**Roskilde
University**

Scenarios for greenhouse warming mitigation

Sørensen, Bent

Publication date:
1995

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Sørensen, B. (1995). *Scenarios for greenhouse warming mitigation*. Roskilde Universitet. Tekster fra IMFUFA No. 300 <http://milne.ruc.dk/lmfufaTekster/>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain.
- You may freely distribute the URL identifying the publication in the public portal.

Take down policy

If you believe that this document breaches copyright please contact rucforsk@kb.dk providing details, and we will remove access to the work immediately and investigate your claim.

Bent Sørensen

To be presented at the International Energy Agency Greenhouse Mitigation Options Conference, London, 1995
To be published in "Energy Conversion and Management"

TEKSTER fra

IMFUFA

ROSKILDE UNIVERSITY • INSTITUTE 2

INSTITUTE OF STUDIES IN MATHEMATICS AND PHYSICS, AND THEIR
FUNCTIONS IN EDUCATION, RESEARCH AND APPLICATIONS

ENERGY
& ENVIRON-
MENT GROUP

ROSKILDE UNIVERSITY, P O BOX 260, DK-4000 ROSKILDE, DENMARK
TEL: (+45) 46 757 711, FAX: (+45) 46 755 065, TELEX 43158.
INSTITUTE OF STUDIES IN MATHEMATICS AND PHYSICS, AND THEIR FUNCTIONS
IN EDUCATION, RESEARCH AND APPLICATION.

8. July 1995

SCENARIOS FOR GREENHOUSE WARMING MITIGATION

by Bent Sørensen

IMFUFA text no. 300, 8 pages.

ISSN 0106 6242

Abstract - Four global scenarios of energy provision are considered, all of which have zero net emissions of greenhouse gases. The scenarios assume the same demand for energy services and a high degree of emphasis on energy efficiency. The supply options are clean fossil fuels, safe nuclear power, centralised or decentralised renewable energy, respectively. The scenarios provide an "existence proof" of greenhouse mitigation options, but otherwise are very different, in terms of energy infrastructure and presumably cost. Detailed estimates of environmental costs and regional setup including trade patterns have not yet been fully carried out, and the results are thus preliminary.

SCENARIOS FOR GREENHOUSE WARMING MITIGATION

BENT SØRENSEN

Roskilde University, Institute 2
P.O.Box 260, DK-4000 Roskilde, Denmark

Abstract - Four global scenarios of energy provision are considered, all of which have zero net emissions of greenhouse gases. The scenarios assume the same demand for energy services and a high degree of emphasis on energy efficiency. The supply options are clean fossil fuels, safe nuclear power, centralised or decentralised renewable energy, respectively. The scenarios provide an "existence proof" of greenhouse mitigation options, but otherwise are very different, in terms of energy infrastructure and presumably cost. Detailed estimates of environmental costs and regional setup including trade patterns have not yet been fully carried out, and the results are thus preliminary.

1. INTRODUCTION

The IPCC Working Group 2 has broadly identified options for mitigation of the greenhouse warming associated with extrapolating the current energy supply structure [1], but it also deplores the absence of well thought-out global scenarios that combine the individual options into a credible picture of the overall future energy supply. The present contribution is a presentation of an ongoing project aimed at supplying such detailed scenarios, and it gives preliminary results for the main characteristics of four key scenarios, each of which is extreme in using basically only one type of energy supply. Actual energy policies may of course select any mix of the base scenarios. However, these are useful in discussing the characteristics as well as the impacts of any combination.

