Matches, Mismatches, and Methods:

Multiple-View Workflows for Energy Portfolio Analysis

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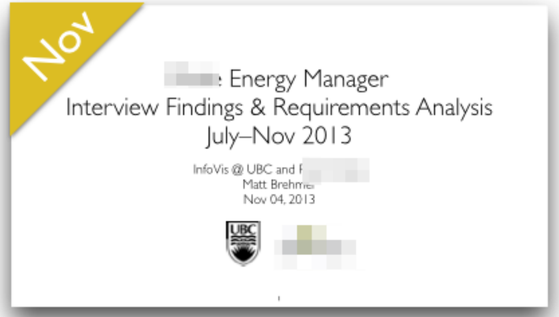
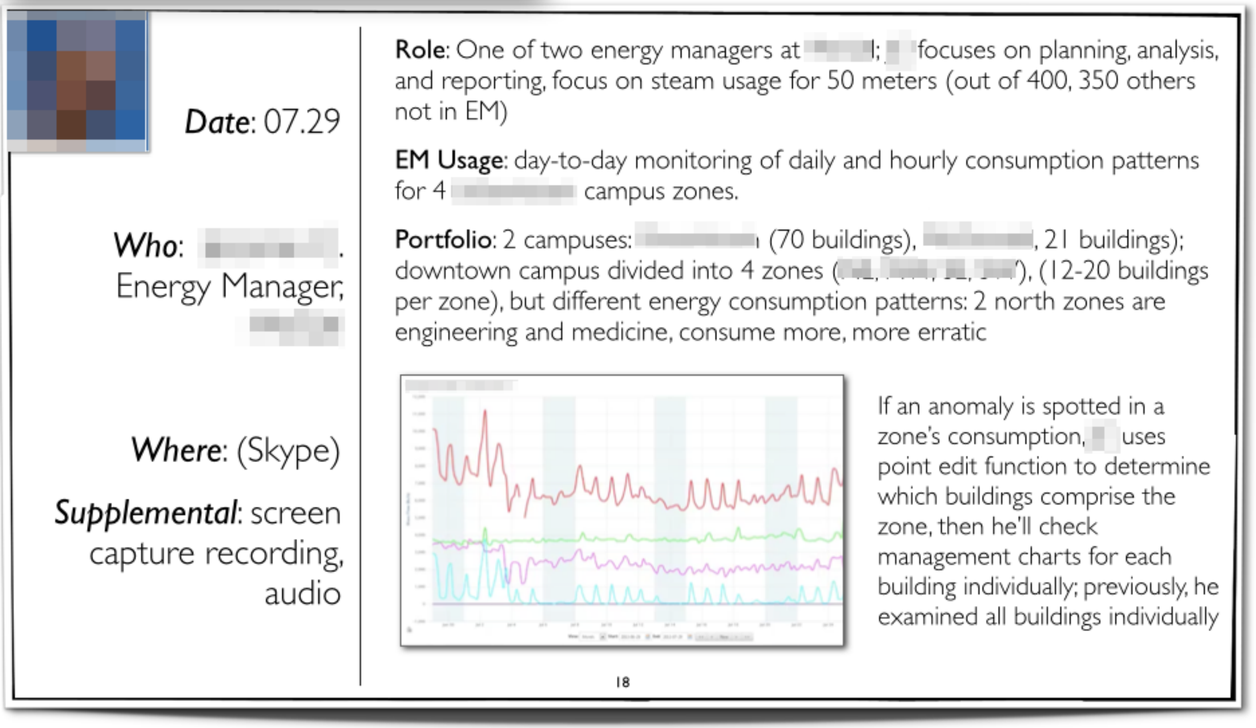
IEEE InfoVis Submission #106
Supplemental Material: Research Artefact Examples
Note: slides that attribute individual energy workers or depict real portfolio data have been sanitized.

Fig. S1: 11 slide decks (302 slides) created between Nov 2013 and February 2014.
Slide decks were iteratively refined research artefacts used to document the research and design process.
Slides 3-12 contain sample slides from these decks.





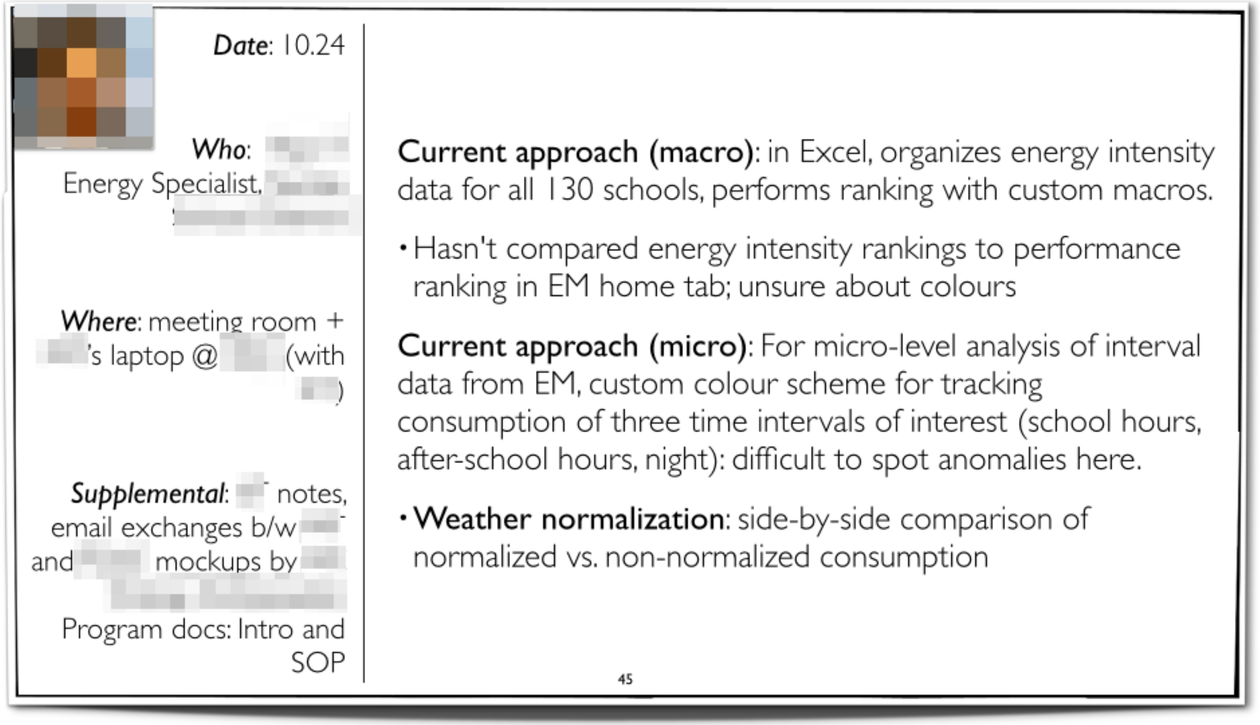
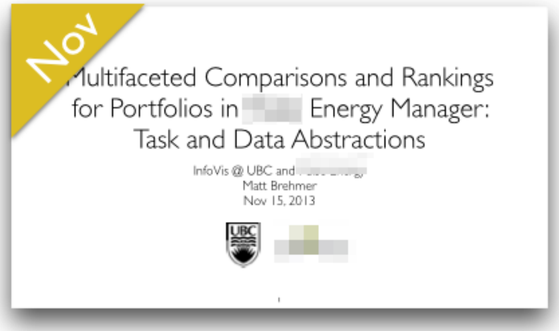
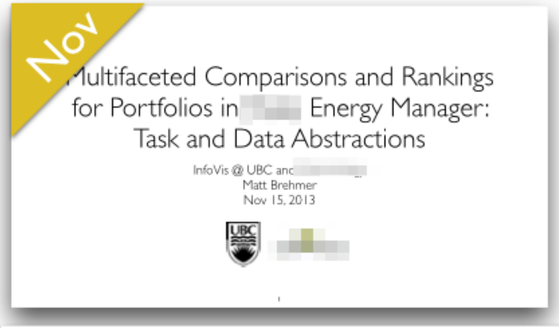


