Eidgenössische
Technische Hochschule
Zürich

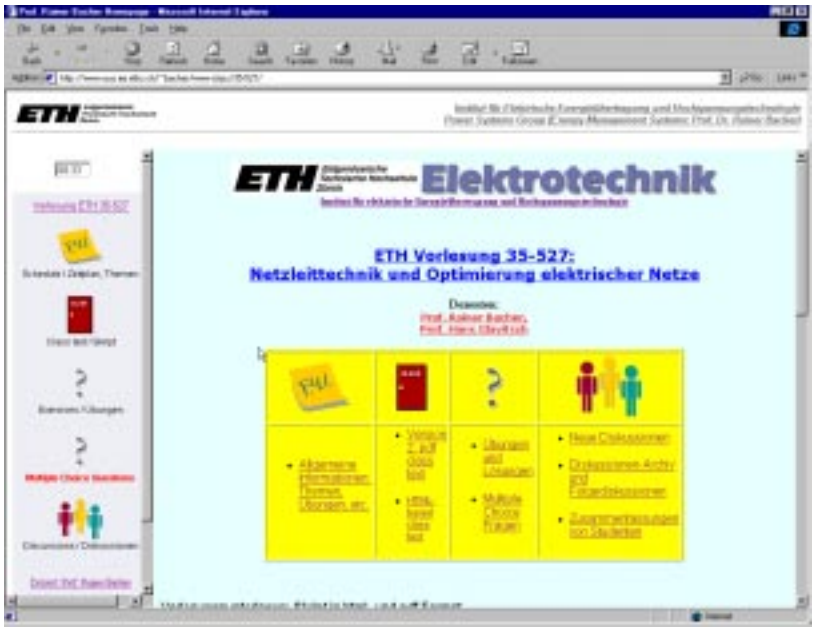
Ecole polytechnique fédérale de Zurich
Politecnico federale di Zurigo
Swiss Federal Institute of Technology Zurich

Institut für Elektrische Energieübertragung und Hochspannungstechnologie

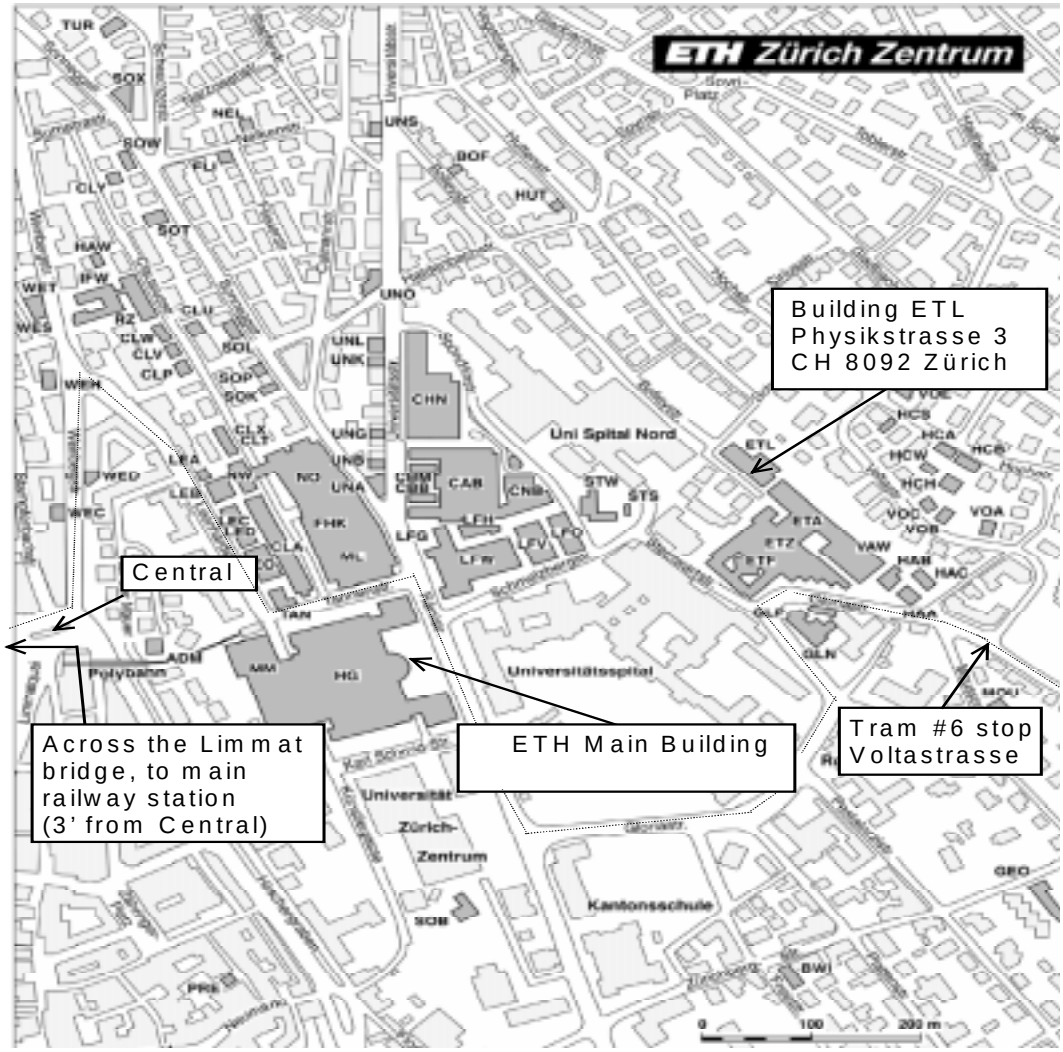
Laboratory for Electric Power Transmission and High Voltage Laboratory

