

What's the Difference?: Evaluating Variants of Multi-Series Bar Charts for Visual Comparison Tasks



Arjun Srinivasan



Matthew Brehmer



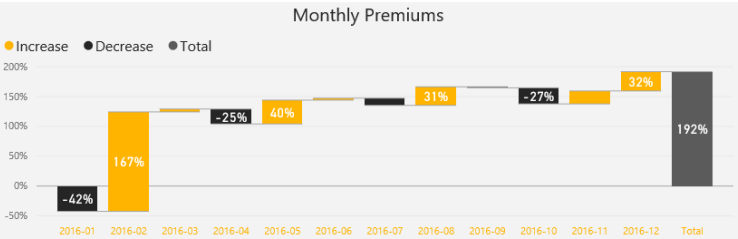
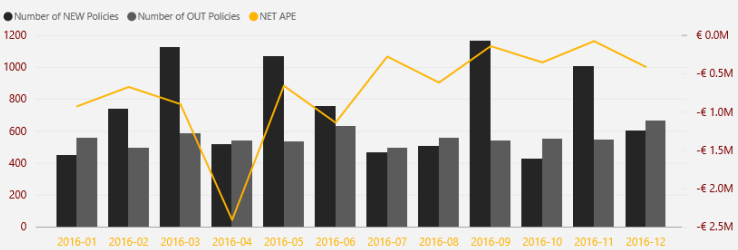
Bongshin Lee



Steven M. Drucker

SALES OVERVIEW

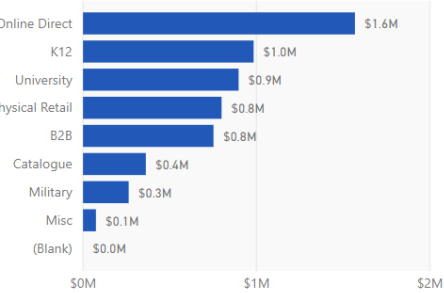
2010 2011 2012 2013 2014 2015 2016



2015 2016 2017

P01 P02 P03 P04 P05 P06 P07 P08 P09 P10 P11 P12

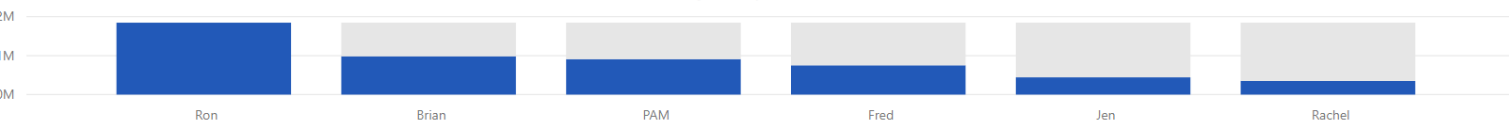
By Segment



By Customer



By Salesperson



Key Performance Indicators

-€ 8.56M

NET APE

1422

Number of Agents

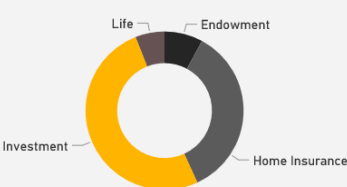
8846

Number of NEW Policies

39.84K

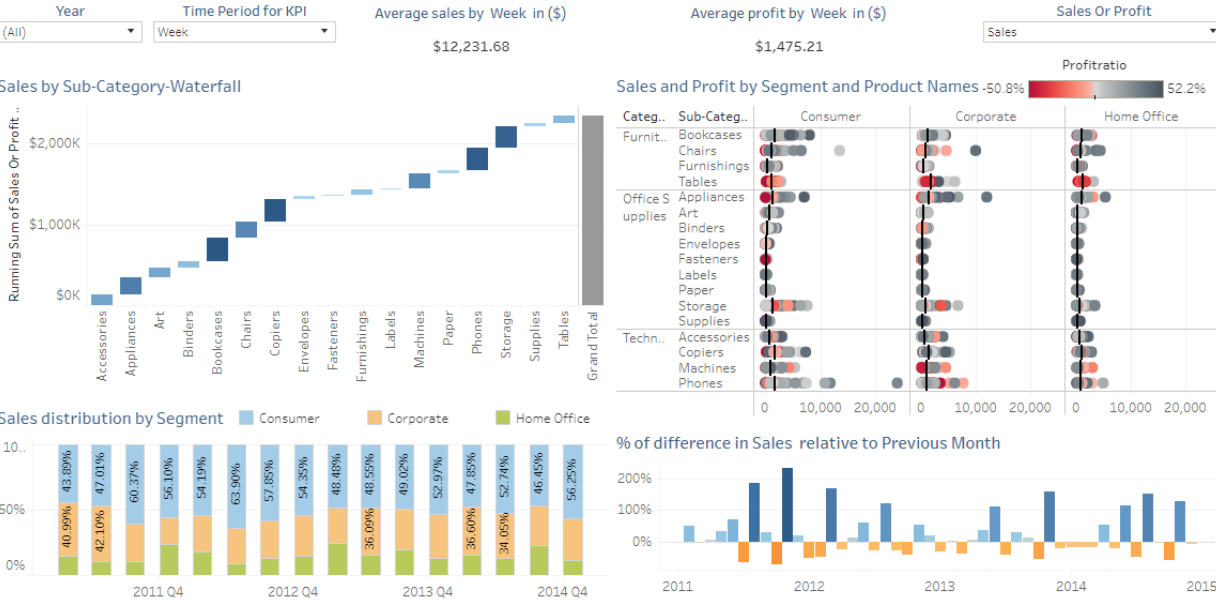
Number of Contracts

Premium Structure

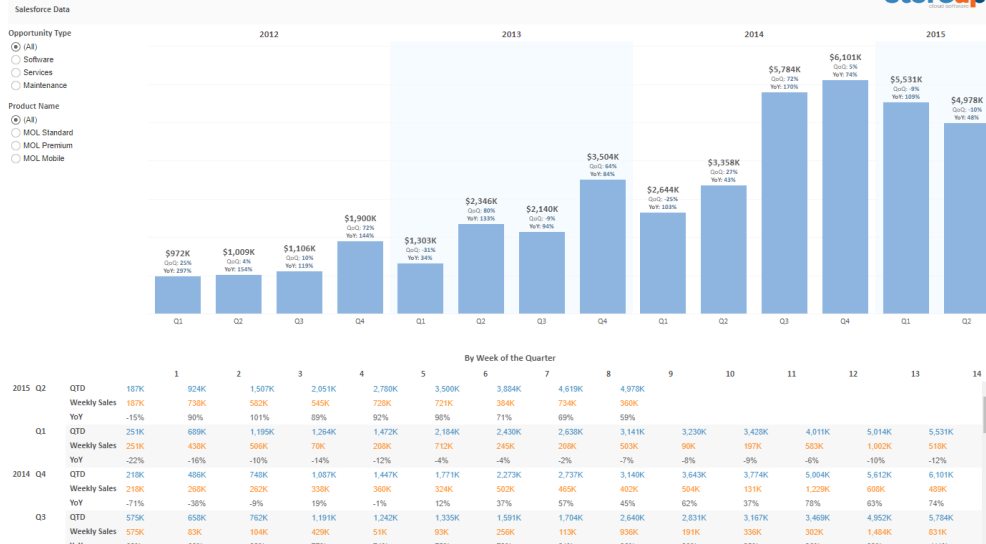


Executive Dashboard Sales Or Profit Dash board Customer Analysis Geography Dashboard Category Dashboard Order Dashboard

Sales and Profit Dashboard

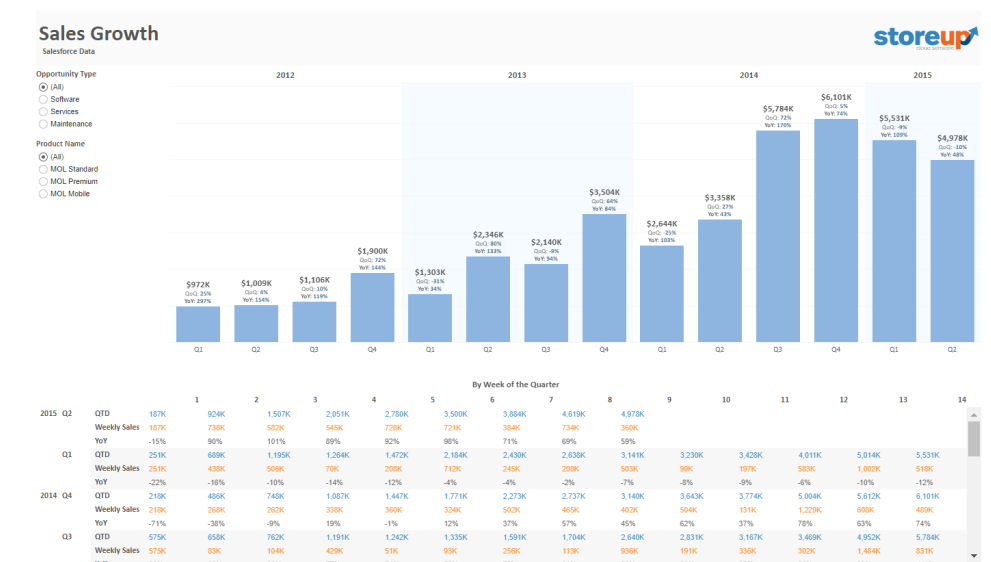
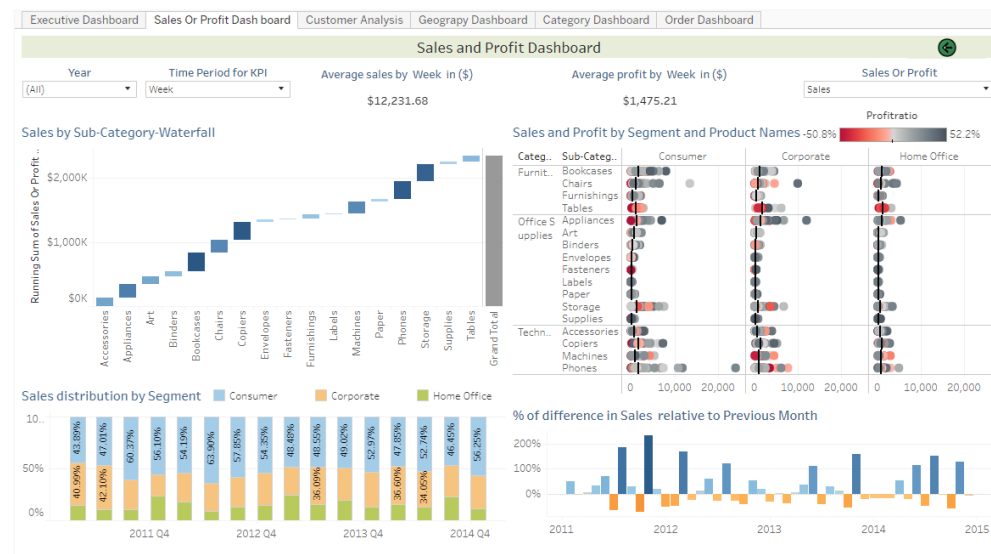
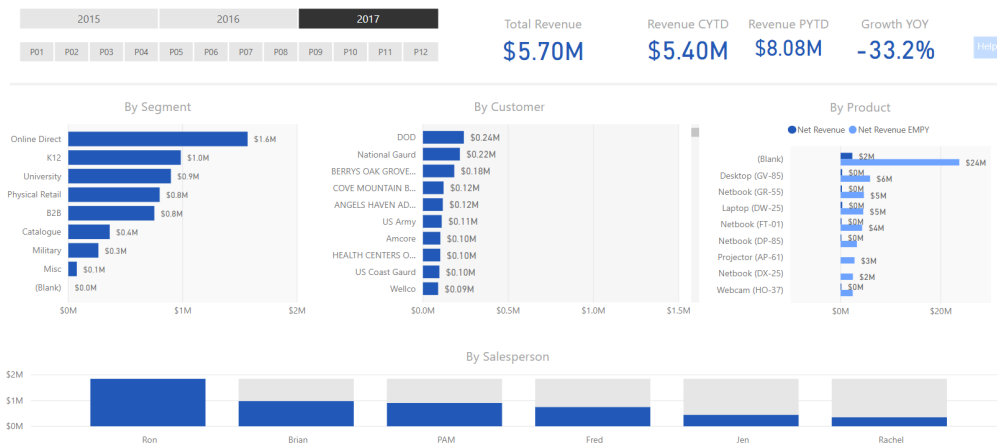
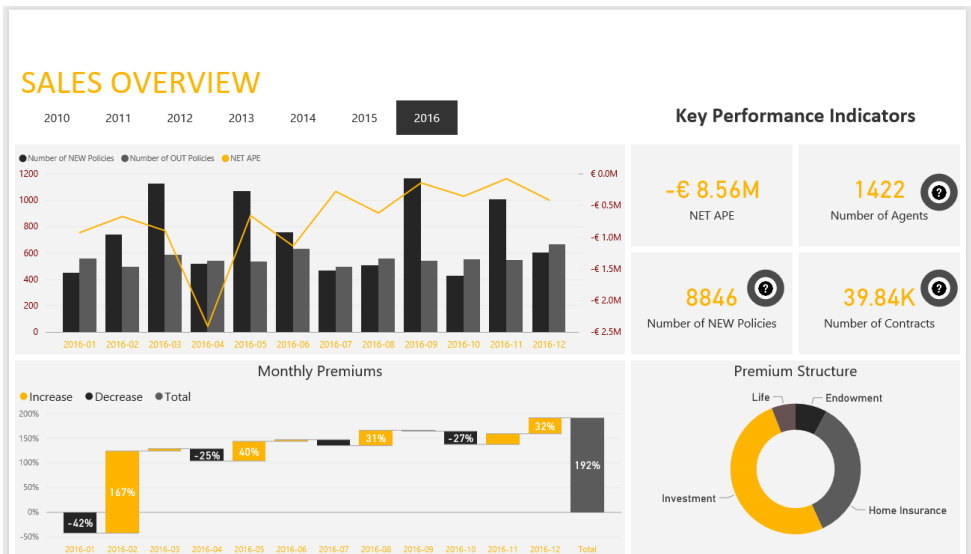


Sales Growth





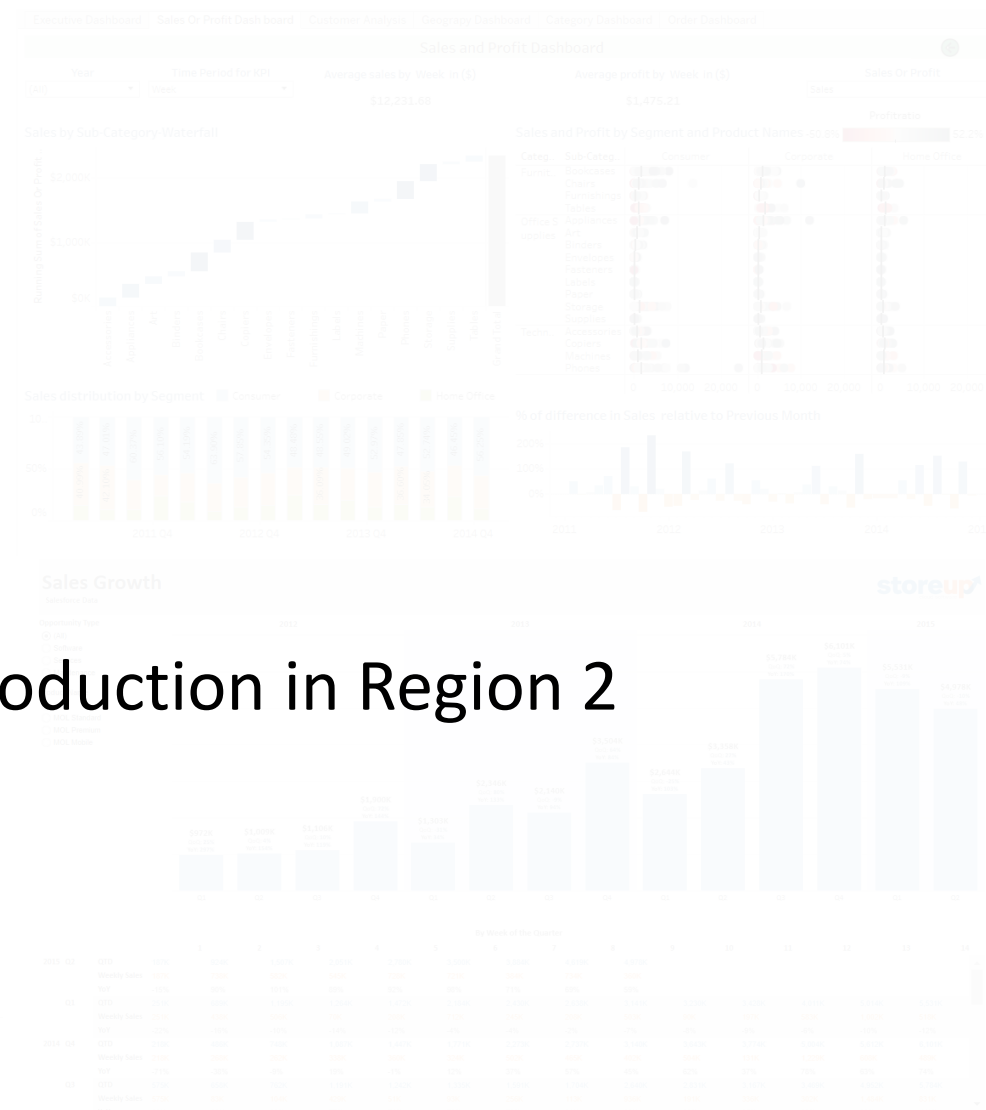
Microsoft | Power BI



Power BI | tableau



Microsoft Power BI



Power BI + tableau

Year(s)

20...

20...

20...

20...

20...

20...

Month(s)

Jan

Feb

Mar

Apr

May

Jun

Jul

Aug

Sep

Oct

Nov

Dec

Carbon Dioxide Quantity Produced and Sold - MCF

CO2 MCF Produced by Region

Northwestern

1,066

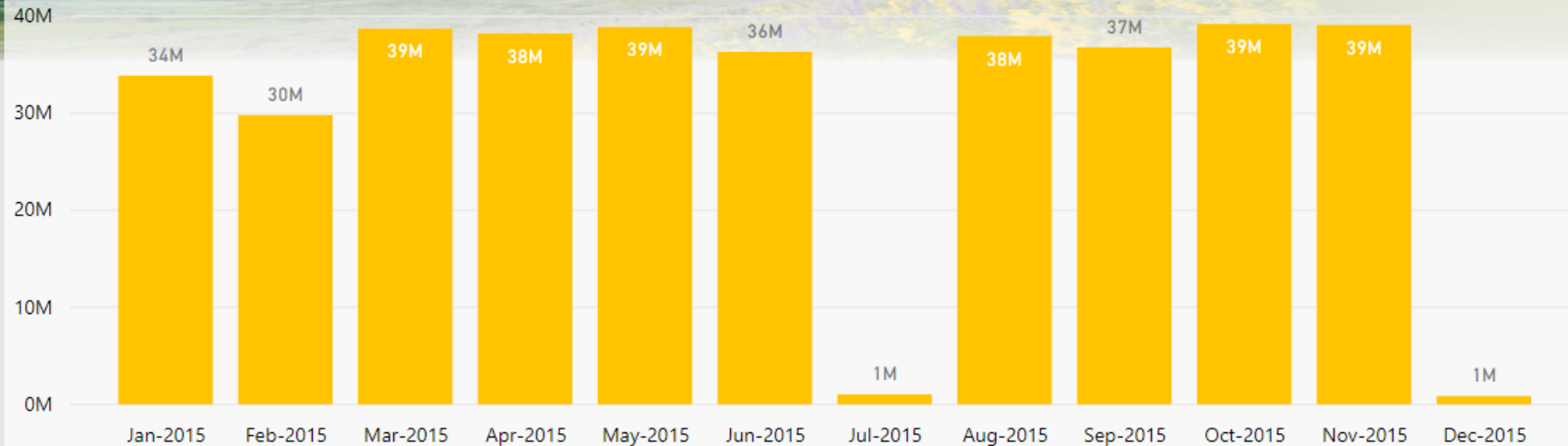
Southeastern

10,062,617

Southwestern

360,706,906

CO2 Production Over Time



CO2 MCF Sold by Region

Southeastern

10,051,643

Southwestern

360,639,463

Key Metric Detail

Region	County	Year	Month Name	Total CO2 Produced	Total CO2 Sold	Total CO2 Remaining
Southwestern	Dolores	2015	Mar	5,005,061	5,004,670	391
			Apr	3,754,301	3,753,943	358
			May	4,644,792	4,643,697	1095
			Jun	4,658,249	4,657,708	541
			Aug	5,206,168	5,206,058	110
			Sep	5,043,591	5,043,591	0
			Oct	5,136,211	5,136,000	211
			Nov	4,770,266	4,769,593	673
			Total	38,218,639	38,215,260	3379
	La Plata	2015				
			Total	38,218,639	38,215,260	3379
			Jan	6,788	6,220	568
			Feb	8,869	8,041	828

North Central

Northeastern

Northern Mountain

Northwestern

South Central

Southeastern

Southwestern

prepared by



Year(s)

20... 20... 20... 20... 20... 20...