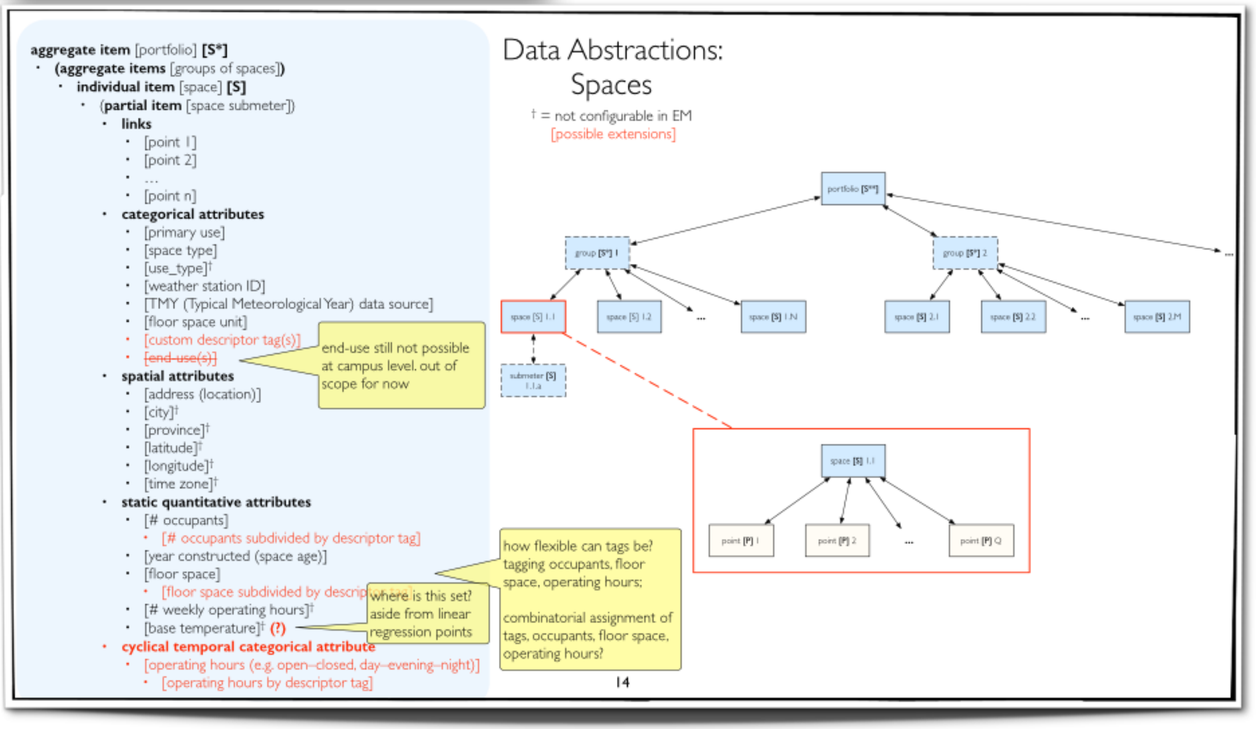
Fig. S2: Partial summaries of findings from initial interviews with energy workers.



User	Role	Affiliation	EM Use & Frequency	Port-folio?	Portfolio Size, Organization	Task abstractions: current (not in EM)	Task abstractions: desirable	Task abstractions: possible (does data exist?)	Task abstractions: target
	space automation specialist		meta-user / power-user: frequently setting up charts, baselines for clients	YES	(Client portfolios range in size, hierarchical structure)	• **Lookup → Compare**: ranked performance (absolute and normalized) • **Lookup → Identify**: CUSUM of entire portfolio, single space	• **Locate → Compare**: portfolio performance faceted by any database field (tag, geographical location, primary use, square footage, year constructed, …) • **Locate → Identify**: space's contribution to portfolio's CUSUM • **Lookup → Compare**: multivariate ranking of portfolio performance • **Locate → Identify**: validated savings vs. unvalidated savings • **Locate → Identify**: end-use disaggregation within a space: • **Locate → Identify** contributions of parameters and events baselines (ECMs, weather, outages, holidays, other events) • **Locate → Compare** multiple baselines • **Produce** aggregate baselines • **Locate → Identify** noise / confidence / uncertainty in baseline	• **Locate → Compare**: portfolio performance faceted by any database field (geographical location, primary use, square footage, year constructed, …), faceted by tag • **Locate → Identify**: space's contribution to portfolio's CUSUM • **Lookup → Compare**: multivariate ranking of portfolio performance	• **Locate → Compare**: portfolio performance faceted by space or by space attributes (over time) • **Locate → Identify**: contribution of individual space performance to aggregate space performance (over time) • **Lookup → Compare | Summarize**: multivariate ranking of spaces (over time)
	energy analyst		several hours a week, additional analysis in Excel	YES	mpus: ~100 spaces (90% concentrated on single campus), subset in EM, departments cross-cuts spaces	• **Locate → Compare**: consumption of [largest spaces, libraries, mid-size spaces] • **Locate → Identify**: causes of threshold events in reference to OAT • **Lookup → Compare**: ranked space performance • **Locate → Compare**: before & after ECMs • **Lookup → Compare**: monthly department performance	• **Lookup → Compare**: department performance at arbitrary time scales • **Locate → Identify** contribution of department(s) to space consumption • **Lookup → Compare** OAT-demand regression curves before & after ECMs • **Locate → Identify**: end-use disaggregation within a space • **Lookup → Identify** changes in space sensitivity to OAT • **Locate → Compare**: consumption of other universities: • **Lookup → Identify**: weather predictions, trends	• **Lookup → Compare**: monthly department performance • **Lookup → Compare**: departments (arbitrary groups of spaces) performance at arbitrary time scales • **Locate → Identify** contribution of department(s) to space consumption (assuming assignment of tags to sq. footage, occupants within a space) • **Lookup → Identify** changes in space sensitivity to OAT • **Lookup → Identify**: weather predictions, trends	• **Locate → Compare**: portfolio performance faceted by space or by space attributes (over time) • **Lookup → Compare | Summarize**: multivariate ranking of spaces (over time)
	energy manager		day-to-day monitoring	YES	mpuses, 4 zones in ampus (~70 spaces), mpus (~20 spaces); all in EM focuses on 50 steam meters	• **Locate → Compare | Summarize**: combined consumption of two campuses: four groups of spaces for main campus • **Browse → Identify**: contribution of individual spaces to combined consumption, anomalies (spikes, surges) • **Lookup → Identify**: threshold events	• **Lookup → Identify**: contribution of individual spaces to combined consumption, anomalies (spikes, surges) • **Locate → Identify**: causes of threshold events in wider context • **Lookup → Identify**: contributions of parameters to PAM baselines (weather, occupancy)	• **Lookup → Identify**: contribution of individual spaces to combined consumption, anomalies (spikes, surges) • **Locate → Identify**: causes of threshold events in wider context	• **Locate → Compare**: portfolio performance faceted by space or by space attributes (over time) • **Locate → Identify**: contribution of individual space performance to aggregate space performance (over time)
	energy specialist		EM for data export; analysis done in Excel, EM analysis offloaded to student volunteers	YES	~130 schools, 2 accounts, 36 in EM (Electricity, 2 submetered), 4 in EM (Natural Gas)	• **Lookup → Compare**: ranked performance (absolute and normalized) • **Browse → Identify**: anomalies (jumps in rankings), trends (consistent rankings) at macro-level between spaces • **Locate → Compare**: single-space performance across N time periods • **Produce** annotations to explain aspects of performance	• **Lookup → Compare**: multivariate ranking of portfolio performance • **Locate → Identify | Compare**: single space performance, within and between operating hours and between days	• **Lookup → Identify**: anomalies (jumps in rankings), trends (consistent rankings) at macro-level between spaces • **Locate → Compare**: single-space performance across N time periods • **Produce** annotations to explain aspects of performance • **Lookup → Compare**: multivariate ranking of portfolio performance • **Locate → Identify | Compare**: single space performance, within and between operating hours and between days	• **Lookup → Compare | Summarize**: multivariate ranking of individuals (over time) • **Locate → Compare**: individual performance (over time)
	head maintenance engineer, automation		daily email digest, follow-up in EM ~3-4 hrs / week	YES	campus, ~100 spaces and 2 zones in EM, monitors about 10 spaces / week	• **Lookup → Compare**: ranked space performance • **Locate | Explore → Identify**: anomalies, causes of threshold events / alerts	• **Locate → Identify**: end-use disaggregation within a space • **Locate → Identify** contributions of parameters to PAM baselines (weather, outages, holidays, other events)		**Lookup → Compare | Summarize**: multivariate ranking of individuals (over time)
	climate and energy engineer		infrequent (annual, semi-annual reports)	YES	mpus, ~100 spaces and 2 zones in EM y interested in handful of spaces	• **Lookup → Identify**: differential between actual and predicted performance • **Lookup → Identify**: CUSUM • **Locate → Compare**: actual to baseline performance	• **Locate → Identify**: cause of long-term trend alerts • **Locate → Identify**: baseline precisions / uncertainty • **Locate → Compare**: performance across, arbitrary time periods	**Locate → Compare**: performance across arbitrary time periods	**Locate → Compare**: individual performance (over time)
	energy efficiency engineer (consultant)		some exploratory analysis, most analysis done in Excel	NO (small)	(single-space focus or small group of spaces (e.g. 5))	• **Explore | Browse → Identify**: load profile of space, anomalies: • **Lookup | Locate → Compare**: within and across spaces: monthly and seasonal differences in consumption / schedule / demand; OAT vs. demand for occupied and unoccupied periods. • **Lookup → Summarize**: distribution of OAT, demand	**Locate → Identify**: end-use disaggregation use within a space; **Locate → Identify | Compare**: effects of simulated ECMs on space performance	• **Lookup | Locate → Compare**: within and across spaces: monthly and seasonal differences in consumption / schedule / demand; OAT vs. demand for occupied and unoccupied periods. • **Lookup → Summarize**: distribution of OAT, demand	• **Locate → Compare**: individual performance (over time) • **Lookup → Summarize**: distributions of individual's attributes (over time)
	energy efficiency engineer (consultant)		some exploratory amnalysis, confirmatory analysis done in Excel	NO	(single-space focus)	**Lookup → Compare**: month-to month %Δ in consumption, peak demand, actual ; baseline	• **Locate → Identify**: effects of simulated ECMs on a space based on previous success • **Locate → Compare**: effect of ECMs between spaces	**Lookup → Compare**: month-to month %Δ in consumption, peak demand, actual ; baseline	**Locate → Compare**: individual performance (over time)

