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#libraries

library(ggplot2)
library(hrbrthemes)
library(scales)
library(readxl)
library(ggrepel)
library(ggthemes)
library(reshape2)
library(tidyr)
library(gridExtra)

#make sure to make a folder on your desktop that is named "Figure3" and contains the data files

setwd("~/Desktop/Figure3")

#spreadsheets in the Figure3 folder should be structured in a certain way, see the spreadsheet structures

Figure3a_EU <- read_excel("FigureData_ElectricUtilities.xlsx",sheet = "Metric1")
Figure3b_EU <- read_excel("FigureData_ElectricUtilities.xlsx",sheet = "Metric2A")
Figure3c_EU <- read_excel("FigureData_ElectricUtilities.xlsx",sheet = "Metric3")

Figure3d_CE <- read_excel("FigureData_Cement.xlsx",sheet = "Metric1")
Figure3e_CE <- read_excel("FigureData_Cement.xlsx",sheet = "Metric2A")
Figure3f_CE <- read_excel("FigureData_Cement.xlsx",sheet = "Metric3")

SuppFigure3_EU <- read_excel("FigureData_ElectricUtilities.xlsx",sheet = "SuppFig3")
SuppFigure4a_EU <- read_excel("FigureData_ElectricUtilities.xlsx",sheet = "SuppFig4_M2B")
SuppFigure4b_EU <- read_excel("FigureData_ElectricUtilities.xlsx",sheet = "SuppFig4_M2C")

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#####Figure 3a, d METRIC 1 (March 29 2022)
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#####ELECTRIC UTILITIES#####

plot_figure3a <- ggplot(Figure3a_EU, aes( x= Cumulative_Emissions, y = Metric1))+
  geom_point(fill="red", color="red", shape=16, alpha=0.5, size=14)+
  annotate("rect", xmin = -Inf, xmax = Inf, ymin = 1, ymax = Inf, alpha = 0.1, fill = "red")+
  geom_text(aes(label=rownames(Figure3a_EU)), size=12)+
  labs(size = "    MWh
      (2019 Millions)",title="",
      x="Cumulative emissions to date (Mt)",
      y="Proportion of Paris Compliant
Pathway emitted in 2021")+
  theme( legend.background = element_rect(fill = "white", color = "black"),
        axis.title=element_text(size=30,face="bold"),
        legend.text=element_text(size=20),
        axis.text=element_text(size=30),
        legend.box.background = element_rect(colour = "black"),
        legend.position = "right",
        text=element_text(size=10),
        plot.title = element_text(hjust = .5),
        axis.line = element_line(colour = "black"),

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    panel.border = element_rect(colour = "black", fill=NA, size=3),
    panel.background = element_blank(),
    plot.margin = unit(c(1,1,1,1),"cm")+
ggplot2::annotate("label", 150,1.7, label="exceeded PCP", color="red", size=8)+
geom_hline(yintercept=1, color="red", linetype="dashed", size=2)+
scale_size_continuous(range=c(5,35))+
scale_x_continuous(breaks=seq(0,300,100), limits=c(0,300), expand = expansion(mult = 0, 0.05))+
scale_y_continuous(breaks=seq(0.4,1.8,0.2), limits=c(0.4,1.8), expand = expansion(mult = 0, 0.05))