Month(s)

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

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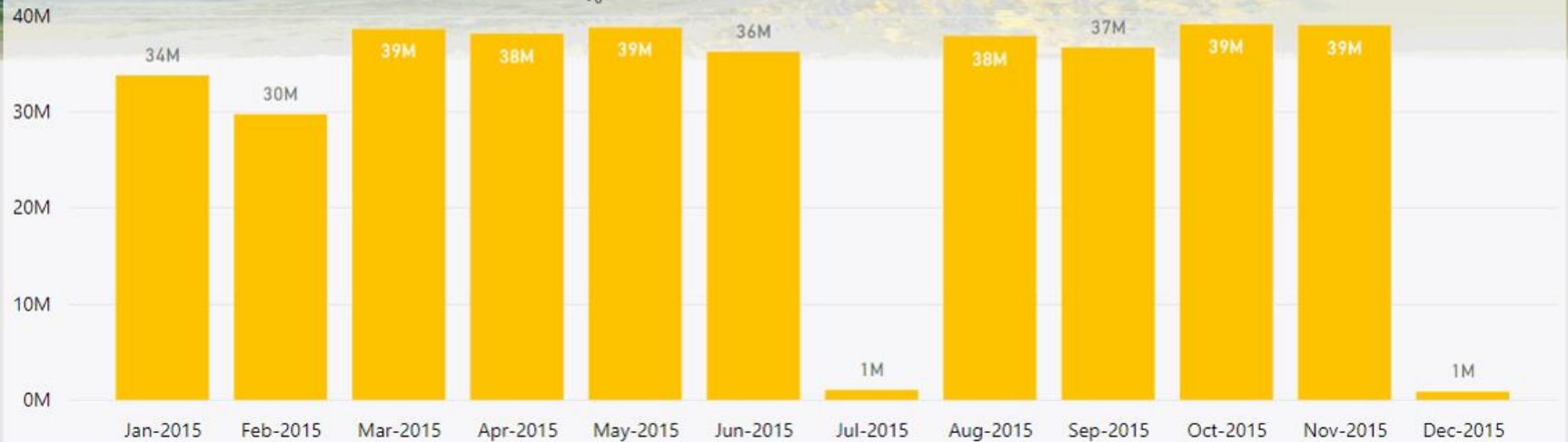
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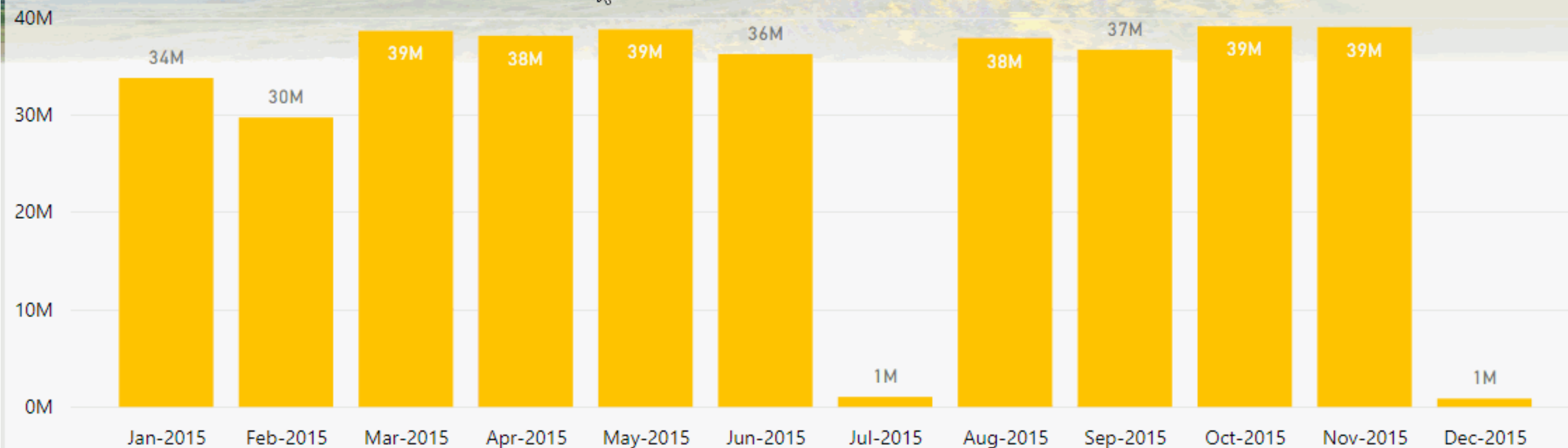
Oct

Nov

Dec

Carbon Dioxide Quantity Produced and Sold - MCF

CO2 Production Over Time



How can we facilitate **visual comparison** in **multi-series bar charts**?

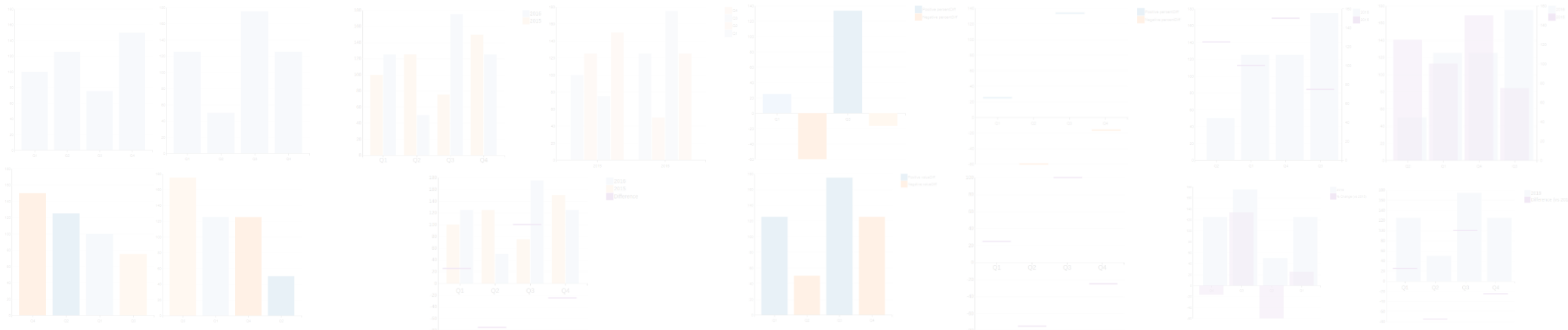
Interviews & Survey



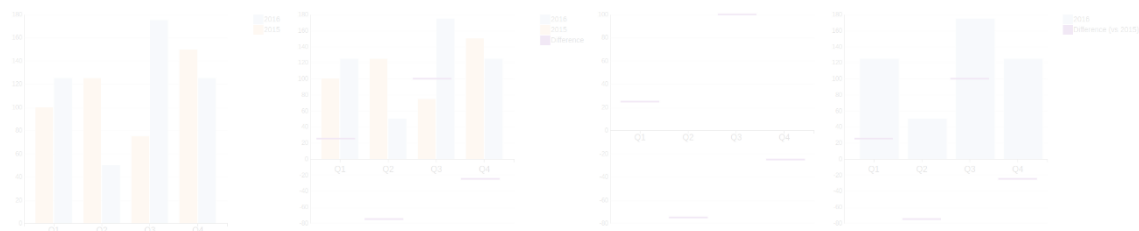
Power BI

+tableau+public

Exploration of design alternatives



Evaluation



Extremes- Target

Extremes- Source

Max. Change

Value Difference

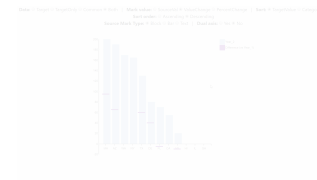
Old Categories

New Categories

Constant

Varying

Applications & Extensions



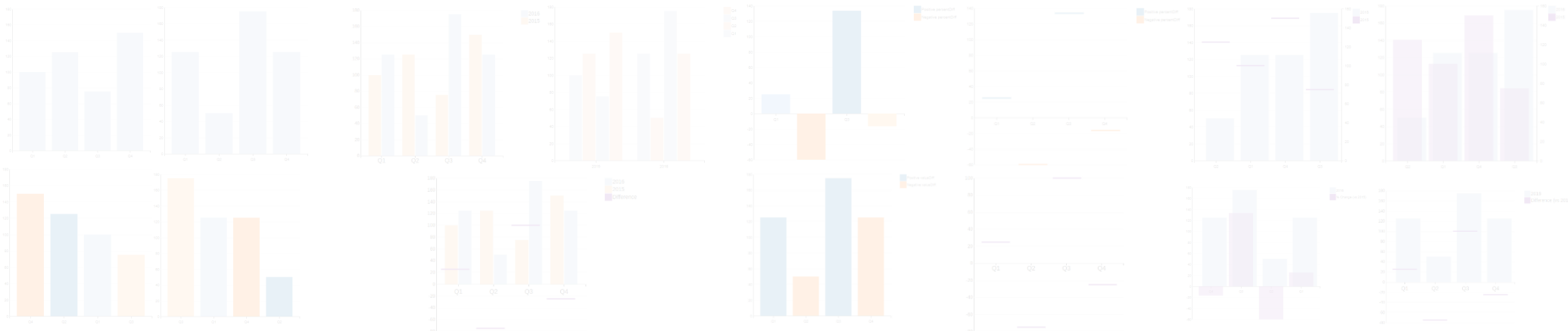
Interviews &
Survey



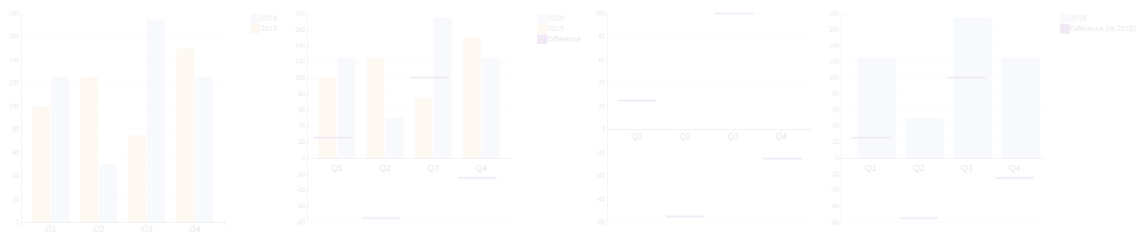
Power BI

+tableau⁺public

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Bar charts were the most common visualizations

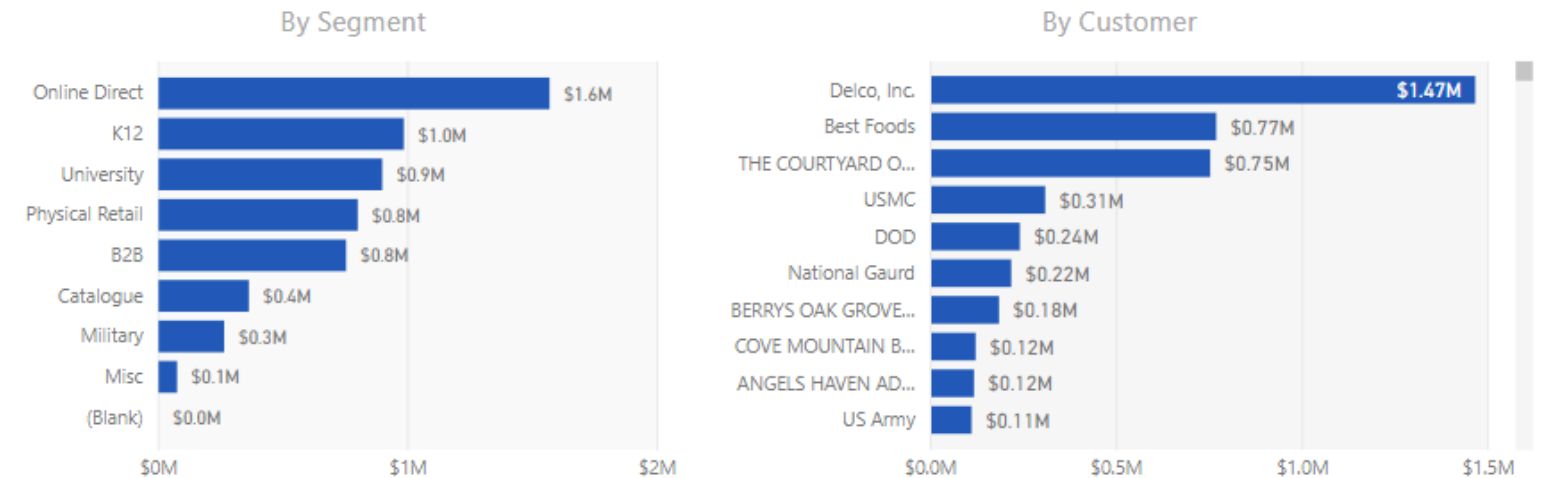
Ordinal x Quantitative (e.g., monthly sales)

[constant]



Nominal x Quantitative (e.g., individual employee sales)

[varying]

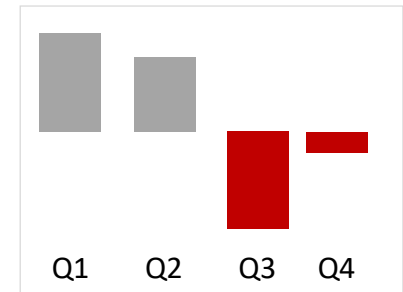
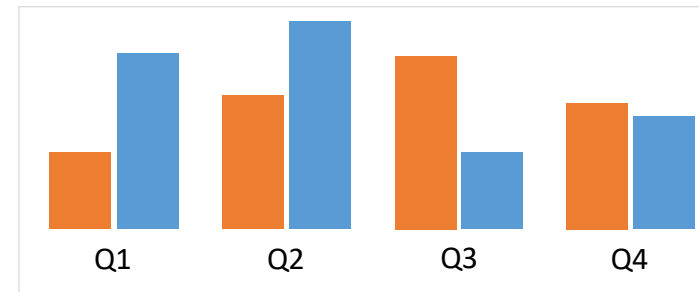
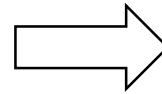
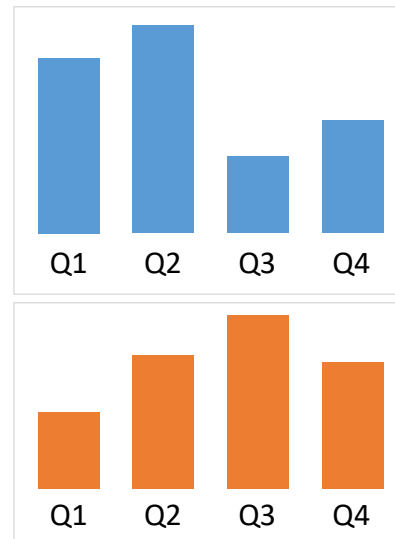


Design considerations:

- Show raw values

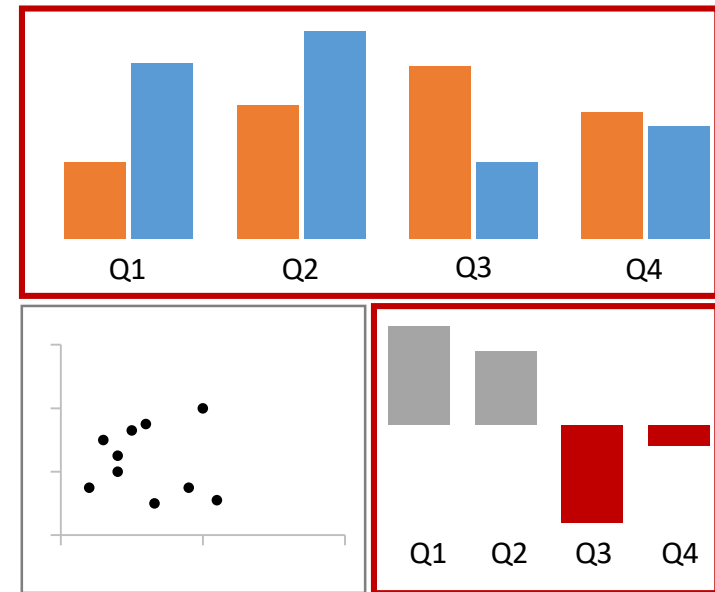
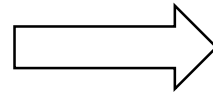
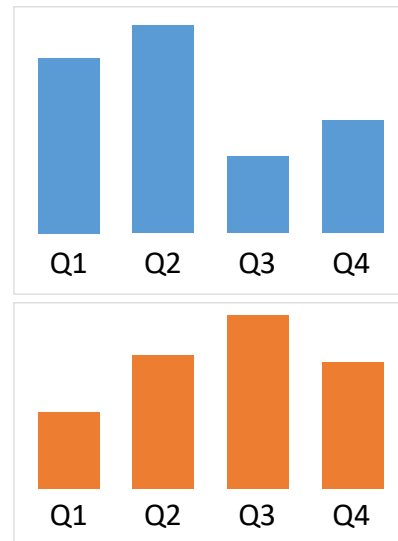


Power BI



Design considerations:

- Show raw values
- Do not occupy additional space

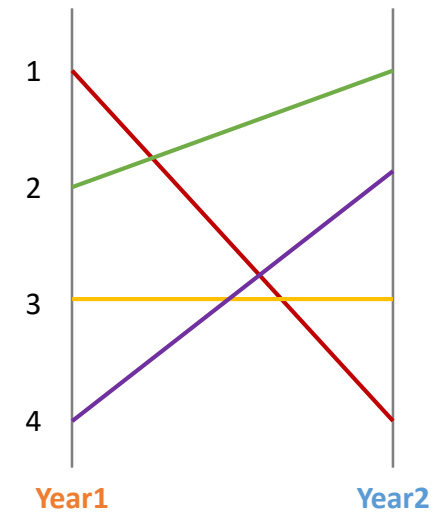
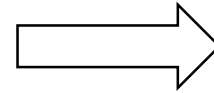
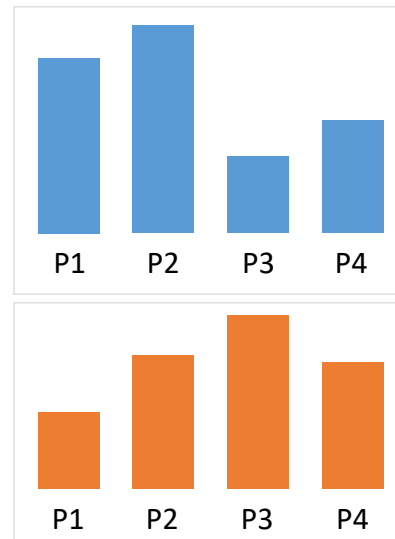


Design considerations:



Power BI

- Show raw values
- Do not occupy additional space
- Maintain visualization type



P1

P2

P3

P4



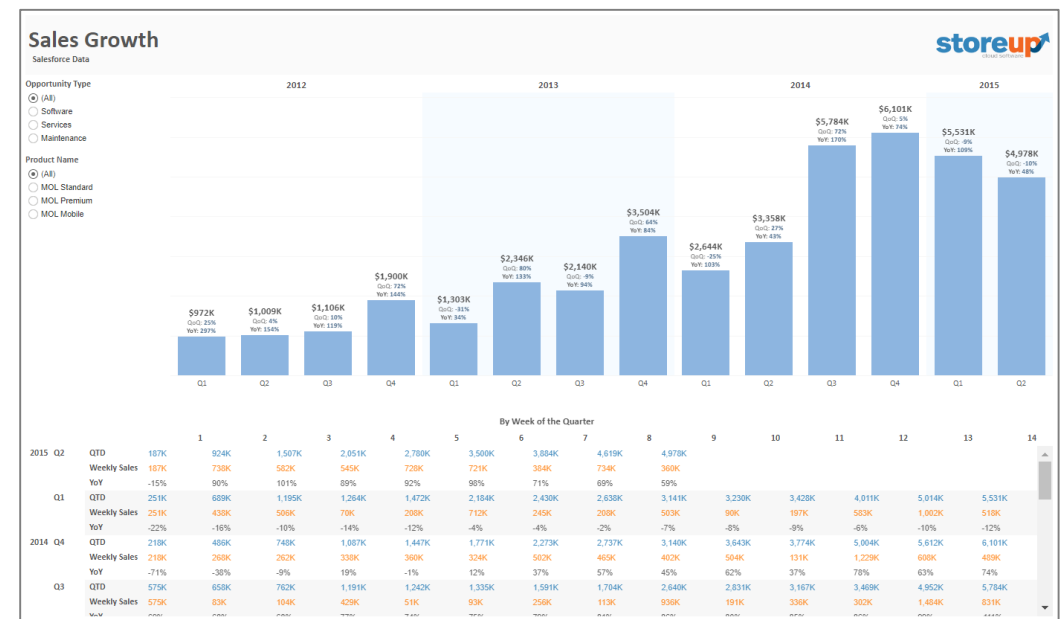
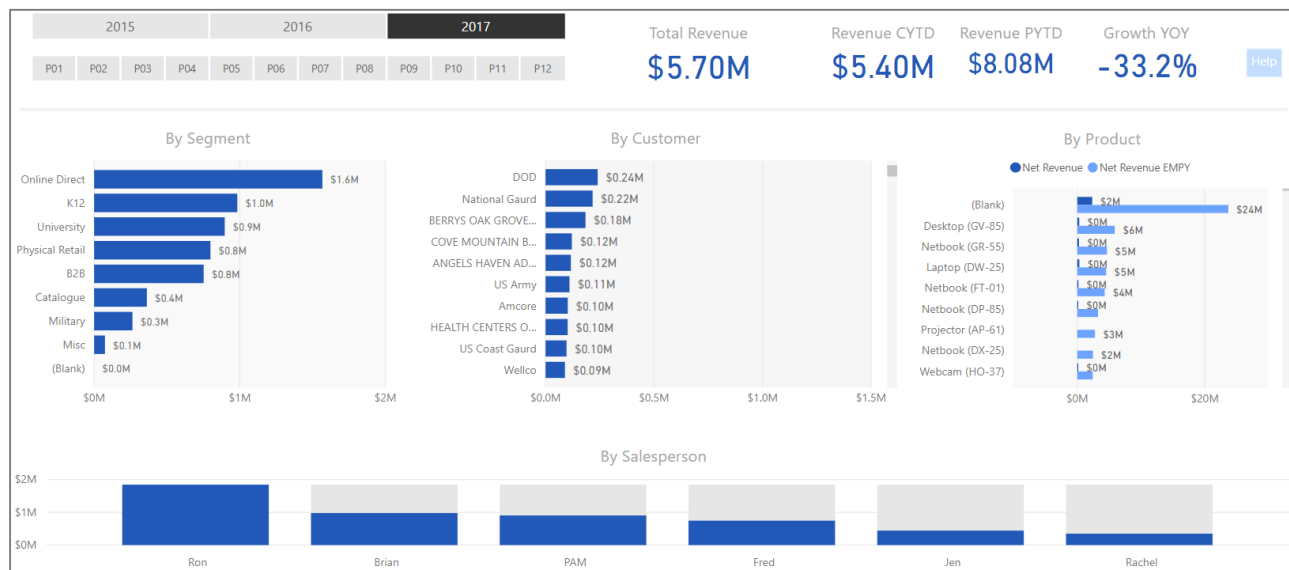
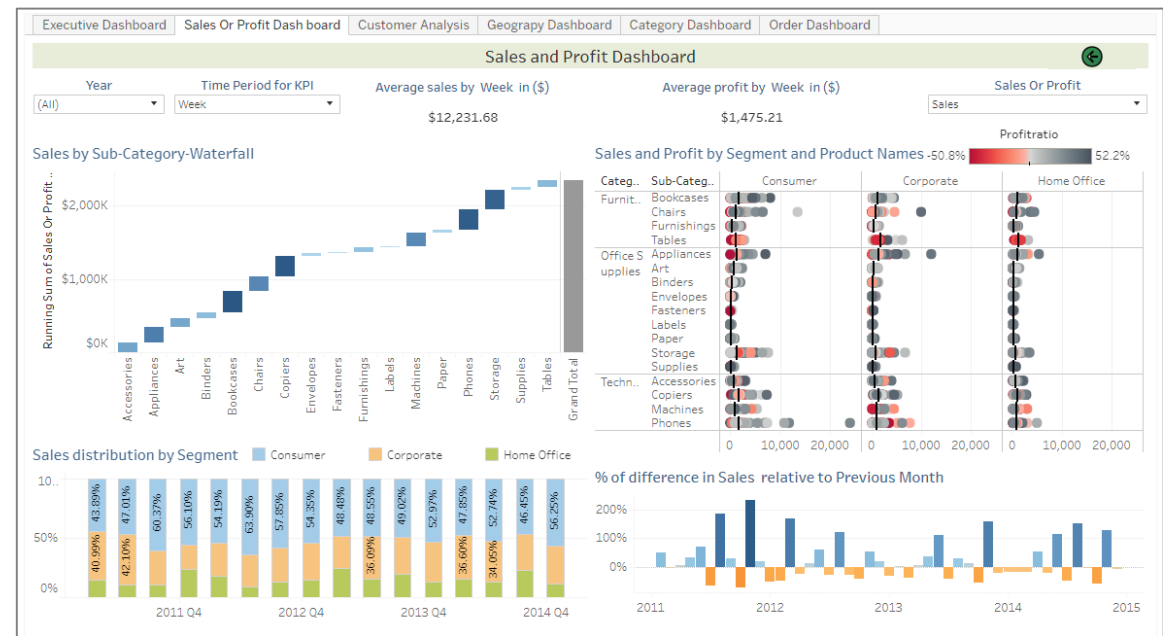
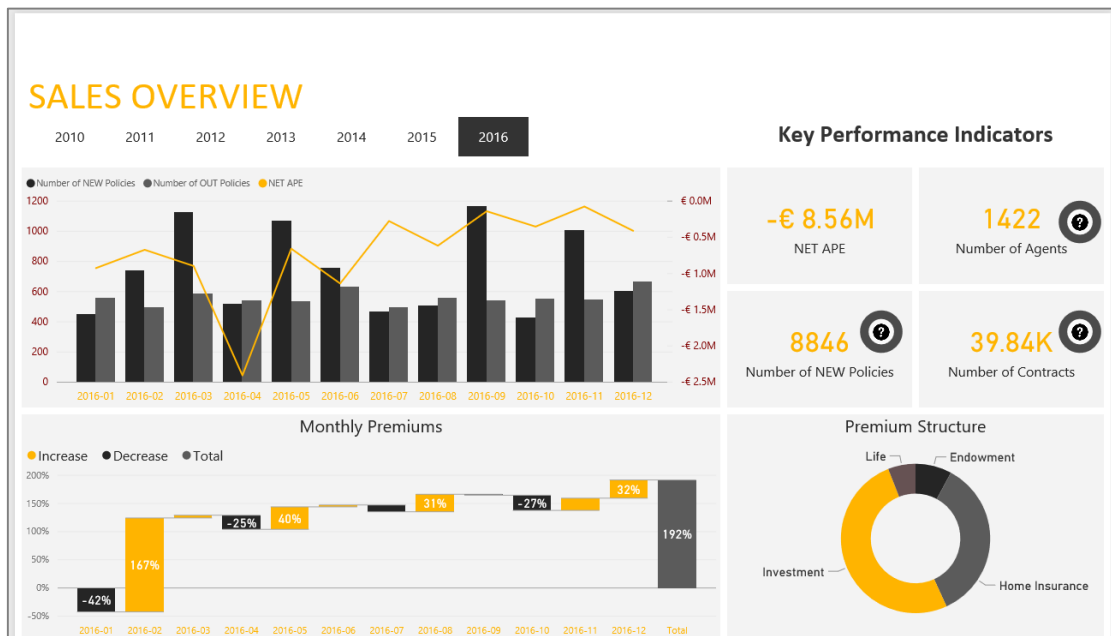
Design considerations:



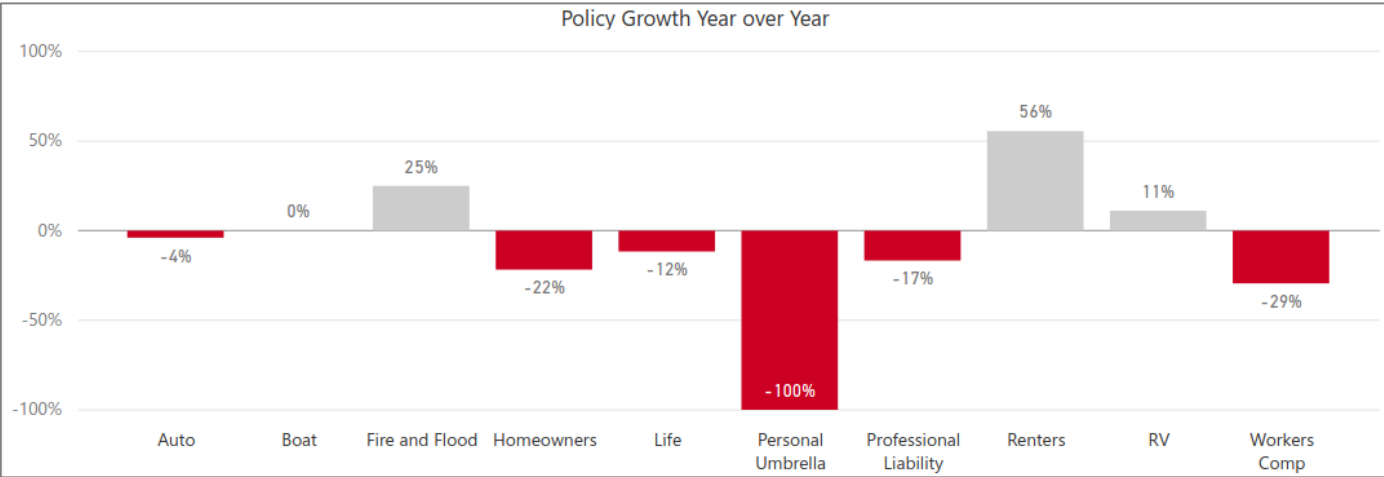
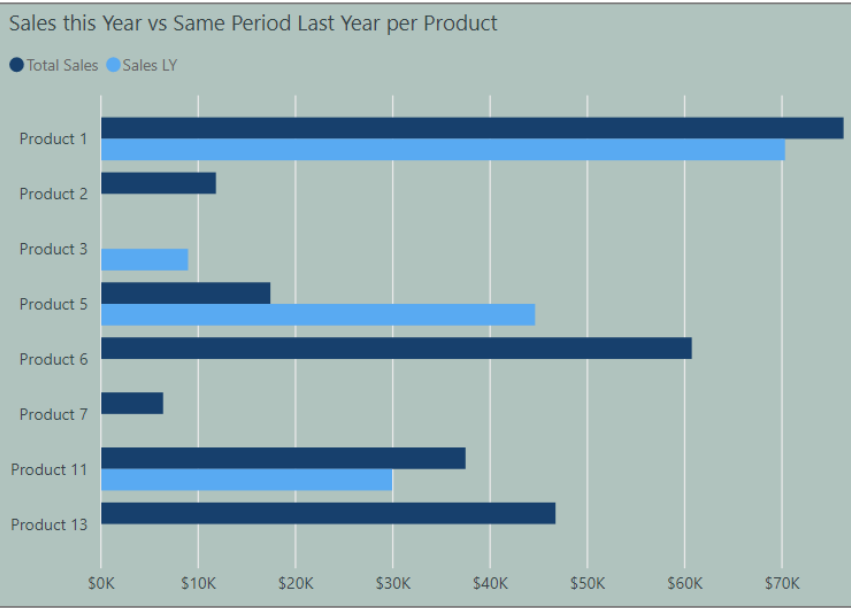
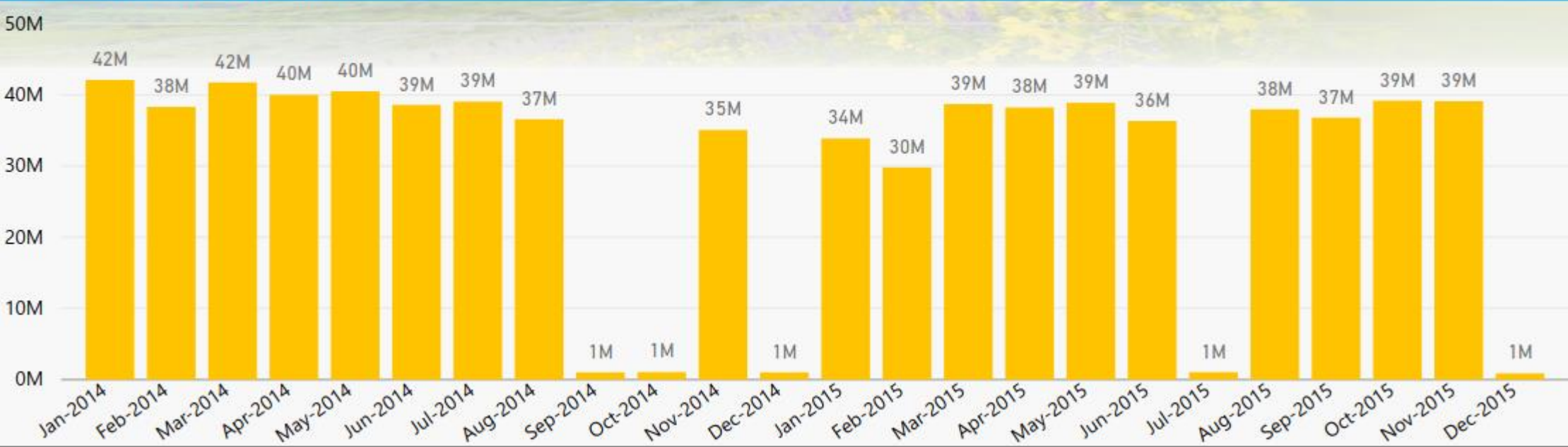
Microsoft

Power BI

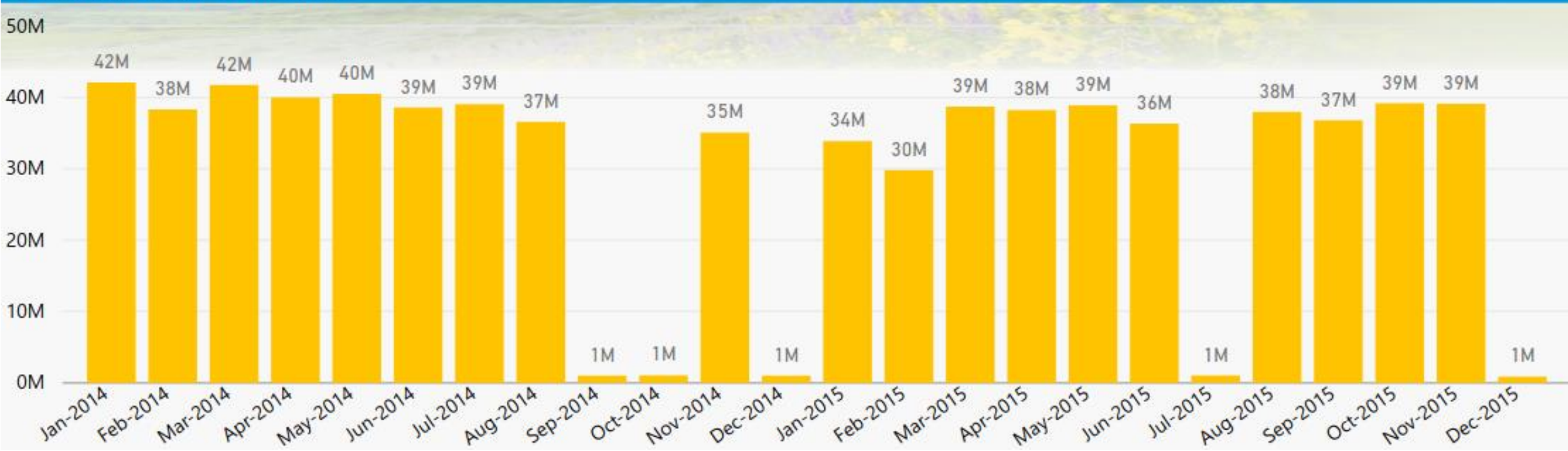
- Show raw values
- Do not occupy additional space
- Maintain visualization type
- Account for varying vs. constant data conditions
- Make it easier to measure differences