Fig. S3: Characterizing energy worker's activities as abstract tasks according to the typology of Brehmer and Munzner (2013, IEEE TVCG / Proc. InfoVis)





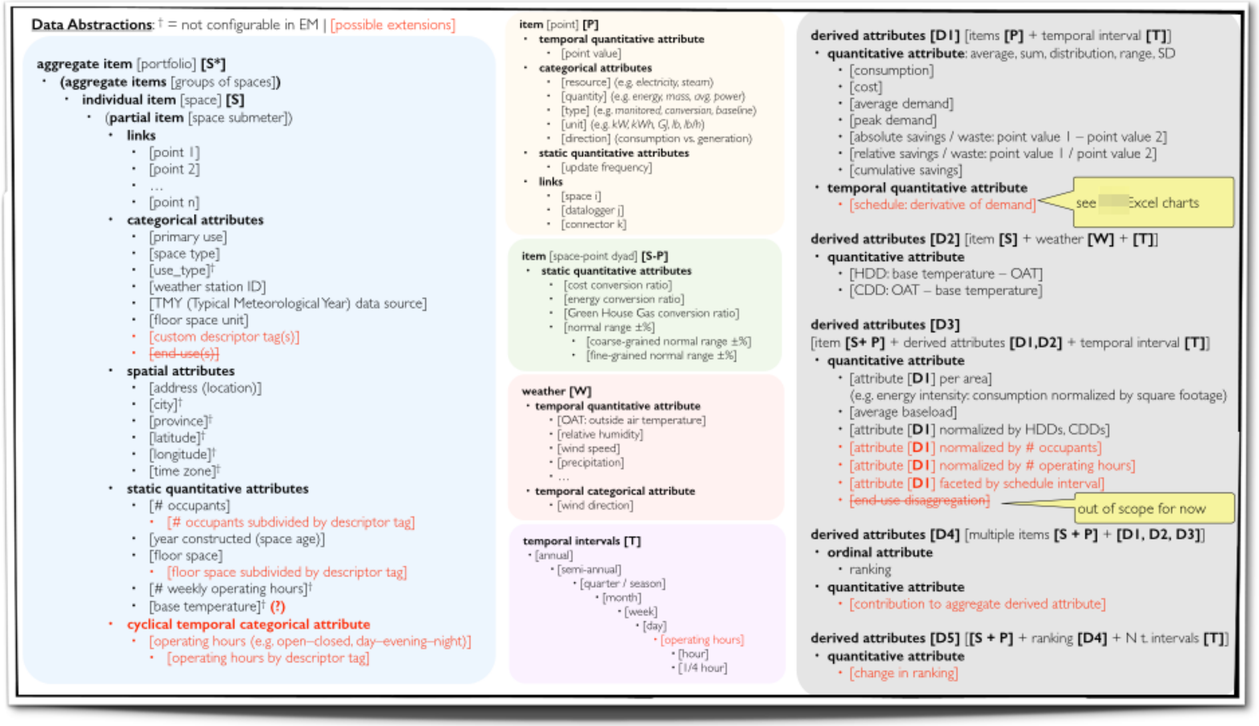


Fig. S4: Partial characterization of data abstractions relevant to energy workers' activities.

