Rapport projekt X

Mattias Sandberg, TIDB, matsandb@kth.se

Uppgift 1: Visualisera data

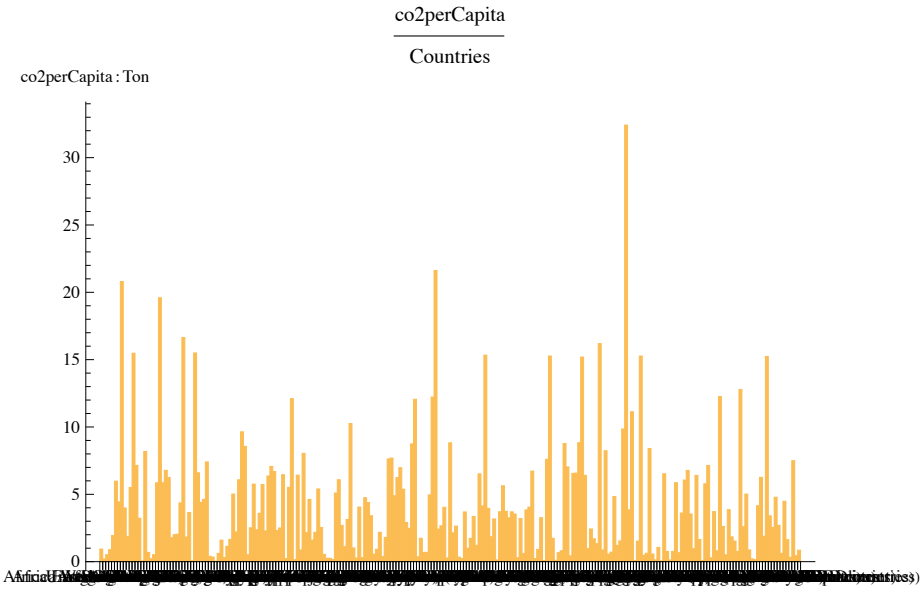
Sammanfattning

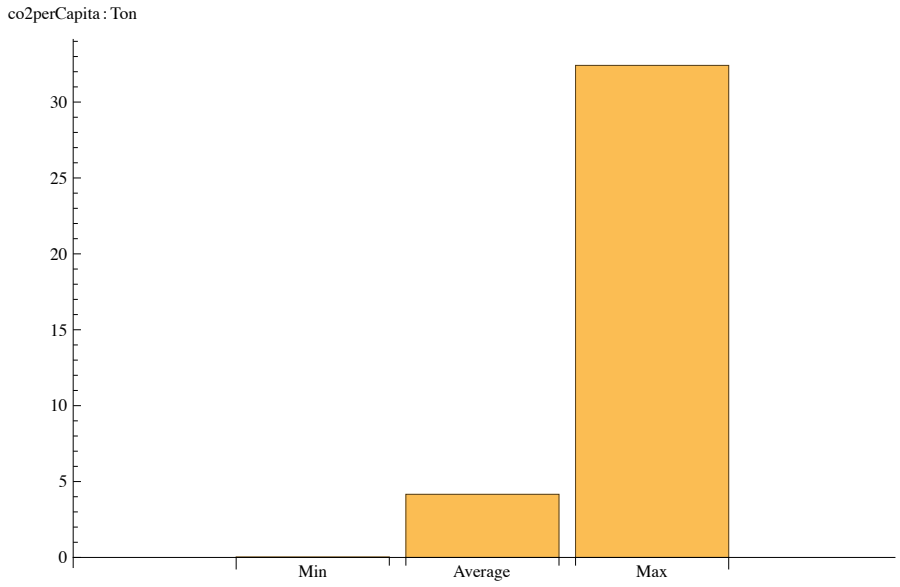
Uppgift

Nedan finns data för länders total territoriella CO_2-utsläpp och CO_2 per capita. Första listan innehåller länderna. Kombinera länder med data (de är i samma ordning) och visualisera detta med lämpliga grafer som visar utsläpp totalt för de länder som släpper ut mest jämfört med resten av världen. På samma sätt för per capita data. Varje graf skall ha följande:
1. Axelbeckningar
2. Enheter
3. Figurtext som kortfattat förklarar figuren

Resultat

1, a)

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25
20
15
10
5
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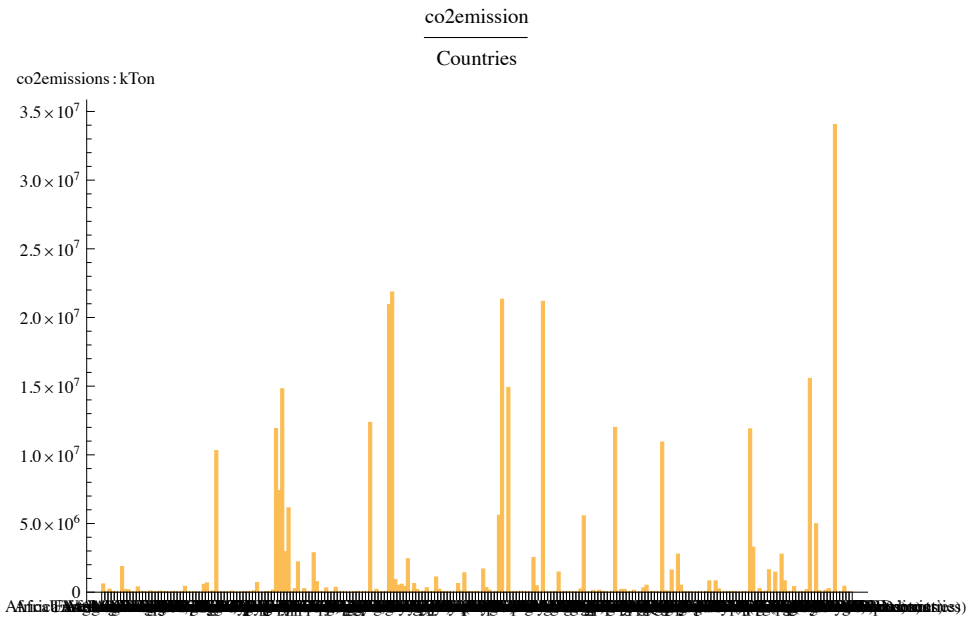
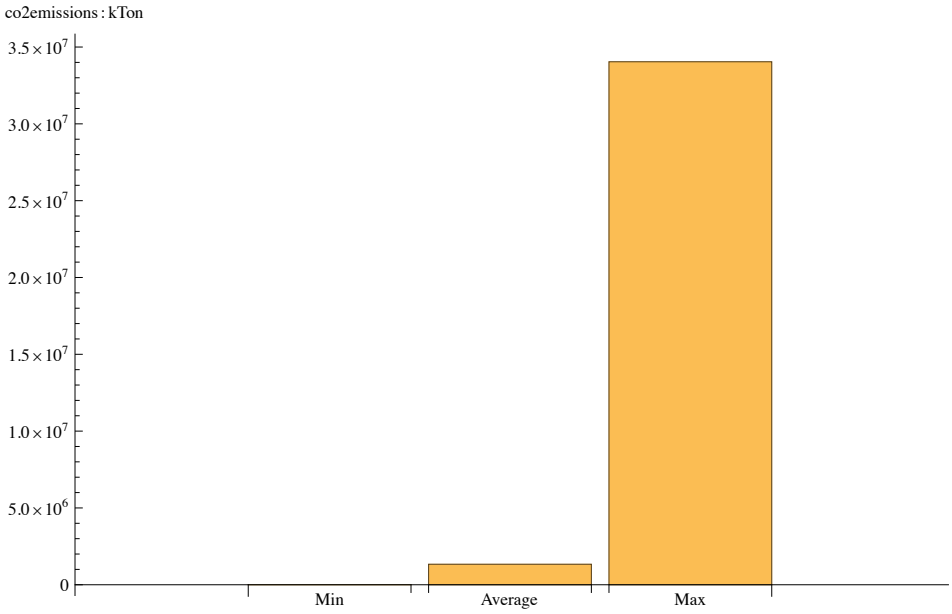
Min
Average
Max

1, b)





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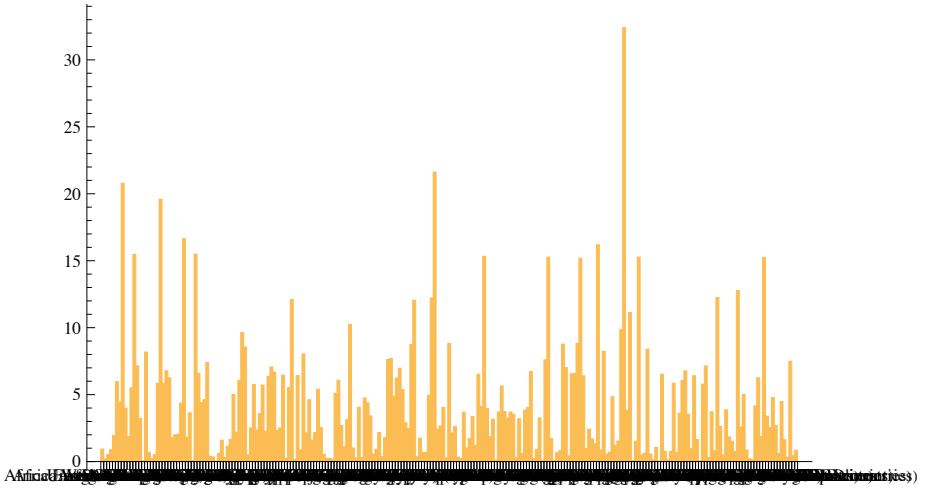

