

# Technical and economical analysis of an electric vehicle including design of a charging station fed by renewable energy

Studienarbeit von Mirco Zeiss

Tag der Einreichung:

1. Gutachten: Prof. #1
2. Gutachten: Prof. #2



TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

Department of Electrical Engineering  
and Information Technology  
Electrical Energy Conversion

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Vorgelegte Studienarbeit von Mirco Zeiss

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## Todo list

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Translate text to english . . . . .	7
Something else to do . . . . .	7

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## Contents

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<b>List of Figures</b>	<b>III</b>
<b>List of Tables</b>	<b>IV</b>
<b>1 Equations</b>	<b>1</b>
<b>2 Acronyms</b>	<b>2</b>
<b>3 Citations</b>	<b>3</b>
<b>4 Page numbering</b>	<b>4</b>
<b>5 Table</b>	<b>5</b>
<b>6 To-do notes</b>	<b>7</b>
<b>7 Images</b>	<b>8</b>
<b>8 Bar charts</b>	<b>9</b>
8.1 Simple bar chart . . . . .	9
8.2 Stacked bar chart . . . . .	10
8.3 Grouped bar chart . . . . .	11
<b>9 Pie chart</b>	<b>12</b>
<b>10 Line graph</b>	<b>13</b>
<b>11 Two y-axes</b>	<b>14</b>
<b>12 Text replacement</b>	<b>15</b>
<b>13 Electronic circuits</b>	<b>16</b>

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## List of Figures

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7.1	The Mitsubishi i-MiEV . . . . .	8
8.1	New electric vehicles between Januar 2010 and Januar 2011 . . . . .	9
8.2	Energy production in Austria . . . . .	10
8.3	CO <sub>2</sub> savings from wind turbines . . . . .	11
9.1	Break down of the CO <sub>2</sub> emissions of a wind turbine . . . . .	12
10.1	Weibull distribution with varying scaling factor . . . . .	13
11.1	Covered distance and immobilization time between trips of my awesome electric vehicle . . . . .	14
12.1	Geometric conditions between solar irradiation and alignment of the photovoltaic panel . . . . .	15
13.1	One diode equivalent circuit of a real solar cell . . . . .	16

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## List of Tables

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5.1	Economic situation in Austria . . . . .	5
5.2	Technical Data of the Mitsubishi i-MiEV . . . . .	6

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## Acronyms

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CO <sub>2</sub>	Carbon dioxide
NEDC	New European Driving Cycle
ROR	Run-of-the-river hydroelectricity

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## Nomenclature

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$D$		Examination days
$H_{SR}$		Hour angle at sunrise (+) and sunset (-)
$L$	$^{\circ}$	Latitude
$SC$	$W/m^2$	Solar constant
$\bar{I}_0$	$kWh/m^2$ per day	Average solar irradiance
$\delta$	$^{\circ}$	Declination of the sun
$n$		Day in a year



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## 1 Equations

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Equation for extraterrestrial radiation with  $\bar{I}_0$ ,  $SC$ ,  $n$ ,  $L$ ,  $\delta$  and  $H_{SR}$ .

$$\bar{I}_0 = \frac{24}{\pi} SC \left[ 1 + 0,034 \cos \left( \frac{360n}{365} \right) \right] (\cos L \cos \delta \sin H_{SR} + H_{SR} \sin L \sin \delta) \quad (1.1)$$

Equation for average wind power.

$$\bar{P}_w = \frac{c_1}{T} \int_0^T v_w^3 dt \neq c_1 \left( \frac{1}{T} \int_0^T v_w dt \right)^3 = c_1 \cdot \bar{v}_w^3. \quad (1.2)$$

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## 2 Acronyms

---

Use package glossaries.

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### 3 Citations

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This could be a sentence from a book.[wagner2010]

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## 4 Page numbering

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The template consists of four parts.

The first part includes the title and second page and doesn't have any page numbers.

The second part consists of the table of contents, list of figures, list of tables, acronyms and symbols. It has roman page numbers and starts at **I**.

The third part contains the main content. It has arabic page numbers and starts at **1**.

The fourth and last part includes the bibliography. It has roman page numbers and continues the counting from part two.

