Session 2: Energy-efficient Datacenters

Joint Capacity Planning and Operational Management for Sustainable Data Centers and Demand Response

June 22, 2016

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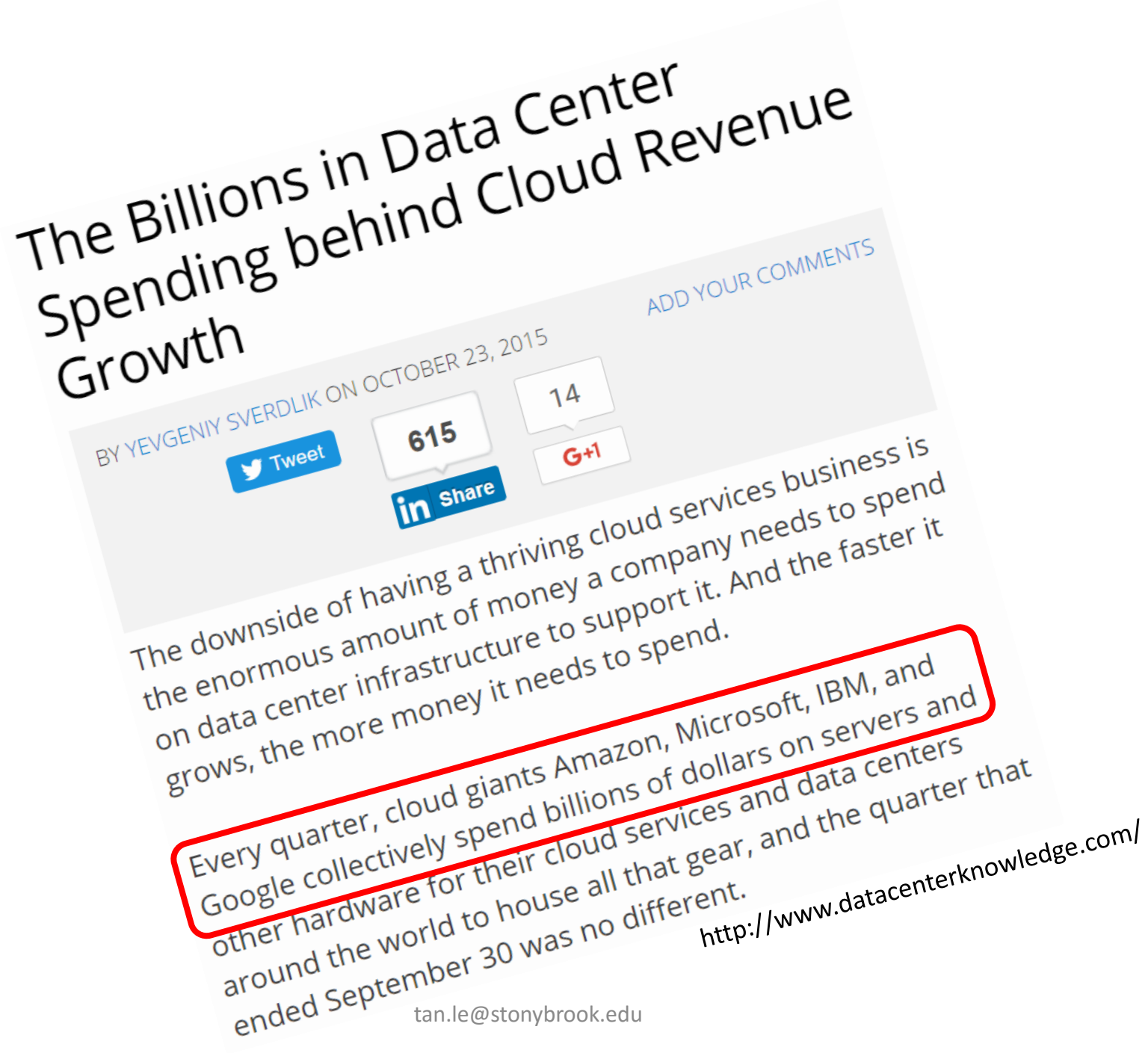
Total global cloud traffic growth

www.cisco.com



The Billions in Data Center Spending behind Cloud Revenue Growth

BY YEVGENIY SVERDLIK ON OCTOBER 23, 2015

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The downside of having a thriving cloud services business is the enormous amount of money a company needs to spend on data center infrastructure to support it. And the faster it grows, the more money it needs to spend.

Every quarter, cloud giants Amazon, Microsoft, IBM, and Google collectively spend billions of dollars on servers and other hardware for their cloud services and data centers around the world to house all that gear, and the quarter that ended September 30 was no different.