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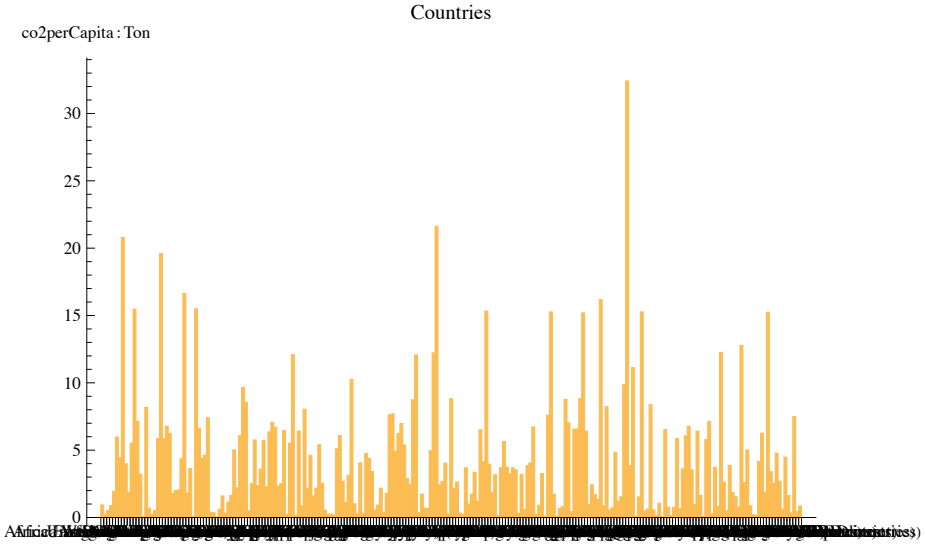

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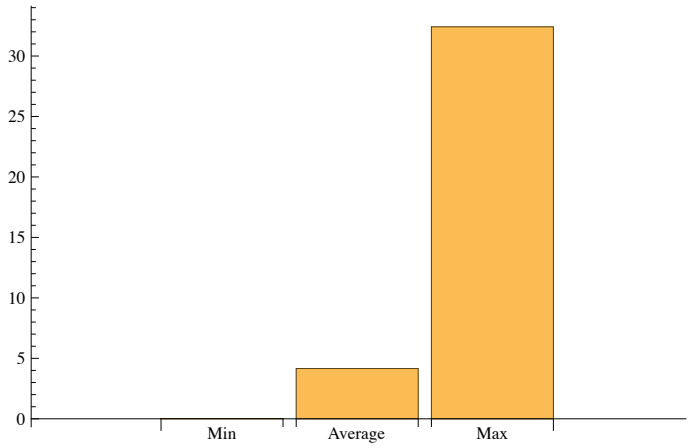

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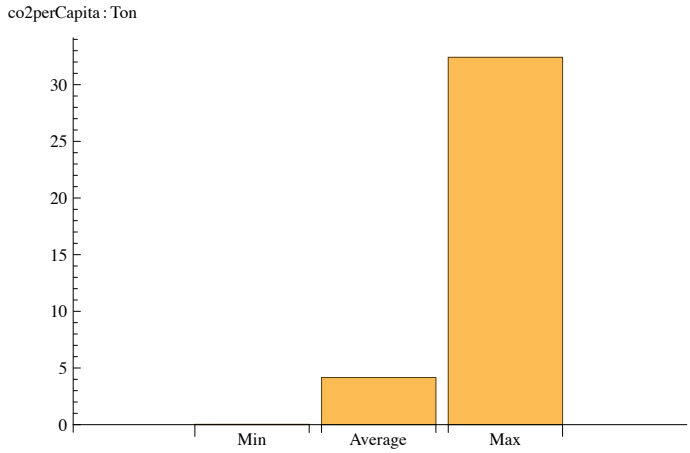

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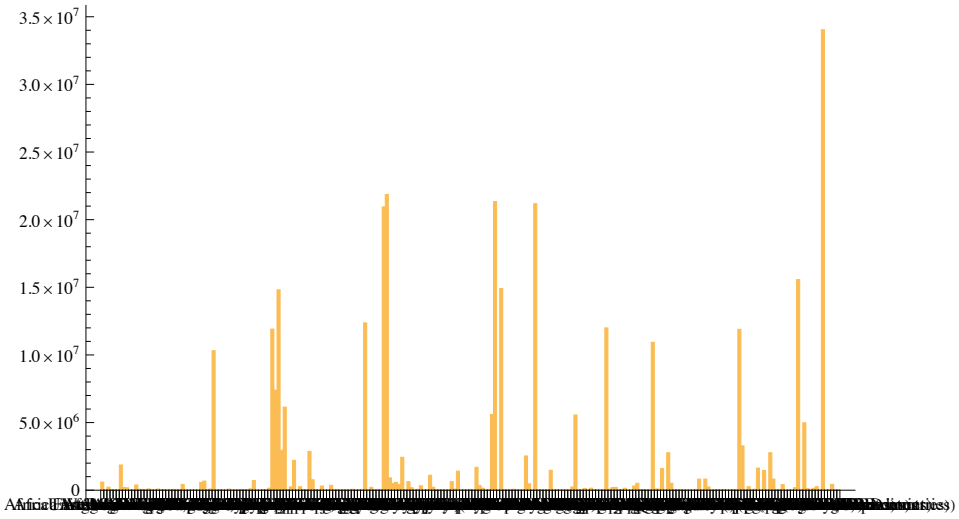
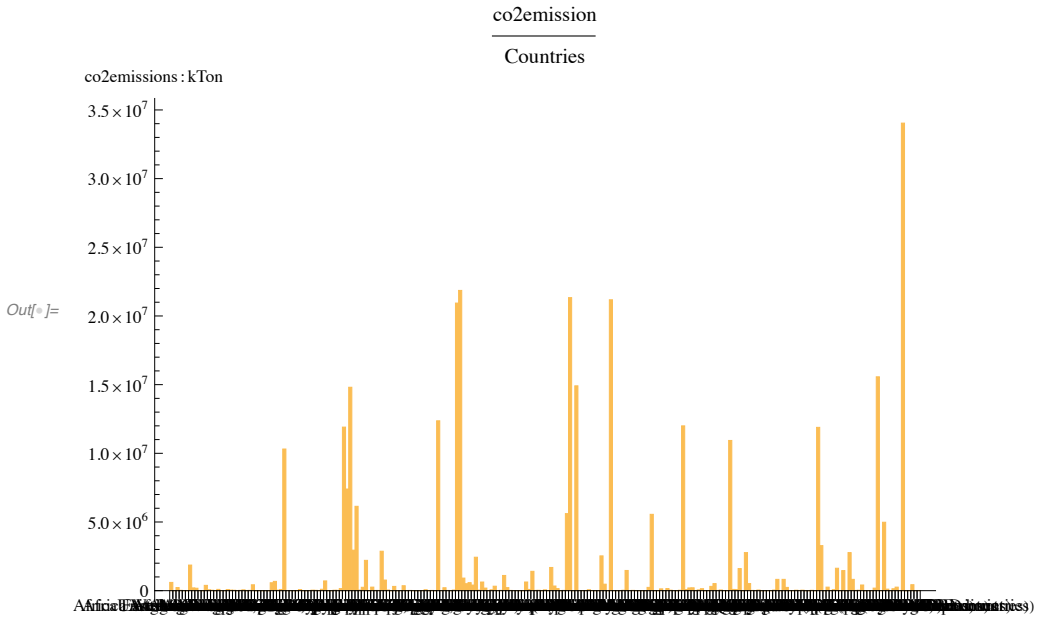
"Lebanon", "Liberia", "Libya", "St. Lucia", "Latin America & Caribbean",
"Least developed countries: UN classification", "Low income",
"Liechtenstein", "Sri Lanka", "Lower middle income", "Low & middle income",
"Lesotho", "Late-demographic dividend", "Lithuania", "Luxembourg", "Latvia",
"Morocco", "Moldova", "Madagascar", "Maldives", "Middle East & North Africa",
"Mexico", "Marshall Islands", "Middle income", "North Macedonia", "Mali",
"Malta", "Myanmar", "Middle East & North Africa (excluding high income)",
"Montenegro", "Mongolia", "Mozambique", "Mauritania", "Mauritius",

```
"Malawi", "Malaysia", "North America", "Namibia", "Niger", "Nigeria",
"Nicaragua", "Netherlands", "Norway", "Nepal", "Nauru", "New Zealand",
"OECD members", "Oman", "Other small states", "Pakistan", "Panama",
"Peru", "Philippines", "Palau", "Papua New Guinea", "Poland",
"Pre-demographic dividend", "Korea, Dem. People's Rep.", "Portugal",
"Paraguay", "Pacific island small states", "Post-demographic dividend",
"Qatar", "Romania", "Russian Federation", "Rwanda", "South Asia",
"Saudi Arabia", "Sudan", "Senegal", "Singapore", "Solomon Islands",
"Sierra Leone", "El Salvador", "Somalia", "Serbia",
"Sub-Saharan Africa (excluding high income)", "South Sudan",
"Sub-Saharan Africa", "Small states", "Sao Tome and Principe", "Suriname",
"Slovak Republic", "Slovenia", "Sweden", "Eswatini", "Seychelles",
"Syrian Arab Republic", "Chad", "East Asia & Pacific (IDA & IBRD countries)",
"Europe & Central Asia (IDA & IBRD countries)",
"Togo", "Thailand", "Tajikistan", "Turkmenistan",
"Latin America & the Caribbean (IDA & IBRD countries)", "Timor-Leste",
"Middle East & North Africa (IDA & IBRD countries)", "Tonga",
"South Asia (IDA & IBRD)", "Sub-Saharan Africa (IDA & IBRD countries)",
"Trinidad and Tobago", "Tunisia", "Turkey", "Tuvalu", "Tanzania", "Uganda",
"Ukraine", "Upper middle income", "Uruguay", "United States", "Uzbekistan",
"St. Vincent and the Grenadines", "Venezuela, RB", "Vietnam", "Vanuatu",
"World", "Samoa", "Yemen, Rep.", "South Africa", "Zambia", "Zimbabwe"}]
```



In[•]:=
```
Show[%35, AxesLabel → {HoldForm[Countries], HoldForm[co2emissions : kTon]},
 PlotLabel → HoldForm[co2emission / Countries], LabelStyle → {GrayLevel[0]}]
```