CO2 Production Over Time

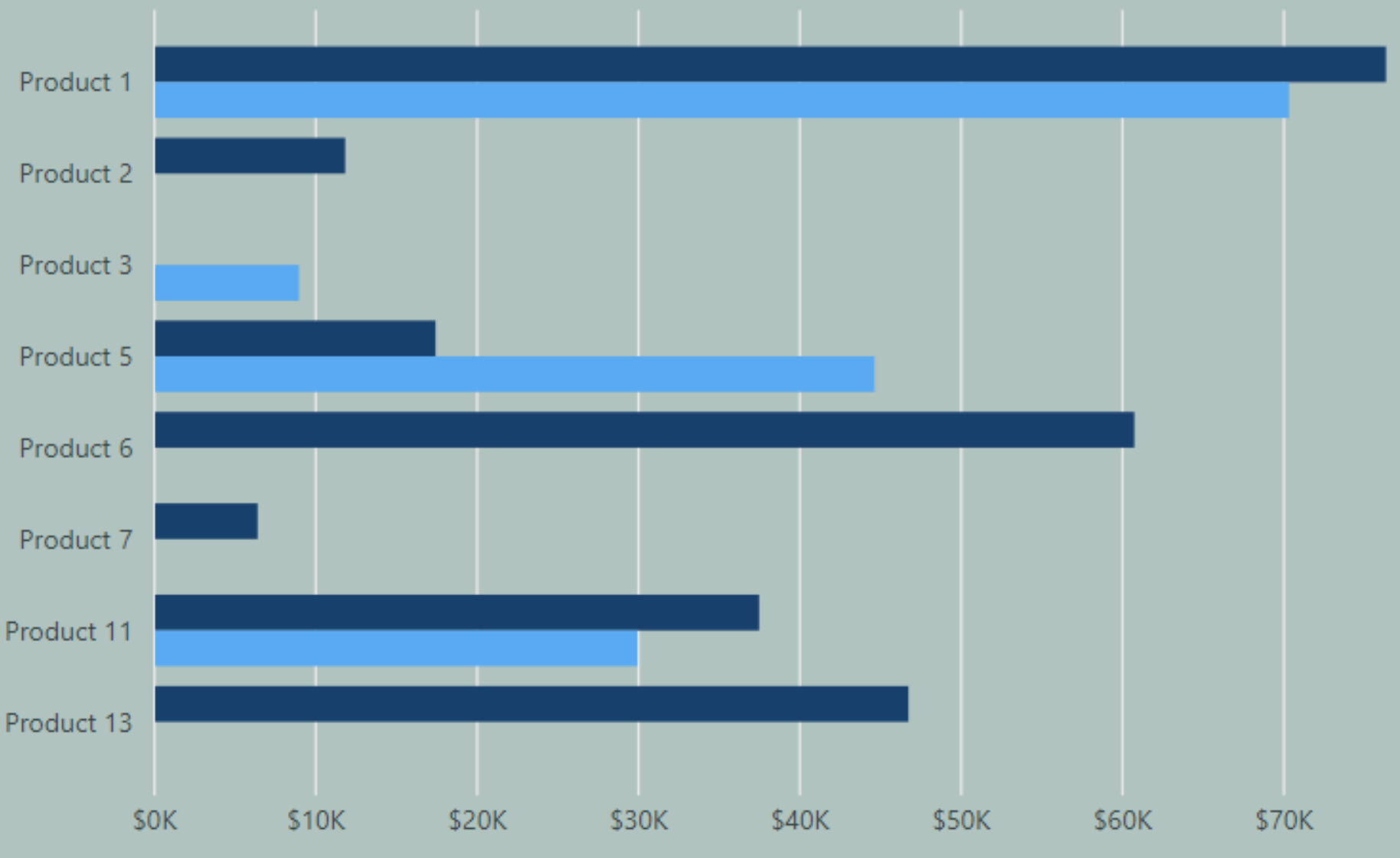


CO2 Production Over Time

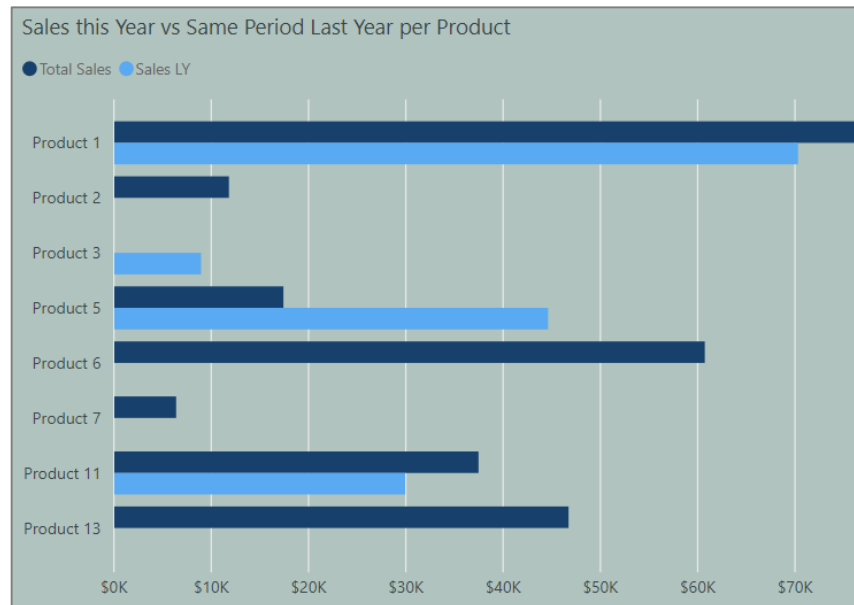


Sales this Year vs Same Period Last Year per Product

● Total Sales ● Sales LY



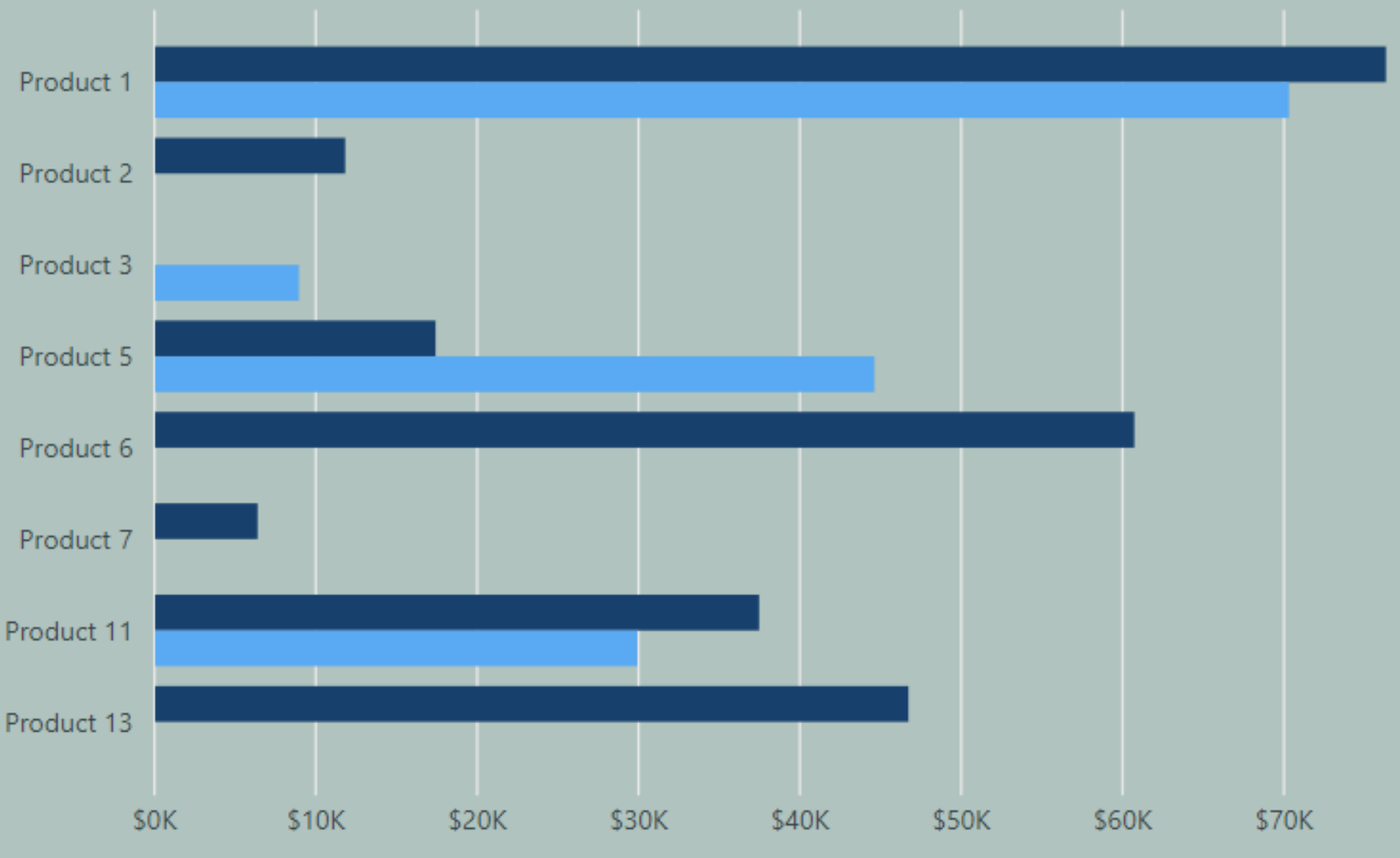
CO2 Production Over Time



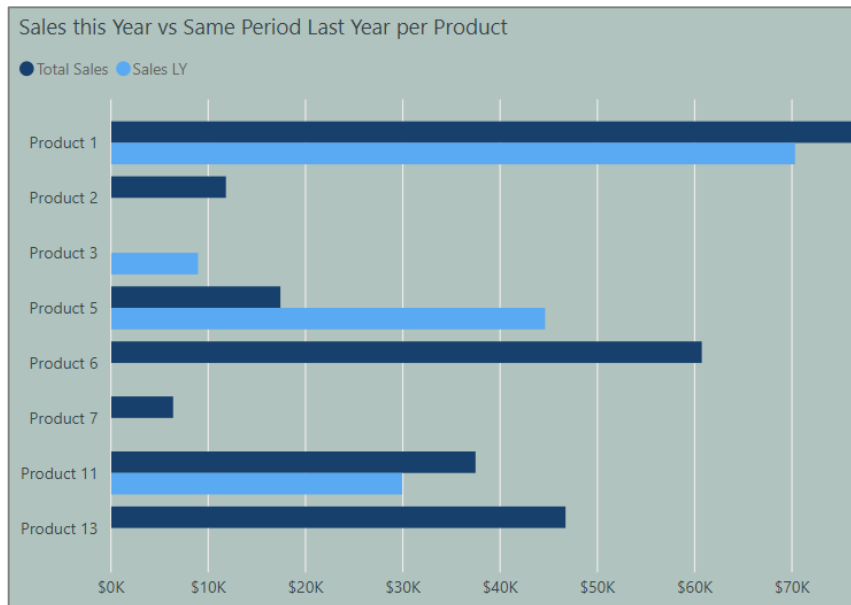
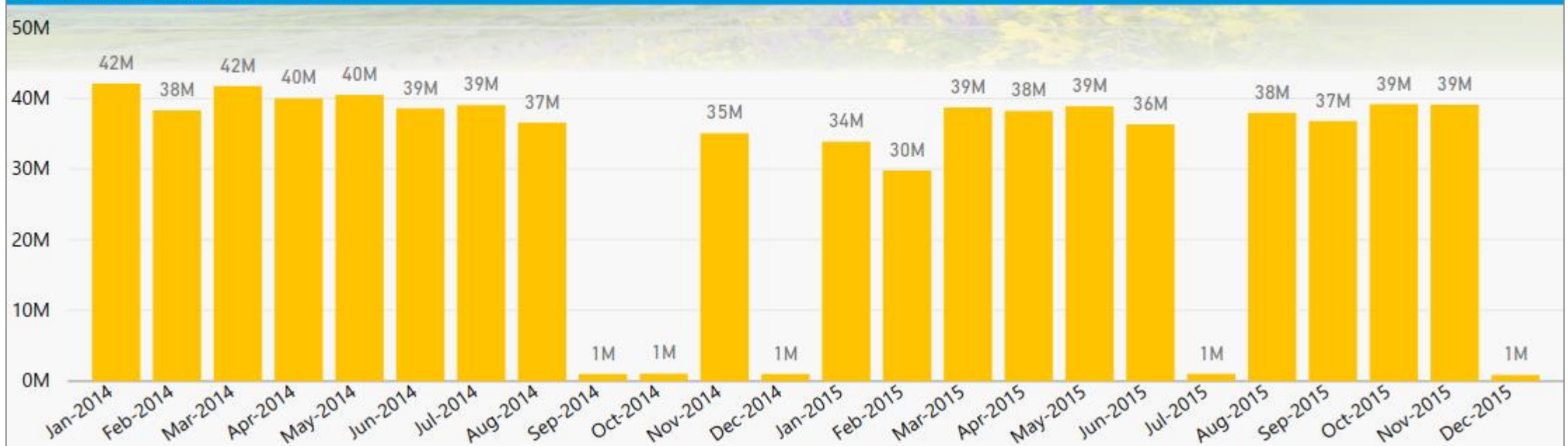
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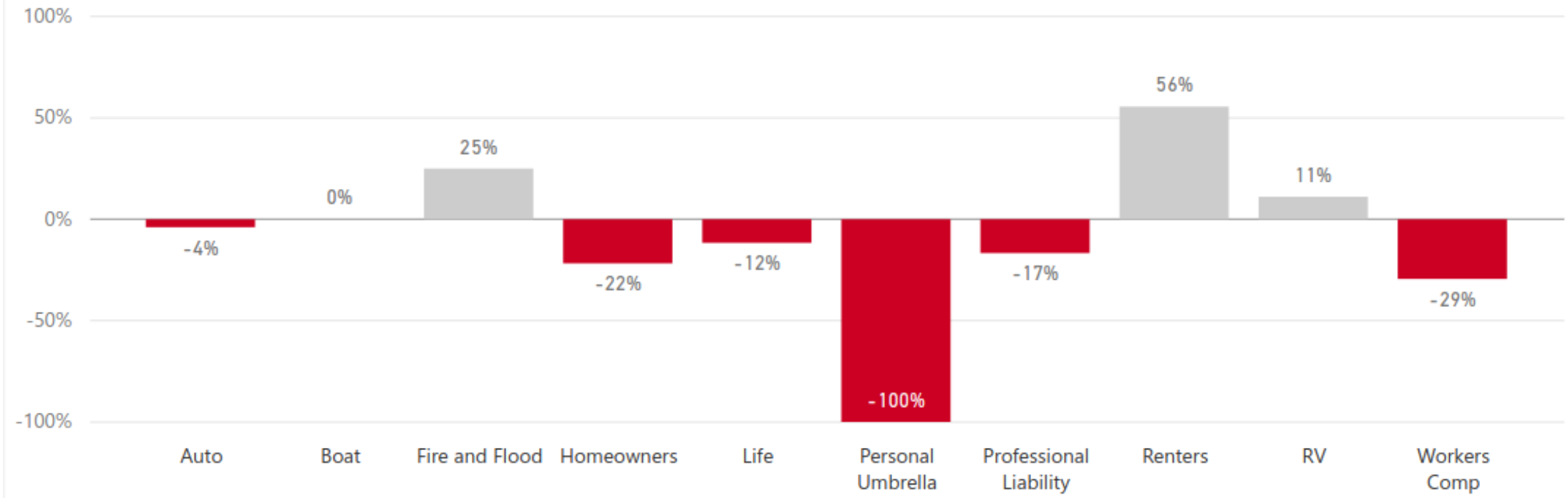


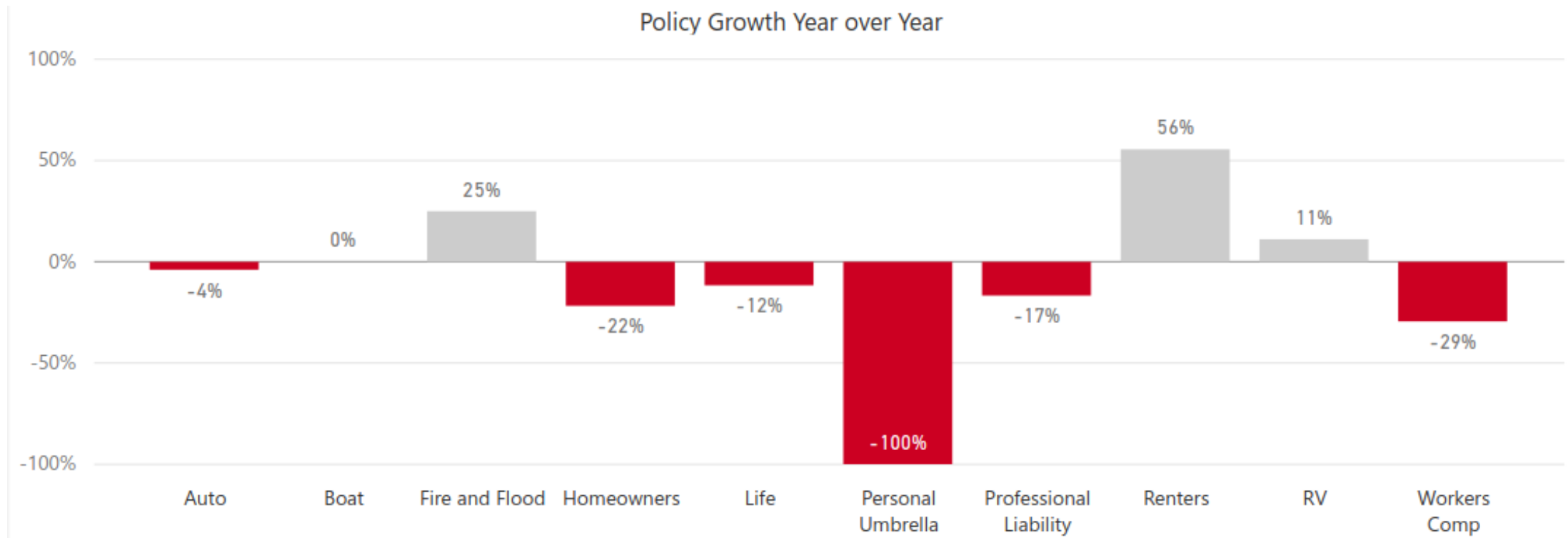
CO2 Production Over Time



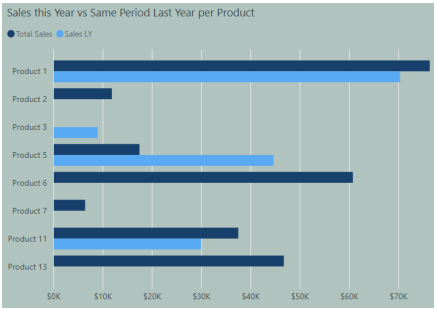
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Policy Growth Year over Year





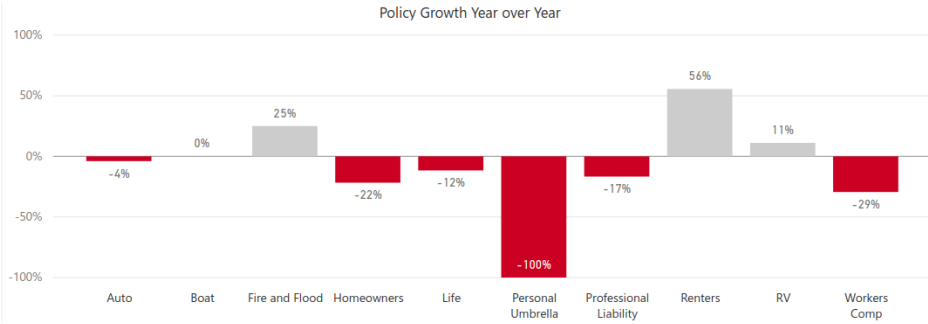
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- Show raw values
- Do not occupy additional space
- Maintain visualization type
- Account for variations in data
- Make it easier to measure difference



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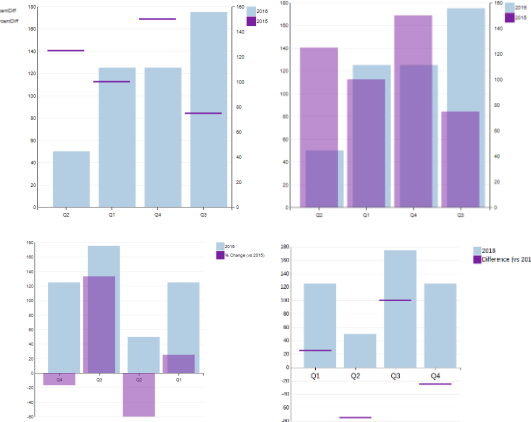
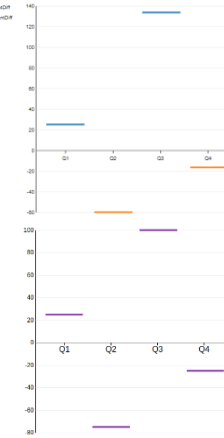
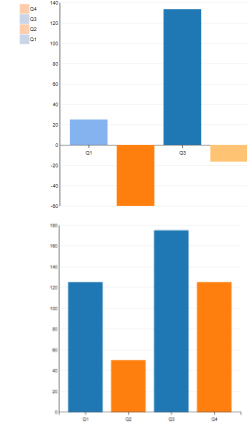
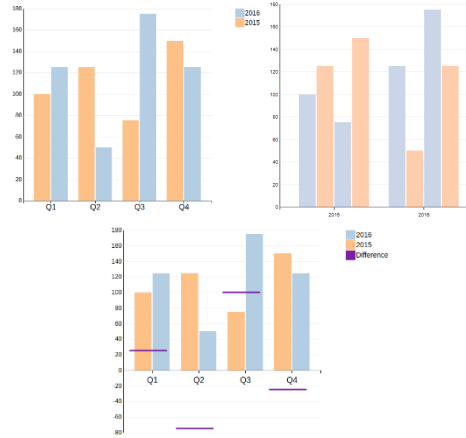
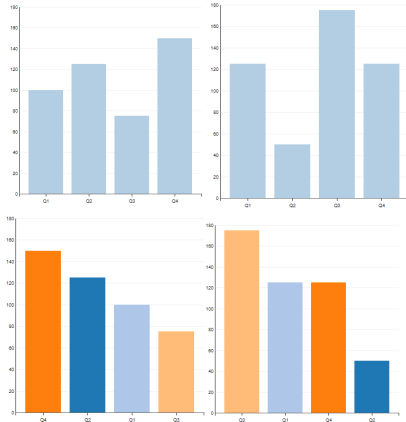
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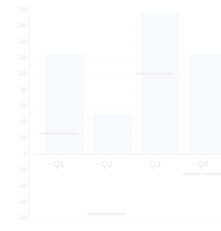
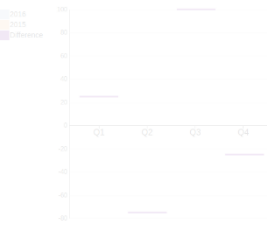
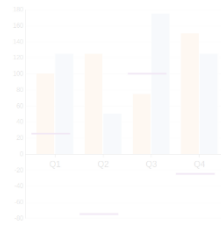
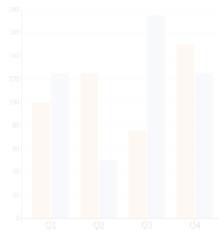
Power BI

+tableau+public

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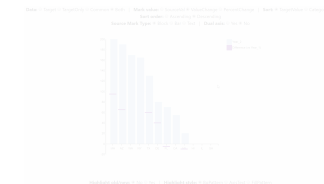
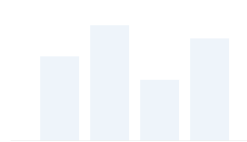
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Juxtaposition

Explicit Encoding

Superimposition



Juxtaposition

Explicit Encoding

Superimposition



BarTender

Juxtaposition

Explicit Encoding

Superimposition

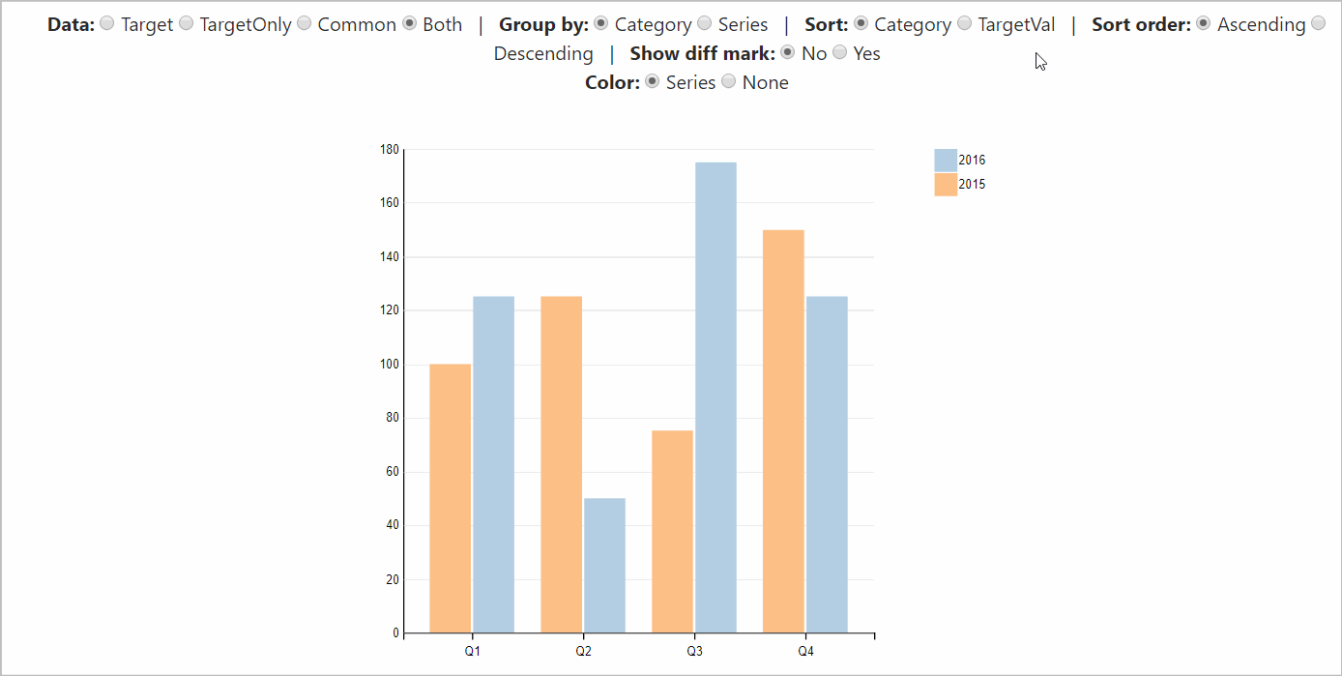
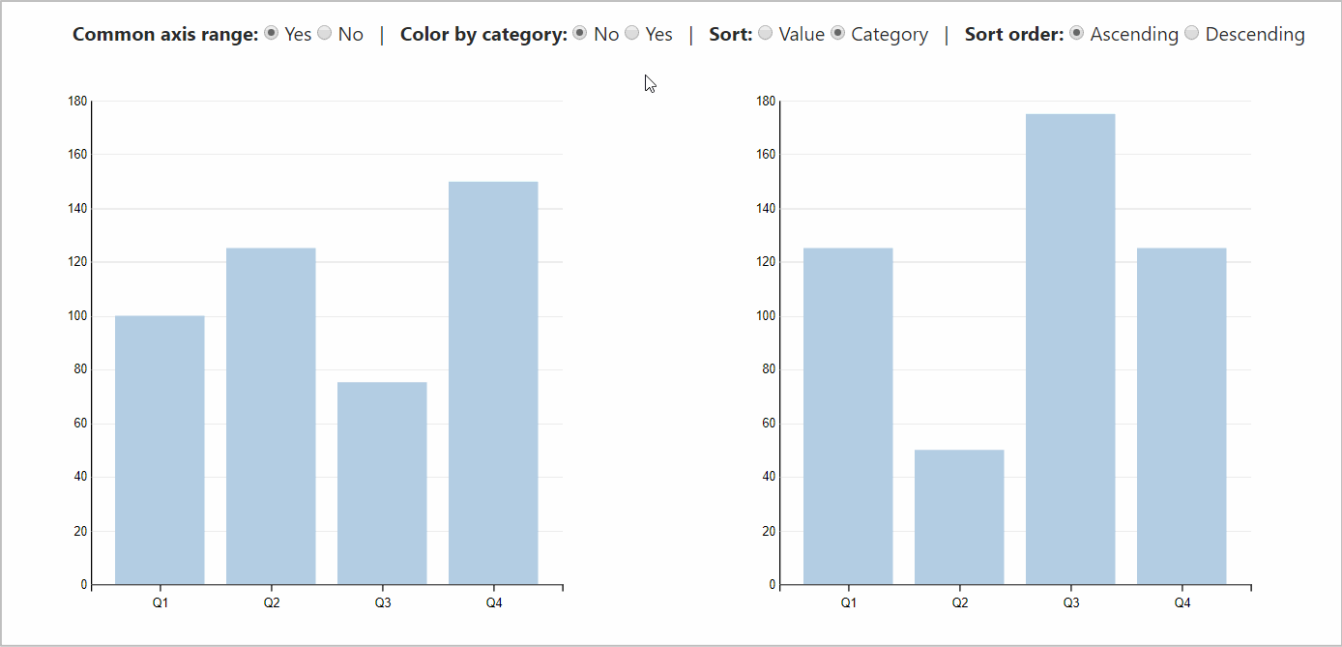