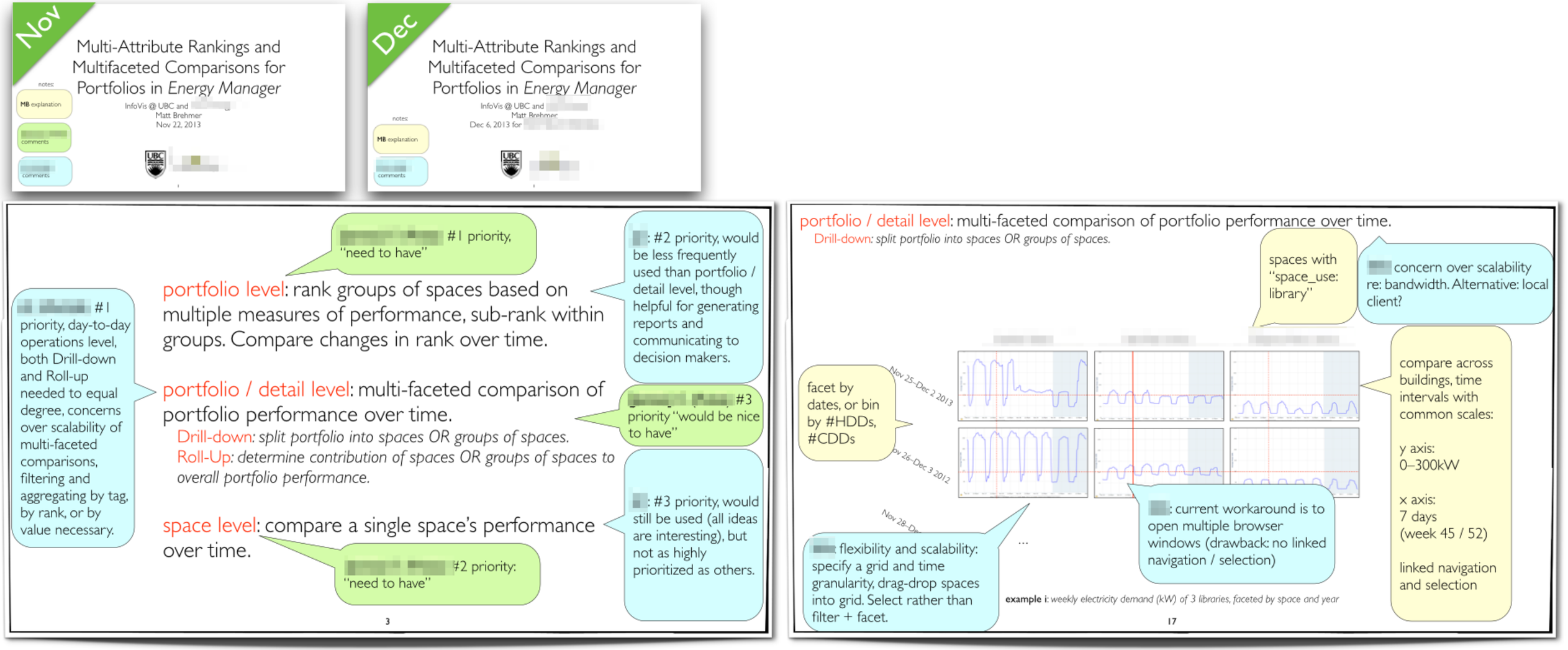


Fig. S5: Verifying the task and data abstractions with power user energy workers (left: summary of tasks; right: a mockup of a faceted line graph).

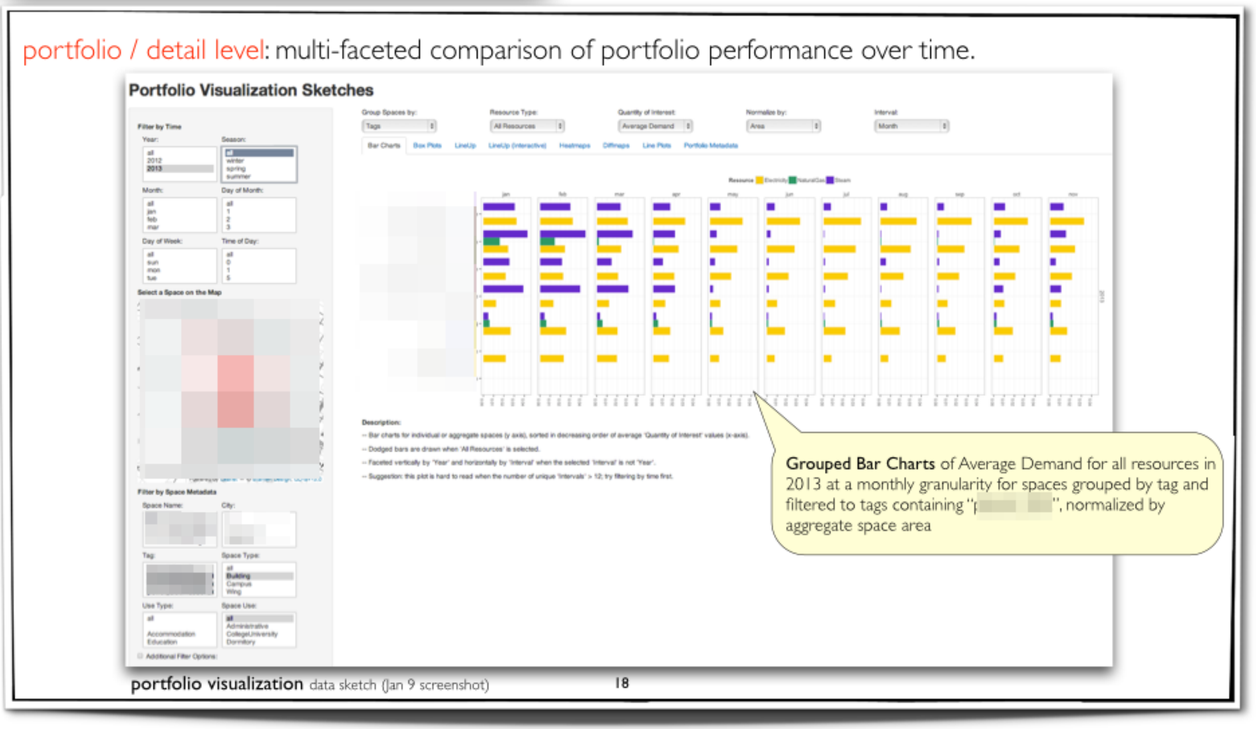
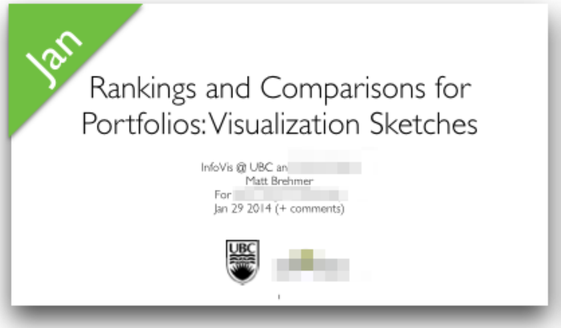
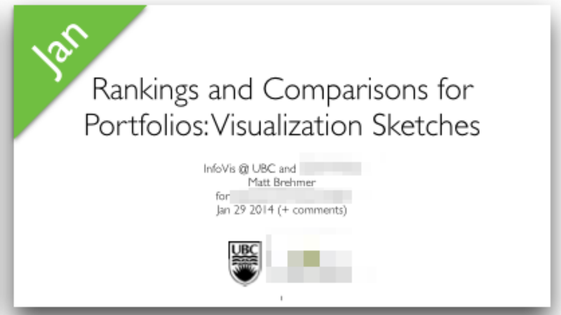
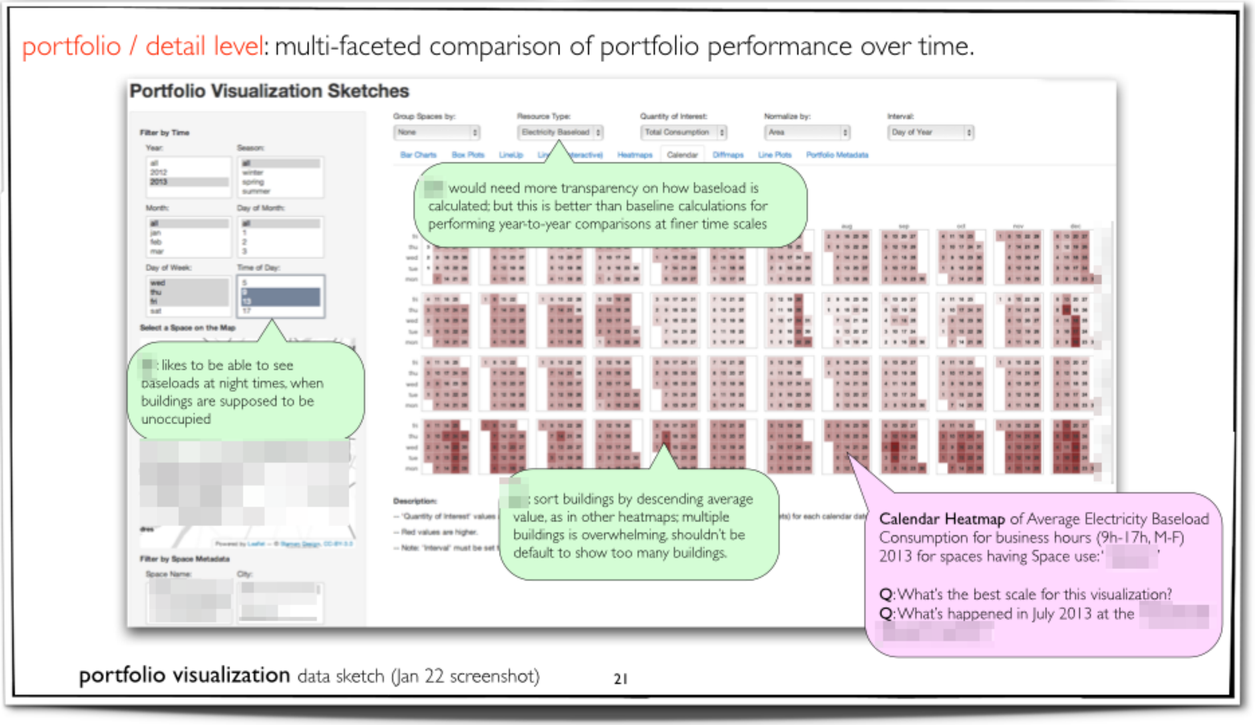


Fig. S6: Initial data sketches produced within the sandbox environment (left: faceted bar charts; right: an early version of the bar + bump plot).