Out[ ]=

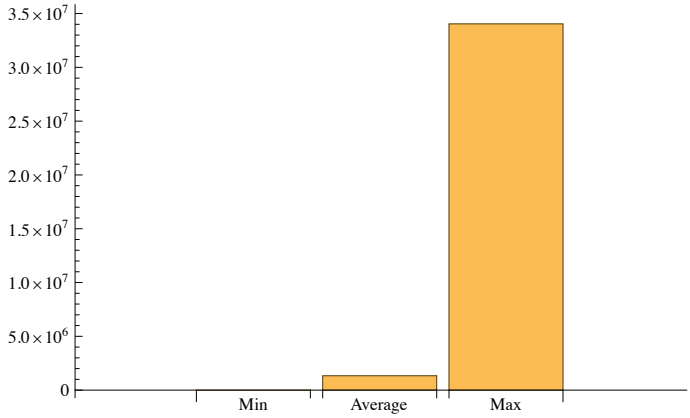


In[ ]:=
```
co2emissions = {600 351.1333, 7440, 224 380, 27 340, 5560, 460, 1 863 603.727, 200 300,
    177 410, 5550, 530, 386 620, 63 180, 32 020, 590, 93 470, 7910, 4270, 82 760,
    41 130, 30 750, 2260, 22 540, 59 310, 680, 22 710, 427 710, 1250, 7140, 1380,
    8210, 330, 574 400, 676 470, 37 480, 86 620, 10 313 460, 9910, 8620, 2200,
    3220, 79 490, 260, 620, 8260, 36 920, 24 970, 7230, 102 480, 709 540, 490,
    180, 33 380, 25 120, 151 670, 11 907 866.46, 7 400 359.524, 14 810 056.87,
    2 949 087.39, 6 142 069.263, 39 530, 246 260, 2 207 420, 800, 258 340, 16 000,
    16 280, 2 871 000, 771 602.9297, 44 360, 1900, 309 960, 180, 4610, 358 800,
    9460, 16 110, 3120, 570, 310, 6670, 65 290, 300, 18 210, 2440, 12 366 368.33,
    9770, 211 980, 16 580, 3330, 46 390, 20 938 730, 21 860 535.52, 915 178.5696,
    505 410, 583 110, 407 199.3144, 2 434 520, 37 110, 629 290, 188 140, 2200,
    61 970, 324 850, 8510, 24 700, 1 106 150, 220 450, 18 400, 11 000, 11 160, 80,
    260, 630 870, 89 460, 1 408 370, 18 790, 27 710, 1320, 58 940, 390, 1 689 187.436,
    338 640.0291, 149 413.7119, 140, 21 630, 5 608 350.968, 21 334 207.73, 2570,
    14 912 796.92, 11 590, 9320, 7630, 66 680, 8590, 3370, 1910, 2 531 611.759,
    472 140, 190, 21 177 938.67, 7370, 5620, 1550, 32 520, 1 470 946.392, 2520,
    21 320, 6640, 4000, 4130, 1570, 239 620, 5 558 099.304, 4250, 2290, 130 670,
    5210, 151 170, 37 350, 12 030, 70, 32 210, 11 998 460, 73 370, 197 072.5527,
    208 370, 10 140, 54 280, 142 240, 290, 7460, 312 740, 513 004.5719, 18 120,
    49 780, 8420, 3780, 10 935 463.93, 90 170, 74 880, 1 607 550, 1080, 2 770 040,
    514 600, 20 200, 9860, 47 360, 370, 1020, 6810, 690, 45 540, 822 805.4476,
    1380, 823 424.7218, 237 761.658, 140, 2080, 33 000, 14 050, 36 000, 1090,
    620, 27 910, 1070, 11 889 820, 3 278 021.798, 2260, 257 860, 7330, 71 730,
    1 633 250, 640, 1 461 080, 190, 2 770 040, 823 424.7218, 17 760, 29 980,
    412 970, 10, 11 580, 6130, 185 370, 15 569 855.45, 6520, 4 981 300, 112 090,
    280, 138 160, 257 860, 180, 34 041 045.97, 320, 9310, 433 250, 7740, 12 270};
Max[co2emissions]
```

Out[ ]= 3.4041×10^7

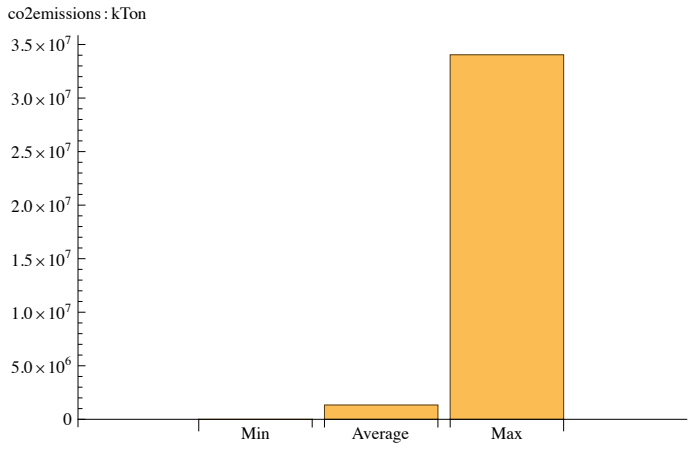
```
In[ ]:= Mean[co2emissions]
Out[ ]= 1.33554 × 10^6

In[ ]:= Min[co2emissions]
Out[ ]= 10

In[ ]:= BarChart[{10, 1.3355376685054393`*^6, 3.404104597`*^7},
         ChartLabels → {"Min", "Average", "Max"}]
```

Out[ ]=




```
In[ ]:= Show[%41, AxesLabel → {None, HoldForm[co2emissions : kTon]},
         PlotLabel → None, LabelStyle → {GrayLevel[0]}]
```

Out[ ]=



Uppgift 2: Analysera data

Sammanfattning

Uppgift

Nedan finns data för världens energikonsumtion *i* TWh/år för olika energislag och för världens totala energikonsumtion.Anpassa lämpliga modeller (exponentialmodell, linjär modell, etc) till givet data nedan så att du kan förutsäga världens framtida energiandvändning.Använd funktionen FindFit för att hitta lämpliga koefficienter till modellerna.Tips : Förskjut tidsskalan med $t \to t - 1990$ för att göra det enklare att hitta parametrarna *i* FindFit för icke – linjära anpassningar.Varje graf skall ha följande :

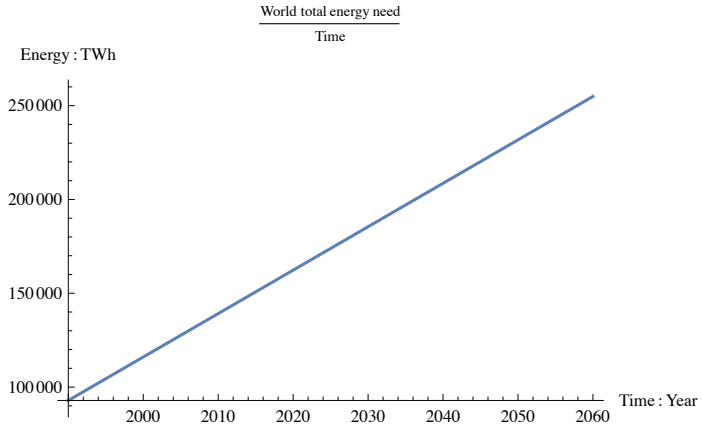
1. Axelbeckningar
2. Enheter
3. Figurtext som kortfattat förklarar figuren

Svara på följande frågor :

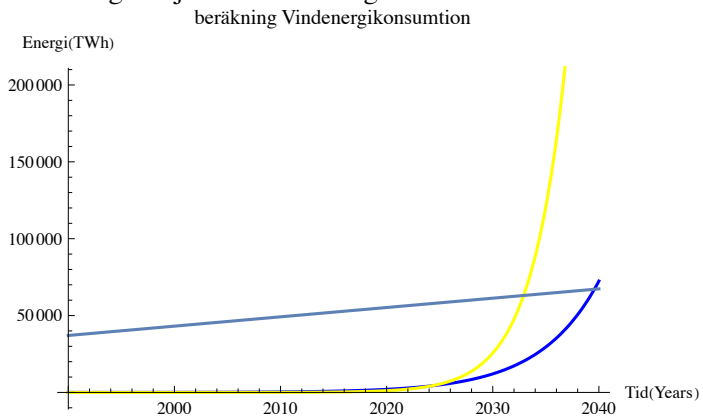
1. Uppskatta världens energikonsumtion år 2050 !
2. Uppskatta när olja som energikälla kan ersättas av förnybara energikällor !
3. Uppskatta om / när världens energikonsumtion är CO_2 fri !
4. Vilket förnybart energislag uppskattas vara viktigast år 2050 ? 5. Vad har val av modell för betydelse ? 6. Är ovanstående förutsägelser rimliga ? Är förutsägelserna rimliga till 2030 ? 7. Vilka felkällor finns ?