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plot_figure3a

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#####CEMENT#####
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plot_figure3d <- ggplot(Figure3d_CE, aes( x= Cumulative_Emissions, y = Metric1))+
  geom_point(fill="blue", color="blue", shape=17, alpha=0.5, size=14)+
  annotate("rect", xmin = -Inf, xmax = Inf, ymin = 1, ymax = Inf, alpha = .1, fill = "red")+
  geom_text(aes(label=rownames(Figure3d_CE)), size=12)+
  labs(size = "    MWh
    (2019 Millions)",title="",
    x="Cumulative emissions to date (Mt)",
    y="Proportion of Paris Compliant
Pathway emitted in 2020")+
  theme( legend.background = element_rect(fill = "white", color = "black"),
    axis.title=element_text(size=30,face="bold"),
    legend.text=element_text(size=20),
    axis.text=element_text(size=30),
    legend.box.background = element_rect(colour = "black"),
    legend.position = "right",
    text=element_text(size=15),
    plot.title = element_text(hjust = 0.5),
    axis.line = element_line(colour = "black"),
    panel.border = element_rect(colour = "black", fill=NA, size=3),
    panel.background = element_blank(),
    plot.margin = unit(c(1,1,1,1),"cm")+
ggplot2::annotate("label", 150,1.6, label="exceeded PCP", color="red", size=8)+
geom_hline(yintercept=1, color="red", linetype="dashed", size=2)+
scale_size_continuous(range=c(5,35))+
scale_x_continuous(breaks=seq(0,900,300), limits=c(0,900), expand = expansion(mult = 0, 0.05))+
scale_y_continuous(breaks=seq(0.4,2.4,0.2), limits=c(0.4,2.4), expand = expansion(mult = 0, 0.05))

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plot_figure3d

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#####Figure 3b, e METRIC 2(a) (March 29 2022)#####
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##### Figure 3b ELECTRIC UTILITIES #####
figure3b <- ggplot(Figure3b_EU, aes(x = Cumulative_Emissions, y = EYF))+
  geom_point(fill="red", color="red", shape=16, alpha=0.5, size=14)+
  annotate("rect", xmin = -Inf, xmax = Inf, ymin = 2015, ymax = 2050, alpha = .1, fill = "red")+
  geom_text(aes(label=rownames(Figure3b_EU)), size=12)+
  labs(size = "",title="",
    x="Cumulative emissions to date (Mt)",
    y="Estimated Year to Finish (EYF)")+
  theme( legend.background = element_rect(fill = "white", color = "black"),
    axis.title=element_text(size=30,face="bold"),
    legend.text=element_text(size=20),
    axis.text=element_text(size=30),
    legend.box.background = element_rect(colour = "black"),

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    legend.position = "right",
    text=element_text(size=15),
    plot.title = element_text(hjust = 0.5),
    axis.line = element_line(colour = "black"),
    panel.border = element_rect(colour = "black", fill=NA, size=3),
    panel.background = element_blank(),
    plot.margin = unit(c(1,1,1,1),"cm")+
    geom_hline(yintercept=2060, color="red", linetype="dashed", size=2)+
    scale_size_continuous(range=c(5,35))+
    scale_y_continuous(breaks=seq(2015,2055,10), limits=c(2015,2060), expand = expansion(mult =
0, 0.05))+
    scale_x_continuous(breaks=seq(0,300,100), limits=c(0,300), expand = expansion(mult = 0, 0.05))

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figure3b

Figure 3e CEMENT#####

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figure3e <- ggplot(Figure3e_CE, aes(x = Cumulative_Emissions, y = EYF))+
geom_point(fill="blue", color="blue", shape=17, alpha=0.5, size=14)+
annotate("rect", xmin = -Inf, xmax = Inf, ymin = 2015, ymax = 2060, alpha = .1, fill = "red")+
geom_text(aes(label=rownames(Figure3b_EU)), size=12)+
labs(size = "",title="",
      x="Cumulative emissions to date (Mt)",
      y="Estimated Year to Finish (EYF)")+
theme( legend.background = element_rect(fill = "white", color = "black"),
      axis.title=element_text(size=30,face="bold"),
      legend.text=element_text(size=20),
      axis.text=element_text(size=30),
      legend.box.background = element_rect(colour = "black"),
      legend.position = "right",
      text=element_text(size=15),
      plot.title = element_text(hjust = 0.5),
      axis.line = element_line(colour = "black"),
      panel.border = element_rect(colour = "black", fill=NA, size=3),
      panel.background = element_blank(),
      plot.margin = unit(c(1,1,1,1),"cm")+
      geom_hline(yintercept=2060, color="red", linetype="dashed", size=2)+
      scale_size_continuous(range=c(5,35))+
      scale_y_continuous(breaks=seq(2015,2065,10), limits=c(2015,2070), expand = expansion(mult = 0,
0.1))+
      scale_x_continuous(breaks=seq(0,900,300), limits=c(0,900), expand = expansion(mult = 0, 0.1))