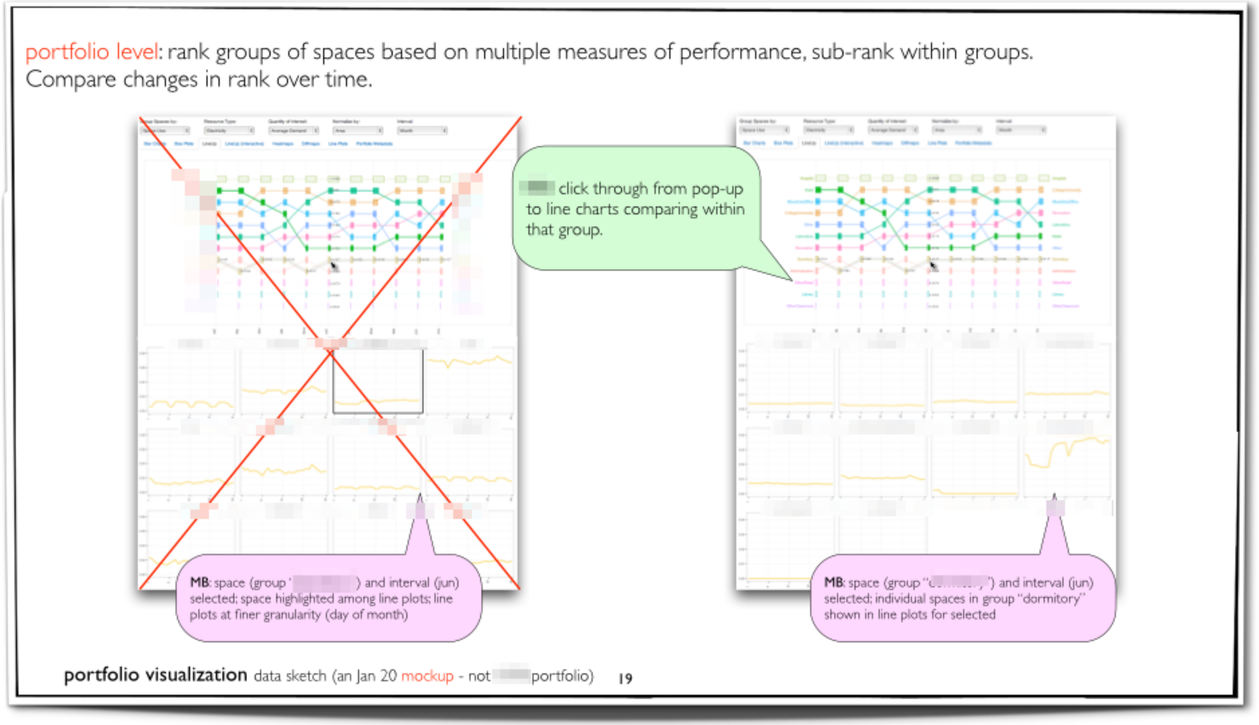
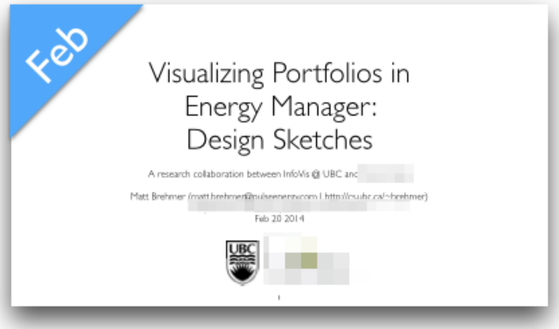
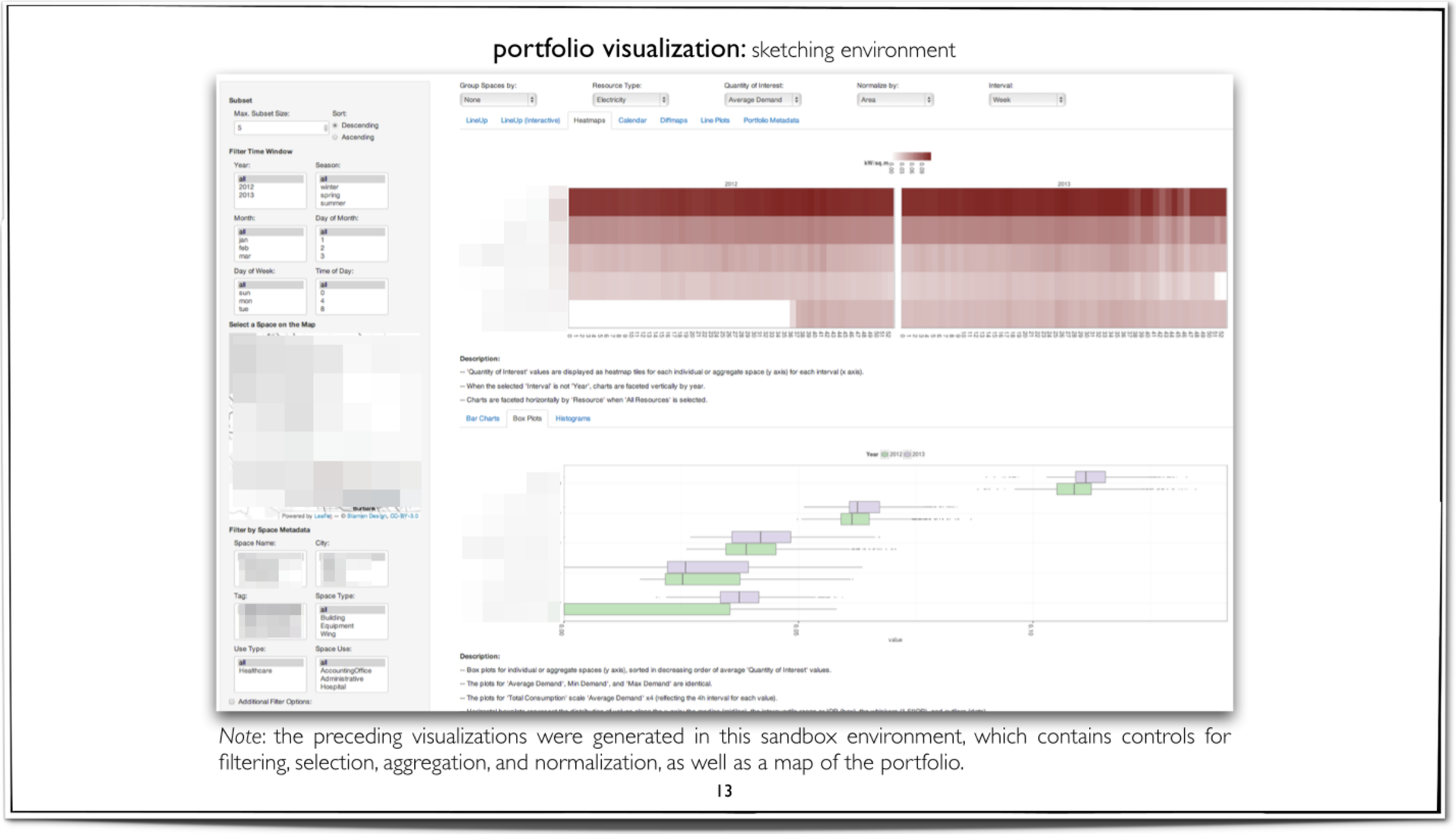


Fig. S7: Following-up with the power user energy workers with designs from our sandbox design (left: calendar-partitioned time series matrix; right: view coordination mockups).