Resultat

1, Svar: Ca:232000 TWh



2, Svar: Solenergi kommer kunna ersätta Olja vid år ca: 2031 och tätt där efter år ca: 2036 passerar vindenergin oljan. Visualisering:



3, Svar: Ca: år 2036 kommer förnybar energi kunna försörja världens energibehov enligt informationen från föregående år.

```
totaltfunktion[2036]
```

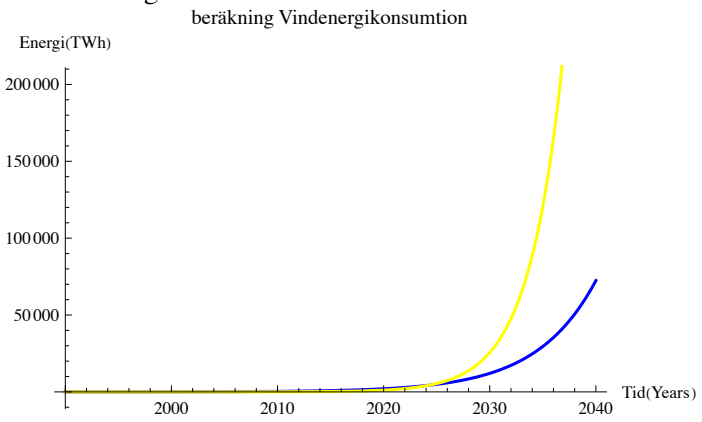
```
199 339.
```

```
vattenfunktion[2036] + vindfunktion[2036] +
 solfunktion[2036] + karnkraftfunktion[2036]
```

```
208 512.
```

(*TWh*)

4, Svar: Vi kan se att solen och därefter vinden är dom viktigaste förnybara energikällorna 2050. dessa förnybara energikällor domderar TWh/År och därmed ritas ej resterande förnybara energikällor ut.
Visualisering:



5, Svar: Beroende på vilken modell du väljer, tex linjär, exponentiell eller polynomekvation kommer tillväxten respektive minskiningen variera då derivatan ändras på olika sätt. Om man försöker plotta en exponetialekvation kommer i detta fall ökningarna representeras mycket snabbare än vad tillexempel det skulle i en linjär ekvation.

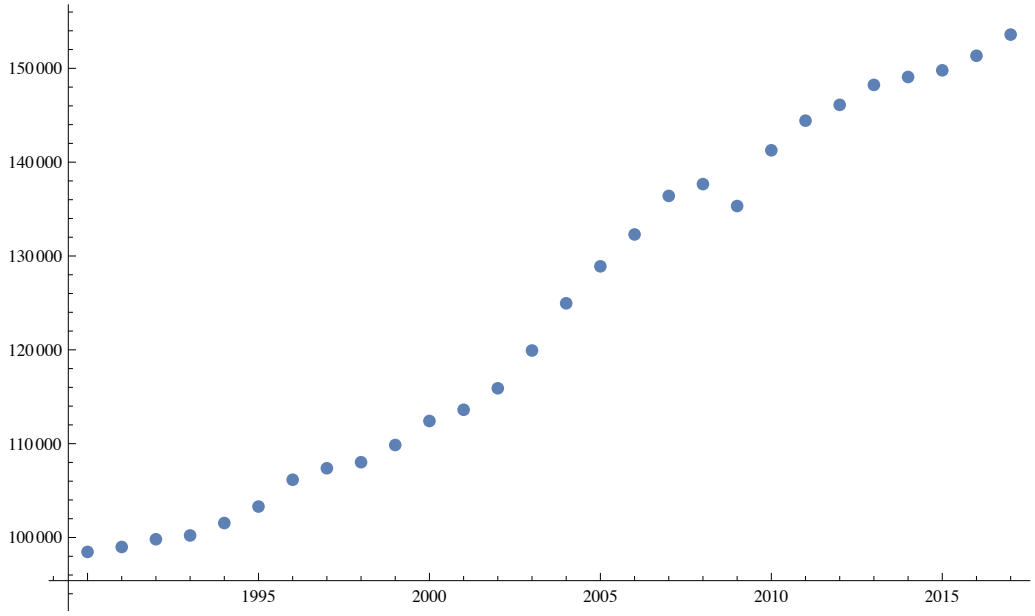
6, Svar: ovanstående förutsägelser är rimliga då det baseras på föregående års fakta och därefter representerar en modell för framtiden. Man kan argumentera att förändringrna kan ske snabbbare då det finns ett större politiskt stöd för co2 fritt i dagsläget än vad det eventuellt gjorde innan 2017.

Sen är tillexempel solutvecklingen svår att fortsätta växa exponetielt då byggdelarna till solpaneler blir svåråtkomliga. Co2 fri energi till 2030 är dock en orimlig förusägelse då det inte finns drivkraft eller finasiellt initiativ för det över hela värden.

7, Svar: Exempel på felkällor är att utvecklingarna inte kommer att ske enligt representationerna då det exempelvis kan komma nya forsking och teknik som ändrar uppfattningen om vad som är bra investeringar för klimatsmart el. En annan felkälla är att man kan använda fel lineregen och därmed representerar punkterna på ett felaktigt sätt. Tillsist så skulle en felkälla vara att vi bara har fått information till 2017 vilket gör estiminationerna mer osäkra.

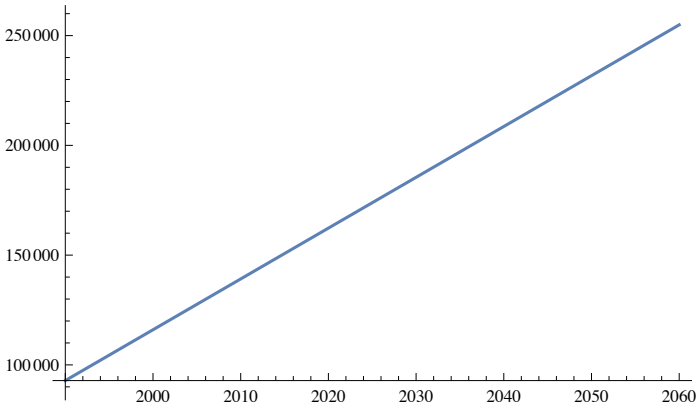
Kod

In[108]:=
```
1 , total = {{1990.`, 98462.371847116`}, {1991.`, 98987.38143285`},
    {1992.`, 99813.54908523199`}, {1993.`, 100216.423316547`},
    {1994.`, 101537.18489717401`}, {1995.`, 103296.25934793001`},
    {1996.`, 106154.70010584098`}, {1997.`, 107376.31135546902`},
    {1998.`, 108022.57284627101`}, {1999.`, 109856.69807370701`},
    {2000.`, 112416.258116246`}, {2001.`, 113610.635952175`},
    {2002.`, 115901.223848704`}, {2003.`, 119930.15013616001`},
    {2004.`, 124960.08846344402`}, {2005.`, 128897.75152416898`},
    {2006.`, 132297.06634468702`}, {2007.`, 136405.679742778`},
    {2008.`, 137662.43593741`}, {2009.`, 135324.15543267998`},
    {2010.`, 141265.10288404`}, {2011.`, 144422.53459229`},
    {2012.`, 146106.05926769998`}, {2013.`, 148234.8407671`},
    {2014.`, 149077.14748530003`}, {2015.`, 149790.2224058`},
    {2016.`, 151341.68784990002`}, {2017.`, 153595.6630277`}};

ListPlot[total, AxesLabel → HoldForm[Time : Year]]
```



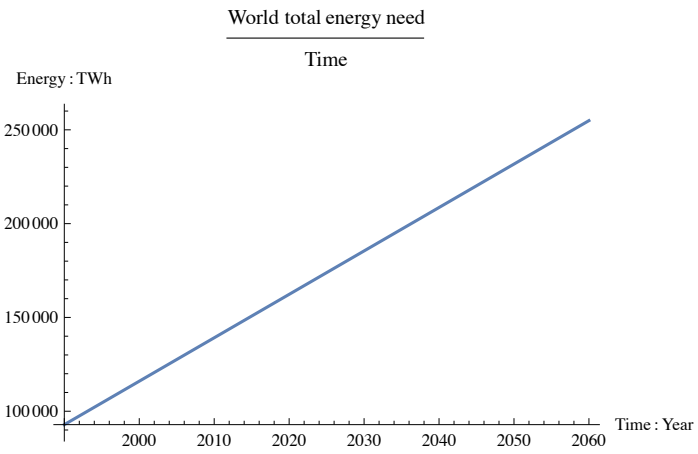
```
In[ ]:= total = {{1990.`, 98462.371847116`}, {1991.`, 98987.38143285`},
    {1992.`, 99813.54908523199`}, {1993.`, 100216.423316547`},
    {1994.`, 101537.18489717401`}, {1995.`, 103296.25934793001`},
    {1996.`, 106154.70010584098`}, {1997.`, 107376.31135546902`},
    {1998.`, 108022.57284627101`}, {1999.`, 109856.69807370701`},
    {2000.`, 112416.258116246`}, {2001.`, 113610.635952175`},
    {2002.`, 115901.223848704`}, {2003.`, 119930.15013616001`},
    {2004.`, 124960.08846344402`}, {2005.`, 128897.75152416898`},
    {2006.`, 132297.06634468702`}, {2007.`, 136405.679742778`},
    {2008.`, 137662.43593741`}, {2009.`, 135324.15543267998`},
    {2010.`, 141265.10288404`}, {2011.`, 144422.53459229`},
    {2012.`, 146106.05926769998`}, {2013.`, 148234.8407671`},
    {2014.`, 149077.14748530003`}, {2015.`, 149790.2224058`},
    {2016.`, 151341.68784990002`}, {2017.`, 153595.6630277`}};
  model = LinearModelFit[total, x, x]

Out[ ]= FittedModel[ -4.51374 ×10^6 + 2314.87 x ]

In[ ]:= model["RSquared"]

Out[ ]= 0.978342

In[ ]:= lineEquation = model[x]

In[ ]:= -4.51373668000478`*^6 + 234.870212774434` x
  bestFit = Plot[lineEquation, {x, 1990, 2060}]

Out[ ]= -4.51374 × 10^6 + 234.87 x
```

Out[ ]=



In[ ]:=
```
Show[bestFit, AxesLabel → {HoldForm[Time : Year], HoldForm[Energy : TWh]},
 PlotLabel → HoldForm[World total energy need / Time], LabelStyle → {GrayLevel[0]}]
```