The title and second page don't have any page numbers. It is therefore important to start with the roman page numbering below the command `\makethesistitle`. Otherwise L<sup>A</sup>T<sub>E</sub>X will throw warnings like

```
pdfTeX warning (ext4):
```

```
destination with the same identifier (name{page.}) has been already used,
```

```
duplicate ignored
```

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## 5 Table

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Table 5.1 shows a simple example with footnotes.

**Table 5.1:** Economic situation in Austria  
[verbraucher2011, prognose2011]

Year	Inflation rate in % <sup>1</sup>	Price trend <sup>2</sup>
2000	2,3	125,7
2001	2,7	129,1
2002	1,8	131,5
2003	1,3	133,2
2004	2,1	136,0
2005	2,3	139,1
2006	1,5	141,2
2007	2,2	144,3
2008	3,2	148,9
2009	0,5	149,6
2010	1,9	152,4
2011 <sup>3</sup>	2,1	155,6
2012 <sup>3</sup>	1,8	158,4

<sup>1</sup> Consumer price index

<sup>2</sup> Index 1990 = 100

<sup>3</sup> Forecast value

Table 5.2 shows a more complex example

**Table 5.2:** Technical data of the Mitsubishi i-MiEV [imiev\_daten]

Description	Specification	Value
Dimensions	Length	3475 mm
	Width	1475 mm
	Height	1610 mm
	Wheel base	2550 mm
Load capacity	Luggage space	227 / 860 liters
	Curb weight	1110 kg
	Permissible maximum weight	1450 kg
	Payload	340 kg
	Seats	4 People
Driving characteristics	Energy consumption	135 Wh/km
	Range	150 km <sup>1</sup>
	max. Velocity	130 km/h
Battery data	Nominal voltage	330 V
	Electric charge	50 Ah
	Theoret. energy	16500 Wh
	Mass	165 kg
	Energy density	100 Wh/kg
Motor data	Typ	Permanent Synchronous Motor
	Nominal power	35 kW
	max. Torque	180 Nm

<sup>1</sup> Data measured in NEDC

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## 6 To-do notes

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Very useful while writing the thesis. Don't forget to delete them before printing the final copy.

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Translate text to english

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Something else to do

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## 7 Images

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Figure 7.1 shows two pictures side by side with one caption.



**Figure 7.1:** The Mitsubishi i-MiEV [mmd2010]



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## 8 Bar charts

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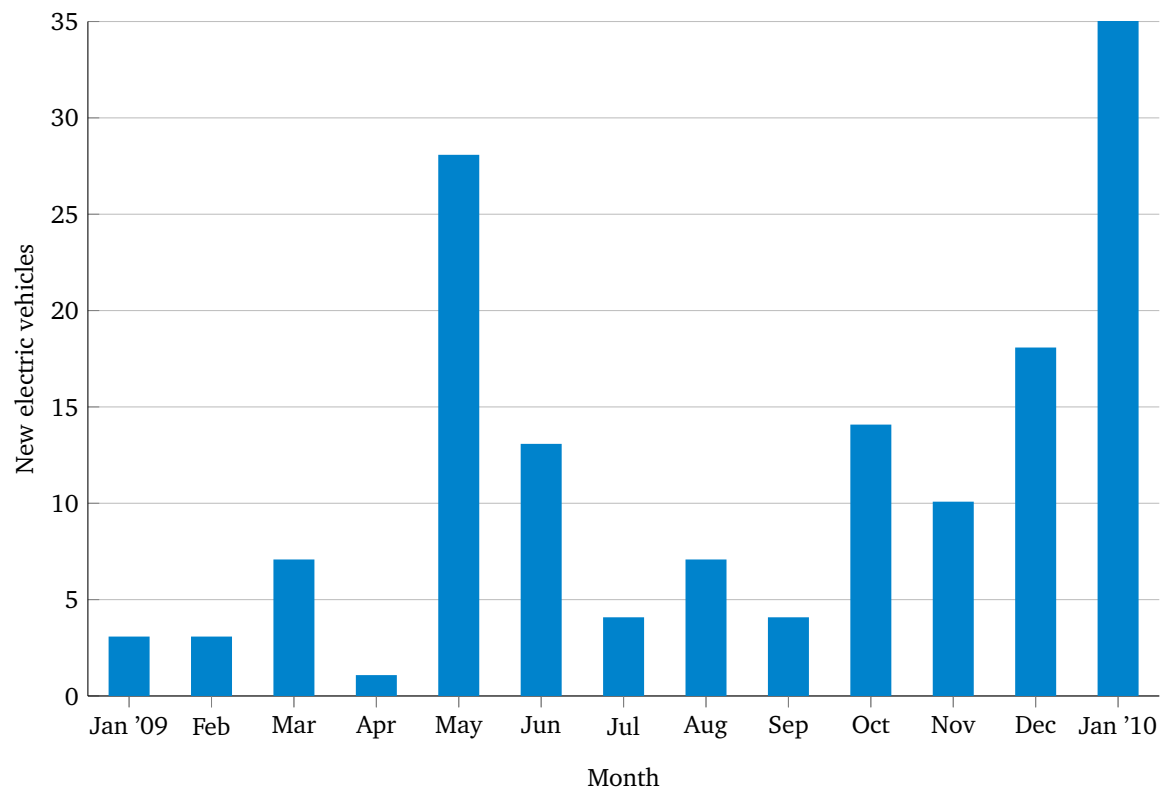
This chapter shows how to render a simple bar chart, a stacked bar chart and a grouped bar chart.