Note: the preceding visualizations were generated in this sandbox environment, which contains controls for filtering, selection, aggregation, and normalization, as well as a map of the portfolio.

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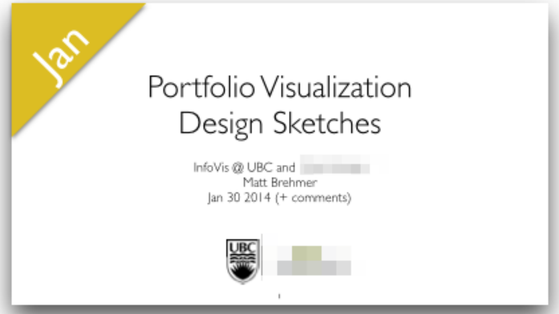
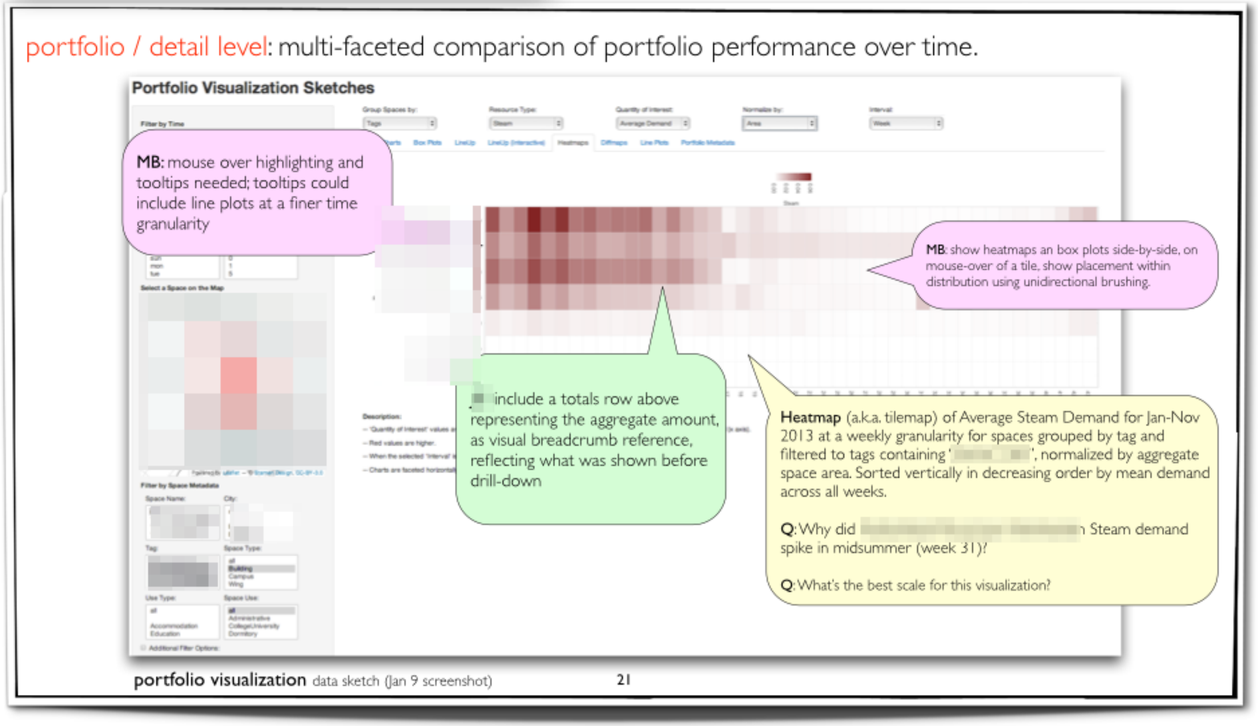
Fig. S8: Early view coordination design depicting a matrix with auxiliary boxplots.





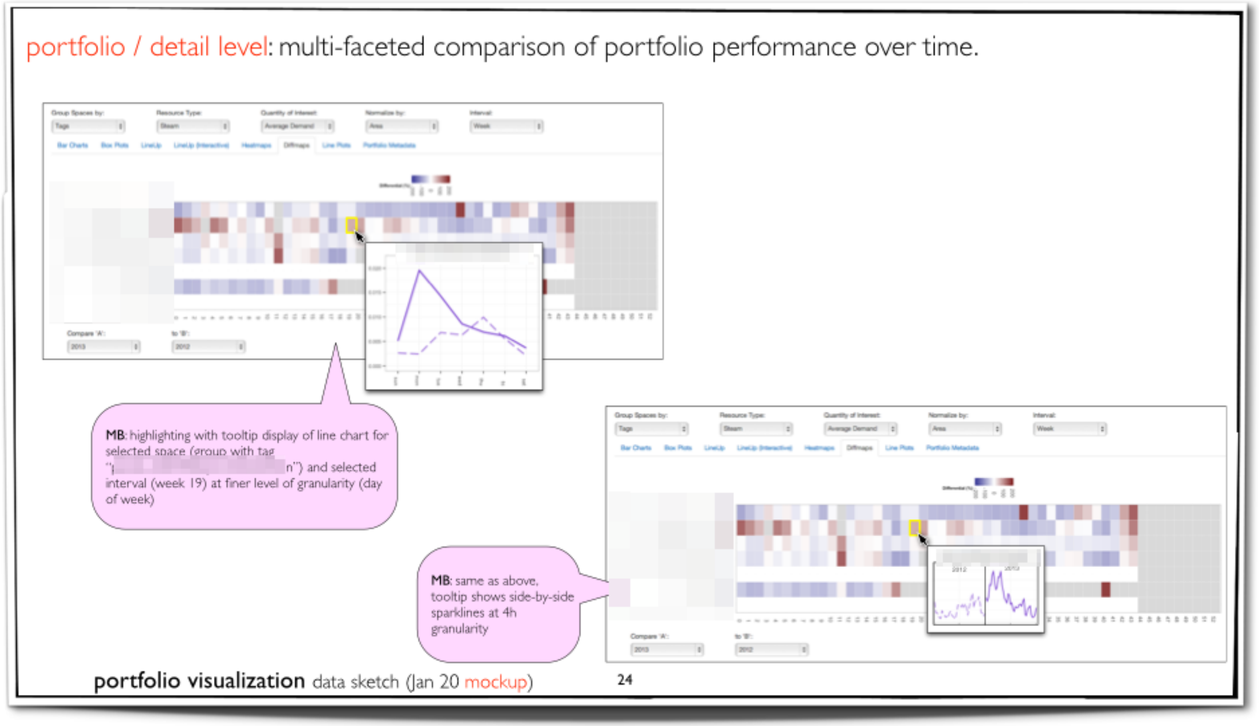


Fig. S9: Another iteration of data sketches produced using the sandbox environment (left: time series matrix; right: interactivity mockups).