2. BASIC ASSUMPTIONS AND DEMAND MODEL

The scenario year is 2050, in order to allow for a complete replacement of all equipment (except some buildings) with the best technology available. This implies a uniform assumption of high conversion efficiencies, right to the final conversion of energy into the service or product demanded, for all the scenarios. Table 1 gives the assumptions regarding population and end-use energy demand. The population estimates are from the World Bank [2] and the 2050 values correspond to the assumptions of high welfare and economic activity. The end-use energy estimates are the minimum amounts of energy, that could deliver the service actually demanded, using the best method and conversion equipment known today. The goal, which in 2050 has not been achieved in all regions, is based on a basic and derived needs analysis made previously [3]. It assumes that the Earth will continue to be populated by a mixture of audacious and concerned citizens. The audacious citizens are risk takers, who want to implement new ideas quickly and not to deal with negative impacts until they show. The concerned citizens worry about the environment and possible side effects of human activities, so they want to move very cautiously ahead. The scenario growth in demand satisfaction between 1990 and 2050 is seen to be 2-3 times higher than the corresponding growth between 1930 and 1990, which indicates that very challenging assumptions regarding future economic and social development have been invoked. The regional distribution of energy supply will only appear after the energy system analysis has been carried out, but it is already clear, that it will be substantially different from the IPCC and WEC scenarios [1], due to the analysis made of the detailed composition of the energy use at the end-user (a feature that is deplorably missing from most current international statistics).

Figure 1 gives the 1990 energy supply and conversion structure in condensed form. Out of the 10 TWy/y primary energy, about 77% is delivered to the final user. This is reduced to about 50% taking into account some obvious losses in end-use conversion [4,5], but further down to 10%, when the above definition of energy service is used. It is thus clear, that the most significant area for improvement is in the processes taking place at the end-user. Significantly better design of end-use supply systems and better technical efficiencies of end-use equipment is thus a common assumption for all the scenarios. At unchanged demand, this alone would reduce the necessary energy supply by about a factor of four, but it will have to be folded with activity increase and alterations in the system setup, between now and 2050.

3. THE CLEAN FOSSIL (CF) SCENARIO

The clean fossil fuel scenario assumes that by 2050, fossil energy will be used without emission of carbon dioxide. Either the fuel has been transformed into hydrogen or CO₂ is captured and removed from the flue gases.

Hydrogen can be produced from natural gas using the chemical reaction energy to form the steam required, or from coal by the water-to-gas shift reaction [6,7]. Flue gas cleaning lowers the efficiency of power plants, but is technically feasible [8]. The captured CO₂ would subsequently be stored in abandoned natural gas fields or other types of natural or artificial caverns [1]. The total energy system is shown in Figure 2. The hydrogen is used directly as a fuel in industry, or in fuel cell plants producing electricity and if feasible also heat, to be distributed by appropriate power and district heating lines. Half the transportation sector is run on electric vehicles (with batteries if not on tracks), the other half on hydrogen, using small size fuel cells for increased efficiency. Heat pumps are used to provide low-temperature heat, in addition to the district heating. Oil is only used as a feedstock for non-energy purposes, and the chief source of energy is coal. For natural gas the currently identified resources will only last to around 2030 at the rate of usage assumed, and although additional resources may be turned into commercial reserves, this scenario has to be considered transitional. However, a shift towards only relying on coal would prolong the transitional periods to several hundred years.

Table 1. Population (million) and end-use energy (W/cap), the 2050 values used in all scenarios

Region	Pop.			energy			
	1930	1990	2050	1930	1990	2050	goal
USA, Canada	132	265	310	800	900	1100	1100
W Europe, Jap., Austr.	362	545	610	700	900	1100	1100
E Europe, former Soviet, Middle East	240	530	880	200	380	800	1200
Latin America, SE Asia	660	1860	4000	100	115	700	1000
China, rest of Asia	442	1190	2000	60	60	700	1100
Africa	152	610	2000	60	40	200	900
World (average energy)	2000	5000	9800	251	248	644	1026

