Applying Time-Dependent Analytic Hierarchy Process for Incorporating Customer Preferences in Load Scheduling

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Analytic Hierarchy Process

- Incorporates quantitative and qualitative judgments in decision making
- Pairwise comparison matrices form judgments based on the AHP fundamental scale[1]
- Numerical priorities are calculated for each of the criteria and alternatives by using the Eigenvector corresponding to the maximum Eigenvalue
- Total priority for each alternative reflects its importance to the user with respect to the goal and criteria
- The alternative with the maximum priority value is the best alternative

Dynamic AHP

- Preferences and opinions are not always static
- Pairwise comparison matrices are evaluated at individual points during the time period
- Elements of the pairwise comparison matrices form an interpolating polynomial using the Piecewise Cubic Hermite Interpolating Polynomial (PCHIP)[2]
- Piecewise-defined time dependent functions can then be evaluated at the desired time step

Load Scheduling Method (LSM)

- AHP is used to rank importance of **schedulable** set of total loads
  - Schedulable loads have a power electronics interface that allow for their automated control
- The total load profile is given by the set of non-schedulable loads plus the loads scheduled with AHP

LSM Case Study

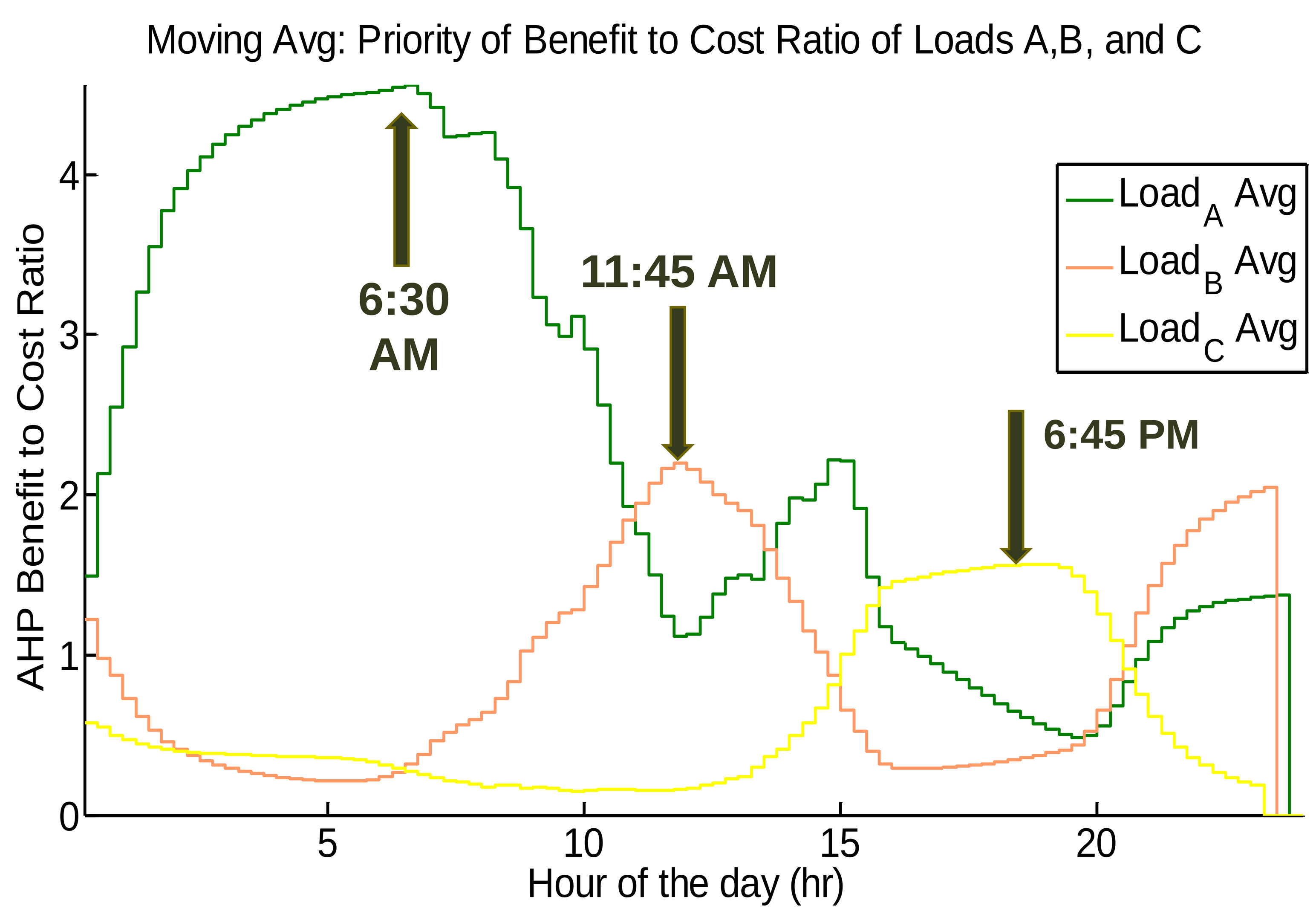
- Assume customer-owned installation with schedulable loads A,B, and C