BarTender

Juxtaposition

Explicit Encoding

Superimposition

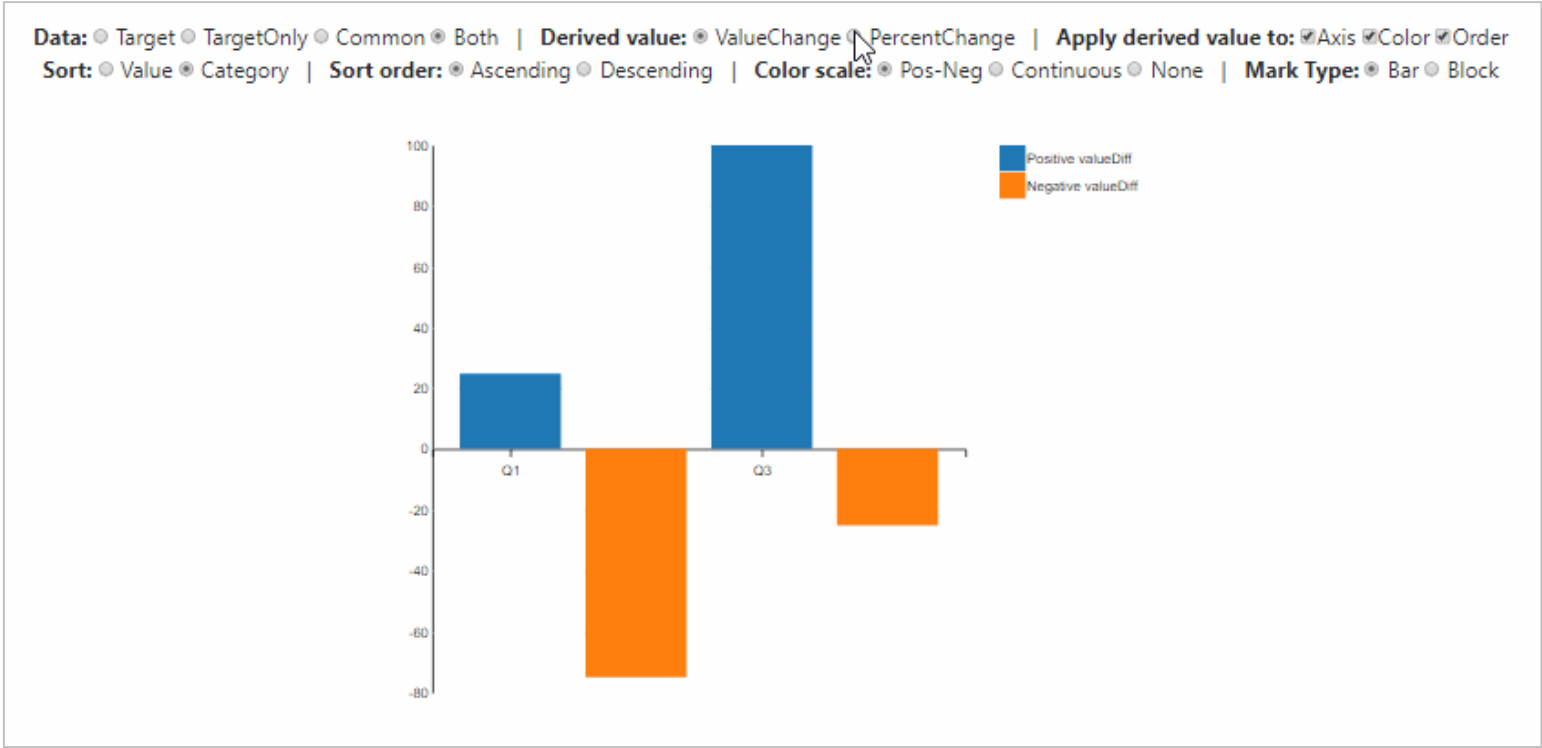


BarTender

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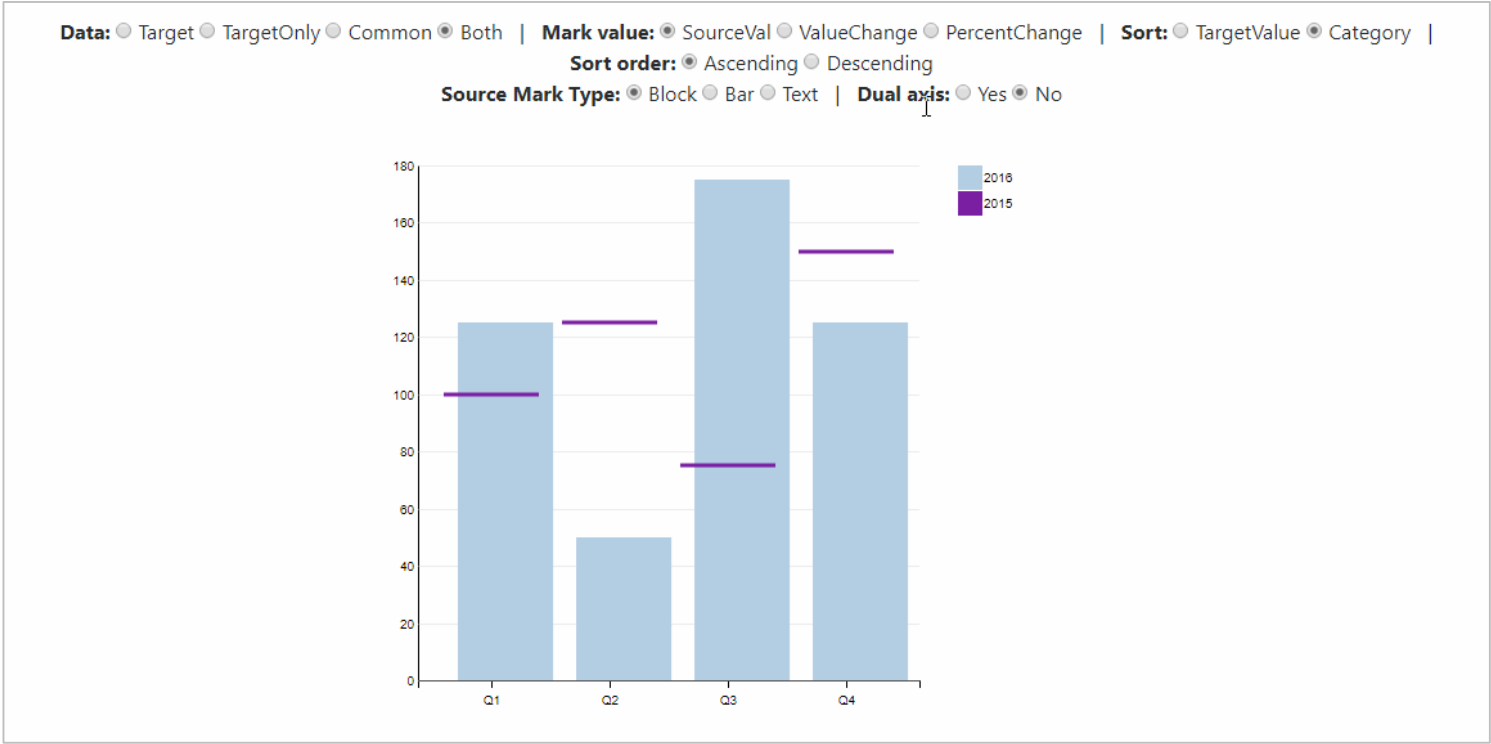


BarTender

Juxtaposition

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BarTender

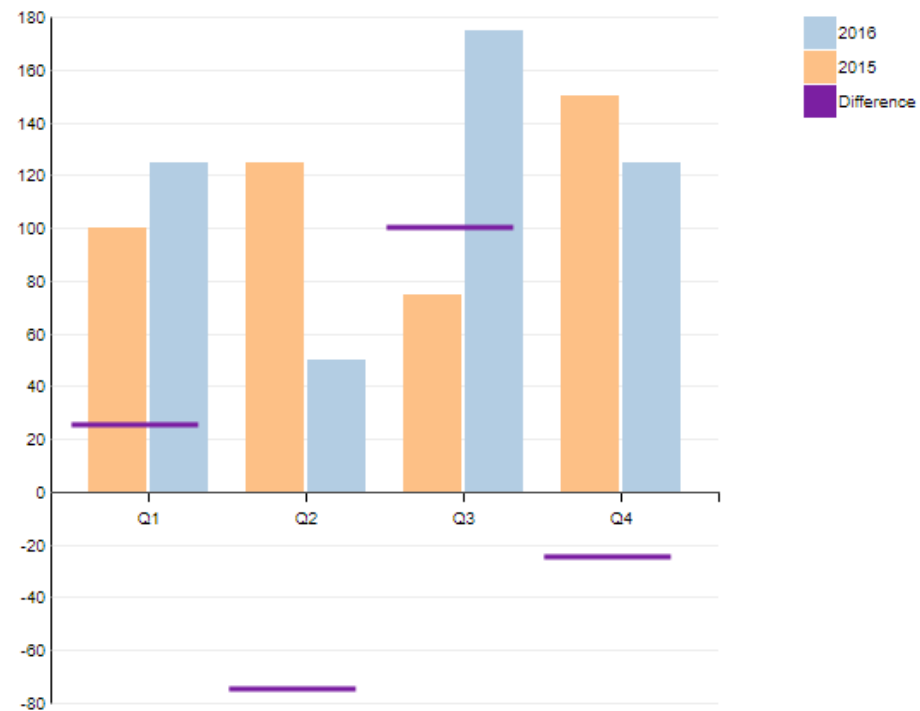
Juxtaposition

+

Explicit Encoding

+

Superimposition



BarTender

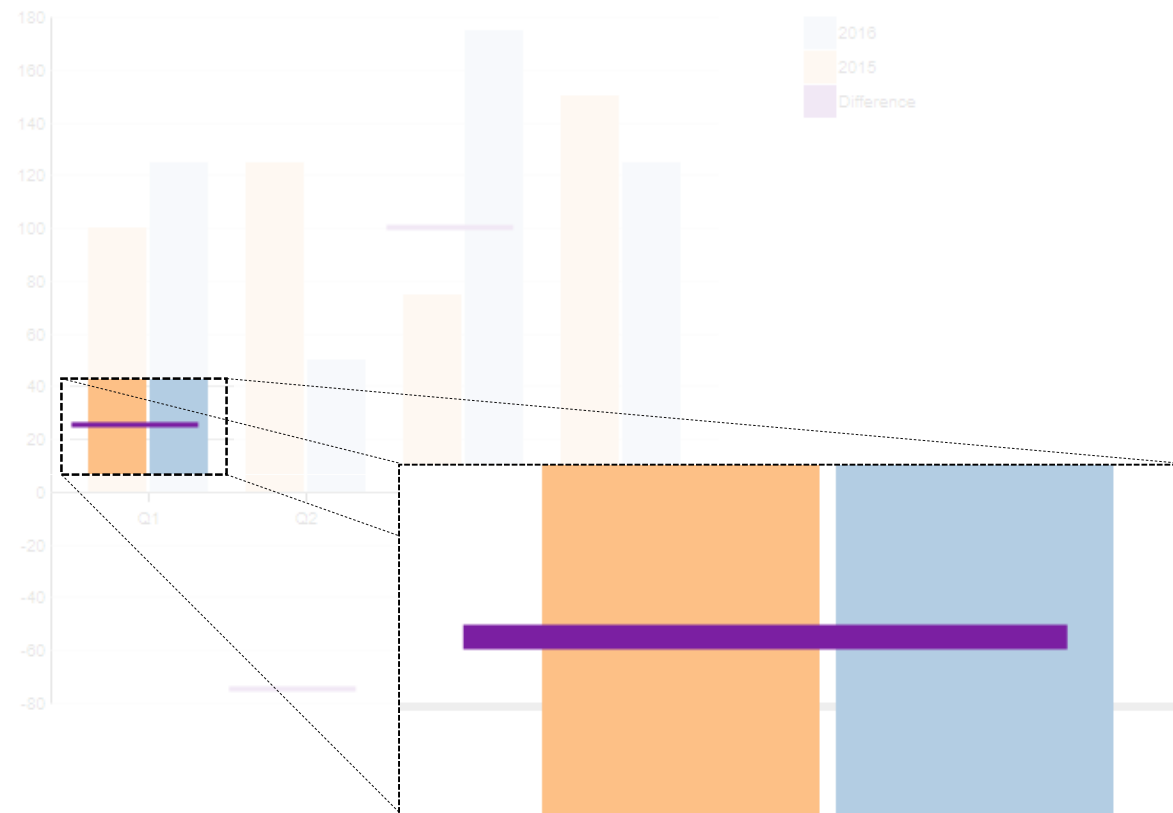
Juxtaposition



Explicit Encoding



Superimposition



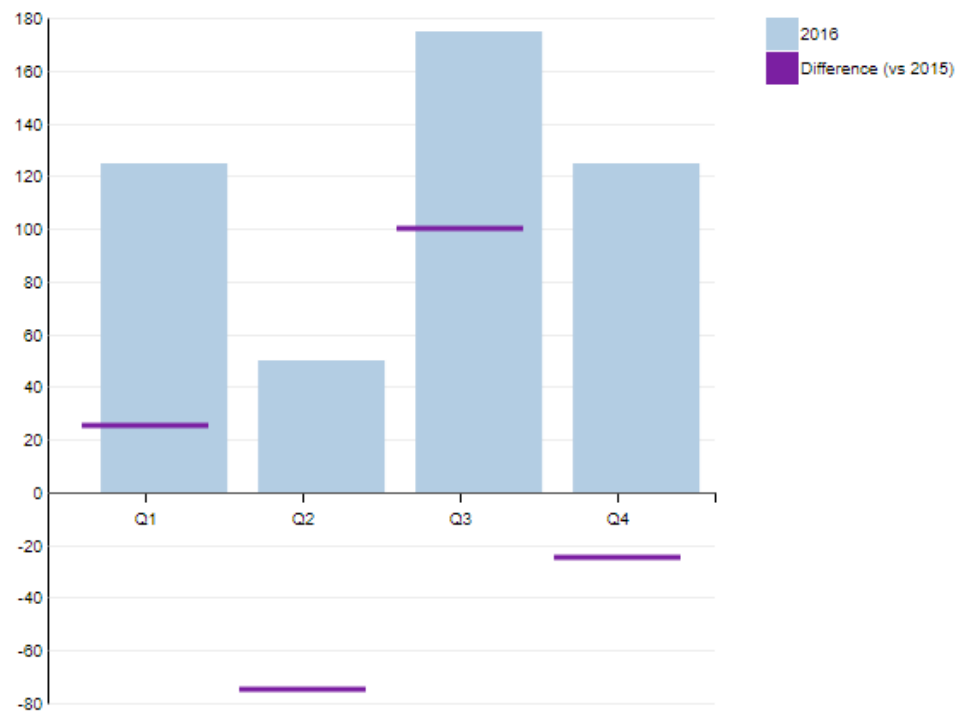
BarTender

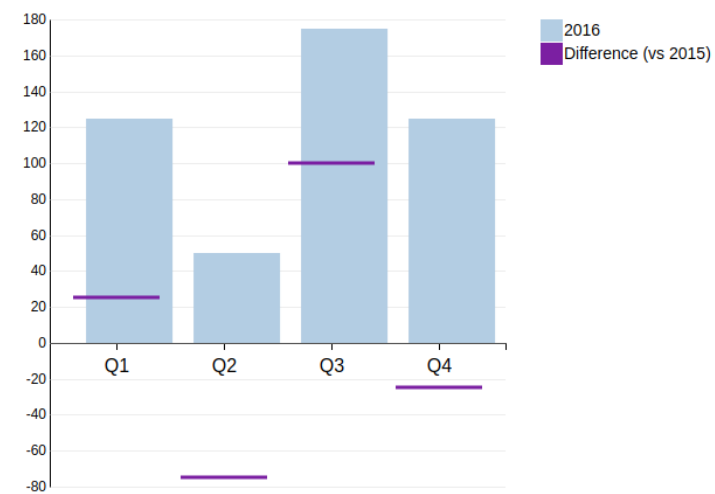
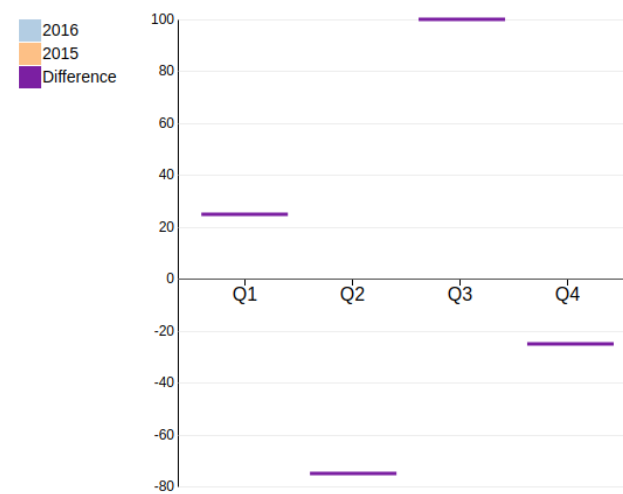
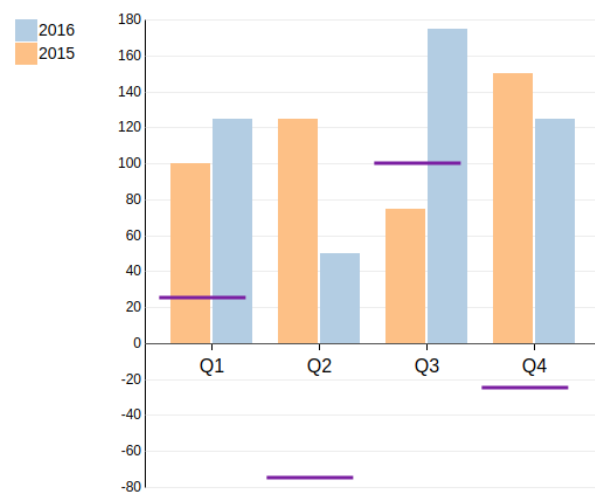
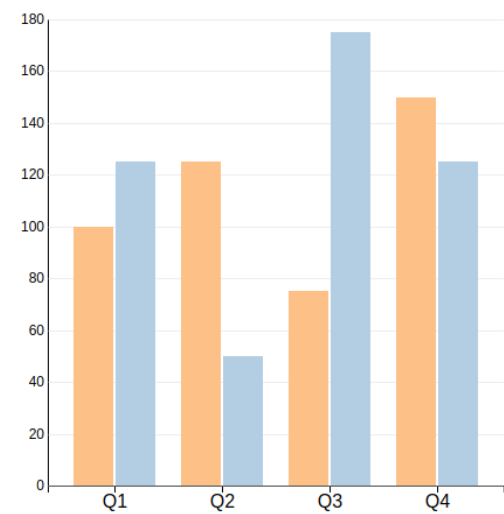
Juxtaposition

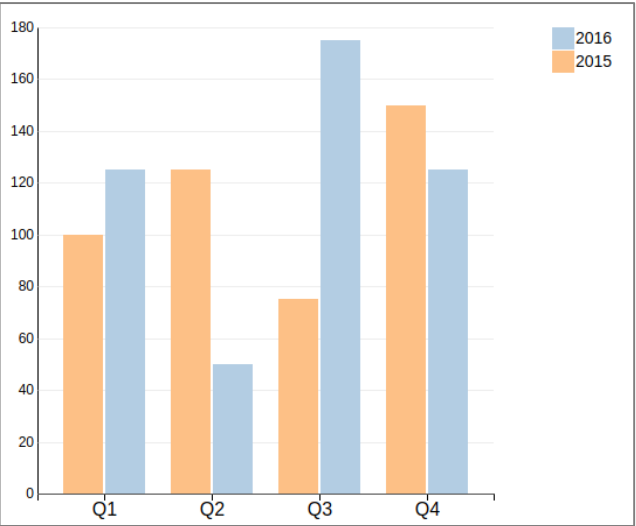
Explicit Encoding



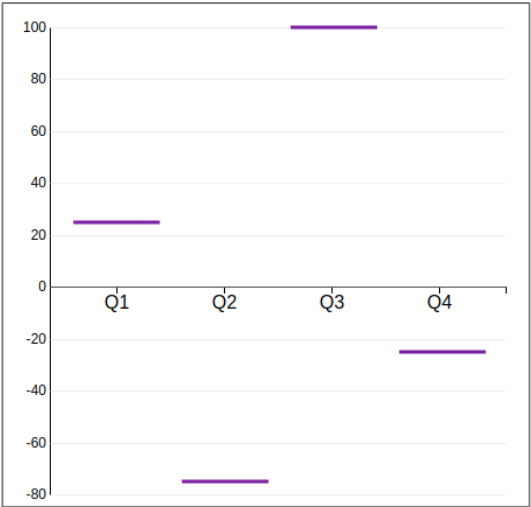
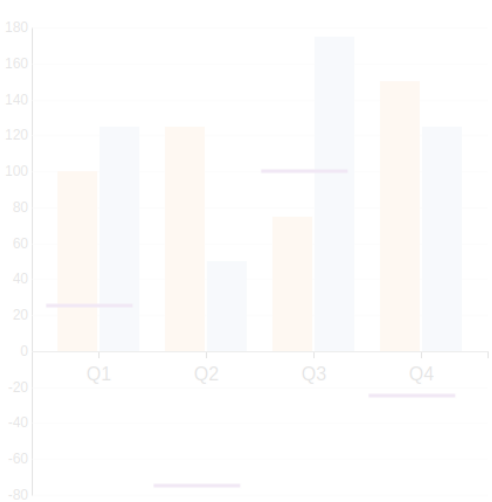
Superimposition