4. THE SAFE NUCLEAR (SN) SCENARIO

The safe nuclear scenario addresses the main objections to current nuclear power technologies: proliferation issues, large nuclear accidents and long-term storage of waste. To avoid proliferation of fissile material such as plutonium, spent fuel from reactors would be recycled to an accelerator breeder rather than being reprocessed [9]. One thereby reduces the fuel input by a factor of three, while also avoiding at least part of the proliferation problem. The reactors themselves can be made more safe in two ways. One is to reduce the size so much that core melt accidents almost certainly can be contained. This involves maximum unit sizes of 50-100 MW. The other method is to make the conventional light water reactor inherently safe, by enclosing the reactor core of a pressurized water reactor (PWR) within a vessel of boronated water, that will flood the core if pressure is lost, as there is no barrier between the core and the pool of water, that in the absence of pressure in the primary system will shut the reactor down and continue to remove heat from the core by natural circulation. It is calculated that in an accident situation, replenishing of cooling fluid can be done at weekly intervals (in contrast to hours or less for current light water reactor designs) [10]. Finally, as regards nuclear waste, the most long-lived components could be removed by transmutation. At present, the only scheme for doing this would involve a liquid metal breeder reactor [11], which does not fulfill the demand for inherent safety. For this reason, the transmutation step is just indicated in the energy system diagram shown in Figure 3, but not actually used. On the other hand, breeders seem to be required in any scenario of this kind, due to the resource aspect. Even with the factor 3 accelerator breeding, presently identified resources would at the scenario usage rate become depleted in 9 years, and only the true breeding at over a factor 60 will make this scenario sustainable for even the lifetime of the equipment involved.

5. THE DECENTRALISED RENEWABLE ENERGY (DRE) SCENARIO

The renewable energy scenario depicted in Figure 4 is similar to one constructed earlier for Denmark [12] and under construction for the European Union [13]. It uses the currently available low-temperature solar thermal, wind and biogas technologies, as well as anticipated photovoltaic technology that is similar to the current one,

but affordable for large-scale power production. As in the fossil scenario, fuel cell technology is assumed to be available, as well as technology for producing hydrogen from biomass (gasification plus shift reaction as for coal) [14]. For the non-electrified part of the transportation sector, liquid biofuels such as methanol are introduced [6,15], in order to minimize the change from current gasoline use. The large share of bioenergy ensures that there is backup for the variable renewable energy sources (solar radiation and wind), notably through active storage of either primary biomass or of biogas and hydrogen in caverns, in combination with the flexibility offered by use of reversible fuel cells instead of conventional power stations. This allows surplus wind and solar cell produced electricity to be converted to a storable fuel, whereas in the transportation sector, the liquid biofuels play this role. In the heating sector, some of the solar heat is stored in (communal size) heat stores connected to district heating lines. However, district heating only makes sense in regions with fairly high heat use density, so in other regions, a backup for the solar panels is provided by biogas and by having heat pumps available.

6. THE CENTRALISED RENEWABLE ENERGY (CRE) SCENARIO

The amount of biomass used in the DRE scenario is large (almost as large as in the IPCC high-biomass scenario [1]) and it requires partly an integrated food and energy production (using residues for biogas and returning fertilizer), partly a biomass to hydrogen and methanol path that may require dedicated bioenergy growth (wood plantations etc.). Only in some parts of the world is this possible, and generally, one has to ensure not only a sustainable energy production, but also a sustainable food production. This involves a number of issues, such as ecological farming (without pesticides) and altered animal and vegetable production ratios [12]. Only the detailed analysis of DRE scenarios will determine, if such sustainability is possible. It is therefore explored here, if a scenario with considerably less biomass use would be feasible. The methanol production is removed and the biomass gasification reduced. The additional energy is obtained from photovoltaics. The decentralized potential on building roofs and facades is considered exploited already in the DRE scenario, so the additional solar cell installations are assumed to be central plants located on infertile lands (deserts etc.). The price for this arrangement is considerable intercontinental power transmission, but losses are still smaller than in the liquid biofuel production. A detailed analysis is needed in order to ensure that the storage capacity in this scenario is sufficient. A positive feature is that the solar electricity production is likely to be higher and more stable in the mostly equatorial desert areas considered, and that the increased power production per unit collector area may pay for the additional structure and transmission equipment.