Jahresbericht / Annual Report

1998



Lageplan
Proff. Bacher, Fröhlich, Glavitsch, Spreng
ETH Zürich
ETL-Gebäude



JAHRESBERICHT / ANNUAL REPORT 1998

Herausgeber:

Institut für Elektrische Energieübertragung und Hochspannungstechnologie

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Redaktion: Prof. Rainer Bacher, Assistenzprofessur für Netzleittechnik
Dr. T.H. Teich, Fachgruppe Hochspannungstechnologie
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This yearly report can be downloaded from the Internet (WWW) at
http://www.eus.ee.ethz.ch/main/eus_research.html#yearly_report

Inhaltsverzeichnis

Sehr geehrte Freunde unseres Instituts,

aus besonderem Anlass, nämlich im Hinblick auf meinem Rücktritt, erlaube ich mir die Begrüssung und Einleitung zum diesjährigen Jahresbericht in eigener Sache zu verfassen. Nach 21-jähriger Tätigkeit am Institut als Leiter der Fachgruppe Energieübertragungssysteme trete ich in den Ruhestand. Ich habe in meiner Berufung an die ETH die Aufgabe gesehen, die mit der Computertechnik sich entwickelnden Methoden der Analyse, Simulation und Optimierung für elektrische Netze in Lehre und Forschung zu pflegen. Beginnend mit drei Assistenten konnte ich in dieser Zeit ein weites Forschungsgebiet abdecken und dabei Schwerpunkte setzen, die international Beachtung gefunden haben. Ich konnte dabei auf wertvolle Beiträge meiner Doktoranden, Assistenten und Professorenkollegen zählen. Dazu möchte ich das Gebiet des korrigierenden und optimierenden Schaltens, grundlegende Entwicklungen im Bereich des optimalen Lastflusses, Verfahren für den offenen Strommarkt, Konzepte zur Erhöhung der Übertragungskapazität von Netzen, den Einsatz von Flexible AC Transmission Systems (FACTS) und das Software Engineering erwähnen. Die Fachgruppe war bei den einschlägigen Konferenzen wie Power Industry Computer Application (PICA), Power Systems Computation Conference (PSCC) und IEEE Winter Meeting über die Jahre lückenlos präsent und zwar nicht nur mit Beiträgen, sondern auch durch Sitzungsleitung, Panels und vor allem durch Vertretung in den Technischen Komitees. Ich selbst habe bei Antritt meiner Professur das CIGRE-Studienkomitee 32 „Betrieb und Regelung elektrischer Netze“ als Präsident geleitet. Diese Aktivitäten haben zu einer Vielzahl von persönlichen Kontakten weltweit geführt, wodurch sich im Laufe der Zeit Einladungen zu interessanten Gastaufenthalten an den Universitäten in Kapstadt, Berkeley, Tokyo, Beijing, Seattle und im Gegenzug zu Besuchen der Kollegen in Zürich ergeben haben.

Durch die persönliche Initiative von Prof. Spreng und später durch die Unterstützung der Privatindustrie konnte sich die Forschungsgruppe Energieanalysen in der Fachgruppe etablieren, die heute in der Energieforschung der Schweiz einen festen Platz und entsprechende Anerkennung gefunden hat. Nicht nur dies, die Forschungsgruppe ist heute weltweit in den Aktivitäten der „Alliance for Global Sustainability“ integriert. Im Kerngebiet der Fachgruppe konnte durch die Berufung von Dr. Rainer Bacher zum Assistenzprofessor ein nennenswerter Forschungsbereich aufgenommen werden, der eine starke Verbindung zur Informatik und Softwareentwicklung aufweist. Die durchgeführten Arbeiten beschäftigten sich mit grundlegenden Verfahren der Optimierung, der Modellierung von Netzen, der Code-Generierung für komplexe Softwaresysteme und Daten-Engineering. Wie sich gezeigt hat, haben entsprechende Beiträge zu internationalen Konferenzen Spitzenplätze in der Bewertung eingenommen. Die in der Fachgruppe aufbereiteten Verfahren sind grundlegend und zukunftsweisend für die Systemtechnik des offenen Strommarkts und für den umfassenden Einsatz von FACTS im vermaschten Netz. Es ist zu erwarten, dass die heute für den Einsatz im Strommarkt und für FACTS vorgesehenen Konzepte Schritt für Schritt durch diese mehr theoretisch orientierten Verfahren ersetzt werden.