Out[ ]=



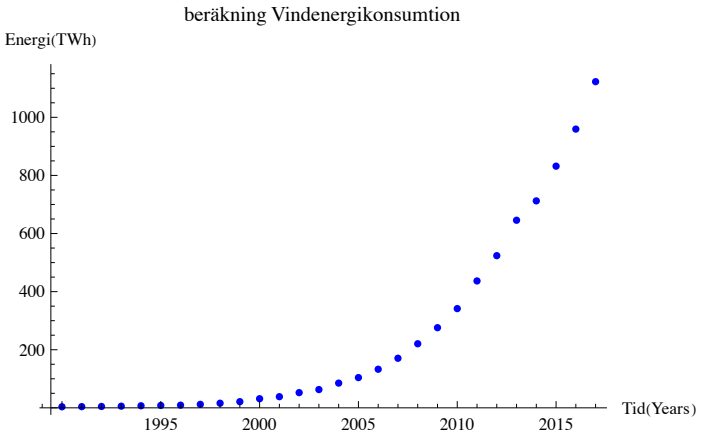
In[ ]:=
```
model[2050]
```

```
231747.5618280936`
(*Svar: Ca:232000 TWh*)

2,
```

In[110]:=
```
vind = {{1990.`, 3.632470516`}, {1991.`, 4.086706675`},
  {1992.`, 4.733212019`}, {1993.`, 5.697568819`},
  {1994.`, 7.122929844`}, {1995.`, 8.261923444`}, {1996.`, 9.204610762`},
  {1997.`, 12.01757667`}, {1998.`, 15.91490057`}, {1999.`, 21.21534431`},
  {2000.`, 31.41996387`}, {2001.`, 38.39098735`}, {2002.`, 52.33180737`},
  {2003.`, 62.91691456`}, {2004.`, 85.11605376`}, {2005.`, 104.0868359`},
  {2006.`, 132.8592792`}, {2007.`, 170.6860872`}, {2008.`, 220.5696719`},
  {2009.`, 275.9292658`}, {2010.`, 341.5652412`}, {2011.`, 436.8034429`},
  {2012.`, 523.8148612`}, {2013.`, 645.7219776`}, {2014.`, 712.4070431`},
  {2015.`, 831.8262454`}, {2016.`, 959.4687163`}, {2017.`, 1122.74585`}}
ListPlot[vind, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
 PlotStyle → {Blue}, PlotLabel → Vindenergikonsumtion beräkning ]
```

Out[110]=
```
{{1990., 3.63247}, {1991., 4.08671}, {1992., 4.73321}, {1993., 5.69757},
 {1994., 7.12293}, {1995., 8.26192}, {1996., 9.20461}, {1997., 12.0176},
 {1998., 15.9149}, {1999., 21.2153}, {2000., 31.42}, {2001., 38.391},
 {2002., 52.3318}, {2003., 62.9169}, {2004., 85.1161}, {2005., 104.087},
 {2006., 132.859}, {2007., 170.686}, {2008., 220.57}, {2009., 275.929},
 {2010., 341.565}, {2011., 436.803}, {2012., 523.815}, {2013., 645.722},
 {2014., 712.407}, {2015., 831.826}, {2016., 959.469}, {2017., 1122.75}}
```

Out[111]=



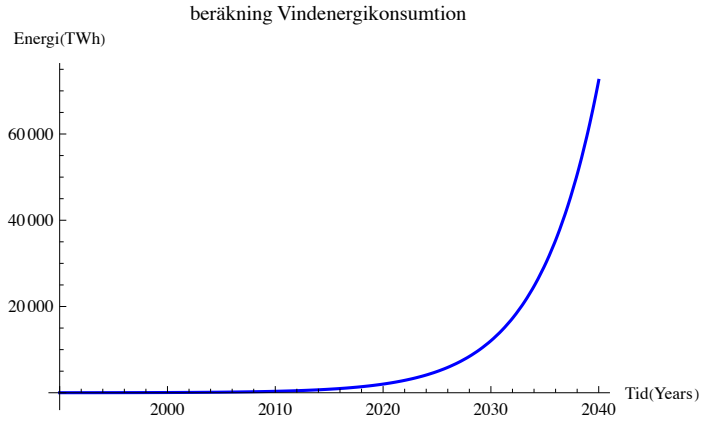
In[•]:=
```
{avind, bvind} = {a, b} /. FindFit[vind, {a Exp[b (t - 1990)]}, {a, b}, t]
```

Out[•]=
```
{9.25548, 0.179304}
```

```
vindfunktion[t_] := avind Exp[bvind (t - 1990)]
```

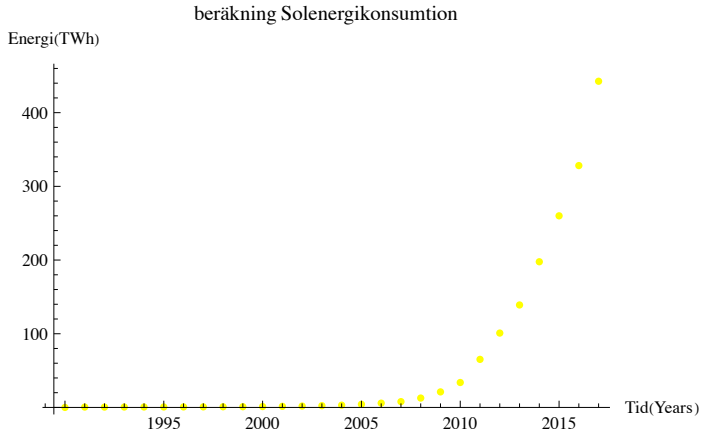
In[ ]:=
```
beraknavind = Plot[vindfunktion[t], {t, 1990, 2040},
  PlotRange → All, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
  PlotStyle → {Blue}, PlotLabel → Vindenergikonsumtion beräkning]
```

Out[ ]=



In[108]:=
```
sol = {{1990.`, 0.`}, {1991.`, 0.505223075`},
   {1992.`, 0.468615413`}, {1993.`, 0.556737928`}, {1994.`, 0.60006443`},
   {1995.`, 0.640874386`}, {1996.`, 0.705278679`}, {1997.`, 0.756655499`},
   {1998.`, 0.880289501`}, {1999.`, 0.965823997`}, {2000.`, 1.177935576`},
   {2001.`, 1.463956125`}, {2002.`, 1.831247734`}, {2003.`, 2.3293707`},
   {2004.`, 3.054656084`}, {2005.`, 4.249617769`}, {2006.`, 5.818328387`},
   {2007.`, 7.864870878`}, {2008.`, 12.72162081`}, {2009.`, 21.09259048`},
   {2010.`, 33.82948514`}, {2011.`, 65.21188479`}, {2012.`, 100.9252749`},
   {2013.`, 139.0442186`}, {2014.`, 197.6716635`}, {2015.`, 260.0058008`},
   {2016.`, 328.1826964`}, {2017.`, 442.6183606`}};
ListPlot[sol, PlotRange → All, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
 PlotStyle → {Yellow}, PlotLabel → Solenergikonsumtion beräkning]
```

Out[109]=



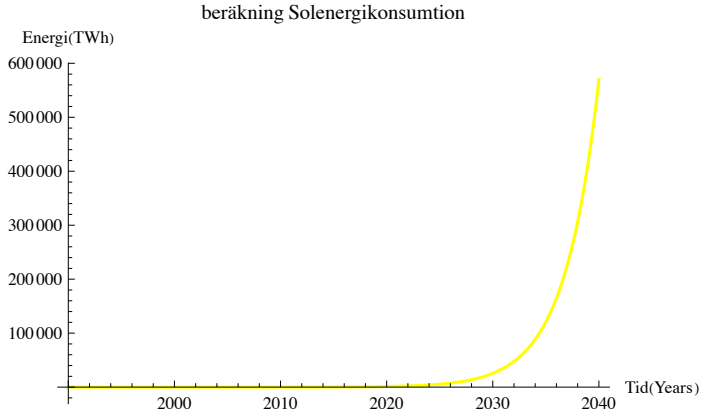
In[ ]:=
```
{asol, bsol} = {a, b} /. FindFit[sol, {a Exp[b (t - 1990)]}, {a, b}, t]
```

Out[ ]=
```
{0.104136, 0.310299}
```

In[ ]:=
```
solfunktion[t_] := asol Exp[bsol (t - 1990)]
```

In[ ]:=
```
beraknasol = Plot[solfunktion[t], {t, 1990, 2040},
  PlotRange → All, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
  PlotStyle → {Yellow}, PlotLabel → Solenergikonsumtion beräkning]
```