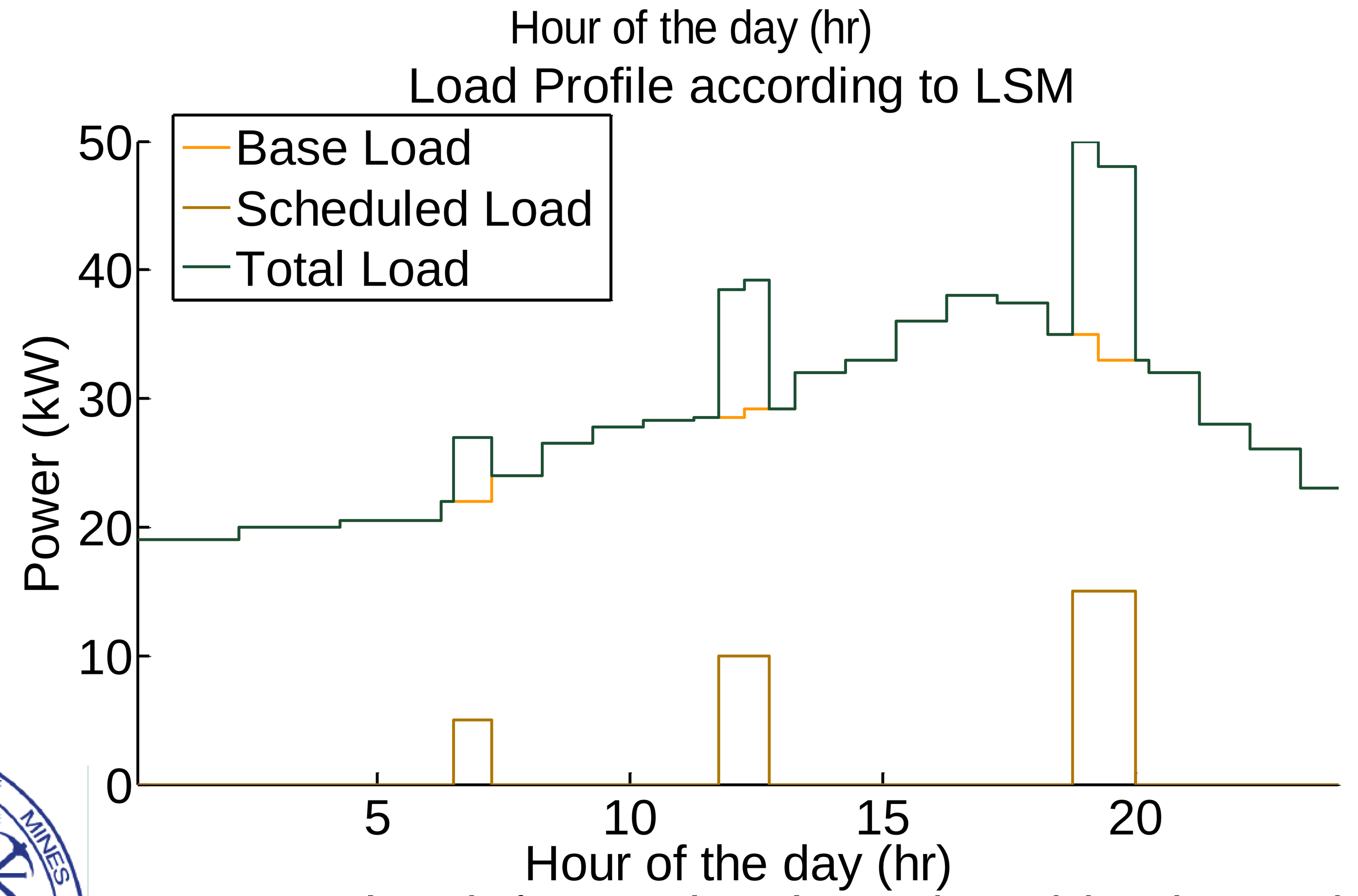
LOAD	A	B	C
Runtime (min)	45	60	75
Load Rating (kW)	5	10	15

- **Objective:** Schedule loads according to customer-preference based on information on day-ahead dynamic electricity pricing for a 24 hr period
- Customer makes 6 pairwise comparison matrices, and PCHIP forms time-dependent functions
- Load priorities are calculated using AHP

LSM Case Study

- Benefit priority rankings represent the preference to the customer to run each load
- Cost to run each load is dependent on the day-ahead dynamic price of electricity and load rating
- Benefit-to-cost ratio found by dynamic AHP represents the priority ranking of the customer's loads
- The moving average of the benefit-to-cost ratio is evaluated with respect to each load's individual runtime
- Each load is scheduled when the moving average of the benefit-to-cost ratio is at its maximum





Synthetic pairwise comparison matrices that represent the benefit of each load:

t=1	Load A	Load B	Load C
Load A	1	1/5	1/3
Load B	5	1	2
Load C	3	1/2	1

C.R.=.0036

t=6	Load A	Load B	Load C
Load A	1	9	5
Load B	1/9	1	1/3
Load C	1/5	3	1

C.R.=.0279

t=12	Load A	Load B	Load C
Load A	1	1/5	3
Load B	5	1	9
Load C	3/8	1/9	1

C.R.=.0153

t=16	Load A	Load B	Load C
Load A	1	2	1/4
Load B	1/2	1	1/7
Load C	4	7	1

C.R.=.0019

t=20	Load A	Load B	Load C
Load A	1	1/2	1/9
Load B	2	1	1/6
Load C	9	6	1

C.R.=.0088

t=24	Load A	Load B	Load C
Load A	1	1/3	3
Load B	3	1	9
Load C	1/3	1/9	1

C.R.=0

Conclusions

- LSM allows for active participation by the customer in Demand Side Management
- AHP provides a customer friendly method to quantify load preferences
- Each customer can tailor their own loading profile to suit their needs

Future Work

- Incorporate more loads and customer parameters
- Include costs like employee wages, productivity, etc. especially in industrial or large commercial settings
- Include more load parameters such as power factor, harmonic injection, etc.
- Extend LSM to operate in the presence of day-ahead dynamic real *and* reactive power pricing

[1] T. L. Saaty, *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process* vol. VI, Pittsburgh, PA: RWS Publications, 2006.
[2] C. B. Moler, "Interpolation," in *Numerical Computing with MATLAB* Philadelphia, PA: Cambridge University Press, 2004.

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