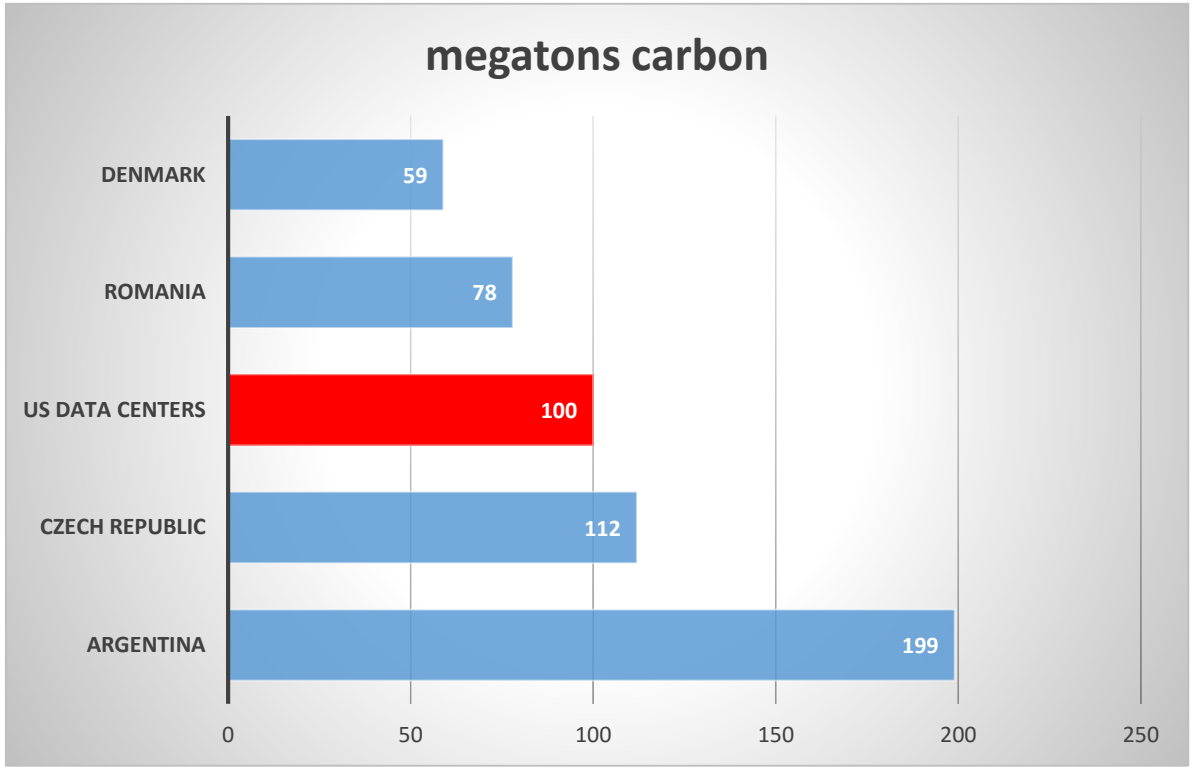
http://www.datacenterknowledge.com/

Environmental threat from data centers

450W 5.2 tons carbon a year

=

Emissions in 2013

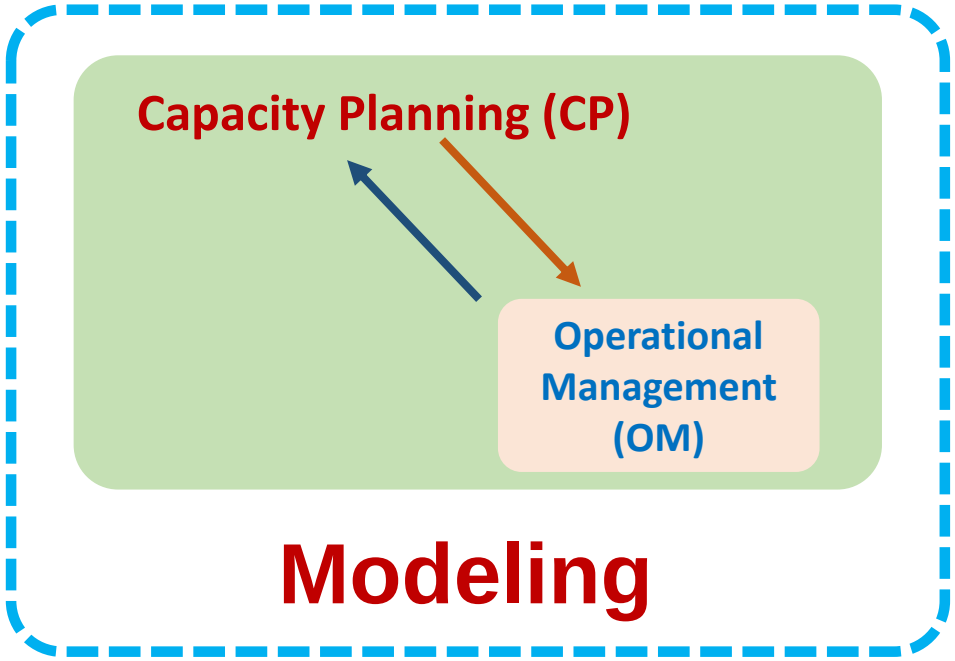


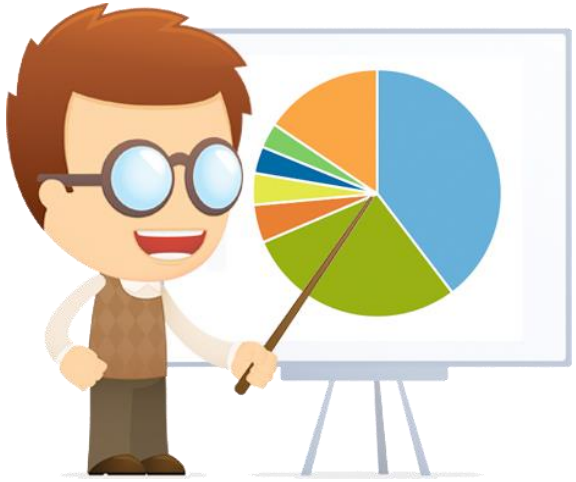
Carbon footprints of servers can vary by 10x, www.vertatique.com
E. Facts. Greenhouse gas emissions from a typical passenger vehicle, 2005.

www.nrdc.org & wikipedia.org

Goal: Reduce costs and emissions for data centers with **renewables**

Approach: Joint Optimization of CP and OM



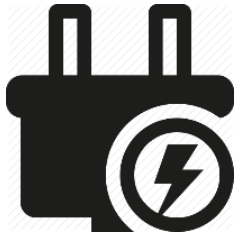


servers

Power sources

cooling

Capacity Planning (CP)



electricity bills

fuel

maintenance

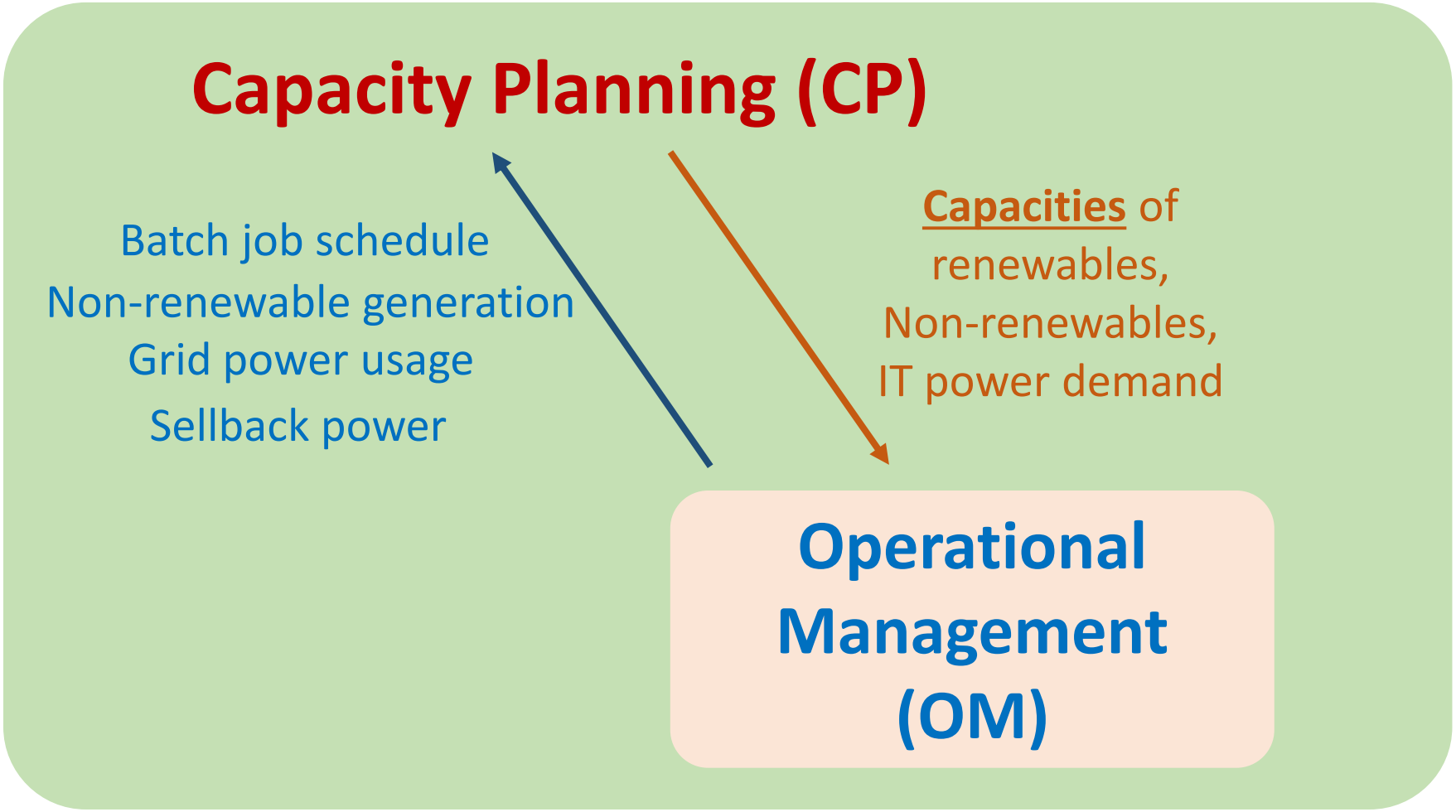
Operational Management (OM)