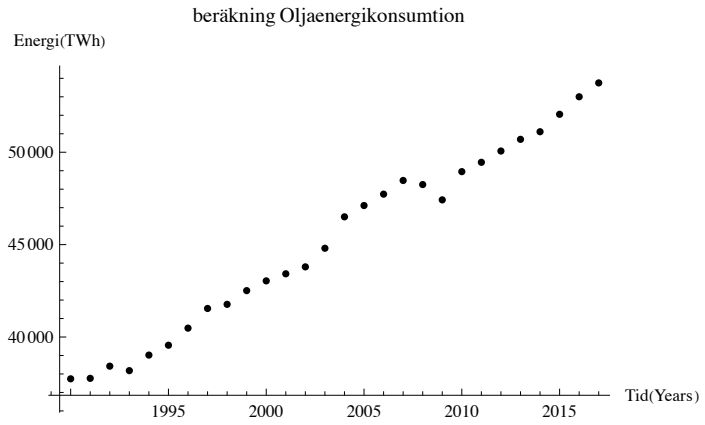
Out[ ]=



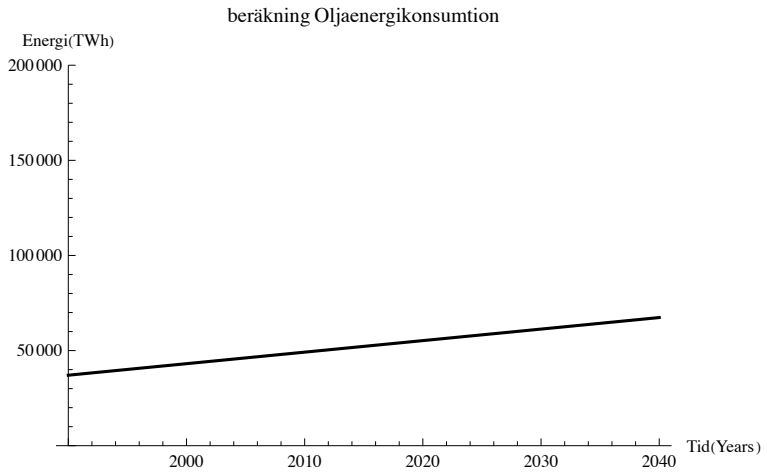
In[112]:=
```
olja = {{1990.`, 37736.94729`}, {1991.`, 37763.14824`},
  {1992.`, 38422.53103`}, {1993.`, 38179.42324`}, {1994.`, 39021.80173`},
  {1995.`, 39555.43054`}, {1996.`, 40480.1731`}, {1997.`, 41544.67299`},
  {1998.`, 41768.48384`}, {1999.`, 42510.09274`}, {2000.`, 43038.62001`},
  {2001.`, 43421.10755`}, {2002.`, 43796.55068`}, {2003.`, 44803.21017`},
  {2004.`, 46503.96733`}, {2005.`, 47115.72728`}, {2006.`, 47732.19992`},
  {2007.`, 48471.73162`}, {2008.`, 48250.64229`}, {2009.`, 47422.36853`},
  {2010.`, 48949.72046`}, {2011.`, 49455.27172`}, {2012.`, 50065.86499`},
  {2013.`, 50698.38455`}, {2014.`, 51109.97172`}, {2015.`, 52053.27008`},
  {2016.`, 53001.86598`}, {2017.`, 53752.27638`}}
ListPlot[olja, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
 PlotStyle → {Black}, PlotLabel → Oljaenergikonsumtion beräkning]
```

Out[112]=
```
{{1990., 37 736.9}, {1991., 37 763.1}, {1992., 38 422.5}, {1993., 38 179.4},
 {1994., 39 021.8}, {1995., 39 555.4}, {1996., 40 480.2}, {1997., 41 544.7},
 {1998., 41 768.5}, {1999., 42 510.1}, {2000., 43 038.6}, {2001., 43 421.1},
 {2002., 43 796.6}, {2003., 44 803.2}, {2004., 46 504.}, {2005., 47 115.7},
 {2006., 47 732.2}, {2007., 48 471.7}, {2008., 48 250.6}, {2009., 47 422.4},
 {2010., 48 949.7}, {2011., 49 455.3}, {2012., 50 065.9}, {2013., 50 698.4},
 {2014., 51 110.}, {2015., 52 053.3}, {2016., 53 001.9}, {2017., 53 752.3}}
```

Out[113]=

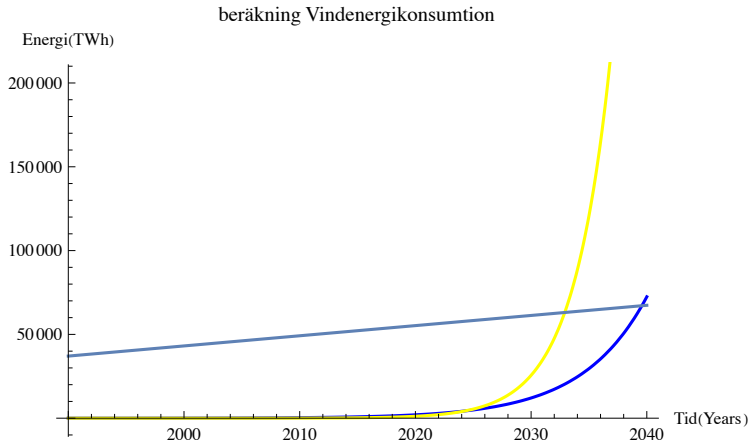


```
model = FindFit[olja, a x + b, {a, b}, x]

beraknaolja = Plot[a x + b /. model, {x, 1990, 2040},
  PlotRange → {200 000, 0}, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
  PlotStyle → {Black}, PlotLabel → Oljaenergikonsumtion beräkning]
```




```
Show[beraknavind, beraknasol, beraknaolja, PlotRange → {200 000, 0}]
```