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figure3e

#####Figure 3c, f METRIC 2(a) (March 29 2022)
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Figure 3c ELECTRIC UTILITIES

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figure3c <- ggplot(Figure3c_EU, aes(x=Cumulative_Emissions, y=Metric3))+
geom_point(fill="red", color="red", shape=16, alpha=0.5, size=14)+
geom_text(aes(label=rownames(Figure3c_EU)), size=12)+
labs(title="",
      x="Cumulative emissions to date (Mt)",
      y="Required decarbonisation rate multiplier
to meet carbon budget")+
theme(axis.ticks.x = element_blank(),

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axis.ticks.y = element_blank(),
legend.background = element_rect(fill = "white", color = "black"),
axis.title=element_text(size=30,face="bold"),
legend.text=element_text(size=20),
axis.text=element_text(size=30),
legend.box.background = element_rect(colour = "black"),
legend.position = "right",
text=element_text(size=20),
plot.title = element_text(hjust = 0.5),
axis.line = element_line(colour = "black"),
panel.border = element_rect(colour = "black", fill=NA, size=3),
panel.background = element_blank(),
plot.margin = unit(c(1,1,1,1),"cm")+
scale_y_continuous(breaks=seq(0,6, 2), limits=c(0, 6), expand = expansion(mult = 0, 0.1))+
scale_x_continuous(breaks=seq(0, 300, 100), limits=c(0, 300), expand = expansion(mult = 0, 0.1))

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figure3c

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figure3f <- ggplot(Figure3f_CE, aes(x=Cumulative_Emissions, y=Metric3))+
geom_point(fill="blue", color="blue", shape=17, alpha=0.5, size=14)+
geom_text(aes(label=rownames(Figure3f_CE)), size=12)+
labs(title="",
x="Cumulative emissions to date (Mt)",
y="Required decarbonisation rate multiplier
to meet carbon budget")+
theme(axis.ticks.x = element_blank(),
axis.ticks.y = element_blank(),
legend.background = element_rect(fill = "white", color = "black"),
axis.title=element_text(size=30,face="bold"),
legend.text=element_text(size=20),
axis.text=element_text(size=30),
legend.box.background = element_rect(colour = "black"),
legend.position = "right",
text=element_text(size=20),
plot.title = element_text(hjust = 0.5),
axis.line = element_line(colour = "black"),
panel.border = element_rect(colour = "black", fill=NA, size=3),
panel.background = element_blank(),
plot.margin = unit(c(1,1,1,1),"cm")+
scale_y_continuous(breaks=seq(0,6, 2), limits=c(0, 6), expand = expansion(mult = 0, 0.1))+
scale_x_continuous(breaks=seq(0, 900, 300), limits=c(0, 900), expand = expansion(mult = 0, 0.1))

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figure3f

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##### SUPPLEMENTARY FIGURES
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plot_supfig3 <- ggplot(SuppFigure3_EU, aes( x= Cumulative_Emissions, y = ACTexceedance))+
geom_point(fill="red", color="red", shape=16, alpha=0.5, size=14)+
annotate("rect", xmin = -Inf, xmax = Inf, ymin = 1, ymax = Inf, alpha = 0.1, fill = "red")+
geom_text(aes(label=rownames(SuppFigure3_EU)), size=12)+
labs(size = " MWh
(2019 Millions)",title="",
x="Cumulative emissions to date (Mt)",
y="Proportion of Carbon Budget
emitted in 2050")+
theme( legend.background = element_rect(fill = "white", color = "black"),
axis.title=element_text(size=30,face="bold"),