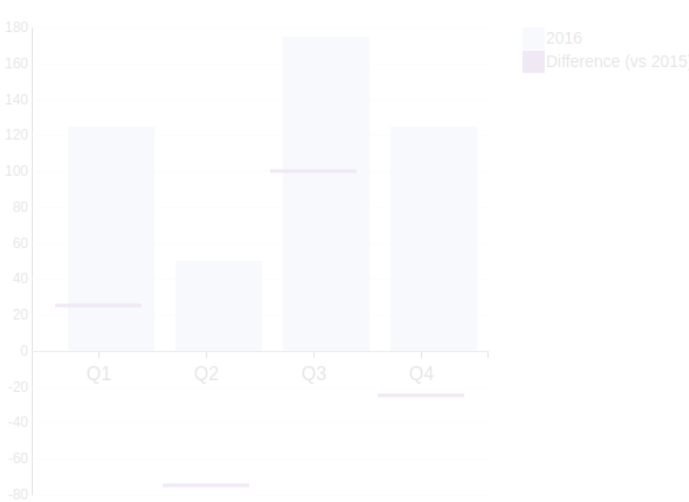


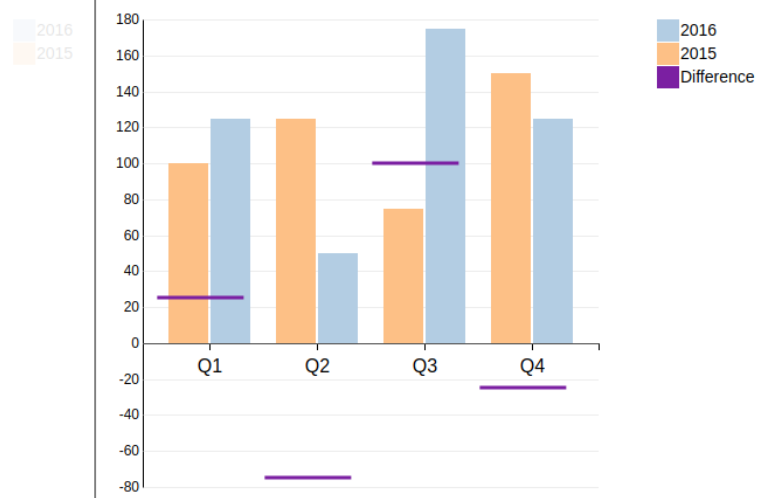
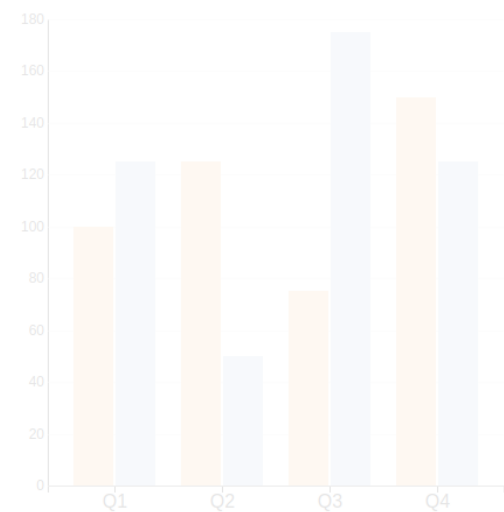


Grouped Bar Chart

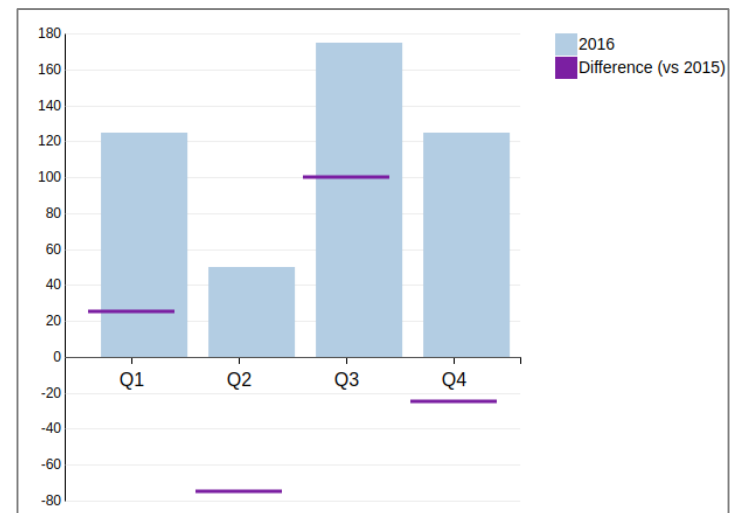
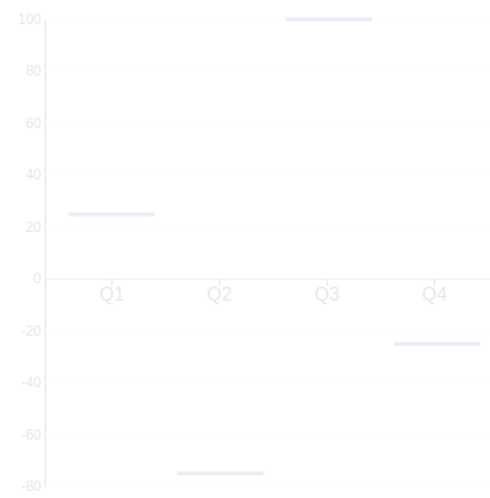


Difference Chart

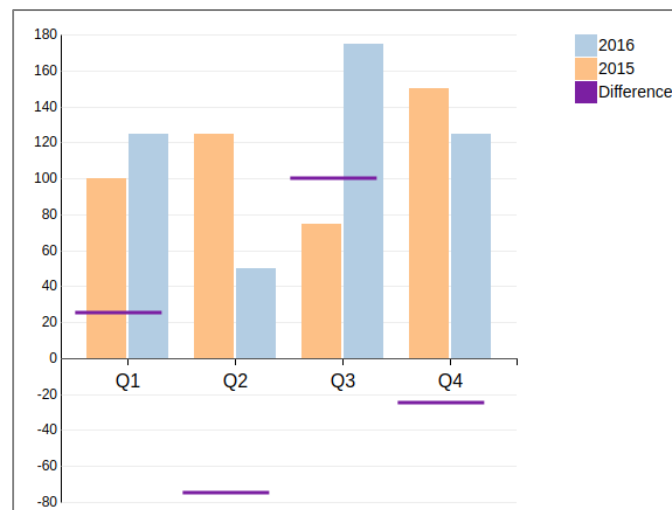
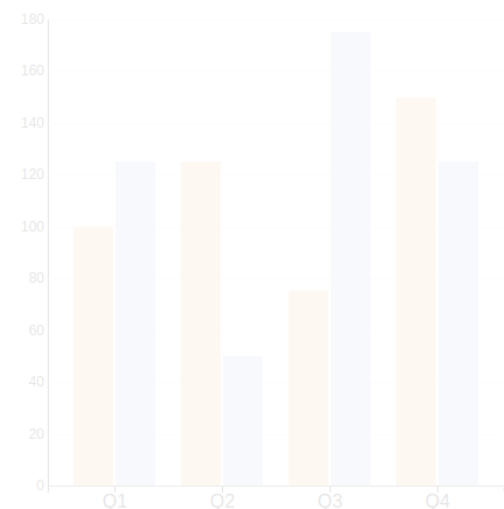




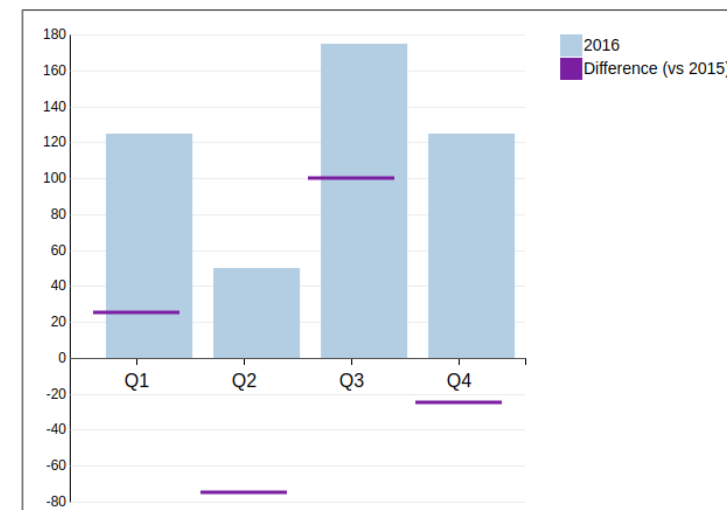
Grouped Bar Chart
w/ difference overlay



Single Bar Chart
w/ difference overlay



Grouped Bar Chart
w/ difference overlay



Single Bar Chart
w/ difference overlay

- Show raw values
- Do not occupy additional space
- Maintain visualization type
- Account for variations in data
- Make it easier to measure difference

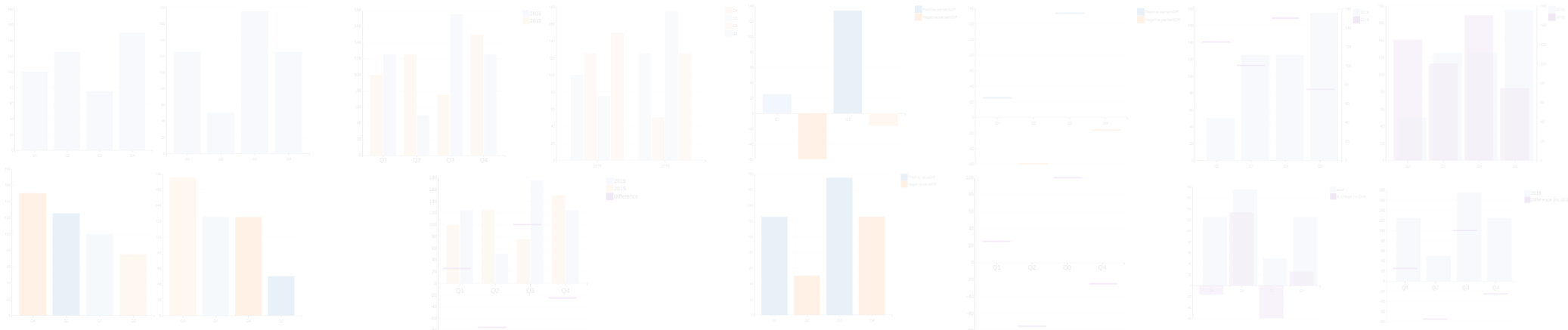
Interviews & Survey



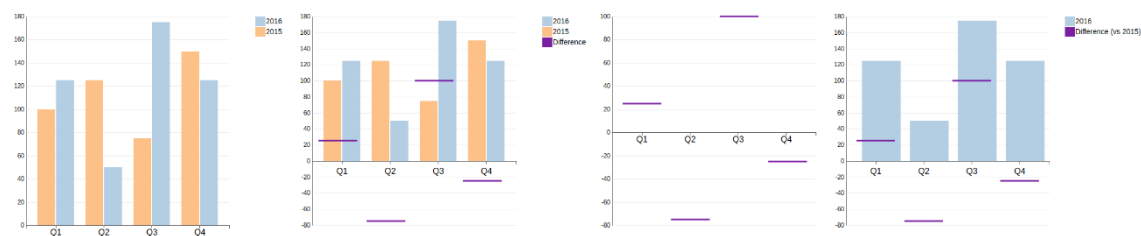
Power BI

+tableau+public

Exploration of
design alternatives



Evaluation



Extremes- Target

Extremes- Source

Max. Change

Value Difference

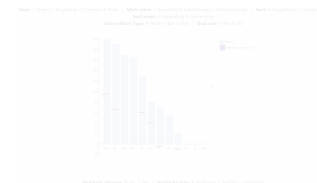
Old Categories

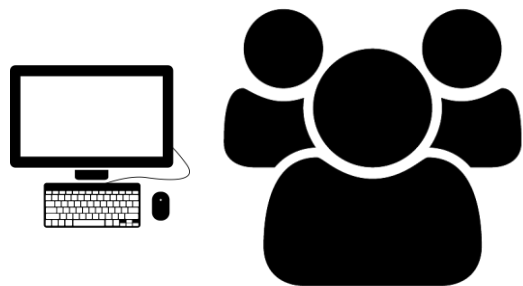
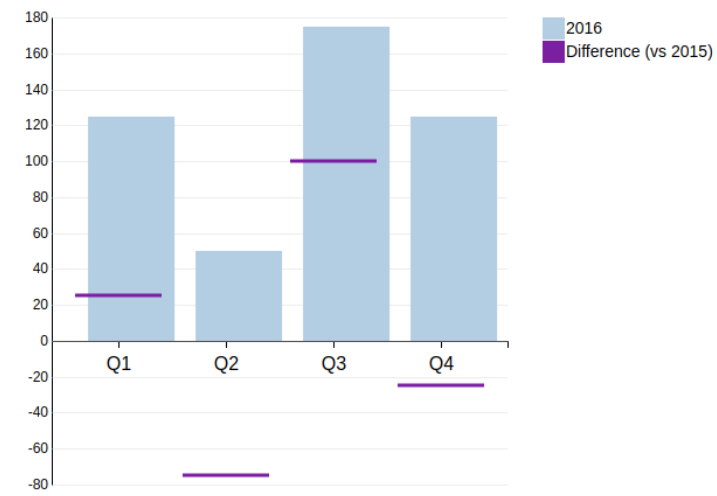
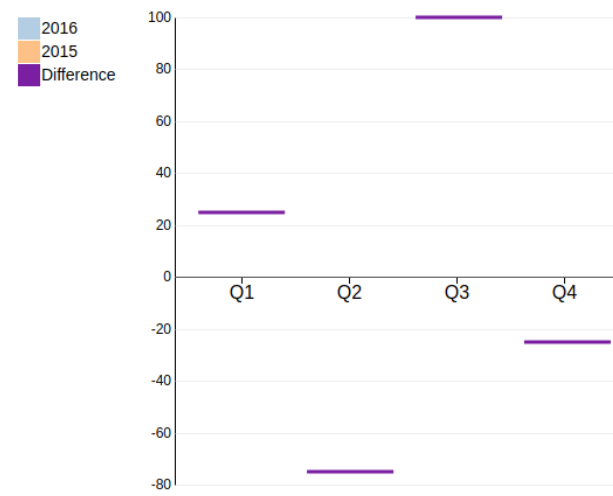
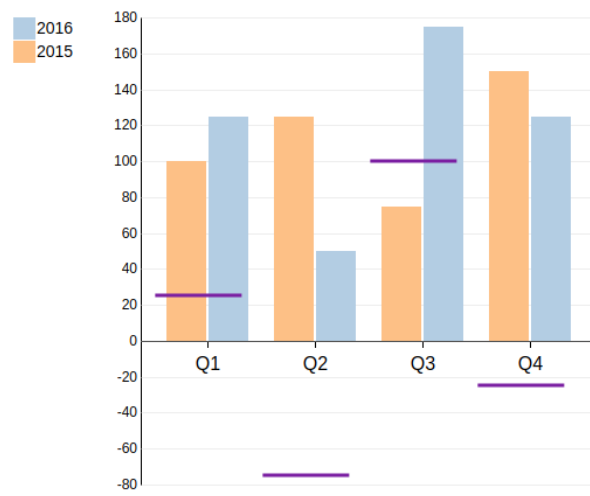
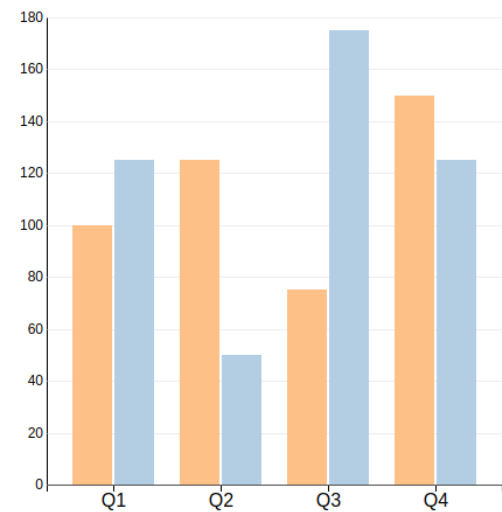
New Categories

Constant

Varying

Applications





74 Participants



- Extremes- Target
- Extremes- Source
- Max. Change
- Value Difference
- Old Categories
- New Categories

6 Tasks



- Constant
- Varying

2 Data Conditions

Tasks

Extremes- Target

Extremes- Source

Max. Change

Value Difference

Old Categories

New Categories

Tasks

Extremes- Target

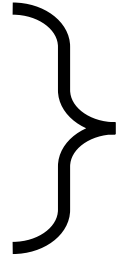
Extremes- Source

Max. Change

Value Difference

Old Categories

New Categories



Value interpretation

Tasks

Extremes- Target

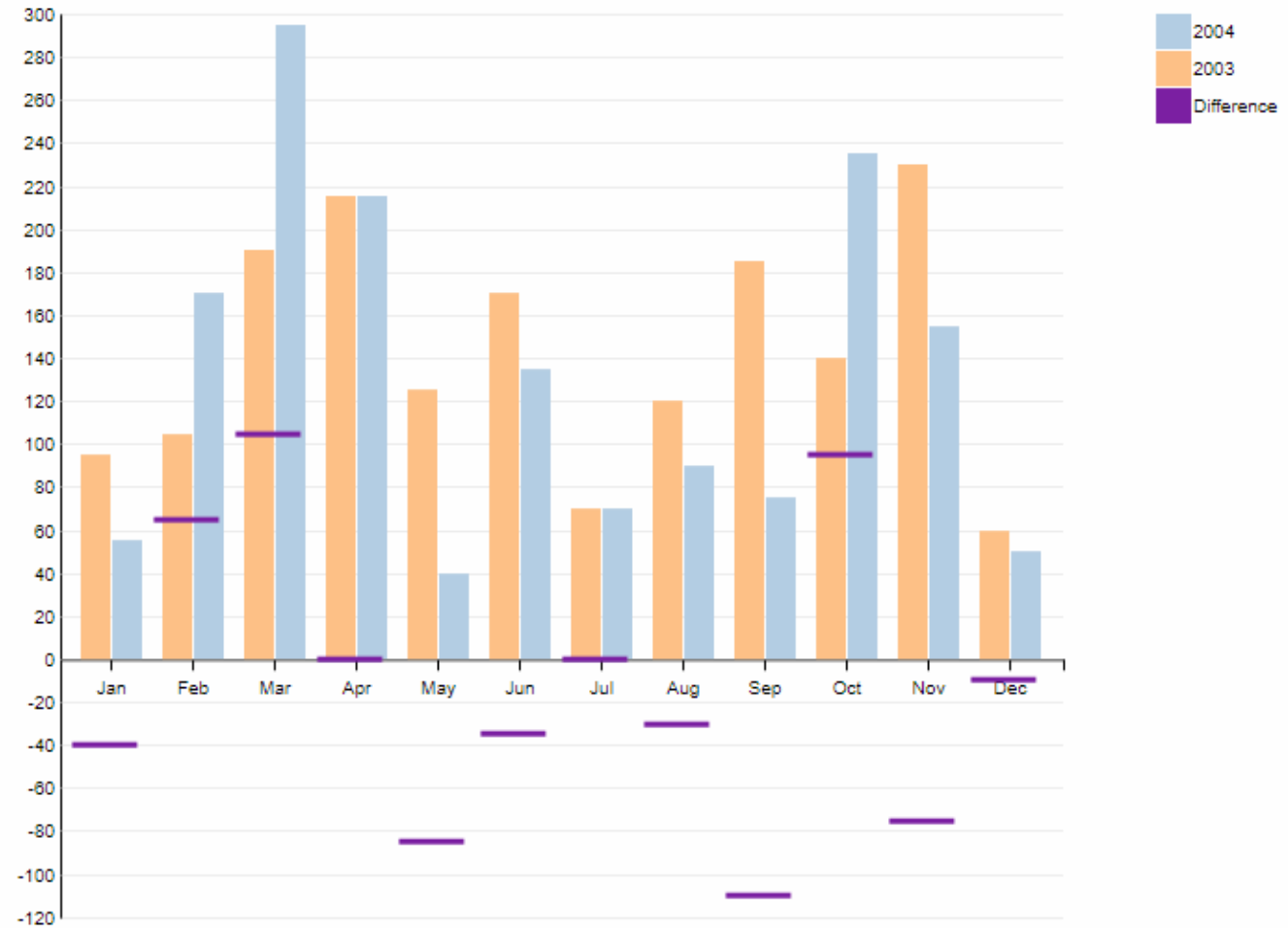
Extremes- Source

Max. Change

Value Difference

Old Categories

New Categories



Selected: None

Trial 1 of 4 : Click on the month with the minimum value in 2004.

Tasks

Extremes- Target

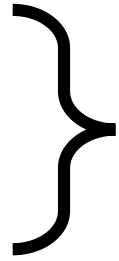
Extremes- Source

Max. Change

Value Difference

Old Categories

New Categories



Difference-based

Tasks

Extremes- Target

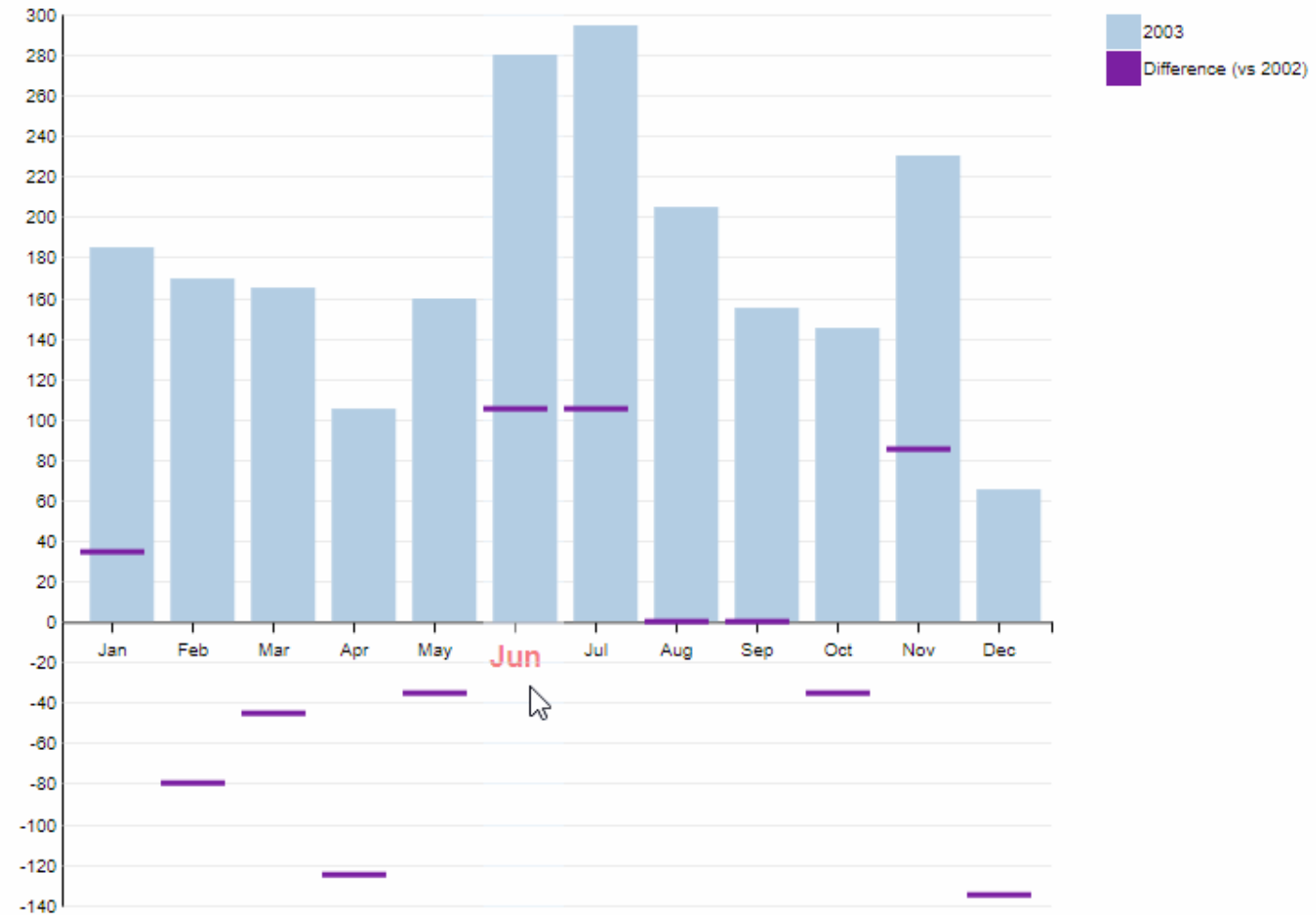
Extremes- Source

Max. Change

Value Difference

Old Categories

New Categories



Change in value: 0

Trial 4 of 4 : Enter the absolute change in value for **Jun** from 2002 to 2003.