Traditionally, they are <u>separate</u>

This results in significant inefficiencies

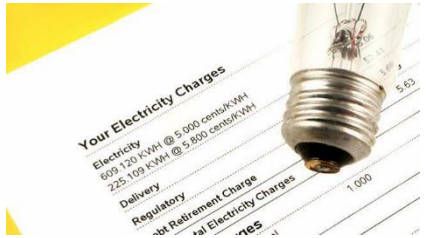
<u>Ex</u>: CP is based on peak demand,
but peak can be shaped in OM

Proposed Joint Optimization Framework



Joint Optimization Framework

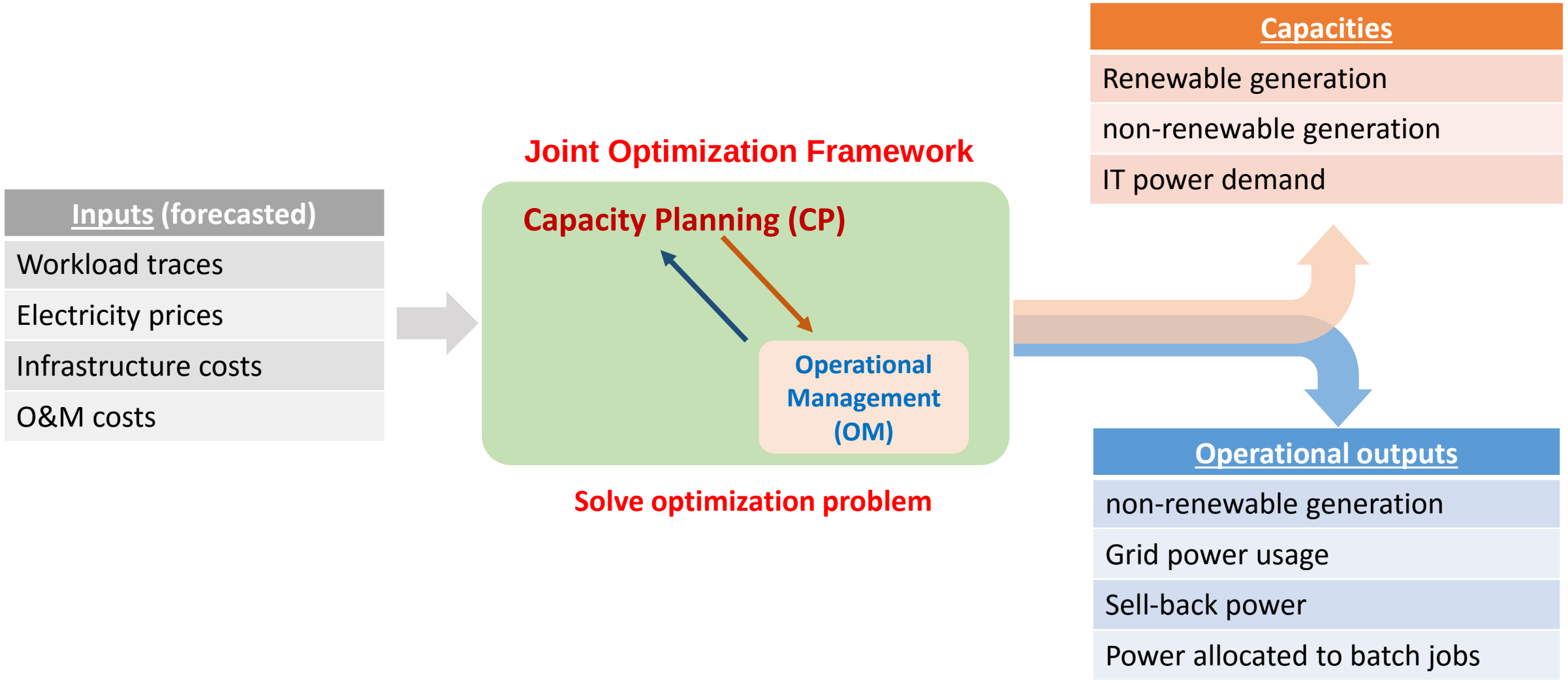
minimize *UtilBill* *+ RGEx* *+ NGEx* *+ ITEx*



	Utility bills (*UtilBill*)	Renewable Generation Expense (*RGEx*)	Non-renewable Generation Expense (*NGEx*)	IT expense (*ITEx*)
CP cost	N/A	Infra. Cost	Infra. Cost	Infra. cost
OM cost	Purchase – Sell back	O&M costs	O&M costs	O&M costs

The optimization problem is convex

How the framework operates?