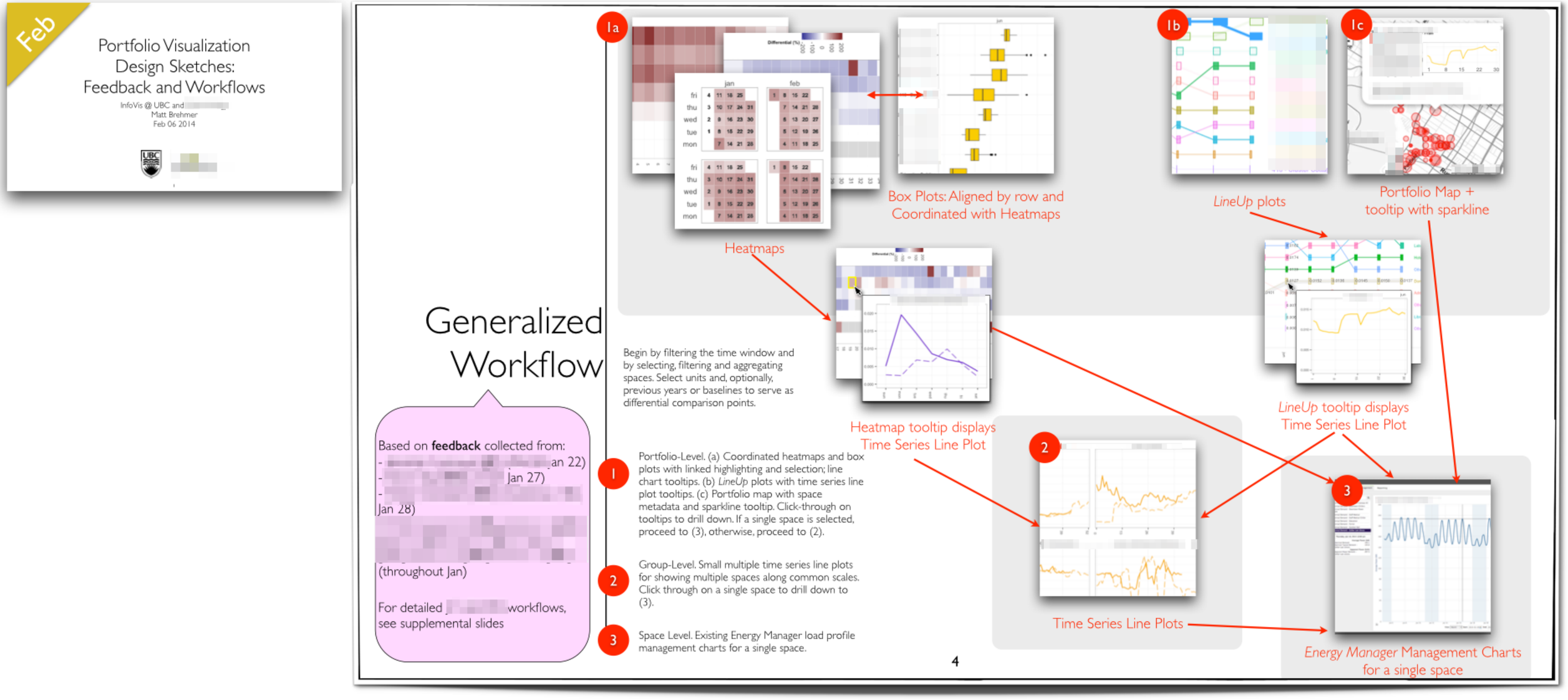
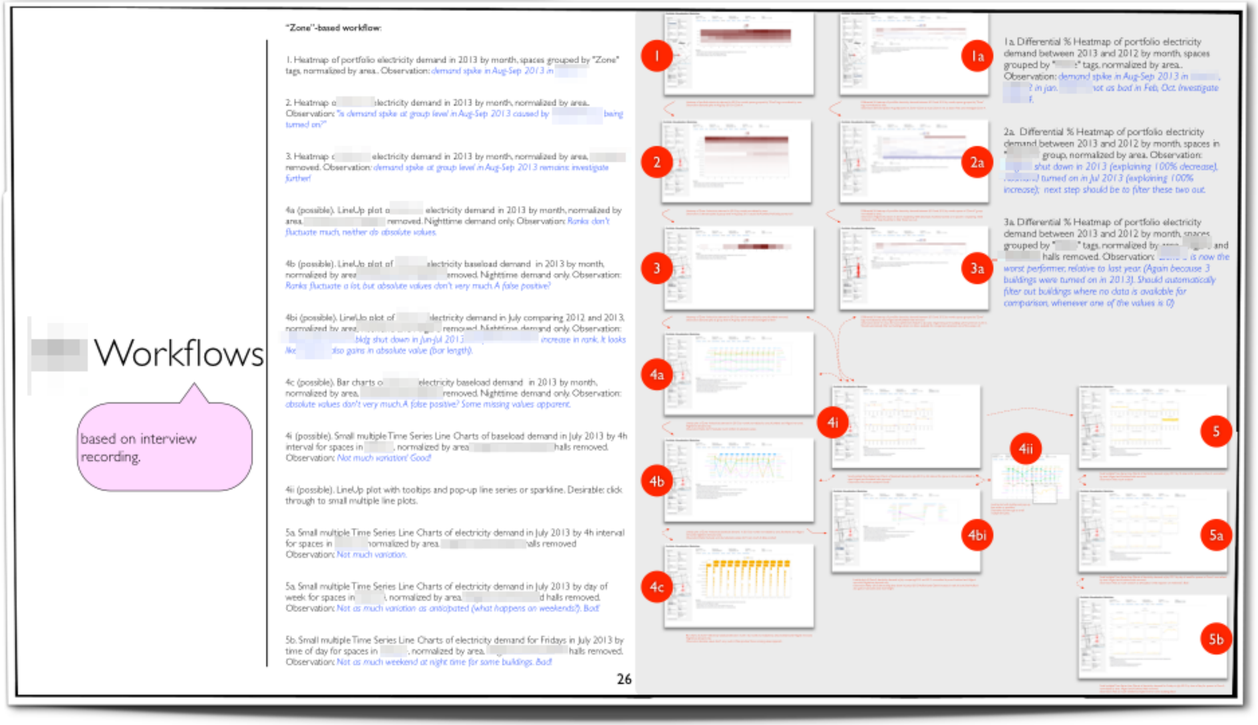


Fig. S10: Proposed workflow design involving multiple views based on consolidated feedback from energy workers.



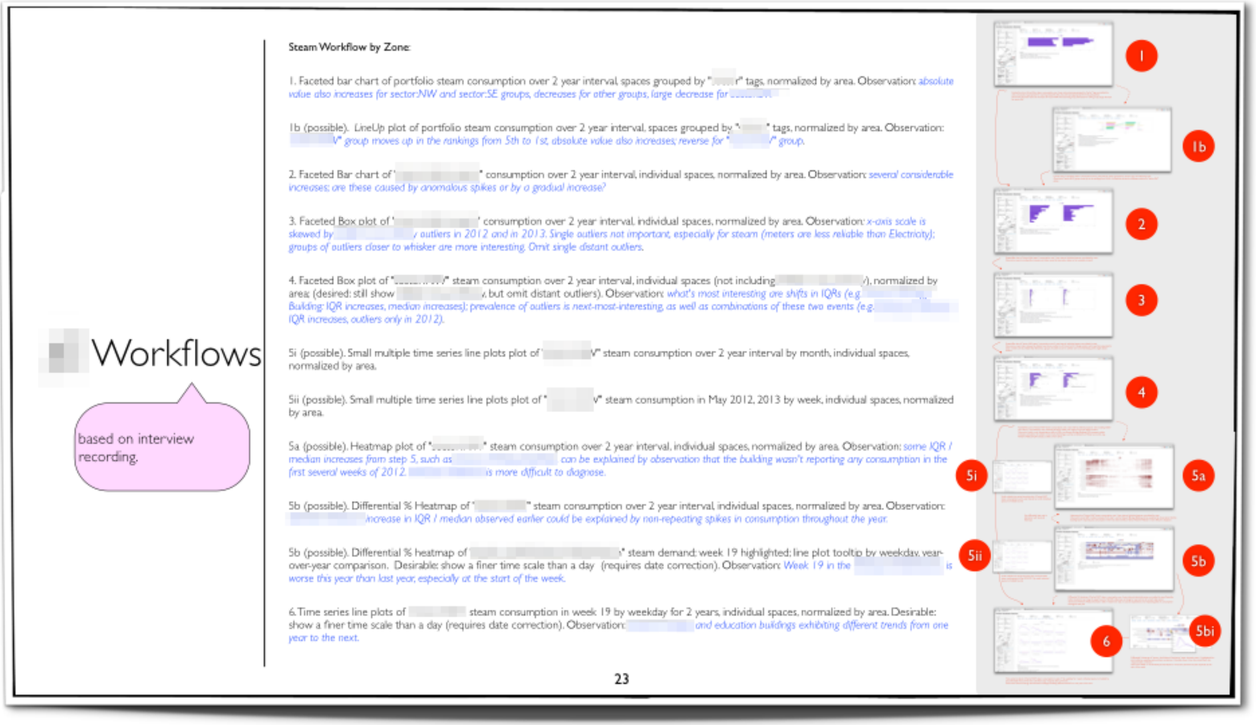


Fig. S11: Storyboards using sandbox screenshots based on power user workflows.