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### 8.1 Simple bar chart

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Figure 8.1 shows a simple bar chart.



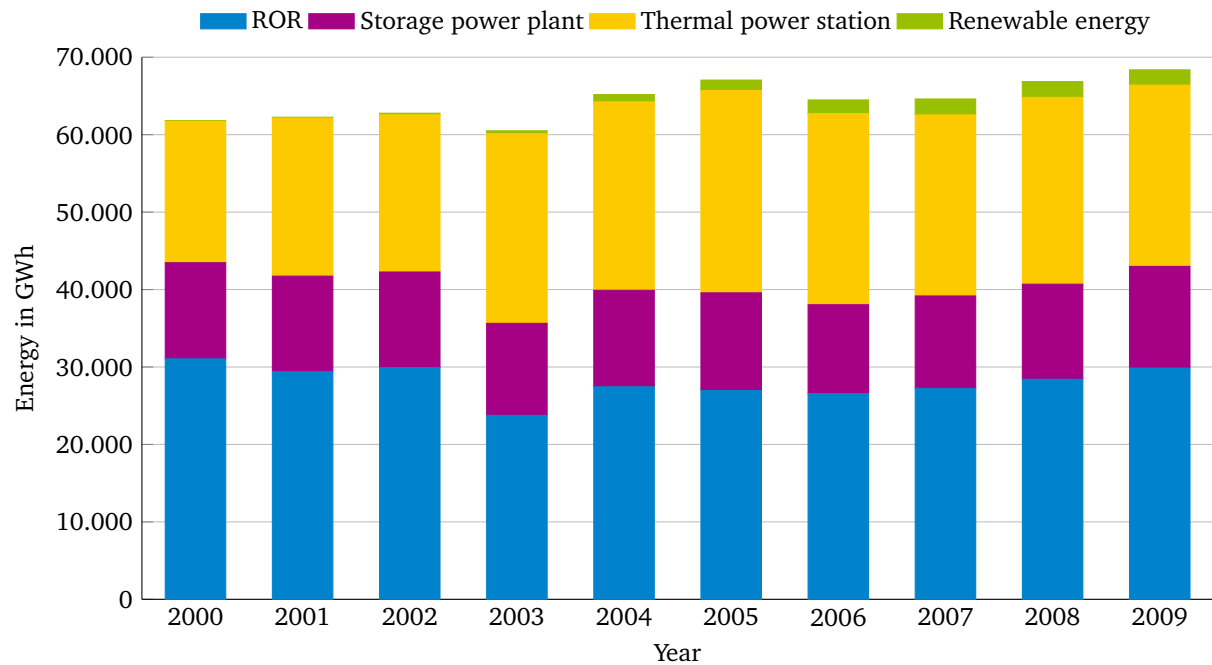
**Figure 8.1:** New electric vehicles between Januar 2010 and Januar 2011 [sa-neuzulassungen]

---

## 8.2 Stacked bar chart

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Figure 8.2 shows a stacked bar chart. Data from Energy Control Austria. Chart shows energy production from Run-of-the-river hydroelectricity (ROR), Storage power plant, Thermal power station and Renewable energy.