7. COST ESTIMATES

In the fossil scenario, decarbonization of fuels is estimated to increase costs less than 50%, whereas removal from flue gases is somewhat more expensive. The cost of CO₂ deposition is little known, but probably affordable for natural gas wells. Totally, the energy cost may rise to 2-3 times the present one, which may match the externality cost of greenhouse warming damages [16]. For the nuclear scenario, entirely new techniques are brought in at unknown or high cost [11]. Adding the uncertainty of the breeder reactor that seems to be required for this scenario, the preliminary conclusion would be that it is not a viable option for introduction before 2050. The renewable energy scenarios incorporate wind and biogas systems with costs only slightly higher than current system costs, and also photovoltaic panels, for which considerable (but envisaged) cost reductions have to become realised. These scenarios also include increased use of energy storage or demand management, at a corresponding cost. For the decentralised scenario, the cost of biofuels has to be considered (currently about twice the present energy price [15]), while for the centralised one, the cost of long-distance power transmission is crucial and probably requires new technologies of lower cost than current ones. The detailed cost and externality estimates will have to be performed in order to complete this discussion.

8. CONCLUSIONS

As the scenarios presented here are preliminary and the detailed region by region analysis still has to be done, one should be careful in attaching too much importance to the evaluation of the scenarios. It does appear that the nuclear scenario will have serious problems and probably is not realisable within the 60 year time period considered. Also the centralized renewable energy scenario depends on unproven technology advances (in transmission technology), or will become very expensive. Only the clean fossil and decentralized renewable scenarios seem to be technically feasible and at costs than may be within the range of "fair market" estimates based on present energy prices (minus subsidies and taxes) but plus externality costs, of which the very uncertain greenhouse warming costs are the most significant (estimated at over 0.1 ecu/kWh [16], mostly due to the effects of extreme events on developing countries).

REFERENCES

1. IPCC Second Assessment Report, Working Group 2 (to be published) (1995).
2. World Bank, World Population Projections (K Zachariah and M Wu). Baltimore (1988).
3. B Sørensen, pp. 35-74 in "Renewable energy and local production". Danish Center for Renewable Energy (1988).
4. B Sørensen, Energy, vol. 6, pp. 293-303 (1981); vol. 7, pp. 783-799 (1982).
5. N Nakicenovic et al., Energy, vol. 18, pp. 401-609, and IIASA database (1993).
6. J Jensen and B Sørensen, Fundamentals of Energy Storage. Wiley, New York (1984).
7. R Williams, Fuel decarbonization for fuel cell applications and sequestration of the separated CO₂. (preprint) (1995).
8. C Hendriks, Thesis. Dept. Science, Technology & Society. Utrecht University (1994).
9. P Grand, Nature, vol. 278, pp. 693-696 (1979).
10. R Klueh, New Scientist, 3. April, pp. 41-45 (1986); K. Hannerz, Nucl. Eng. Int., Dec., p. 41 (1983).
11. T Pigford, pp. 97-99 in "Transmutation as a waste management tool", Conf. Proc. (1991).
12. B Sørensen et al., Renewable energy system of the future. (in Danish). Technology Council, Copenhagen (1994).
13. O Hohmeyer, H Lehman, B Sørensen, et al., Long-term integration of renewable energy into the European energy system. EC APAS project internal reports (1995).
14. R Williams, E Larson, R Katofsky, J Chen, Methanol and hydrogen from biomass for transportation. (preprint) (1995).
15. European Commission, DG XII, Biofuels. Report EUR 15647 EN, Brussels (1994).
16. B Sørensen, The role of life-cycle analysis in risk assessment, Int. J. of Environment and Pollution (to be published).

Figure 1. The 1990 global energy system (GWh/y).

Figure 2. A 2050 clean fossil energy scenario (GWy/y).

Figure 3. A 2050 safe nuclear energy scenario (GWy/y).

Figure 4. A 2050 decentralized renewable energy scenario (GWy/y).

Figure 5. A 2050 centralized renewable energy scenario (GWy/y).