Out[118]= $\{a \to 606.174,\ b \to -1.16923 \times 10^{6}\}$




```
3,
Kol (TWh)
kol = {{1990.`, 25845.88485`}, {1991.`, 25561.41954`},
    {1992.`, 25478.81089`}, {1993.`, 25580.92144`}, {1994.`, 25729.64169`},
    {1995.`, 25867.8533`}, {1996.`, 26516.28457`}, {1997.`, 26549.71899`},
    {1998.`, 26351.79429`}, {1999.`, 26492.77461`}, {2000.`, 27403.94562`},
    {2001.`, 27851.05371`}, {2002.`, 28936.6423`}, {2003.`, 31475.58334`},
    {2004.`, 33656.31109`}, {2005.`, 36118.94545`}, {2006.`, 37979.81684`},
    {2007.`, 40143.91171`}, {2008.`, 40712.5427`}, {2009.`, 40088.33994`},
    {2010.`, 41932.74507`}, {2011.`, 43948.96889`}, {2012.`, 44129.62497`},
    {2013.`, 44953.01385`}, {2014.`, 44916.83781`}, {2015.`, 43786.8458`},
```

```
    {2016.`, 43101.23216`}, {2017.`, 43397.13549`}};
Olja (TWh)
olja = {{1990.`, 37736.94729`}, {1991.`, 37763.14824`},
    {1992.`, 38422.53103`}, {1993.`, 38179.42324`}, {1994.`, 39021.80173`},
    {1995.`, 39555.43054`}, {1996.`, 40480.1731`}, {1997.`, 41544.67299`},
    {1998.`, 41768.48384`}, {1999.`, 42510.09274`}, {2000.`, 43038.62001`},
    {2001.`, 43421.10755`}, {2002.`, 43796.55068`}, {2003.`, 44803.21017`},
    {2004.`, 46503.96733`}, {2005.`, 47115.72728`}, {2006.`, 47732.19992`},
    {2007.`, 48471.73162`}, {2008.`, 48250.64229`}, {2009.`, 47422.36853`},
    {2010.`, 48949.72046`}, {2011.`, 49455.27172`}, {2012.`, 50065.86499`},
    {2013.`, 50698.38455`}, {2014.`, 51109.97172`}, {2015.`, 52053.27008`},
    {2016.`, 53001.86598`}, {2017.`, 53752.27638`}};
Naturgas (TWh)
naturgas = {{1990.`, 19486.64542`}, {1991.`, 19984.58677`},
    {1992.`, 20076.92098`}, {1993.`, 20275.09431`}, {1994.`, 20405.36342`},
    {1995.`, 21121.78818`}, {1996.`, 22143.41796`}, {1997.`, 22082.05319`},
    {1998.`, 22485.93806`}, {1999.`, 23107.57158`}, {2000.`, 24019.89227`},
    {2001.`, 24367.11133`}, {2002.`, 25108.12839`}, {2003.`, 25769.17552`},
    {2004.`, 26752.16794`}, {2005.`, 27537.09099`}, {2006.`, 28347.57835`},
    {2007.`, 29580.25097`}, {2008.`, 30321.37836`}, {2009.`, 29477.9263`},
    {2010.`, 31759.12422`}, {2011.`, 32410.44868`}, {2012.`, 33270.53388`},
    {2013.`, 33714.94785`}, {2014.`, 33986.84723`}, {2015.`, 34741.88349`},
    {2016.`, 35741.82987`}, {2017.`, 36703.96587`}};
Kärnkraft (TWh)
karnkraft = {{1990.`, 2000.642591`}, {1991.`, 2096.356868`},
    {1992.`, 2112.277946`}, {1993.`, 2185.016841`}, {1994.`, 2226.050783`},
    {1995.`, 2322.592422`}, {1996.`, 2407.002623`}, {1997.`, 2390.480054`},
    {1998.`, 2431.571247`}, {1999.`, 2524.546817`}, {2000.`, 2580.976669`},
    {2001.`, 2653.821898`}, {2002.`, 2696.204132`}, {2003.`, 2641.599256`},
    {2004.`, 2757.124087`}, {2005.`, 2769.046942`}, {2006.`, 2803.605088`},
    {2007.`, 2746.479825`}, {2008.`, 2737.860822`}, {2009.`, 2699.245242`},
    {2010.`, 2767.507814`}, {2011.`, 2651.771616`}, {2012.`, 2472.44864`},
    {2013.`, 2491.705601`}, {2014.`, 2541.027341`}, {2015.`, 2575.664304`},
    {2016.`, 2612.83283`}, {2017.`, 2635.561104`}};
Bio - bränslen (TWh)
biobransle = {{1990.`, 11111.11111`}, {1991.`, 11242.7549`},
    {1992.`, 11375.95839`}, {1993.`, 11510.74008`}, {1994.`, 11647.11865`},
    {1995.`, 11785.11302`}, {1996.`, 11924.74234`}, {1997.`, 12066.02598`},
    {1998.`, 12208.98355`}, {1999.`, 12414.05573`}, {2000.`, 12500.`},
    {2001.`, 12500.`}, {2002.`, 12470.`}, {2003.`, 12328.70237`},
    {2004.`, 12159.75217`}, {2005.`, 12076.14729`}, {2006.`, 11993.11724`},
    {2007.`, 11910.65806`}, {2008.`, 11828.76583`}, {2009.`, 11747.43666`},
    {2010.`, 11666.66667`}, {2011.`, 11553.3766`}, {2012.`, 11441.18663`},
    {2013.`, 11330.0861`}, {2014.`, 11220.06442`}, {2015.`, 11111.11111`},
    {2016.`, 11003.2158`}, {2017.`, 10895.32049`}};
Andra Förnybara Energikällor (TWh)
andrafornybara = {{1990.`, 116.4628246`},
```

```
    {1991.`, 121.4122701`}, {1992.`, 130.3448548`}, {1993.`, 134.7069628`},
    {1994.`, 139.8004029`}, {1995.`, 145.5958811`}, {1996.`, 149.6884804`},
    {1997.`, 160.9528063`}, {1998.`, 168.4548712`}, {1999.`, 177.1371664`},
    {2000.`, 185.2722028`}, {2001.`, 191.0179267`}, {2002.`, 205.6996386`},
    {2003.`, 217.2027959`}, {2004.`, 234.3682046`}, {2005.`, 254.3922875`},
    {2006.`, 271.7633551`}, {2007.`, 294.2977297`}, {2008.`, 314.3656167`},
    {2009.`, 338.2157334`}, {2010.`, 378.0383427`}, {2011.`, 397.4546676`},
    {2012.`, 430.3624386`}, {2013.`, 463.9825019`}, {2014.`, 504.3899227`},
    {2015.`, 538.2067786`}, {2016.`, 556.9861292`}, {2017.`, 586.1710901`}};
Vattenkraft (TWh)
vatten = {{1990.`, 2161.045291`}, {1991.`, 2213.110915`},
    {1992.`, 2211.503167`}, {1993.`, 2344.266136`}, {1994.`, 2359.685227`},
    {1995.`, 2488.983207`}, {1996.`, 2523.481143`}, {1997.`, 2569.633113`},
    {1998.`, 2590.551798`}, {1999.`, 2608.338262`}, {2000.`, 2654.953445`},
    {2001.`, 2586.668594`}, {2002.`, 2633.835653`}, {2003.`, 2629.430399`},
    {2004.`, 2808.226932`}, {2005.`, 2918.064831`}, {2006.`, 3030.307944`},
    {2007.`, 3079.79887`}, {2008.`, 3263.589026`}, {2009.`, 3253.601171`},
    {2010.`, 3435.905581`}, {2011.`, 3503.227091`}, {2012.`, 3671.297583`},
    {2013.`, 3797.954118`}, {2014.`, 3887.930335`}, {2015.`, 3891.408797`},
    {2016.`, 4036.073668`}, {2017.`, 4059.868393`}};
Vindkraft (TWh)
vind = {{1990.`, 3.632470516`}, {1991.`, 4.086706675`},
    {1992.`, 4.733212019`}, {1993.`, 5.697568819`}, {1994.`, 7.122929844`},
    {1995.`, 8.261923444`}, {1996.`, 9.204610762`}, {1997.`, 12.01757667`},
    {1998.`, 15.91490057`}, {1999.`, 21.21534431`}, {2000.`, 31.41996387`},
    {2001.`, 38.39098735`}, {2002.`, 52.33180737`}, {2003.`, 62.91691456`},
    {2004.`, 85.11605376`}, {2005.`, 104.0868359`}, {2006.`, 132.8592792`},
    {2007.`, 170.6860872`}, {2008.`, 220.5696719`}, {2009.`, 275.9292658`},
    {2010.`, 341.5652412`}, {2011.`, 436.8034429`}, {2012.`, 523.8148612`},
    {2013.`, 645.7219776`}, {2014.`, 712.4070431`}, {2015.`, 831.8262454`},
    {2016.`, 959.4687163`}, {2017.`, 1122.74585`}};
Solenergi (TWh)
sol = {{1990.`, 0.`}, {1991.`, 0.505223075`},
    {1992.`, 0.468615413`}, {1993.`, 0.556737928`}, {1994.`, 0.60006443`},
    {1995.`, 0.640874386`}, {1996.`, 0.705278679`}, {1997.`, 0.756655499`},
    {1998.`, 0.880289501`}, {1999.`, 0.965823997`}, {2000.`, 1.177935576`},
    {2001.`, 1.463956125`}, {2002.`, 1.831247734`}, {2003.`, 2.3293707`},
    {2004.`, 3.054656084`}, {2005.`, 4.249617769`}, {2006.`, 5.818328387`},
    {2007.`, 7.864870878`}, {2008.`, 12.72162081`}, {2009.`, 21.09259048`},
    {2010.`, 33.82948514`}, {2011.`, 65.21188479`}, {2012.`, 100.9252749`},
    {2013.`, 139.0442186`}, {2014.`, 197.6716635`}, {2015.`, 260.0058008`},
    {2016.`, 328.1826964`}, {2017.`, 442.6183606`}};
Världens total energikonsumtion (TWh)
totalt = {{1990.`, 98462.371847116`}, {1991.`, 98987.38143285`},
    {1992.`, 99813.54908523199`}, {1993.`, 100216.423316547`},
    {1994.`, 101537.18489717401`}, {1995.`, 103296.25934793001`},
    {1996.`, 106154.70010584098`}, {1997.`, 107376.31135546902`},
```

```
    {1998.`, 108022.57284627101`}, {1999.`, 109856.69807370701`},
    {2000.`, 112416.258116246`}, {2001.`, 113610.635952175`},
    {2002.`, 115901.223848704`}, {2003.`, 119930.15013616001`},
    {2004.`, 124960.08846344402`}, {2005.`, 128897.75152416898`},
    {2006.`, 132297.06634468702`}, {2007.`, 136405.679742778`},
    {2008.`, 137662.43593741`}, {2009.`, 135324.15543267998`},
    {2010.`, 141265.10288404`}, {2011.`, 144422.53459229`},
    {2012.`, 146106.05926769998`}, {2013.`, 148234.8407671`},
    {2014.`, 149077.14748530003`}, {2015.`, 149790.2224058`},
    {2016.`, 151341.68784990002`}, {2017.`, 153595.6630277`}};

{ctotalt, dtotalt} = {c, d} /. FindFit[totalt, {c (x - 1990) + d}, {c, d}, x]
{2314.87, 92 × 855.}
totaltfunktion[x_] := ctotalt (x - 1990) + dtotalt
totaltgenomsnitt = Plot[totaltfunktion[x], {x, 1990, 2050},
AxesLabel → { "År", "Energi [TWh]" }, PlotStyle → {Magenta},
PlotLabel → "total konsumtion Genomsnittlig " ]

{colja, dolja} = {c, d} /. FindFit[olja, {c (x - 1990) + d}, {c, d}, x]
{606.174, 37 × 053.3}
oljafunktion[x_] := colja (x - 1990) + dolja
oljaberaknad = Plot[oljafunktion[x], {x, 1990, 2050},
AxesLabel → { "År", "Energi[TWh]" }, PlotStyle → {Black},
PlotLabel → "konsumtion av energi från olja Beräknad" ]

{cvatten, dvatten} = {c, d} /. FindFit[vatten, {c (x - 1990) + d}, {c, d}, x]
{71.3453, 2008.72}
vattenfunktion[x_] := cvatten (x - 1990) + dvatten
vattenberaknad = Plot[vattenfunktion[x], {x, 1990, 2050},
AxesLabel → { "År", "Energi [TWh]" }, PlotStyle → {Grey},
PlotLabel → "konsumtion av energi från vatten Beräknad" ]

{cvind, dvind} = {c, d} /. FindFit[vind, {c Exp[d (x - 1990)]}, {c, d}, x]
{9.25548, 0.179304}
vindfunktion[x_] := cvindExp[bvind (x - 1990)]
vindberaknad = Plot[vindfunktion[x], {x, 1990, 2050},
AxesLabel → { "År", "Energi[TWh]" }, PlotStyle → {Red},
PlotLabel → "konsumtion av energi från vindkraft Beräknad" ]

{csol, dsol} = {c, d} /. FindFit[sol, {c Exp[d (x - 1990)]}, {c, d}, x]
{0.104136, 0.310299}
solfunktion[x_] := csolExp[dsol (x - 1990)]
solberaknad = Plot[solfunktion[x], {1990, 2050},
AxesLabel → { "År", "Energi[TWh]" }, PlotStyle → {Green},
PlotLabel → "konsumtion av solenergi Beräknad" ]
```

```
{candrafornybara, dandrafornybara} =
 {c, d} /. FindFit[andrafornybara, {c (x - 1990) + d}, {c, d}, x]
{17.1558, 47.2089}
andrafornybarafunktion[x_] := candrafornybara (x - 1990) + dandrafornybara
andrafornybaraberaknad = Plot[andrafornybarafunktion[x],
{x, 1990, 2050}, AxesLabel → { "År", "Energi [TWh]" }, PlotStyle → {Cyan},
PlotLabel → "konsumtion av energi andra förnybara källor Beräknad" ]

{ckol, dkol} = {c, d} /. FindFit[kol, {c (x - 1990) + d}, {c, c}, x]
{908.405, 21 × 826.1}
kolfunktion[x_] := ckol (x - 1990) + dkol
kolberaknad = Plot[kolfunktion[x], {x, 1990, 2050},
AxesLabel → { "År", "Energi[TWh]" }, PlotStyle → {Brown},
PlotLabel → "konsumtion av energi från kol Beräknad" ]

{cnaturgas, dnaturgas} =
 {c, d} /. FindFit[naturgas, {c Exp[d (x - 1990)]}, {c, d}, x]
{18 × 874.3, 0.0249077}
naturgasfunktion[x_] := cnaturgasExp[dnaturgas (x - 1990)]
naturgasberaknad = Plot[naturgasfunktion[x], {x, 1990, 2050},
AxesLabel → { "År", "Energi [TWh]" }, PlotStyle → {Purple},
PlotLabel → "konsumtion av energi från naturgaskraft Beräknad" ]

{cbiobransle, dbiobransle} =
 {c, d} /. FindFit[biobransle, {c (x - 1990) + d}, {c, d}, x]
{-17.7882, 11 × 990.9}
biobranslefunktion[x_] := cbiobransle (x - 1990) + dbiobransle
biobransleberaknad = Plot[biobranslefunktion[x], {x, 1990, 2050},
AxesLabel → { "År", "Energi [TWh]" }, PlotStyle → {LightBlue},
PlotLabel → "konsumtion av energi från biobransle Beräknad" ]

{ckarnkraft, dkarnkraft} =
 {c, d} /. FindFit[karnkraft, {c Exp[d (x - 1990)]}, {c, d}, x]
{2276., 0.00738811}
karnkraftfunktion[x_] := ckarnkraftExp[dkarnkraft (x - 1990)]
karnkraftberaknad = Plot[karnkraftfunktion[x], {x, 1990, 2050},
AxesLabel → { "År", "Energi [TWh]" }, PlotStyle → {Yellow},
PlotLabel → "konsumtion av energi från karnkraftkraft Beräknad" ]
```