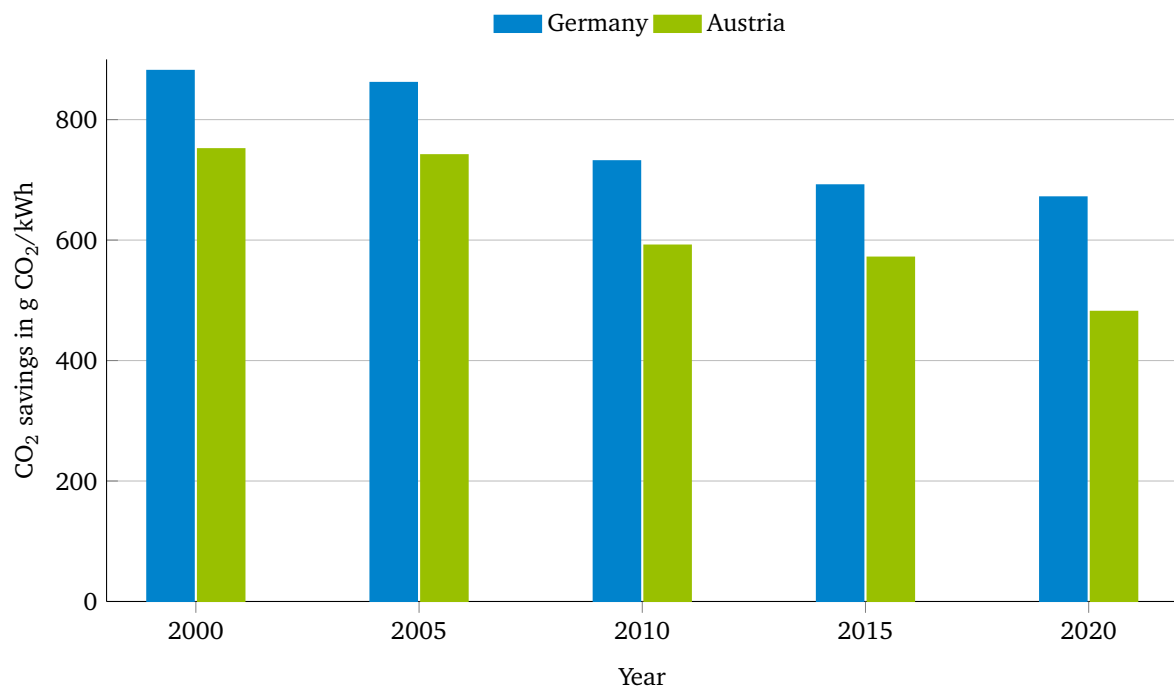
**Figure 8.2:** Energy production in Austria [econtrol2011]

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### 8.3 Grouped bar chart

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Figure 8.3 shows a grouped bar chart. some ref to co2 CO<sub>2</sub>. Taken from Systemmodell zur Optimierung der Integration von Windenergieanlagen in Österreich und Deutschland page 126



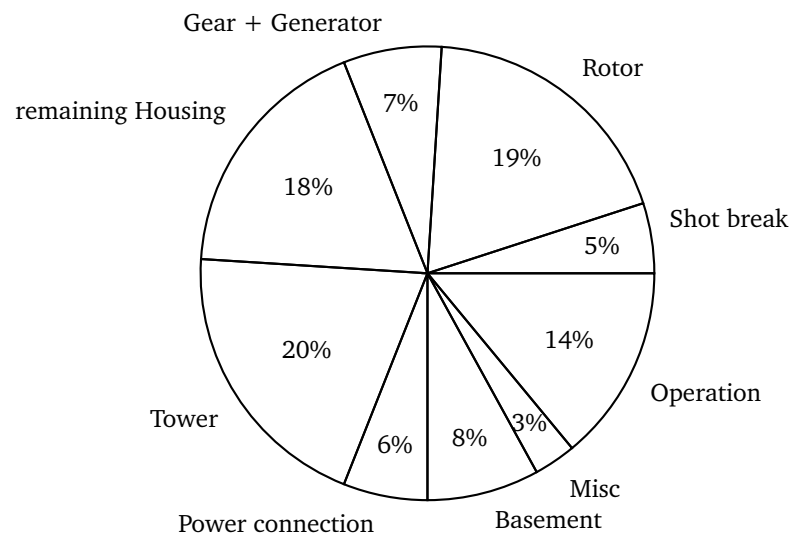
**Figure 8.3:** CO<sub>2</sub> savings from wind turbines in Germany and Austria [auer06]

---

## 9 Pie chart

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Figure 9.1 shows a pie chart.