Liste over tidligere udkomne tekster
tilsendes gerne. Henvendelse herom kan
ske til IMPUFA's sekretariat
tlf. 46 75 77 11 lokal 2263

-
- 217/92 "Two papers on APPLICATIONS AND MODELLING
IN THE MATHEMATICS CURRICULUM"
by: Mogens Niss
- 218/92 "A Three-Square Theorem"
by: Lars Kadison
- 219/92 "RUPNOK - stationær strømning i elastiske rør"
af: Anja Boisen, Karen Birkelund, Mette Olufsen
Vejleder: Jesper Larsen
- 220/92 "Automatisk diagnosticering i digitale kredsløb"
af: Bjørn Christensen, Ole Møller Nielsen
Vejleder: Stig Andur Pedersen
- 221/92 "A BUNDLE VALUED RADON TRANSFORM, WITH
APPLICATIONS TO INVARIANT WAVE EQUATIONS"
by: Thomas P. Branson, Gestur Olafsson and
Henrik Schlichtkrull
- 222/92 On the Representations of some Infinite Dimensional
Groups and Algebras Related to Quantum Physics
by: Johnny T. Ottesen
- 223/92 THE FUNCTIONAL DETERMINANT
by: Thomas P. Branson
- 224/92 UNIVERSAL AC CONDUCTIVITY OF NON-METALLIC SOLIDS AT
LOW TEMPERATURES
by: Jeppe C. Dyre
- 225/92 "HATMODELLEN" Impedansspektroskopi i ultrarent
en-krystallinsk silicium
af: Anja Boisen, Anders Gorm Larsen, Jesper Varmer,
Johannes K. Nielsen, Kit R. Hansen, Peter Bøggild
og Thomas Hougaard
Vejleder: Petr Viscor
- 226/92 "METHODS AND MODELS FOR ESTIMATING THE GLOBAL
CIRCULATION OF SELECTED EMISSIONS FROM ENERGY
CONVERSION"
by: Bent Sørensen

- 227/92 "Computersimulering og fysik"
af: Per M.Hansen, Steffen Holm,
Peter Maibom, Mads K. Dall Petersen,
Pernille Postgaard, Thomas B.Schrøder,
Ivar P. Zeck
Vejleder: Peder Voetmann Christiansen
- 228/92 "Teknologi og historie"
Fire artikler af:
Mogens Niss, Jens Høyrup, Ib Thiersen,
Hans Heddal
- 229/92 "Masser af information uden betydning"
En diskussion af informationsteorien
i Tor Nørretranders' "Mærk Verden" og
en skitse til et alternativ baseret
på andenordens kybernetik og semiotik.
af: Søren Brier
- 230/92 "Vinklens tredeling - et klassisk
problem"
et matematisk projekt af
Karen Birkelund, Bjørn Christensen
Vejleder: Johnny Ottesen
- 231A/92 "Elektrondiffusion i silicium - en
matematisk model"
af: Jesper Voetmann, Karen Birkelund,
Mette Olufsen, Ole Møller Nielsen
Vejledere: Johnny Ottesen, H.B.Hansen
- 231B/92 "Elektrondiffusion i silicium - en
matematisk model" Kildetekster
af: Jesper Voetmann, Karen Birkelund,
Mette Olufsen, Ole Møller Nielsen
Vejledere: Johnny Ottesen, H.B.Hansen
- 232/92 "Undersøgelse om den simultane opdagelse
af energiens bevarelse og isærdeles om
de af Mayer, Colding, Joule og Helmholtz
udførte arbejder"
af: L.Arleth, G.I.Dybkjær, M.T.Østergård
Vejleder: Dorthe Posselt
- 233/92 "The effect of age-dependent host
mortality on the dynamics of an endemic
disease and
Instability in an SIR-model with age-
dependent susceptibility
by: Viggo Andreassen
- 234/92 "THE FUNCTIONAL DETERMINANT OF A FOUR-DIMENSIONAL
BOUNDARY VALUE PROBLEM"
by: Thomas P. Branson and Peter B. Gilkey
- 235/92 OVERFLADESTRUKTUR OG POREUDVIKLING AF KOKS
- Modul 3 fysik projekt -
af: Thomas Jessen
-

