td>
<td>Lattice of open-cell, interlocking grid blocks are placed, and hollows are filled with soil and planted with grass (or wildflowers). Pavers may be made of concrete, metal or recycled plastic. Vehicles can use a reinforced lawn occasionally.</td>
</tr>
<tr>
<td>Crushed rock and gravel</td>
<td>These materials are compacted, and may consist of multiple layers. Finest textured rock is placed at the top and most coarse is placed near the native soil. Can be used with confinement cells or structures for long term and horizontal stability.</td>
</tr>
</tbody>
</table>

Pervious pavings options
Sustainability and Smart Parking

Cardok garage

https://www.youtube.com/watch?v=HZScvqXGLV8
Smart and Flexible Design

- Turn parking facility to landmark for efficiency and city identity

Autostadt Car Towers in Wolfsburg, Germany
Energy Generator

Greenway Self Park, Chicago

Santa Monica Civic Center Parking Garage (LEED Certified, Solar Power, LED lighting)

https://www.youtube.com/watch?v=3P9SJsrbu-g
More Dramatic Ideas – mixed parking in a new way

- Utilize land more efficiently
- Adapt to future changes
- Design with car-less future in mind

https://www.youtube.com/watch?annotation_id=annotation_316022&feature=iv&src_vid=xqmrUw_riGI&v=pkiVEqyRbSU
Smart Parking – Transportation Perspective

- Parking Guidance and Information System (PGIS)
  - E-Parking
- PGIS with Transit
- Automated Parking
- V2H & V2G
Benefits of Smart Parking
-- Transportation Perspective

- Efficiency increase in transportation system or in people’s travel
  - Traffic management
  - Parking management
    - Demand, pricing, usage, and profit
  - Time management by travelers
  - Environmental benefits
    - Reduction in fuel consumption and vehicle emissions
- Efficiency increase in the use of land
- Efficiency increase in the electricity power system
Parking Guidance and Information Systems (PGIS)

- PGIS is an autonomous system to efficiently guide drivers to a parking space within a facility, downtown, or an entire city.
  - Found in major cities in Europe, Japan, the U.K and U.S
1. Sensing: Entrance/exit barriers, vehicle presence sensors etc.
2. Telecommunication networks
3. Control center
4. Information disseminating mechanism: several types of illuminated displays (number of free spaces, directions, etc.).

- https://www.youtube.com/watch?time_continue=21&v=Kkl3EiURius
1. Sensors detect parked vehicles

2. Control center gather/processes traffic & parking info. And controls display of information for drivers

3. Telecommunication network facilitates transfer of information
   - Indicator lights to show a parking spot
   - Parking ticket with Radio Frequency Identification (RFID) tags to locate assigned parking slot with ease

4. Payment for parking
E-Parking

- E-Parking allows drivers to search a parking spot by SMS or the internet, and/or reserve a space at a desired facility
  - Often incorporated with smart payment systems
  - Have been implemented for cities, university campuses, as well as building complexes.
- Customized information can be sent to patrons before or during the trip to parking.
  - e.g. Click & Park (France): [https://www.clicknpark.lu/](https://www.clicknpark.lu/)

Idris et al. 2009

![Fig. 1: Example of parking reservation system message](image)
PGIS with Transit

- PGIS guides drivers to park-and-ride facilities in real-time, and provides information on the status of parking space and public transportation.
- Allows for patrons to plan for transit
- Location of park-and-ride lots determined by the following factors:
  - geographical, network, travel time from demand points to the location of park-and-ride facilities
  - France, Germany, Ireland, Japan, Switzerland, U.K, U.S (Shaheen et al., 2005)
Rockridge BART Smart Parking Experiment

- Dec. 2004 to April 2006; Oakland, CA (7:30am-10am, Mon-Fri)
- Even with a 10% over-subscription of monthly permits, not all spots were used every day.
- Make these available after 10am
  1. Sensors counting the number of cars entering and exiting
  2. A reservation system using an online
  3. Two solar-powered changeable message signs on the freeway to display the number of available spaces and an exit for access
- 13,000 successful drive-in and advanced reservations
- Increased transit trips: additional 5.5 commuting trips/mo and 4 trips/mo to other destinations
- Reduced VMT by 9.7 miles per participant per month
Automated Parking