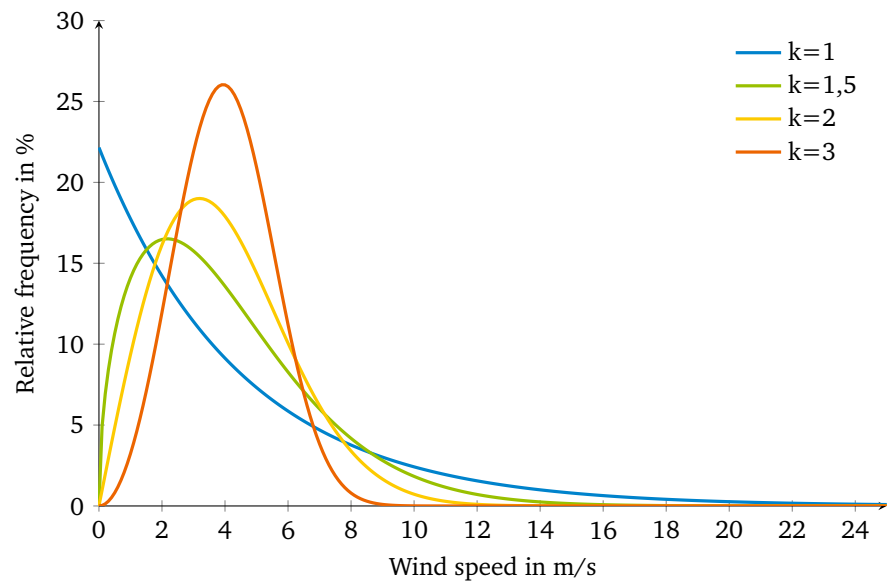
**Figure 9.1:** Break down of the CO<sub>2</sub> emissions of a wind turbine [kaltschmitt2006]

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## 10 Line graph

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Figure 10.1 shows a line graph.



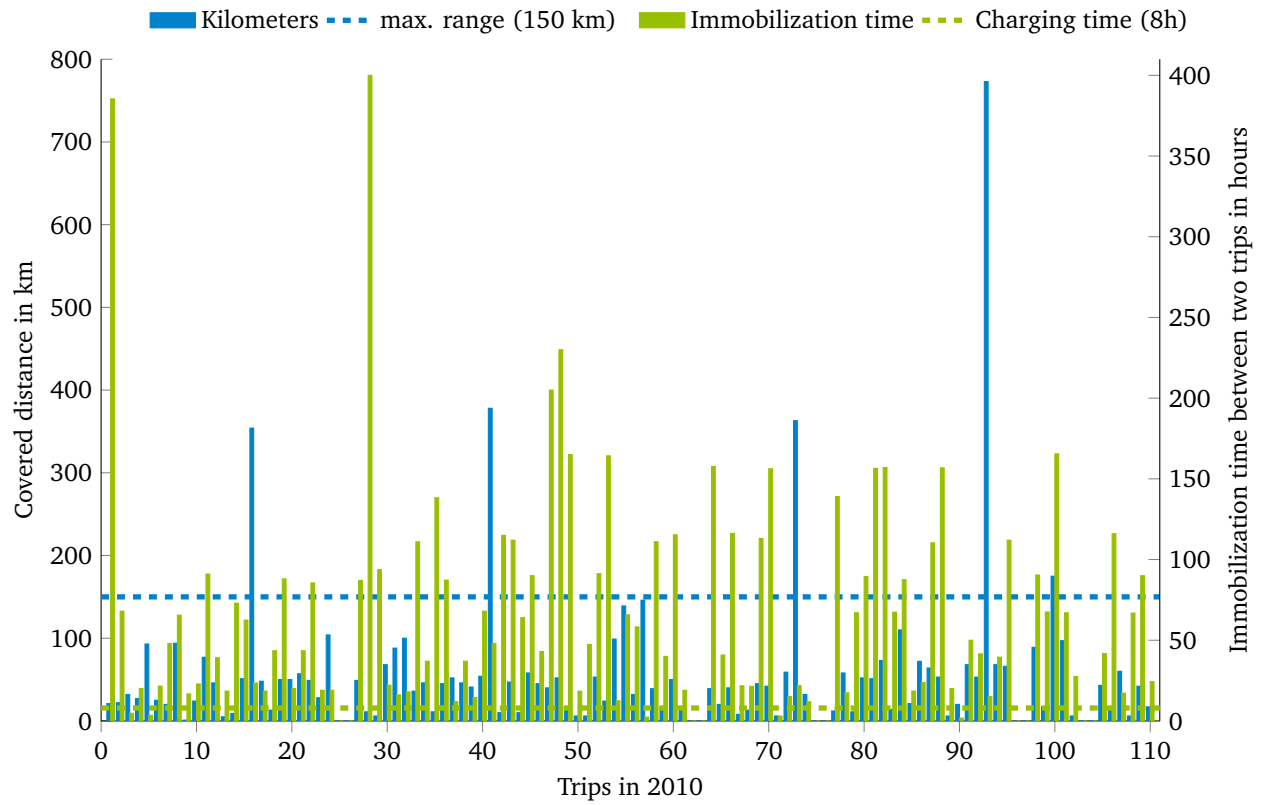
**Figure 10.1:** Weibull distribution with varying scaling factor  $\bar{v}_w = 4 \text{ m/s}$ , scaling factor  $A = 4,51 \text{ m/s}$  and varying form parameter  $k$