- 236a/93 INTRODUKTION TIL KVANTE
HALL EFFEKTEN
af: Anja Boisen, Peter Bøggild
Vejleder: Peder Voetmann Christiansen
Erland Brun Hansen
- 236b/93 STRØMSSAMMENBRUD AF KVANTE
HALL EFFEKTEN
af: Anja Boisen, Peter Bøggild
Vejleder: Peder Voetmann Christiansen
Erland Brun Hansen
- 237/93 The Wedderburn principal theorem and
Shukla cohomology
af: Lars Kadison
- 238/93 SEMIOTIK OG SYSTEMEGENSKABER (2)
Vektorbånd og tensorer
af: Peder Voetmann Christiansen
- 239/93 Valgsystemer - Modelbygning og analyse
Matematik 2. modul
af: Charlotte Gjerrild, Jane Hansen,
Maria Hermannsson, Allan Jørgensen,
Ragna Clauson-Kaas, Poul Lützen
Vejleder: Mogens Niss
- 240/93 Patologiske eksempler.
Om sære matematiske fisks betydning for
den matematiske udvikling
af: Claus Dræby, Jørn Skov Hansen, Runa
Ulsøe Johansen, Peter Meibom, Johannes
Kristoffer Nielsen
Vejleder: Mogens Niss
- 241/93 FOTOVOLTAISK STATUSNOTAT 1
af: Bent Sørensen
- 242/93 Brovedligeholdelse - bevar mig vel
Analyse af Vejdirektoratets model for
optimering af broreparationer
af: Linda Kyndlev, Kare Fundal, Kamma
Tulinus, Ivar Zeck
Vejleder: Jesper Larsen
- 243/93 TANKEEKSPERIMENTER I FYSIKKEN
Et 1.modul fysikprojekt
af: Karen Birkelund, Stine Sofia Korremann
Vejleder: Dorte Posselt
- 244/93 RADONTRANSFORMATIONEN og dens anvendelse
i CT-scanning
Projektrapport
af: Trine Andreassen, Tine Guldager Christiansen,
Nina Skov Hansen og Christine Iversen
Vejledere: Gestur Olafsson og Jesper Larsen
- 245a+b
/93 Time-Of-Flight målinger på krystallinske
halvledere
Specialerapport
af: Linda Szkotak Jensen og Lise Odgaard Gade
Vejledere: Petr Viscor og Niels Boye Olsen
- 246/93 HVERDAGSVIDEN OG MATEMATIK
- LÆREPROCESSER I SKOLEN
af: Lena Lindenskov, Statens Humanistiske
Forskningsråd, RUC, IMFUFA
- 247/93 UNIVERSAL LOW TEMPERATURE AC CON-
DUCTIVITY OF MACROSCOPICALLY
DISORDERED NON-METALS
by: Jeppe C. Dyre
- 248/93 DIRAC OPERATORS AND MANIFOLDS WITH
BOUNDARY
by: B. Booss-Bavnbek, K.P.Wojciechowski
- 249/93 Perspectives on Teichmüller and the
Jahresbericht Addendum to Schappacher,
Scholz, et al.
by: B. Booss-Bavnbek
With comments by W.Abikoff, L.Ahlfors,
J.Cerf, P.J.Davis, W.Fuchs, F.P.Gardiner,
J.Jost, J.-P.Kahane, R.Lohan, L.Lorch,
J.Radkau and T.Söderqvist
- 250/93 EULER OG BOLZANO - MATEMATISK ANALYSE SET I ET
VIDENSKABSTEORETISK PERSPEKTIV
Projektrapport af: Anja Juul, Lone Michelsen,
Tomas Højgård Jensen
Vejleder: Stig Andur Pedersen
- 251/93 Genotypic Proportions in Hybrid Zones
by: Freddy Bugge Christiansen, Viggo Andreassen
and Ebbe Thue Poulsen
- 252/93 MODELLERING AF TILFÆLDIGE FÆNOMENER
Projektrapport af: Birthe Friis, Lisbeth Helmgård,
Kristina Charlotte Jakobsen, Marina Mosbæk
Johannessen, Lotte Ludvigsen, Mette Hass Nielsen
- 253/93 Kuglepakning
Teori og model
af: Lise Arleth, Kåre Fundal, Nils Kruse
Vejleder: Mogens Niss
- 254/93 Regressionsanalyse
Materiale til et statistikkursus
af: Jørgen Larsen
- 255/93 TID & BETINGET UAFHÆNGIGHED
af: Peter Harremoës
- 256/93 Determination of the Frequency Dependent
Bulk Modulus of Liquids Using a Piezo-
electric Spherical Shell (Preprint)
by: T. Christensen and N.B.Olsen
- 257/93 Modellering af dispersion i piezoelektriske
keramikker
af: Pernille Postgaard, Jannik Rasmussen,
Christina Specht, Mikko Østergård
Vejleder: Tage Christensen
- 258/93 Supplerende kursusmateriale til
"Lineære strukturer fra algebra og analyse"
af: Mogens Brun Heefelt
- 259/93 STUDIES OF AC HOPPING CONDUCTION AT LOW
TEMPERATURES
by: Jeppe C. Dyre
- 260/93 PARTITIONED MANIFOLDS AND INVARIANTS IN
DIMENSIONS 2, 3, AND 4
by: B. Booss-Bavnbek, K.P.Wojciechowski