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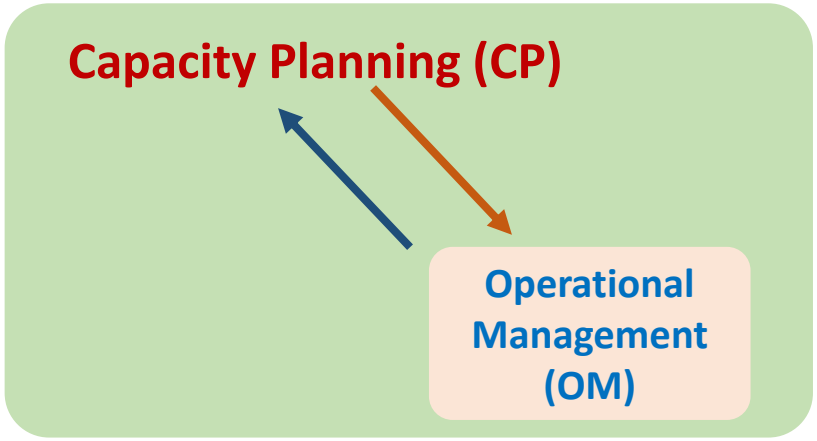
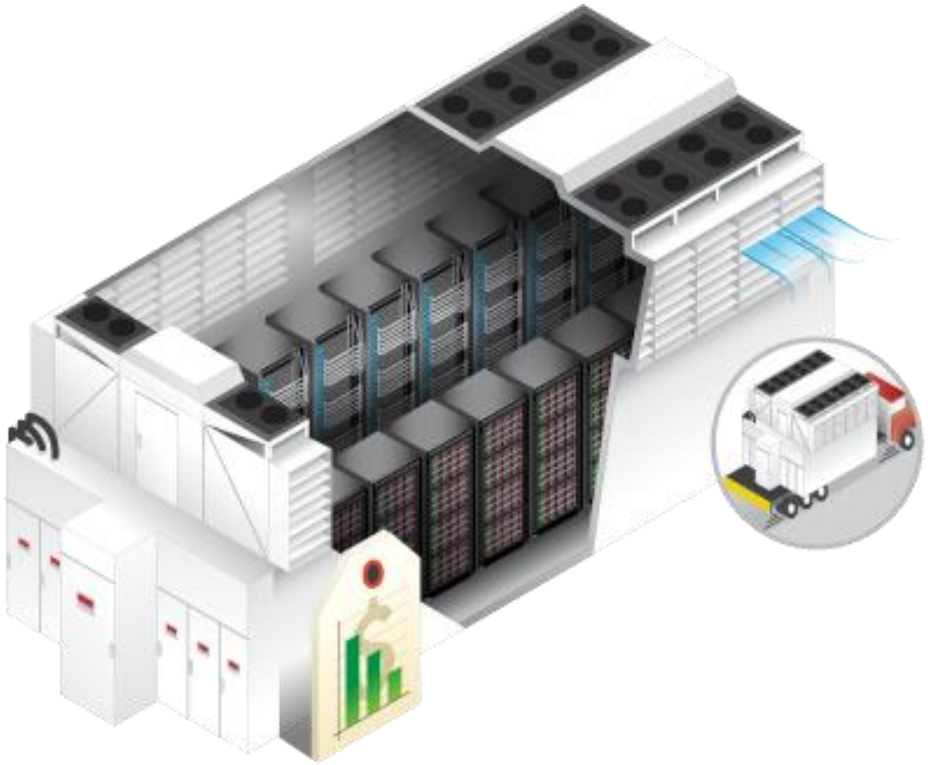


Modeling

Evaluation

Simulation based on 1MW HP EcoPod Data Center



HP EcoPODs 240a

Case study

IT efficiency races forward in eBay Inc.'s data centers with HP EcoPODs

Highly efficient modular data centers are a key part of company's growth strategy

Industry
Online commerce

Objective
Meet ongoing growth in a highly efficient manner.

Approach
Deploy HP EcoPODs and fully loaded server racks.

IT matters
- Cut costs with innovative approaches to power and cooling.
- Streamline the deployment of data center resources.

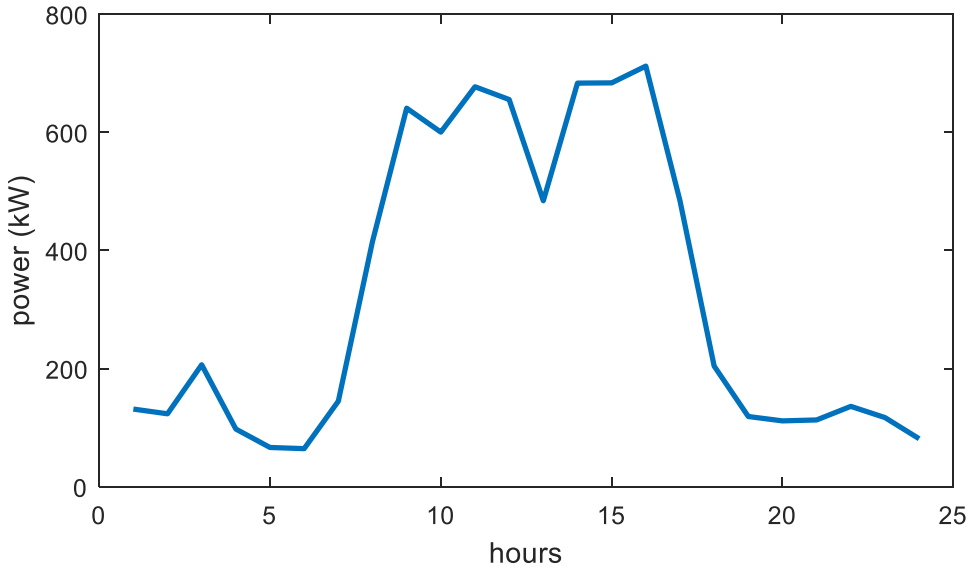
Business matters
- Fuel business growth with on-demand deployment of data center resources.
- Avoid steep upfront costs for brick-and-mortar data centers.

"Our HP EcoPODs are very efficient—sub 1.1 PUEs. That keeps our costs down."

– Paul Santana, Director of Data Center Operations, eBay Inc.

www.hp.com

Demand Side



CPU power usage trace

Peak-to-Mean ratio: 3

PUE: 1.2

Annual increase rate: 9% a year ↗

[www.zdnet.com]

Interactive workload: 50%

Utilization of server: 40%

Batch jobs: 50%

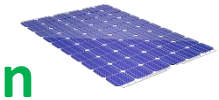
Flexibility 24 hours

Maximum utilization is 90%

We do not include capacity planning for IT equipment

Supply Side

PV generation



Capacity factor: ~18%

[Houston traces]

General Electric (GE)

Natural Gas generation

Electricity grid

[Texas]

Infra. cost: $**2.15**/W a year > Infra. cost: $**1**/W a year > Infra. cost: $**0**/W a year

12% a year [cleantechnica]

Operational cost: $**0**/kWh < Operational cost: $**0.06**/kWh > Price: $**0.056**/kWh

1% a year [www.eia.com] 5% a year [Texas]

Maintenance cost: $**0.005**/kWh = Maintenance cost: $**0.005**/kWh > Maintenance cost: $**0**/kWh

Emission rate: **0.034**g/kWh < Emission rate: **0.443**g/kWh > Emission rate: **0.5**g/kWh