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## 11 Two y-axes

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One on the left and one on the right side.



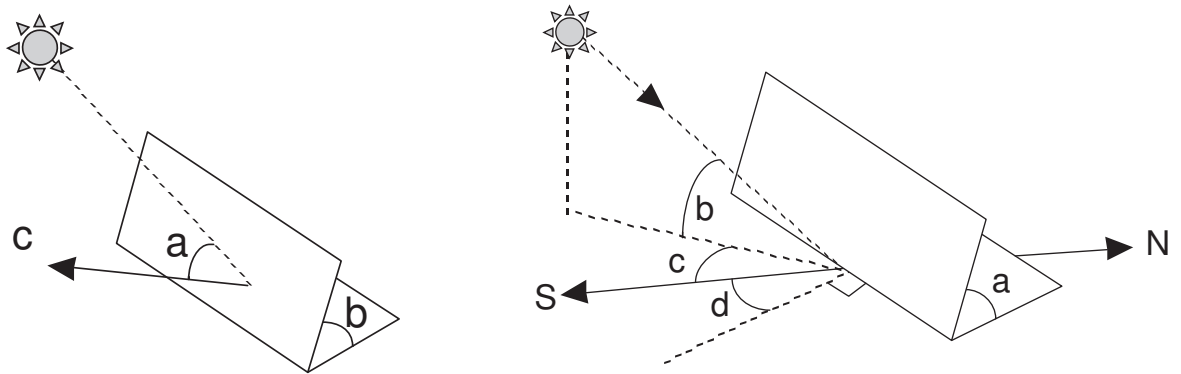
**Figure 11.1:** Covered distance per trip and immobilization time between two trips of my awesome electric vehicle in 2010

---

## 12 Text replacement

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When using psfrag it is important to use **latex** and not **pdflatex** for rendering.



**Figure 12.1:** Geometric conditions between solar irradiation and alignment of the photovoltaic panel [masters04]

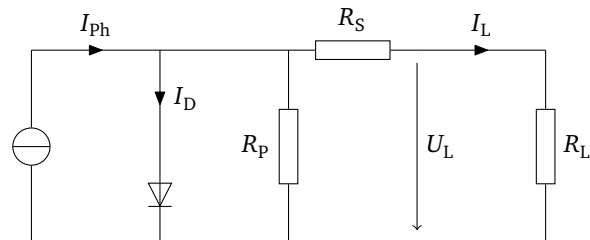
---

### 13 Electronic circuits

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Use the **tikz** package to draw electronic circuits and more.

Figure 13.1 shows the one diode equivalent circuit of a real solar cell.



**Figure 13.1:** One diode equivalent circuit of a real solar cell [wagner2010]