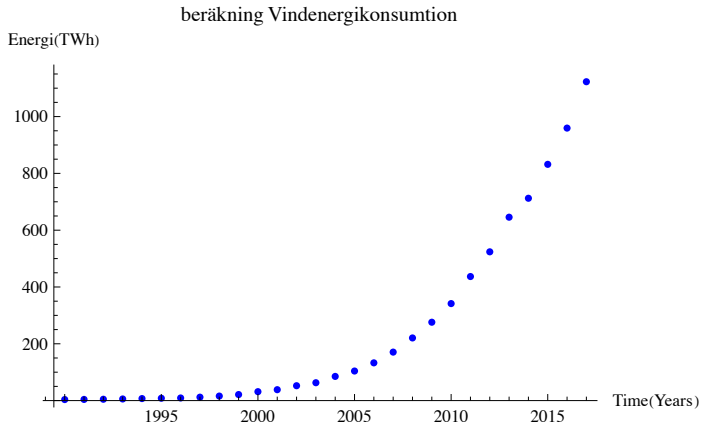
```
totaltfunktion[2036]
199 339.

vattenfunktion[2036] + vindfunktion[2036] +
 solfunktion[2036] + karnkraftfunktion[2036]
208 512.
```

4,

In[104]:=
```
vind = {{1990.`, 3.632470516`}, {1991.`, 4.086706675`},
  {1992.`, 4.733212019`}, {1993.`, 5.697568819`},
  {1994.`, 7.122929844`}, {1995.`, 8.261923444`}, {1996.`, 9.204610762`},
  {1997.`, 12.01757667`}, {1998.`, 15.91490057`}, {1999.`, 21.21534431`},
  {2000.`, 31.41996387`}, {2001.`, 38.39098735`}, {2002.`, 52.33180737`},
  {2003.`, 62.91691456`}, {2004.`, 85.11605376`}, {2005.`, 104.0868359`},
  {2006.`, 132.8592792`}, {2007.`, 170.6860872`}, {2008.`, 220.5696719`},
  {2009.`, 275.9292658`}, {2010.`, 341.5652412`}, {2011.`, 436.8034429`},
  {2012.`, 523.8148612`}, {2013.`, 645.7219776`}, {2014.`, 712.4070431`},
  {2015.`, 831.8262454`}, {2016.`, 959.4687163`}, {2017.`, 1122.74585`}}
ListPlot[vind, PlotRange → All, AxesLabel → {"Time(Years)", "Energi(TWh)"},
 PlotStyle → {Blue}, PlotLabel → Vindenergikonsumtion beräkning]
```

Out[104]=
```
{{1990., 3.63247}, {1991., 4.08671}, {1992., 4.73321}, {1993., 5.69757},
 {1994., 7.12293}, {1995., 8.26192}, {1996., 9.20461}, {1997., 12.0176},
 {1998., 15.9149}, {1999., 21.2153}, {2000., 31.42}, {2001., 38.391},
 {2002., 52.3318}, {2003., 62.9169}, {2004., 85.1161}, {2005., 104.087},
 {2006., 132.859}, {2007., 170.686}, {2008., 220.57}, {2009., 275.929},
 {2010., 341.565}, {2011., 436.803}, {2012., 523.815}, {2013., 645.722},
 {2014., 712.407}, {2015., 831.826}, {2016., 959.469}, {2017., 1122.75}}
```

Out[105]=



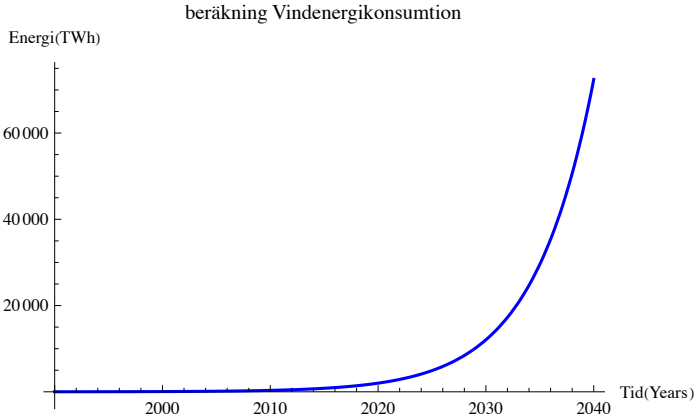
In[•]:=
```
{avind, bvind} = {a, b} /. FindFit[vind, {a Exp[b (t - 1990)]}, {a, b}, t]
```

Out[•]=
```
{9.25548, 0.179304}
```

```
vindfunktion[t_] := avind Exp[bvind (t - 1990)]
```

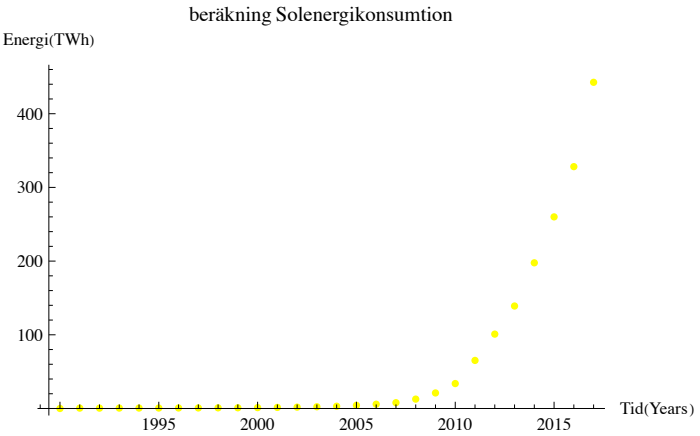
In[•]:=
```
beraknavind = Plot[vindfunktion[t], {t, 1990, 2040},
  PlotRange → All, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
  PlotStyle → {Blue}, PlotLabel → Vindenergikonsumtion beräkning]
```

Out[•]=



In[106]:=
```
sol = {{1990.`, 0.`}, {1991.`, 0.505223075`},
    {1992.`, 0.468615413`}, {1993.`, 0.556737928`}, {1994.`, 0.60006443`},
    {1995.`, 0.640874386`}, {1996.`, 0.705278679`}, {1997.`, 0.756655499`},
    {1998.`, 0.880289501`}, {1999.`, 0.965823997`}, {2000.`, 1.177935576`},
    {2001.`, 1.463956125`}, {2002.`, 1.831247734`}, {2003.`, 2.3293707`},
    {2004.`, 3.054656084`}, {2005.`, 4.249617769`}, {2006.`, 5.818328387`},
    {2007.`, 7.864870878`}, {2008.`, 12.72162081`}, {2009.`, 21.09259048`},
    {2010.`, 33.82948514`}, {2011.`, 65.21188479`}, {2012.`, 100.9252749`},
    {2013.`, 139.0442186`}, {2014.`, 197.6716635`}, {2015.`, 260.0058008`},
    {2016.`, 328.1826964`}, {2017.`, 442.6183606`}};
ListPlot[sol, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
 PlotStyle → {Yellow}, PlotLabel → Solenergikonsumtion beräkning]
```

Out[107]=



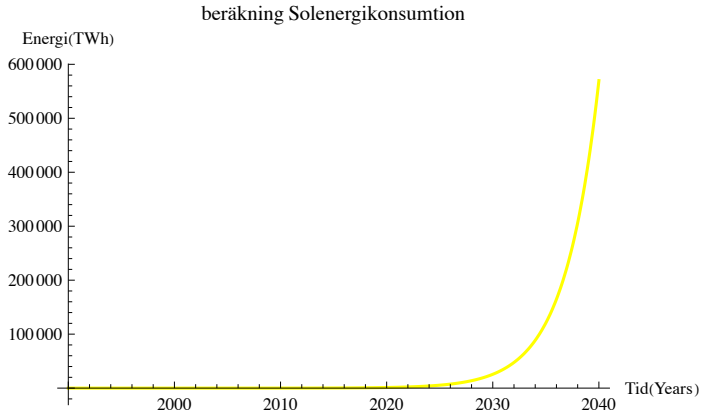
In[•]:=
```
{asol, bsol} = {a, b} /. FindFit[sol, {a Exp[b (t - 1990)]}, {a, b}, t]
```

Out[•]=
```
{0.104136, 0.310299}
```

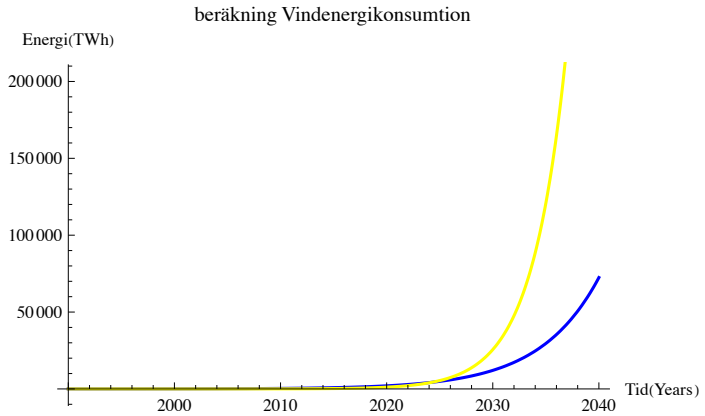
In[•]:=
```
solfunktion[t_] := asol Exp[bsol (t - 1990)]
```

In[ ]:=
```
beraknasol = Plot[solfunktion[t], {t, 1990, 2040},
  PlotRange → All, AxesLabel → {"Tid(Years)", "Energi(TWh)"},
  PlotStyle → {Yellow}, PlotLabel → Solenergikonsumtion beräkning]
```

Out[ ]=




```
Show[beraknavind, beraknasol, PlotRange → {200 000, 0}]
```




```
5, (*Ingen kod trävs*)
6, (*Ingen kod krävs*)
7, (*Ingen kod krävs*)
```