Comparisons with baseline methods

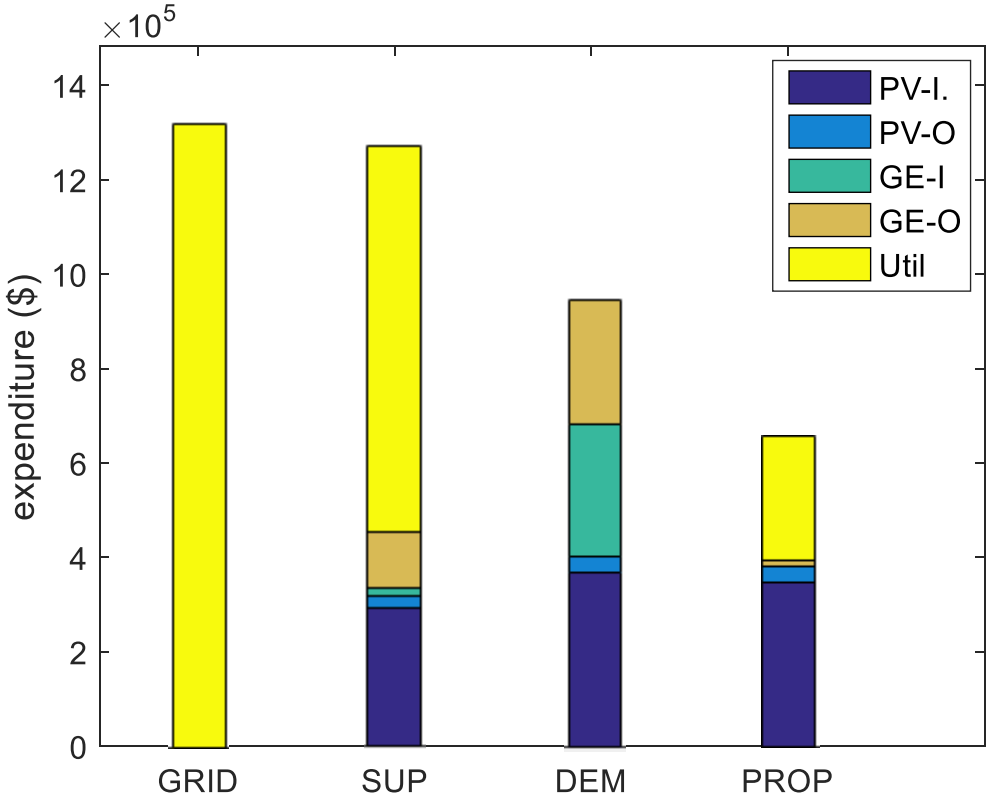
Grid Only (**GRID**) in traditional data centers
provisions power only from the electricity grid

Supply-only Optimization (**SUP**)
optimizes power sources based on given demand

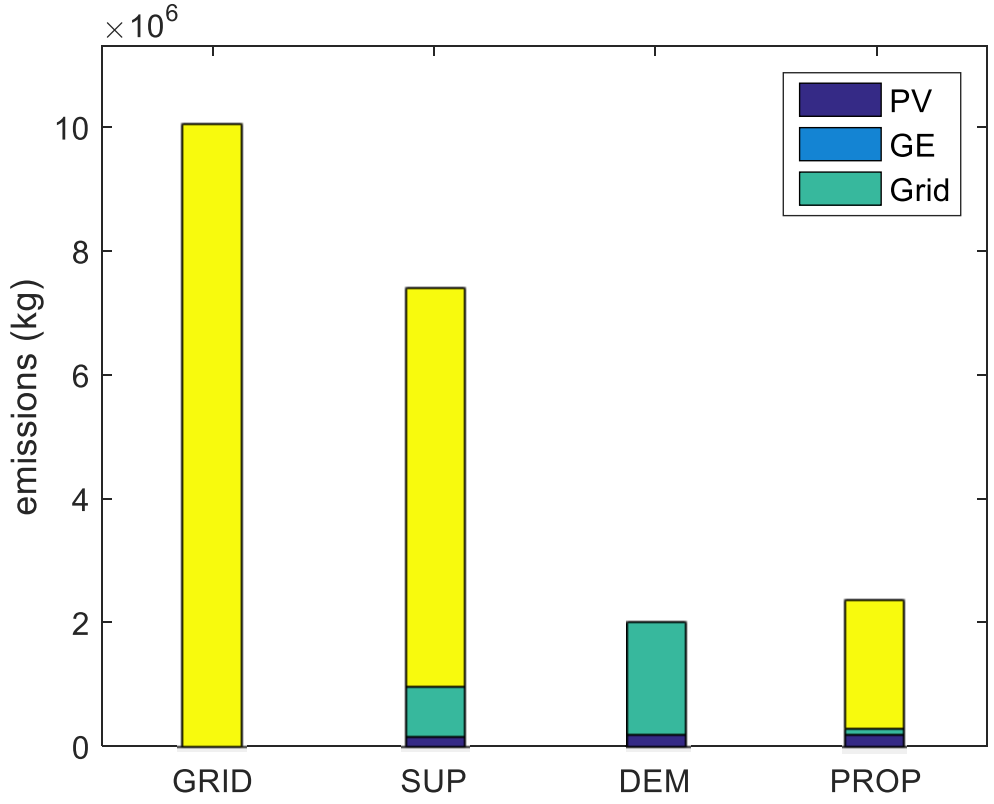
Demand-only Optimization (**DEM**)
optimizes power demand based on given the capacity planning

Proposed framework **(PROP)**
Joint Capacity Planning & Operational Management

Question: How much can we improve?