Tasks

Extremes- Target

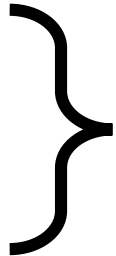
Extremes- Source

Max. Change

Value Difference

Old Categories

New Categories



Varying data conditions

Tasks

Extremes- Target

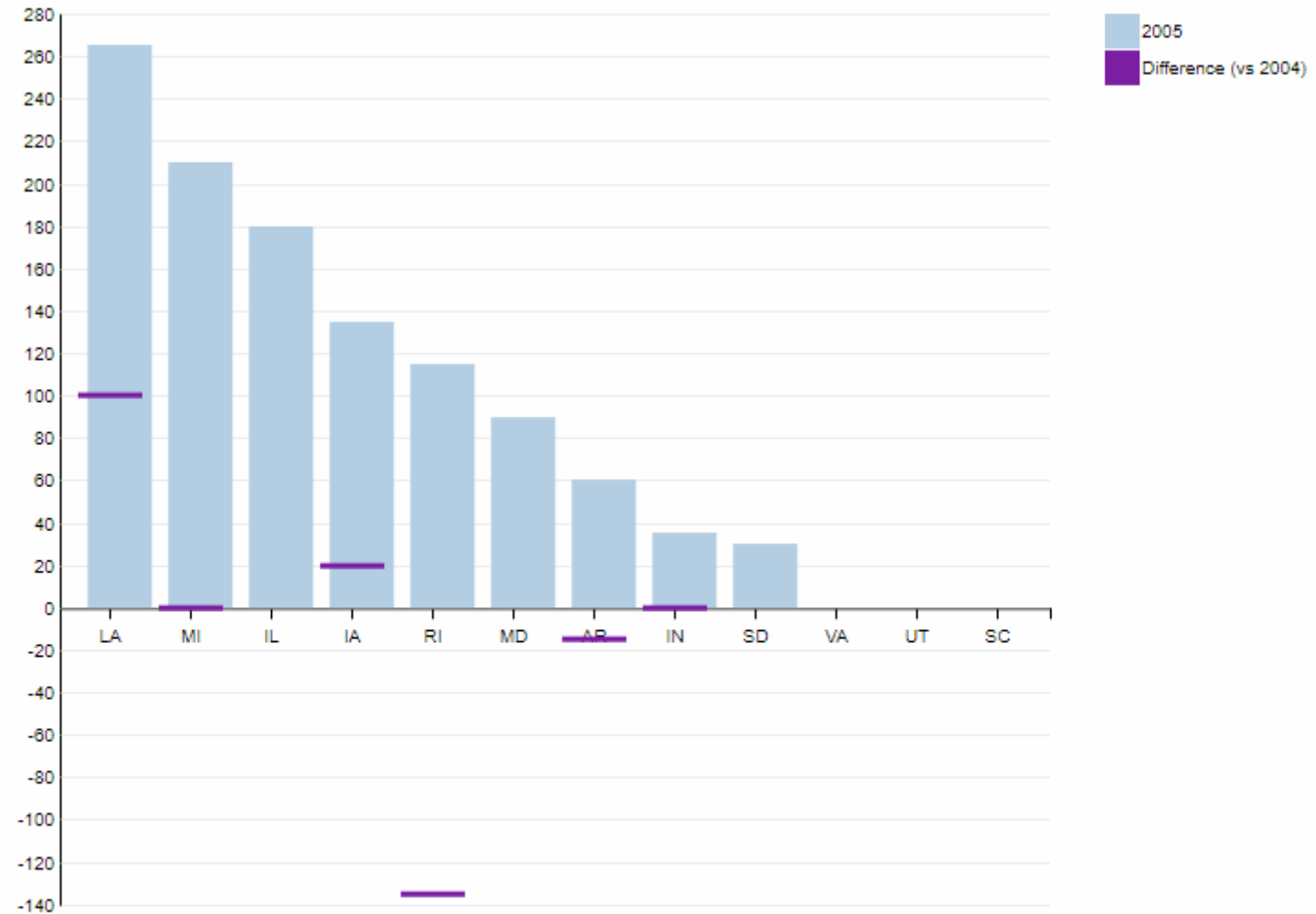
Extremes- Source

Max. Change

Value Difference

Old Categories

New Categories



Selected: None

Trial 3 of 4 : Click on the states that have a value ONLY in 2005.

Design
Introduction

Data Type 1
Introduction

Training
Phase

Testing
Phase

Data Type 2
Introduction

Training
Phase

Testing
Phase

Design Introduction

Data Type 1
Introduction

Training
Phase

Testing
Phase

Data Type 2
Introduction

Training
Phase

Testing
Phase

Chart Design 1 Introduction

Please read and understand these instructions carefully

- » In this design, the **blue bars** represent **values for the more recent year** and the **purple lines** represent the **change in values compared to the previous year**.
- » If there is no purple line for a category in the chart, it means the category did not have a value in one of the two years.

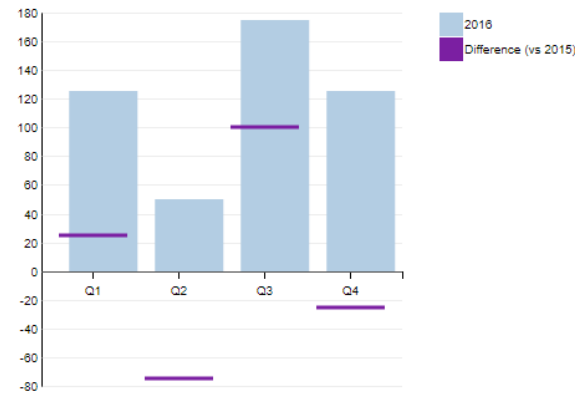
Example:

Consider the example chart below showing values for 2015 and 2016.

In this chart, the bars represent the 2016 values while the horizontal lines represent the change in value from 2015 to 2016 (the right-most column in the adjacent table).

Note: The table will not be shown in subsequent trials.

Quarter	2015	2016	Difference
Q1	100	125	25
Q2	125	50	-75
Q3	75	175	100
Q4	150	125	-25



☐ I have understood this chart design and am ready to perform tasks using it.

Proceed

Design
Introduction

Data Type 1
Introduction

Training
Phase

Testing
Phase

Data Type 2
Introduction

Training
Phase

Testing
Phase

Training phase: values by month

You will be shown values for the 12 months of the year. You will now practice the tasks that you will be asked to perform.

Note:

» For each training trial, you be allowed to **repeat the trial up to 3 times**. If you are unable to solve a task, you will be shown the correct response and taken to the next trial. Please make sure that you understand how to correctly complete the trial.

» **Data** (years and values) **changes for each trial**. Please read the task instruction carefully.

Click "Proceed" when you are ready to begin the training phase.

Training phase: values by state

You will be shown data for 12 US states. Note that some states have a value in only one of the two years. You will now practice the tasks that you will be asked to perform.

Note:

» For each training trial, you be allowed to **repeat the trial up to 3 times**. If you are unable to solve a task, you will be shown the correct response and taken to the next trial. Please make sure that you understand how to correctly complete the trial.

» **Data** (years, values, and states) **changes for each trial**. Please read the task instruction carefully.

Click "Proceed" when you are ready to begin the training phase.

Design
Introduction

Data Type 1
Introduction

Training
Phase

Testing
Phase

Data Type 2
Introduction

Training
Phase

Testing
Phase



Selected: **AZ,IL**

Your were unable to respond correctly. The correct answer was **KS,MD**.

Trial 2 of 4 : Click on the states that have a value ONLY in 2002.

Proceed

Design
Introduction

Data Type 1
Introduction

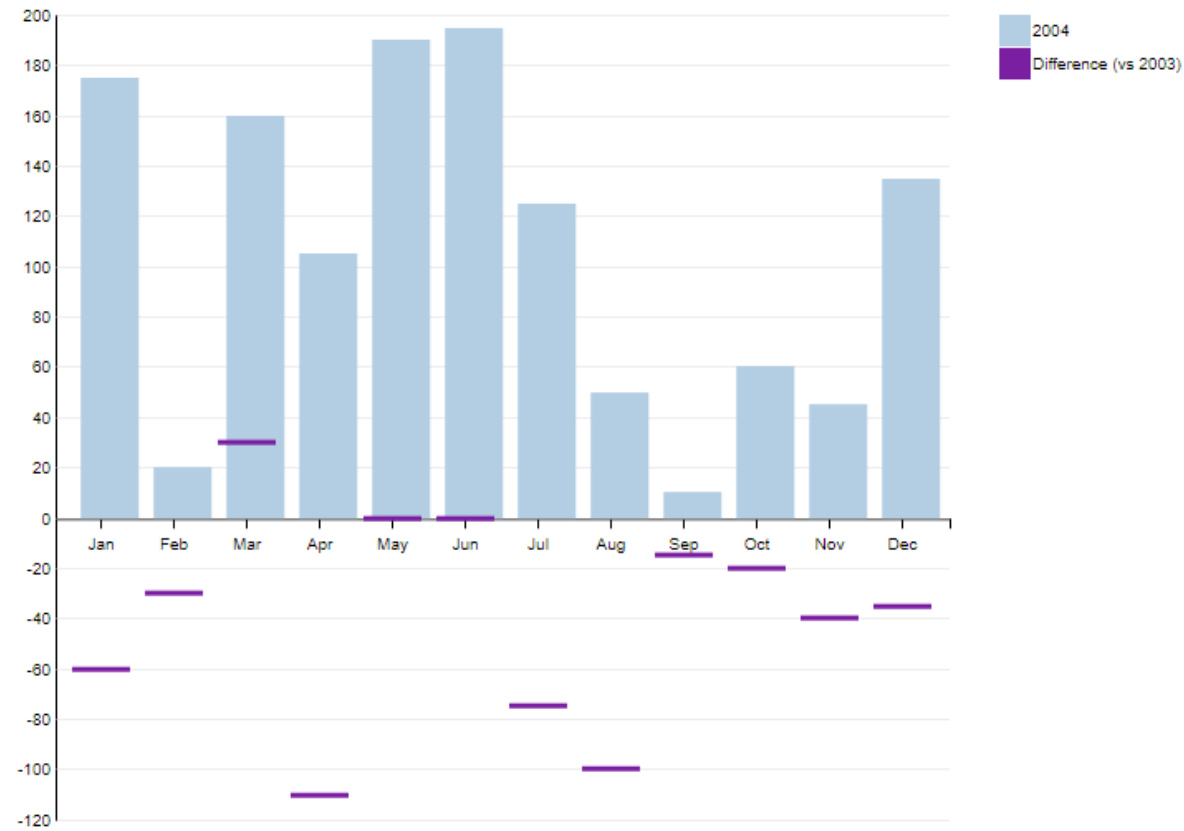
Training
Phase

Testing
Phase

Data Type 2
Introduction

Training
Phase

Testing
Phase



Selected: None

Trial 2 of 9 : Click on the month with the **maximum** value in **2004**.

Submit

Design
Introduction

Data Type 1
Introduction

Training
Phase

Testing
Phase

Data Type 2
Introduction

Training
Phase

Testing
Phase

✕ 4 visualizations

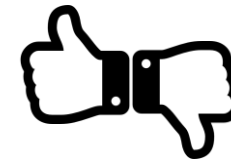
87 trials (28 training, 56 testing, 3 guess checking)



(time)

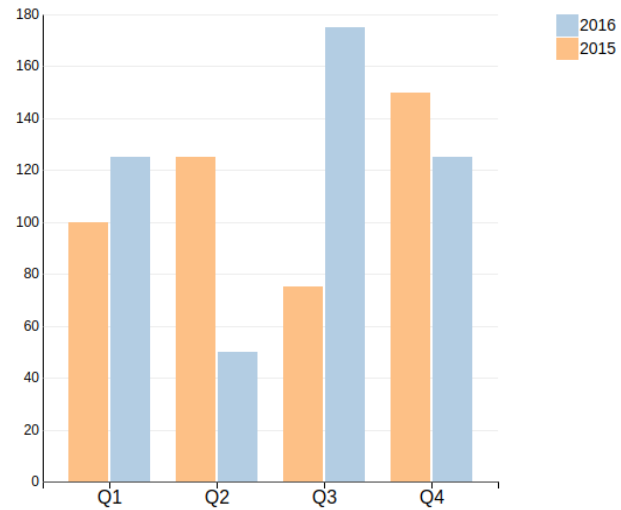


(error)

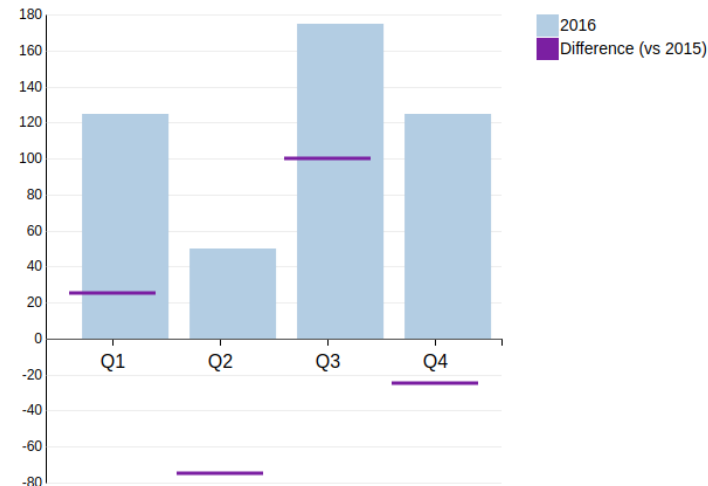
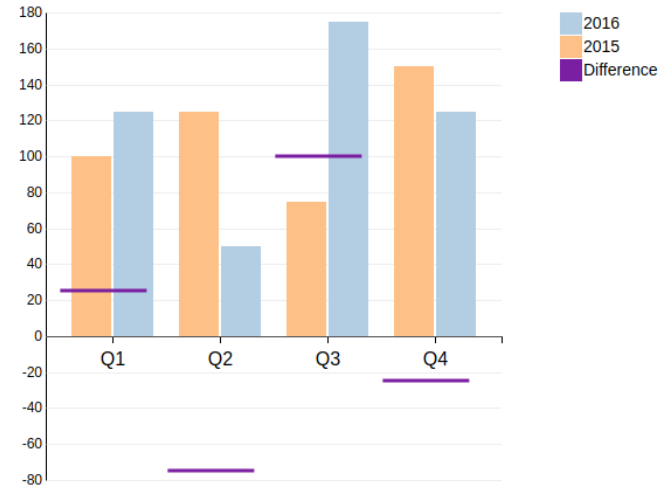


(subjective preferences)

Results



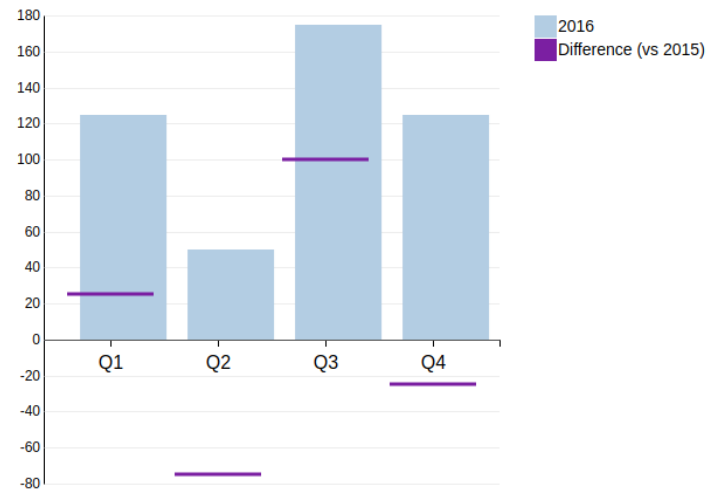
VS



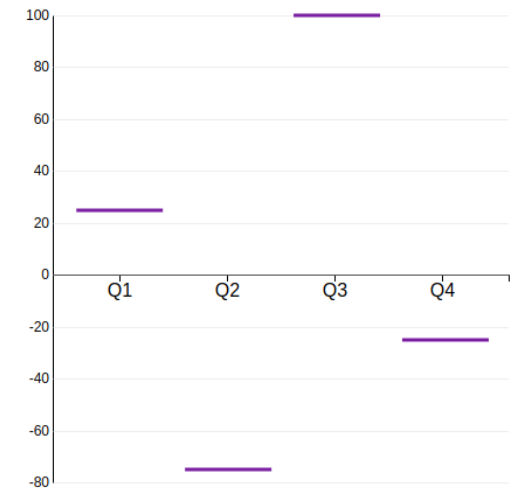
- **Comparable for value interpretation and varying data condition tasks.**
- Performance with **hybrid designs** was **better** for **difference-based** tasks.