- 22 cases as of Feb. 2015, including ones in the pipeline
Automated Parking

- The Hive Parking Structure, Oakland CA
  - [https://www.youtube.com/watch?v=0anGZnff1ns](https://www.youtube.com/watch?v=0anGZnff1ns)
  - 1,600 ft²; 55 feet high; 39 spaces
  - 69% less construction material per parking space

- West Hollywood
  - 200 spaces on a 150’ x 80’ footprint (40% reduction)
  - 27 foot wide landscaped civic plaza
  - Reduced CO₂ emission = reduction of 92 vehicles

- Camden Grand Parc in Washington DC
  - 65,000 sf; 16 Story Residential Development; 55 Residential Units
  - 61 Vehicle Transient Automated Parking Facility
  - Operating cost: approximately $55 to $75 /mo-space, (x 2).
  - Maintenance cost: ½ ; $35 to $45 per /mo-space
Automated Parking

- Increase parking capacity per sq-ft
  - Reduction in the overall footprint
  - Increase in space for a main use
  - Increase in parking revenue
- Reduce construction costs
  - Reduce or eliminate excavation
- Reduce insurance premiums
- Increase safety and security
- No extra space for opening door / height
- Eliminate footprint for ramps/turning radius
- Reduce operation costs (light, ventilation)
- Reduce fuel consumption
- Reduce pollution by 65% or more
  - CO -77%; VOC -68%

National Parking Association
PARKING Magazine, vol. 48, The Garage of the Future Must be Green, Samuel I. Schwartz, P.E.
Using MOBILE 6.2
Smart EV Charging Stations / Parking

- EV chargers can be connected to other systems with smart technologies.
  - V2H – vehicle to home
  - V2G – Vehicle to grid (power grid)
- Function as:
  - Home power consumption controller
  - Electricity storage
  - Distributed power generation system
The V2H system can quickly charge an EV from the HEMS storage battery, and supply electricity from the EV to the house system. It can estimate the daily EV travel distance and household power consumption to best manage the charging and discharging of the electricity of EV and HEMS storage battery (smart energy home) including electricity generated by home solar panels.

Vehicle battery can be used at home in emergencies. (Mitsubishi Highlandar: 10 days with full tank)

- Battery EV (BEV)
- Plug-in hybrid EV (PHEV)
- Fuel cell vehicles (FCV); FCEVs

HEMS: home energy management system
V2H

- Nissan electric car can power a house [https://www.youtube.com/watch?v=ZWm-VWzTnzg](https://www.youtube.com/watch?v=ZWm-VWzTnzg)

- Vehicle-to-Grid technology (V2G) turns Nissan electric cars into energy hubs [https://www.youtube.com/watch?v=3pNbKfXVIeU](https://www.youtube.com/watch?v=3pNbKfXVIeU)
V2G – Vehicle-to-Grid

- EV chargers can provide *charging data* to energy companies.
  - Depending on the status of energy production across the grid, charging can be stopped, reduced, and increased.

- The **peak load** can be shaved.

- The **overall stability** of the grid can be increased.
  - Handle *renewable power*, and make renewable sources even more widely integrated and affordable.
  - **DOD study:** 15kw of bi-directional capacity available for (24hr x 2days + 15hr x 5days) would generate $150/mo of V2G value.

Source: Department of Defense
Parking is an important component of sustainable communities, as well as smart cities.

1) Building and design perspective
2) Transportation perspective

A variety of technologies and systems has been and well be developed.
The ideas presented in this presentation are still limited in terms of establishing synergies to many other components within the Smart City framework to support sustainable communities.

Most ideas connect only a few components / factors at a time. But to take the best out of the Smart City, we need to find more synergies to many other components.

More ideas of system development, as well as more advanced technologies, are warranted.
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