Cost: PROP = 50 % GRID



Emissions: PROP = 25 % GRID

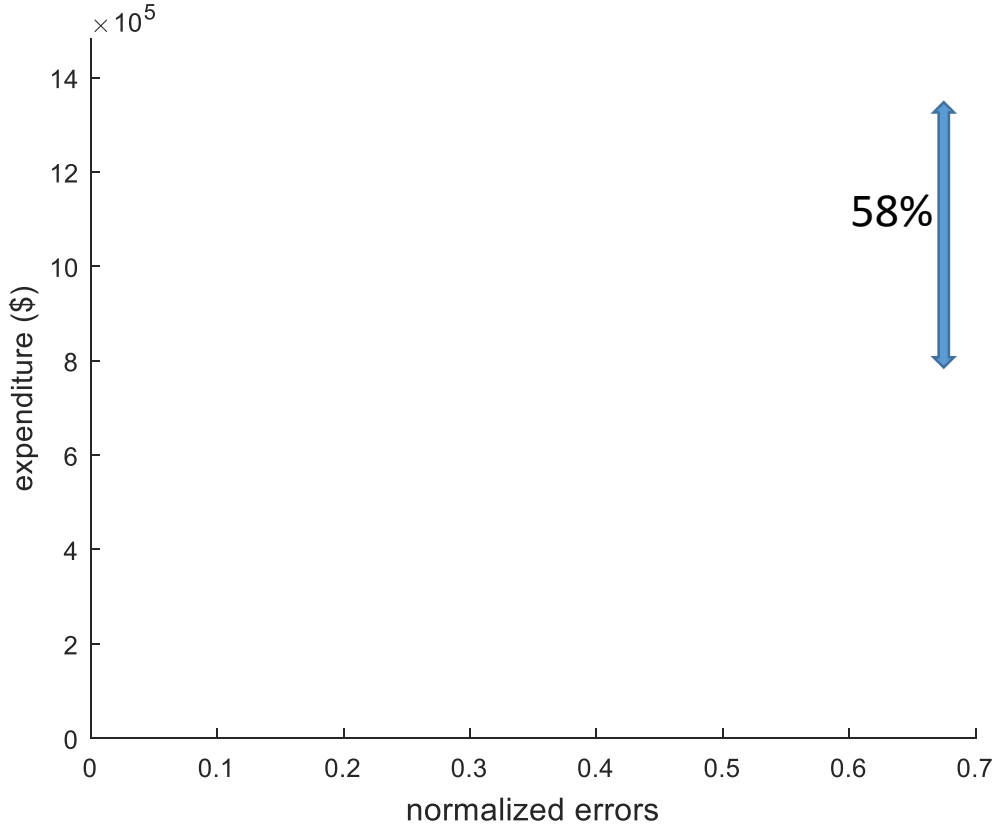
GRID: Grid only

DEM: Demand-only optimization

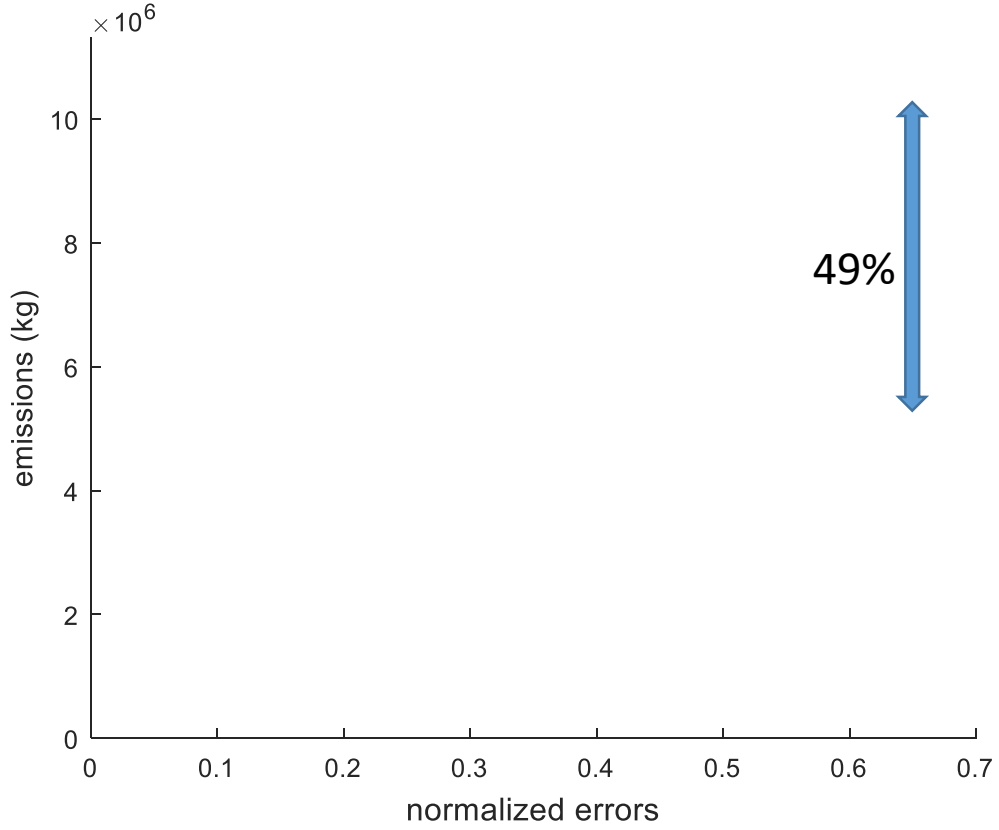
SUP: Supply-only optimization

PROP: Proposed framework

Costs and emissions under prediction errors



Expenditures vs. prediction errors



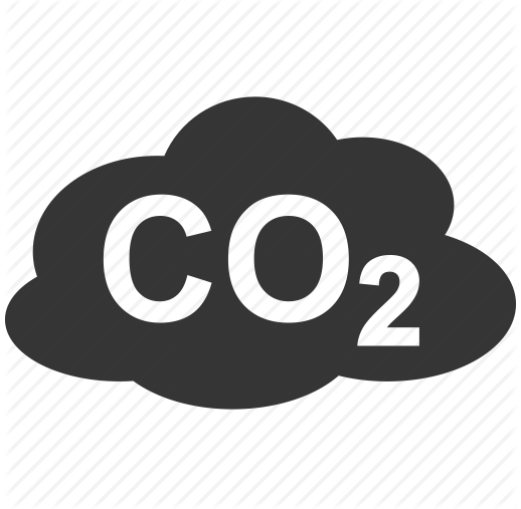
Emissions vs. prediction errors

PROP significantly outperforms GRID under large prediction errors

Joint Capacity Planning and Operational Management

Cost saving 50%

Emission reduction 75%



Goal: Reduce data center costs with **Demand Response**

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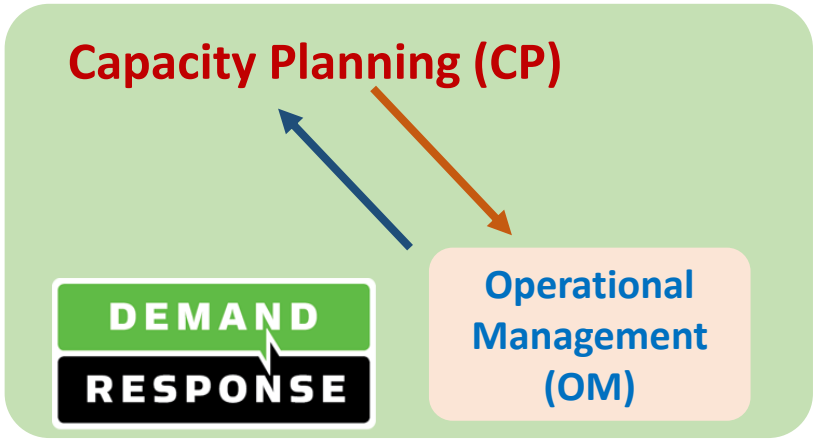
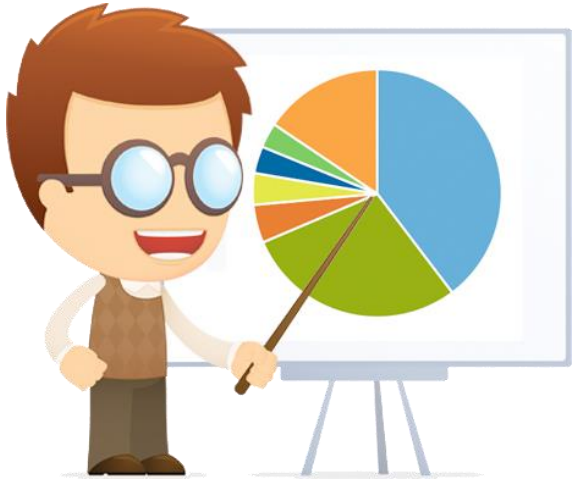