- 261/93 OPGAVESAMLING
Bredde-kursus i Fysik
Eksamensopgaver fra 1976-93
- 262/93 Separability and the Jones Polynomial
by: Lars Kadison
- 263/93 Supplerende kursusmateriale til "Lineære strukturer fra algebra og analyse" II
af: Mogens Brun Heefelt
- 264/93 FOTOVOLTAISK STATUSNOTAT 2
af: Bent Sørensen
-
- 265/94 SPHERICAL FUNCTIONS ON ORDERED SYMMETRIC SPACES
To Sigurdur Helgason on his sixtyfifth birthday
by: Jacques Faraut, Joachim Hilgert and Gestur Olafsson
- 266/94 Kommensurabilitets-oscillationer i laterale supergitre
Fysikspeciale af: Anja Boisen, Peter Bøggild, Karen Birkelund
Vejledere: Rafael Taboryski, Poul Erik Lindelof, Peder Voetmann Christiansen
- 267/94 Kom til kort med matematik på Eksperimentarium - Et forslag til en opstilling
af: Charlotte Gjerrild, Jane Hansen
Vejleder: Bernhelm Booss-Bavnbek
- 268/94 Life is like a sewer ...
Et projekt om modellering af aorta via en model for strømning i kloakrør
af: Anders Marcussen, Anne C. Nilsson, Lone Michelsen, Per M. Hansen
Vejleder: Jesper Larsen
- 269/94 Dimensionsanalyse en introduktion metaprojekt, fysik
af: Tine Guldager Christiansen, Ken Andersen, Nikolaj Hermann, Jannik Rasmussen
Vejleder: Jens Højgaard Jensen
- 270/94 THE IMAGE OF THE ENVELOPING ALGEBRA AND IRREDUCIBILITY OF INDUCED REPRESENTATIONS OF EXPONENTIAL LIE GROUPS
by: Jacob Jacobsen
- 271/94 Matematikken i Fysikken.
Opdaget eller opfundet
NAT-BAS-projekt
vejleder: Jens Højgaard Jensen
- 272/94 Tradition og fornyelse
Det praktiske elevarbejde i gymnasiets fysikundervisning, 1907-1988
af: Kristian Hoppe og Jeppe Guldager
Vejledning: Karin Beyer og Nils Hybel
- 273/94 Model for kort- og mellemdistanceløb
Verifikation af model
af: Lise Fabricius Christensen, Helle Pilemann, Bettina Sørensen
Vejleder: Mette Olufsen
- 274/94 MODEL 10 - en matematisk model af intravenøse anæstetikas farmakokinetik
3. modul matematik, forår 1994
af: Trine Andreasen, Bjørn Christensen, Christine Green, Anja Skjoldborg Hansen. Lisbeth Helmgaard
Vejledere: Viggo Andreasen & Jesper Larsen
- 275/94 Perspectives on Teichmüller and the Jahresbericht 2nd Edition
by: Bernhelm Booss-Bavnbek
- 276/94 Dispersionsmodellering
Projektrapport 1. modul
af: Gitte Andersen, Rehannah Borup, Lisbeth Friis, Per Gregersen, Kristina Vejre
Vejleder: Bernhelm Booss-Bavnbek
- 277/94 PROJEKTARBEJDSPÆDAGOGIK - Om tre tolkninger af problemorienteret projektarbejde
af: Claus Flensted Behrens, Frederik Voetmann Christiansen, Jørn Skov Hansen, Thomas Thingstrup
Vejleder: Jens Højgaard Jensen
- 278/94 The Models Underlying the Anaesthesia Simulator Sophus
by: Mette Olufsen(Math-Tech), Finn Nielsen (RISØ National Laboratory), Per Føge Jensen (Herlev University Hospital), Stig Andur Pedersen (Roskilde University)
- 279/94 Description of a method of measuring the shear modulus of supercooled liquids and a comparison of their thermal and mechanical response functions.
af: Tage Christensen
- 280/94 A Course in Projective Geometry
by Lars Kadison and Matthias T. Kromann
- 281/94 Modellering af Det Cardiovasculære System med Neural Puls kontrol
Projektrapport udarbejdet af:
Stefan Frello, Runa Ulsøe Johansen, Michael Poul Curt Hansen, Klaus Dahl Jensen
Vejleder: Viggo Andreasen
- 282/94 Parallelle algoritmer
af: Erwin Dan Nielsen, Jan Danielsen, Niels Bo Johansen