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legend.text=element_text(size=20),
axis.text=element_text(size=30),
legend.box.background = element_rect(colour = "black"),
legend.position = "right",
text=element_text(size=10),
plot.title = element_text(hjust = .5),
axis.line = element_line(colour = "black"),
panel.border = element_rect(colour = "black", fill=NA, size=3),
panel.background = element_blank(),
plot.margin = unit(c(1,1,1,1),"cm")+
ggplot2::annotate("label", 150,1.7, label="exceeded PCP", color="red", size=8)+
geom_hline(yintercept=1, color="red", linetype="dashed", size=2)+
scale_size_continuous(range=c(5,35))+
scale_x_continuous(breaks=seq(0,300,100), limits=c(0,300), expand = expansion(mult = 0, 0.05))+
scale_y_continuous(breaks=seq(0.4,1.8,0.2), limits=c(0.4,1.8), expand = expansion(mult = 0, 0.05))

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plot_supfig3

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plot_supfig4a <- ggplot(SuppFigure4a_EU, aes( x= Cumulative_Emissions, y = Metric2B))+
geom_point(fill="red", color="red", shape=16, alpha=0.5, size=14)+
annotate("rect", xmin = -Inf, xmax = Inf, ymin = 0, ymax = Inf, alpha = 0.1, fill = "red")+
geom_text(aes(label=rownames(SuppFigure3_EU)), size=12)+
labs(size = "      MWh
      (2019 Millions)",title="",
      x="Cumulative emissions to date (Mt)",
      y="Production levels in EYF
      (Millions of MWh)")+
theme( legend.background = element_rect(fill = "white", color = "black"),
      axis.title=element_text(size=30,face="bold"),
      legend.text=element_text(size=20),
      axis.text=element_text(size=30),
      legend.box.background = element_rect(colour = "black"),
      legend.position = "right",
      text=element_text(size=10),
      plot.title = element_text(hjust = .5),
      axis.line = element_line(colour = "black"),
      panel.border = element_rect(colour = "black", fill=NA, size=3),
      panel.background = element_blank(),
      plot.margin = unit(c(1,1,1,1),"cm")+
ggplot2::annotate("label", 150,1.7, label="exceeded PCP", color="red", size=8)+
geom_hline(yintercept=1, color="red", linetype="dashed", size=2)+
scale_size_continuous(range=c(5,35))+
scale_x_continuous(breaks=seq(0,300,100), limits=c(0,300), expand = expansion(mult = 0, 0.05))+
scale_y_continuous(breaks=seq(0,40,10), limits=c(0,40), expand = expansion(mult = 0, 0.05))

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plot_supfig4a

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plot_supfig4b <- ggplot(SuppFigure4b_EU, aes( x= Cumulative_Emissions, y = Metric2B))+
geom_point(fill="red", color="red", shape=16, alpha=0.5, size=14)+
annotate("rect", xmin = -Inf, xmax = Inf, ymin = 1, ymax = Inf, alpha = 0.1, fill = "red")+
geom_text(aes(label=rownames(SuppFigure3_EU)), size=12)+
labs(size = "      MWh
      (2019 Millions)",title="",
      x="Cumulative emissions to date (Mt)",
      y="Proportion of Carbon Budget
      Emitted in 2050")+
theme( legend.background = element_rect(fill = "white", color = "black"),
      axis.title=element_text(size=30,face="bold"),

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legend.text=element_text(size=20),
axis.text=element_text(size=30),
legend.box.background = element_rect(colour = "black"),
legend.position = "right",
text=element_text(size=10),
plot.title = element_text(hjust = .5),
axis.line = element_line(colour = "black"),
panel.border = element_rect(colour = "black", fill=NA, size=3),
panel.background = element_blank(),
plot.margin = unit(c(1,1,1,1),"cm")+
ggplot2::annotate("label", 150,1.7, label="exceeded PCP", color="red", size=8)+
geom_hline(yintercept=1, color="red", linetype="dashed", size=2)+
scale_size_continuous(range=c(5,35))+
scale_x_continuous(breaks=seq(0,300,100), limits=c(0,300), expand = expansion(mult = 0, 0.05))+
scale_y_continuous(breaks=seq(0,4,1), limits=c(0,4), expand = expansion(mult = 0, 0.05))
```

plot_suppfig4b