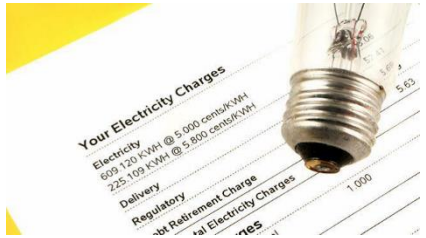
Modeling



Evaluation

Extending Joint Optimization Framework for DCDR

minimize *UtilBill* *+ RGEx* *+ NGEx* *+ ITEx*



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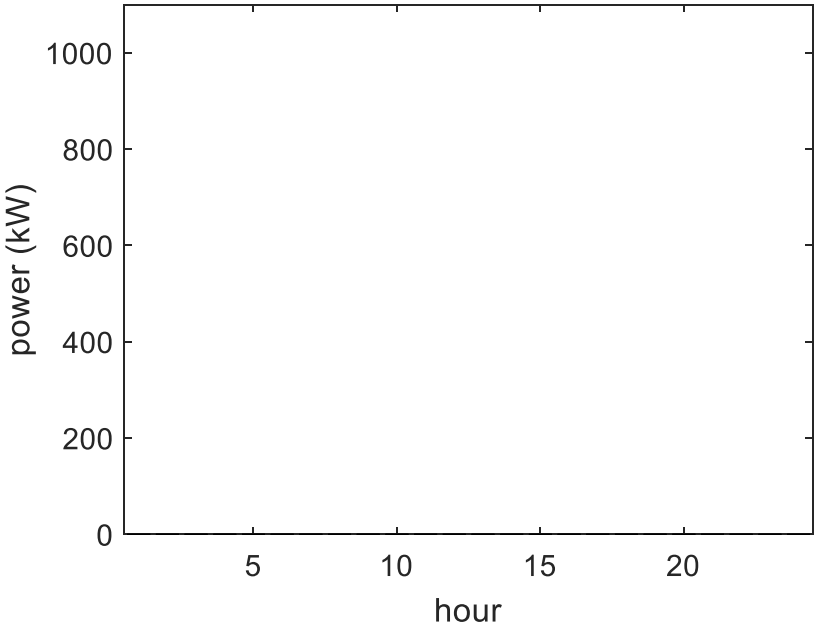
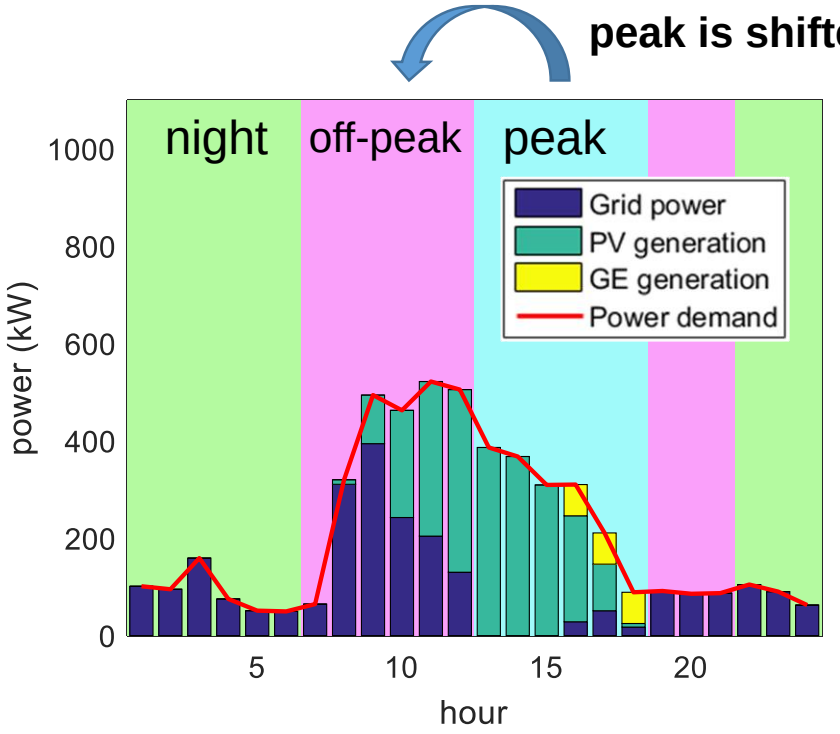
OM cost	**Purchase – Sell back**	**O&M costs**	**O&M costs**	**O&M costs**
	- DR reward + DR penalty			

Operation of Framework in DR programs



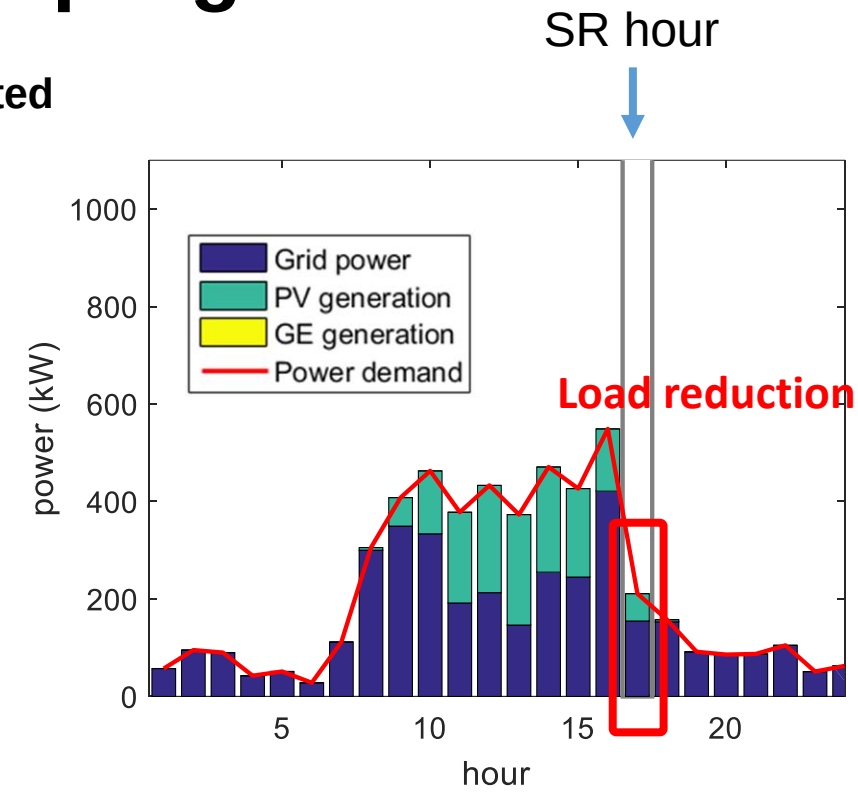
Without DR programs

Base price: $0.056/kWh



Time of Use (ToU)