- 283/94 Grænser for tilfældighed
(en kaotisk talgenerator)
af: Erwin Dan Nielsen og Niels Bo Johansen
- 284/94 Det er ikke til at se det, hvis man ikke
lige ve' det!
Gymnasimatematikens begrundelsesproblem
En specialerapport af Peter Hauge Jensen
og Linda Kyndlev
Vejleder: Mogens Niss
- 285/94 Slow coevolution of a viral pathogen and
its diploid host
by: Viggo Andreassen and
Freddy B. Christiansen
- 286/94 The energy master equation: A low-temperature
approximation to Bässler's random walk model
by: Jeppe C. Dyre
- 287/94 A Statistical Mechanical Approximation for the
Calculation of Time Auto-Correlation Functions
by: Jeppe C. Dyre
- 288/95 PROGRESS IN WIND ENERGY UTILIZATION
by: Bent Sørensen
- 289/95 Universal Time-Dependence of the Mean-Square
Displacement in Extremely Rugged Energy
Landscapes with Equal Minima
by: Jeppe C. Dyre and Jacob Jacobsen
- 290/95 Modellering af uregelmæssige bølger
Et 3.modul matematik projekt
af: Anders Marcussen, Anne Charlotte Nilsson,
Lone Michelsen, Per Mørkegaard Hansen
Vejleder: Jesper Larsen
- 291/95 1st Annual Report from the project
LIFE-CYCLE ANALYSIS OF THE TOTAL DANISH
ENERGY SYSTEM
an example of using methods developed for the
OECD/IEA and the US/EU fuel cycle externality study
by: Bent Sørensen
- 292/95 Fotovoltaisk Statusnotat 3
af: Bent Sørensen
- 293/95 Geometridiskussionen - hvor blev den af?
af: Lotte Ludvigsen & Jens Frandsen
Vejleder: Anders Madsen
- 294/95 Universets udvidelse -
et metaprojekt
Af: Jesper Duelund og Birthe Friis
Vejleder: Ib Lundgaard Rasmussen
- 295/95 A Review of Mathematical Modeling of the
Controlled Cardiovascular System
By: Johnny T. Ottesen
- 296/95 RETIKULER den klassiske mekanik
af: Peder Voetmann Christiansen
- 297/95 A fluid-dynamical model of the aorta with
bifurcations
by: Mette Olufsen and Johnny Ottesen
- 298/95 Mordet på Schrödingers kat - et metaprojekt om
to fortolkninger af kvantemekanikken
af: Maria Hermannsson, Sebastian Horst,
Christina Specht
Vejledere: Jeppe Dyre og Peder Voetmann Christiansen
- 299/95 ADAM under figenbladet - et kig på en samfunds-
videnskabelig matematisk model
Et matematisk modelprojekt
af: Claus Dræby, Michael Hansen, Tomas Højgård Jensen
Vejleder: Jørgen Larsen
- 300/95 Scenarios for Greenhouse Warming Mitigation
by: Bent Sørensen