Results

- **Comparable for difference-based tasks.**

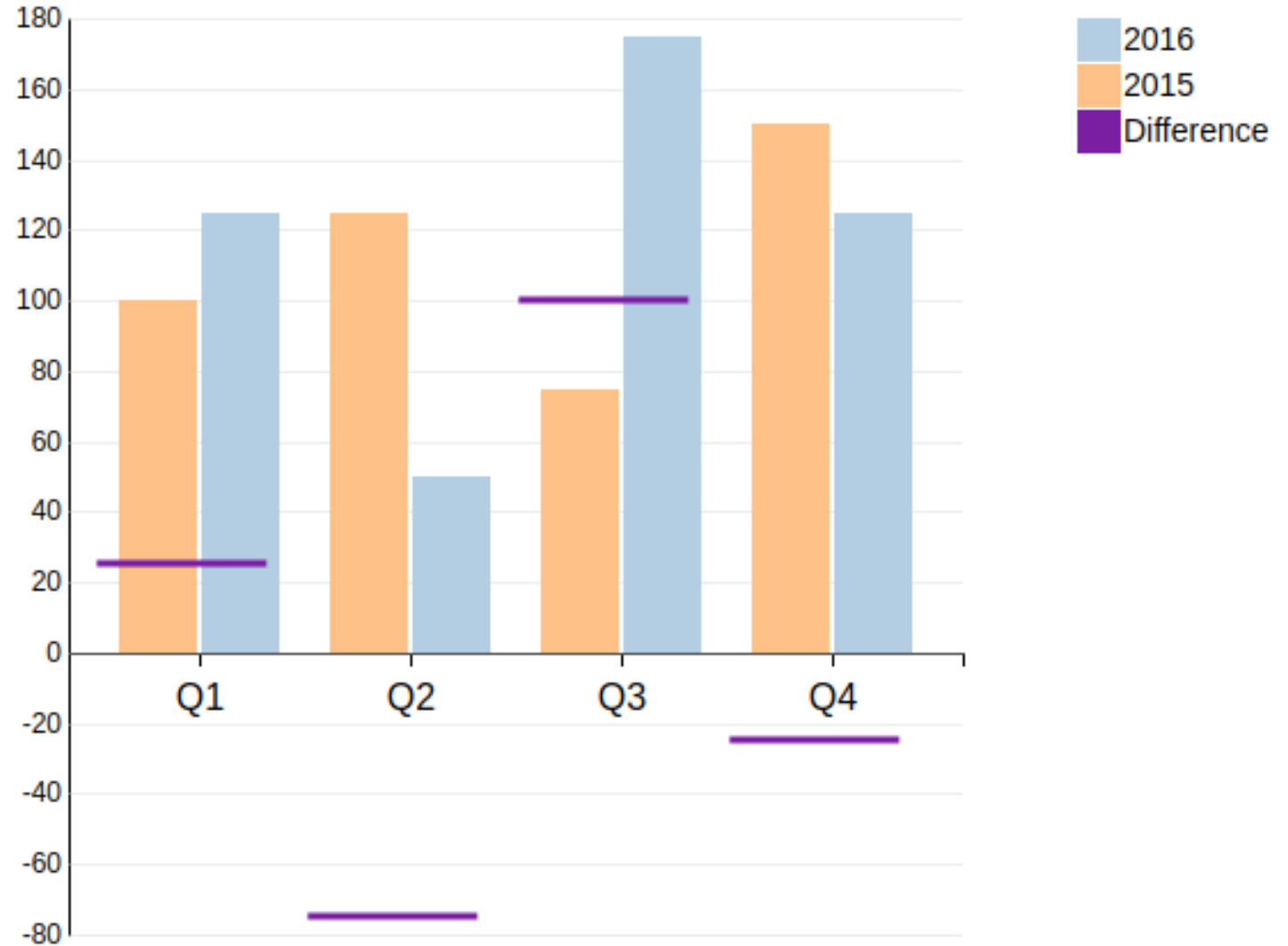


VS



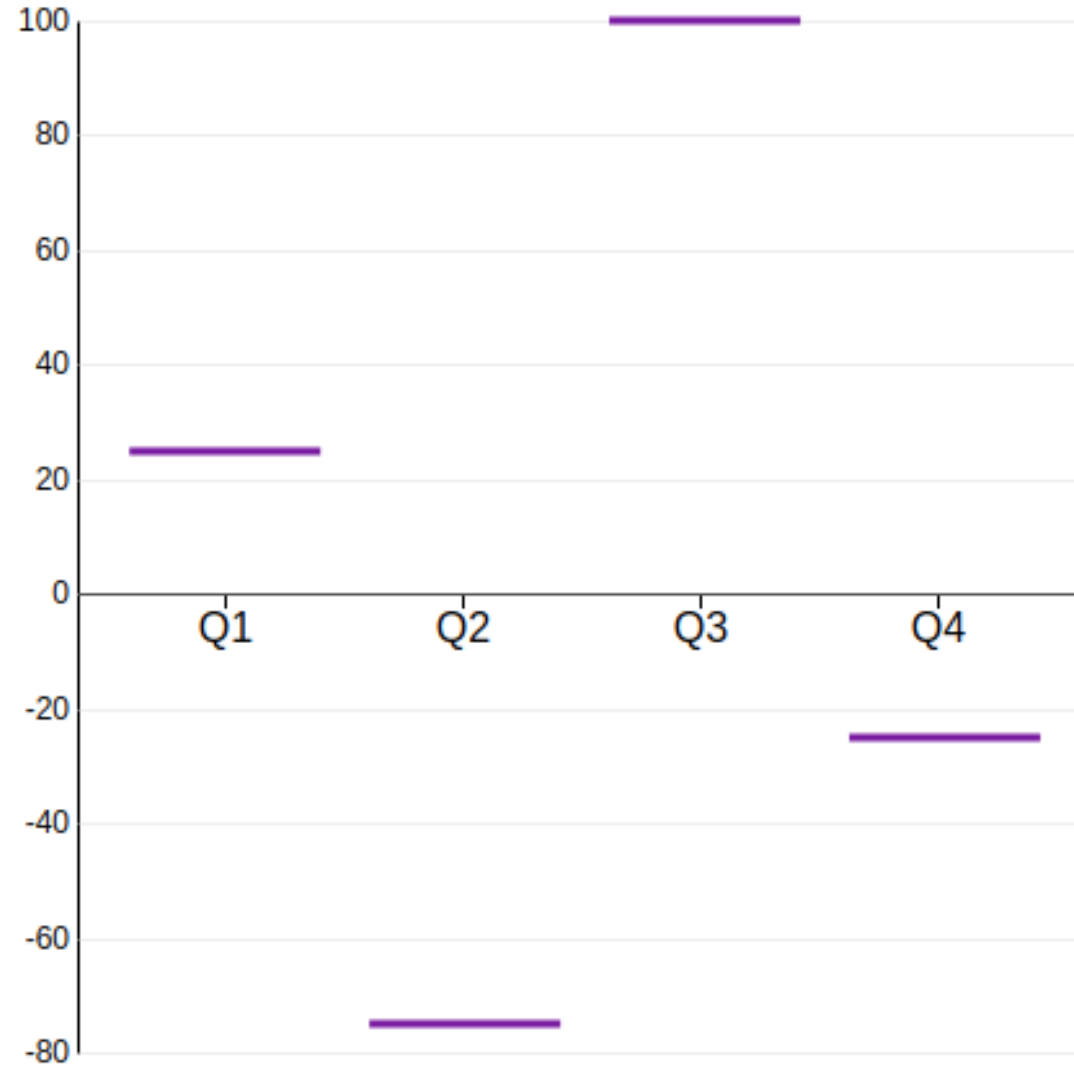
Results

Which of the four chart designs did you **prefer most**?



Results

Which of the four chart designs did you **prefer least**?



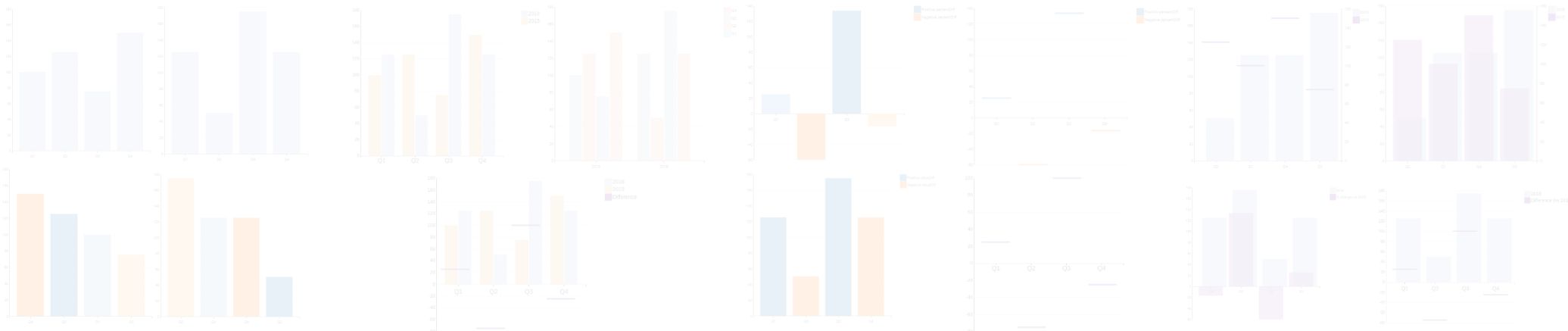
Interviews & Survey



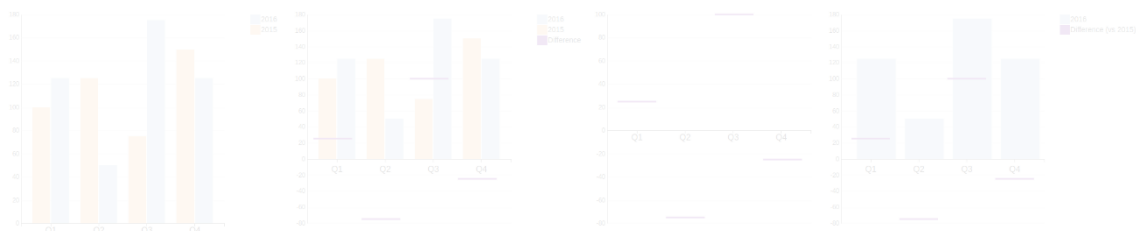
Power BI

+tableau+public

Exploration of
design alternatives



Evaluation



Extremes- Target

Extremes- Source

Max. Change

Value Difference

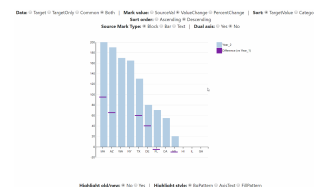
Old Categories

New Categories

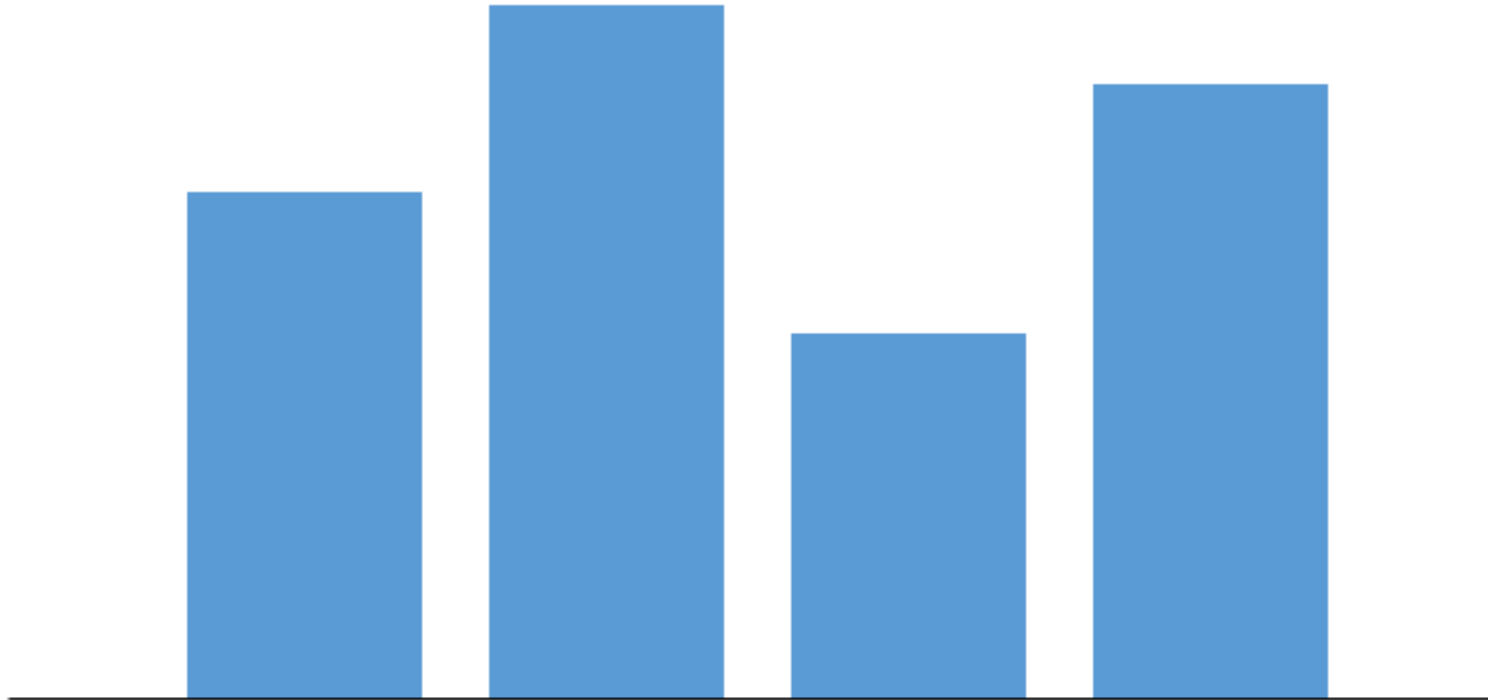
Constant

Varying

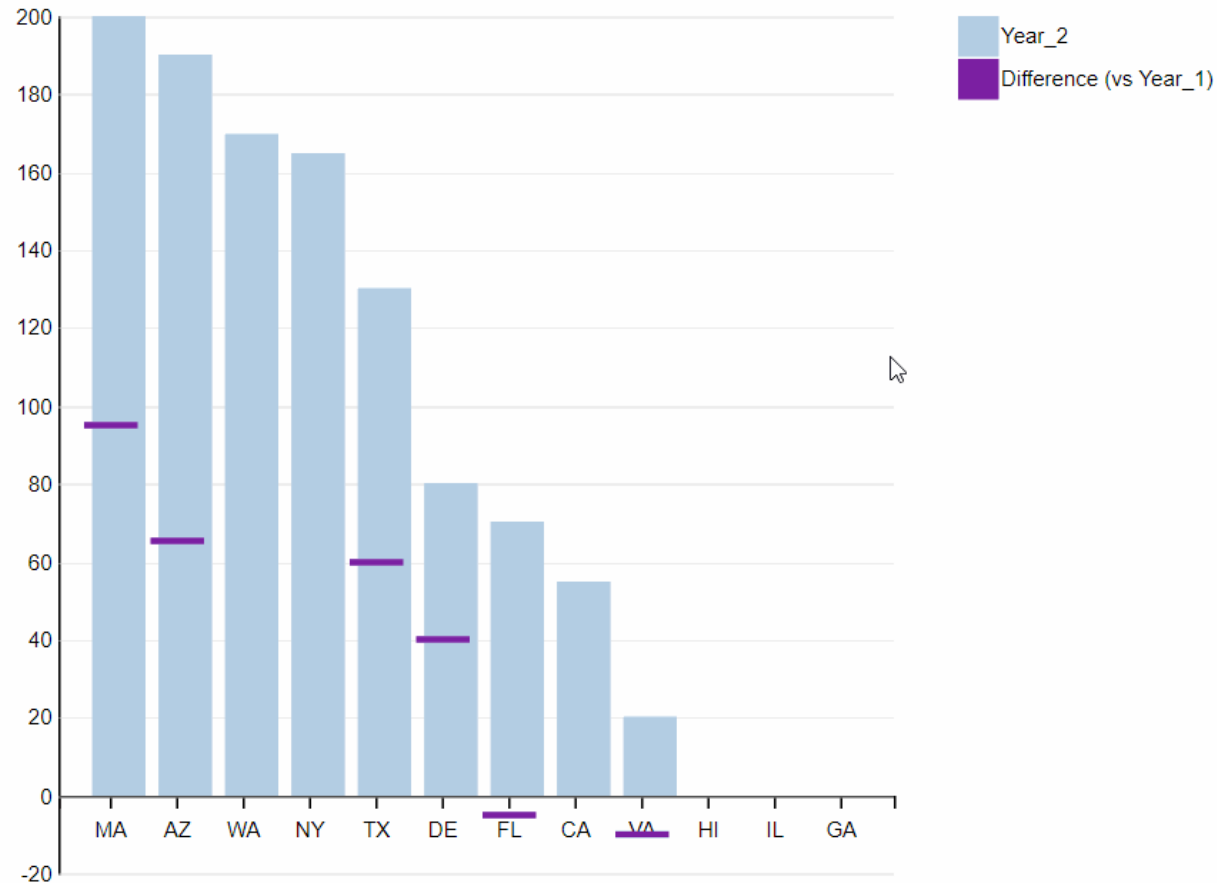
Applications &
Extensions



Revealing changes in narrative visualizations



Complementing overlays with annotations for missing values



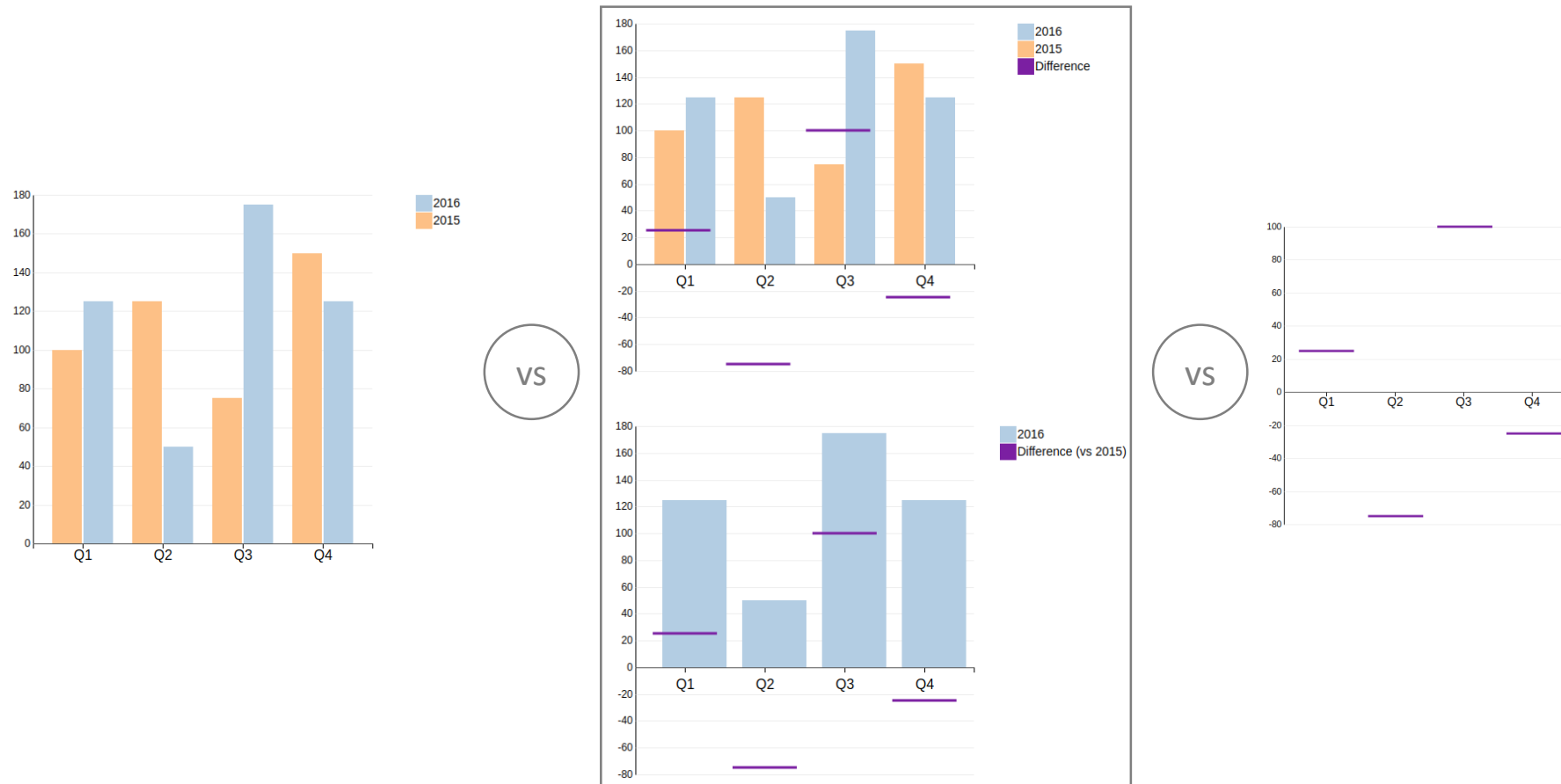
Highlight old/new: ☒ No ☐ Yes | **Highlight style:** ☒ BgPattern ☐ AxisText ☐ FillPattern

Summary

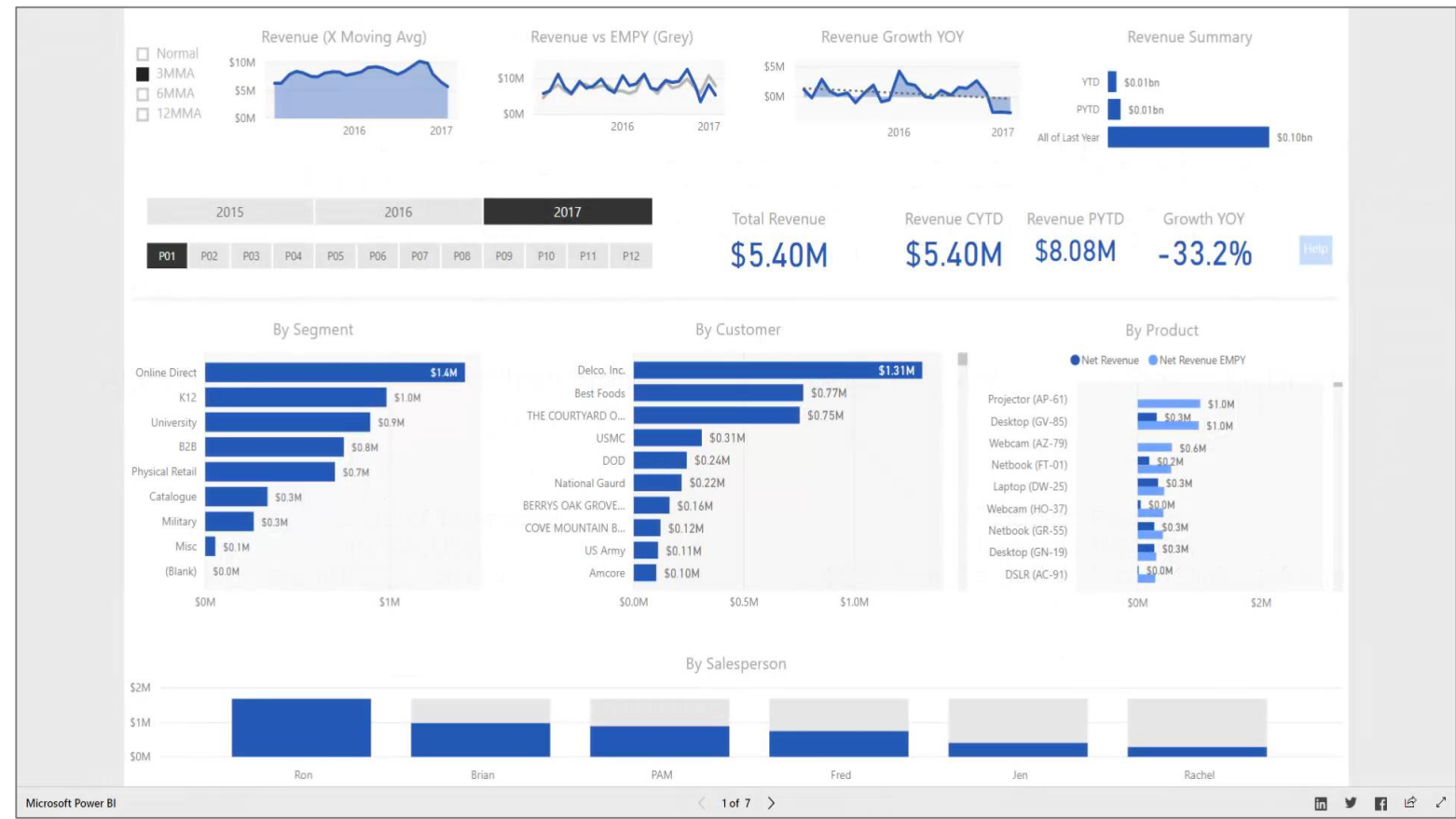
- **Visual comparison** is an **important** task in dashboards
- **Hybrid visualizations** combining design strategies **afford more tasks** while performing comparably on individual tasks.

Summary

- **Visual comparison** is an **important** task in dashboards
- **Hybrid visualizations** combining design strategies **afford more tasks** while performing comparably on individual tasks.



Thank You



Arjun Srinivasan
<http://arjun010.github.io/>



Matthew Brehmer



Bongshin Lee



Steven M. Drucker