$0.05 (night), $0.219 (peak), $0.06 (off) /kWh



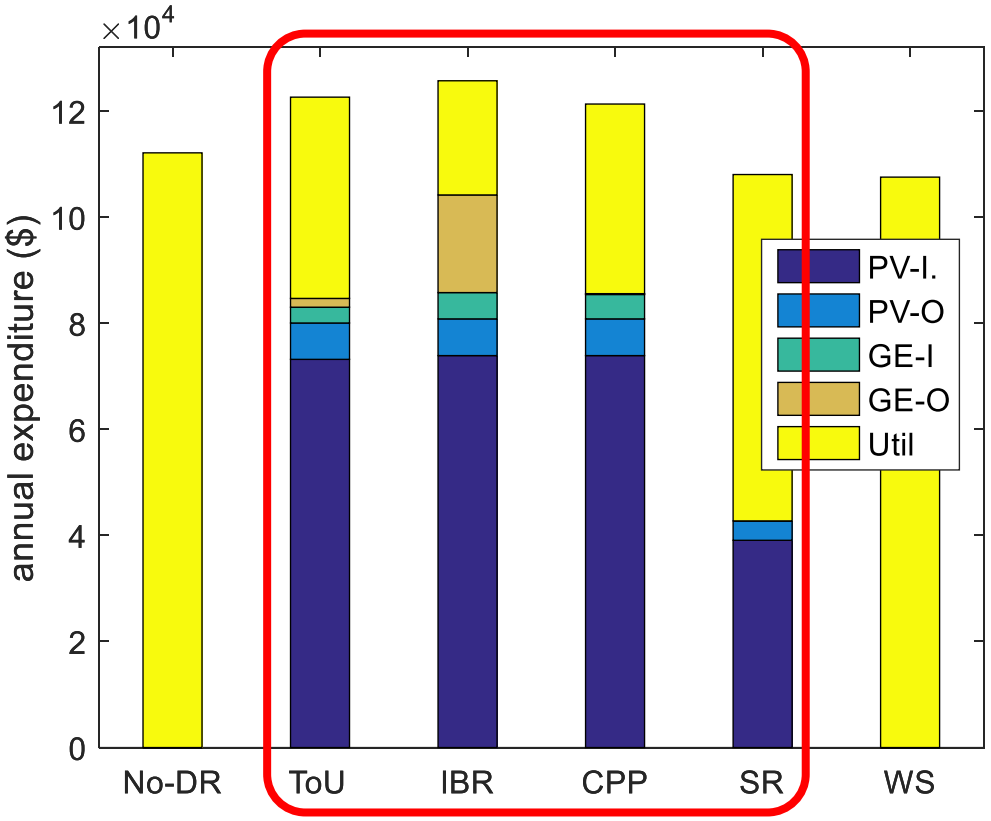
Spinning Reserve (SR)

SR rate: $0.02/kWh

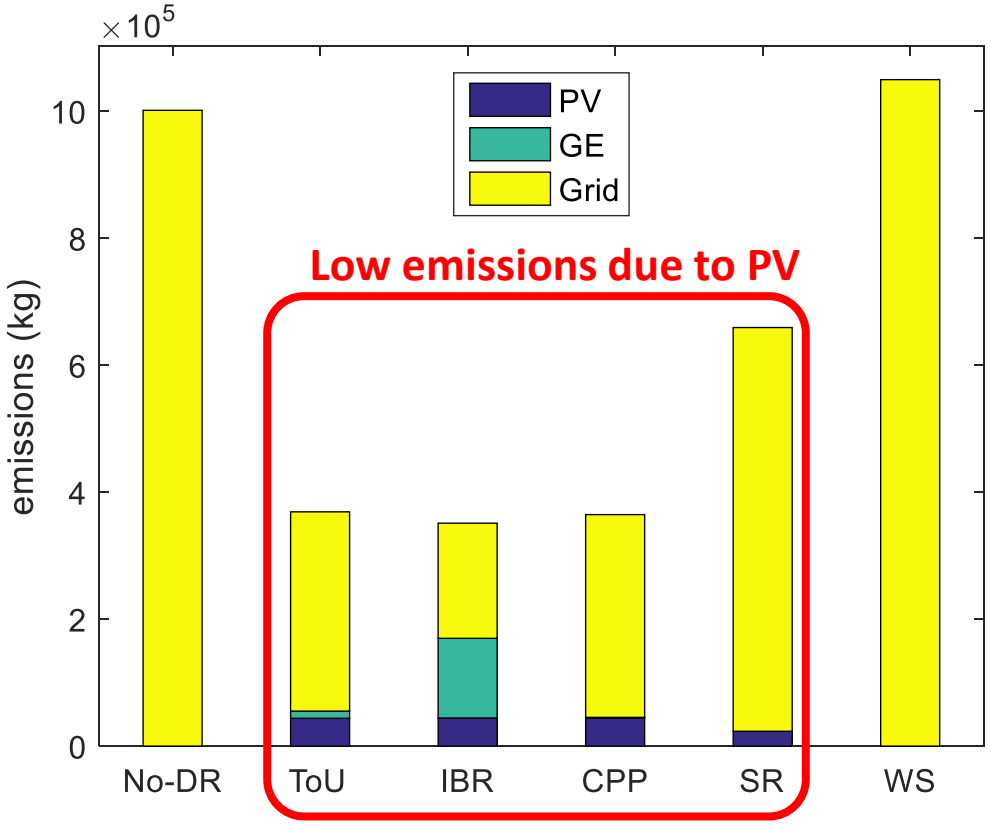
Data center additionally provisions PV & GE to adapt to DR programs

Question: How DR impacts on data centers?

PV & GE are used



Costs & capacities vary in different DR programs



Some DR programs result in low emissions

IBR: Inclining Block Rates

$0.2 (>50kW), $0.5 (>100kW)

CPP: Critical Coincident Peak Pricing

CPP rate: $11.2/kWh

WS: Wholesale market

$0.05/kWh

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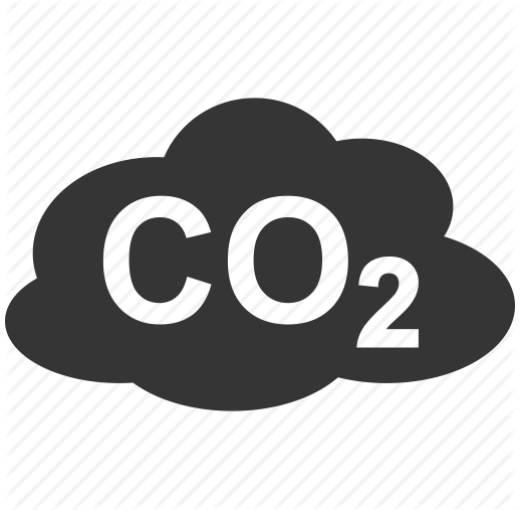
Joint Capacity Planning and Operational Management

Cost saving 50%

Emission reduction 75%



Well adapting to

Thank you

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