This slide contains screenshots of D3 prototypes developed in summer 2014 that address view coordination design.

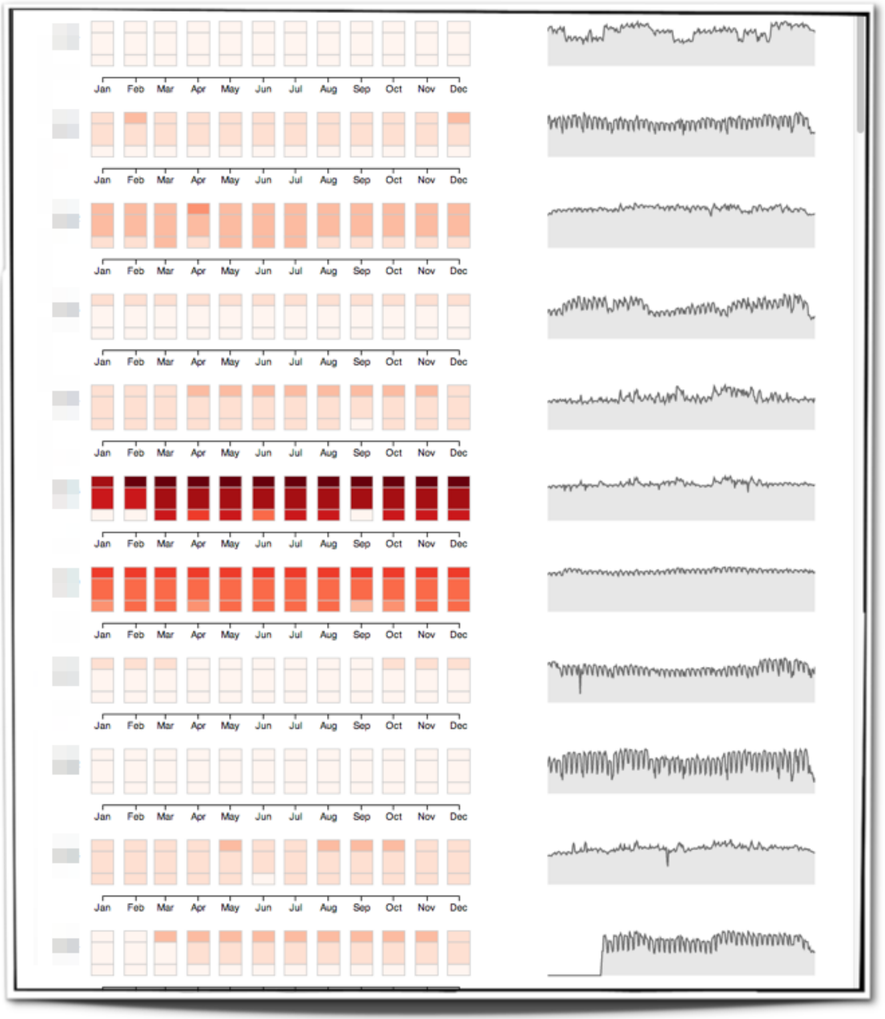


Fig. S12: color stock charts* with juxtaposed line charts as alternative to matrix with juxtaposed boxplots. (* see Albers et al, Proc. CHI 2014)

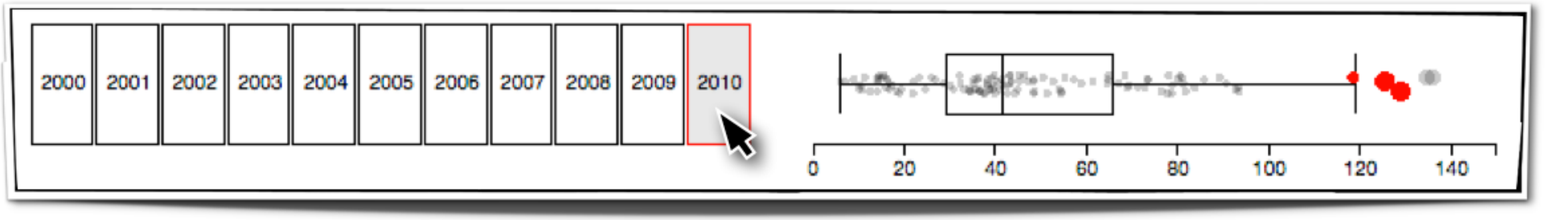


Fig. S13: Values from the brushed time period are highlighted on the juxtaposed boxplots.
http://bl.ocks.org/mattbrehmer/8be29724bdd7a63ff41d

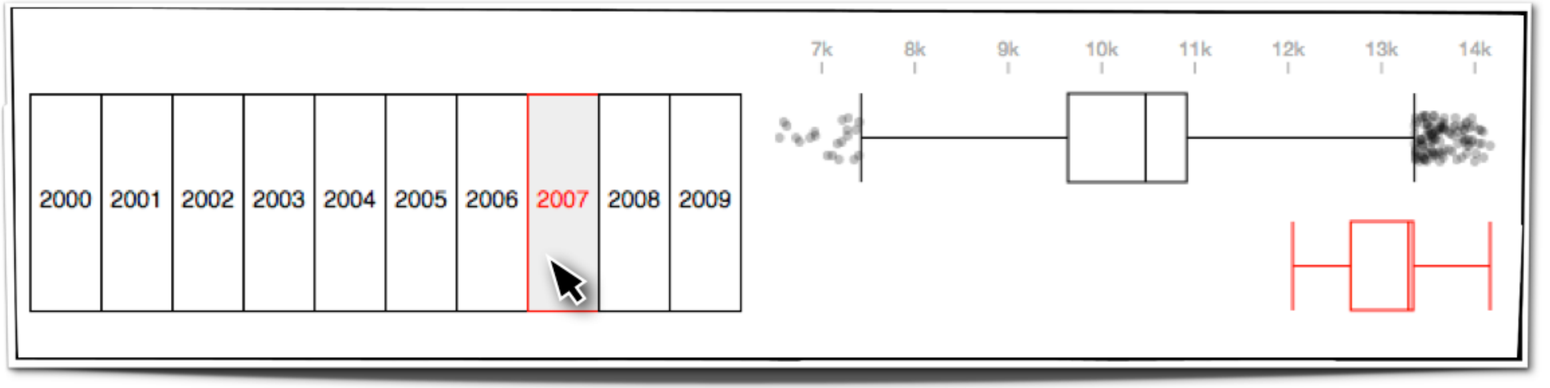


Fig. S14: boxplot for the brushed time period (red) is shown alongside the boxplot for the entire time series.
http://bl.ocks.org/mattbrehmer/287e44c9a12151967874

Development on the redesigned Energy Manager continued throughout Summer 2014.

During this time, we collected feedback on the new designs from 5 energy workers at EnerNOC.

Fig. S15: An example of how this feedback was documented, using a combination of screenshots from the redesigned Energy Manager and earlier mockups.