Durch diese Entwicklungen ist es gelungen, enge Verbindungen zur Industrie und zu Energieversorgungsunternehmen aufzunehmen, die zu gemeinsamen Projekten und Beratungsaufträgen geführt haben. Diese Kontakte sind und waren wertvolle Voraussetzungen für den Praxisbezug der eigenen Forschung, wofür ich meine besondere Wertschätzung zum Ausdruck bringen möchte.

Die Ergebnisse waren nur durch eine enge Zusammenarbeit mit den Kollegen und Mitarbeitern am Institut möglich, sowohl fachlich wie persönlich. Ihnen allen bin ich zu grossem Dank verpflichtet. Nicht zuletzt möchte ich die immer umfassende Unterstützung durch meine Sekretärin Frau Metzler erwähnen. Sie hat vorausschauend für die Abwicklung der notwendigen administrativen Angelegenheiten gesorgt und in heiklen Situationen vollen Einsatz gezeigt.

In jüngster Vergangenheit hat sich der Übergang der Leitung der Fachgruppe Hochspannungstechnologie vom Kollegen Zaengl auf Kollegen Fröhlich ergeben. Ich war in der glücklichen Lage vom Beginn meiner Hochschultätigkeit in Walter Zaengl einen wohlwollenden Kollegen zu haben, der mich mit seiner Erfahrung tatkräftig unterstützt hat, wofür ich sehr dankbar bin. In der kurzen Zeit seit dem Amtsantritt von Klaus Fröhlich hat sich im Institut eine sehr gute persönliche Beziehung aufgebaut, in der viele gemeinsame Aufgaben im besten Einvernehmen gelöst werden konnten. Die Fachgruppe Hochspannungstechnologie hat sich bereits jetzt einen festen Platz in der Abteilung und im Umfeld der ETH erarbeitet. Die zunehmende Anzahl von Forschungsaufträgen geben Zeugnis davon. Damit ist vorauszusehen, dass die Erwartungen, die in die Wiederbesetzung der Fachgruppe gesetzt wurden, voll erfüllt werden.

Ich darf gegenüber den Empfängern dieses Jahresberichtes den Wunsch aussprechen, dass sie in Zukunft weiterhin dem Institut und ihren Aktivitäten ihr Interesse zeigen und gegebenenfalls ihre Unterstützung angedeihen lassen. Auch in dieser Hinsicht meinen besten Dank.

Hans Glavitsch

Die Lehre und Forschung in der **"Assistenzprofessur für Netzleittechnik"** ist geprägt durch konsequente Anwendung neuer Technologien auf aktuelle und zukünftige Problemstellungen und Themenkreise: Technologie wird einerseits im Unterricht (Pilotprojekt: ETH-WWW unterstützter Unterricht; Grossbildschirm-Projektion; interaktive Simulationen) vor allem zur Verbesserung der Lernmotivation der Studierenden wie auch der Erhöhung der Attraktivität der Richtung "Elektrische Energiesysteme" eingesetzt. Andererseits werden neue Technologien (z.B. Software-Engineering, Information-Engineering, WWW-Services) auch in der Forschung auf aktuelle Forschungsgebiete wie z.B. "Wirtschaftlichkeits- und Sicherheitsphänomene des elektrischen Energiemarkts", "flexibler Informationsaustausch und offener Zugang zu Energieinformationssystemen" und "Anwendung innovativer Netzkomponenten (FACTS) in elektrischen Energiesystemen" angewendet.

In der **Forschungsgruppe Energieanalysen** konzentriert sich zur Zeit ein wesentlicher Teil der Forschung auf Arbeiten rund um das Thema Energieindikatoren. Die Alliance for Global Sustainability finanzierte 1998 die Arbeit von zwei Mitarbeitern in diesem Bereich. Es interessieren uns dabei Fragen wie ”Was sind gute Indikatoren?”, ”Wie können die theoretischen Grundlagen zur Konstruktion von Indikatoren verbessert werden?”, ”Gibt es Entwicklungen, bei welchen ganz bestimmte Energieverbrauchsindikatoren als Indikatoren der Nachhaltigkeit gelten können?”. Im Herbst 1998 arbeitete auch Shonali Pachauri, eine indische Ressourcen-Ökonomin, als akademischer Gast an diesem Projekt. Die Forschungsgruppe Energieanalysen sieht gespannt dem nächsten Jahr entgegen. Es ist vorgesehen, dass sie im Frühling 1999 in das geplante Zentrum für Energiewirtschaft umziehen wird.

Die **Gruppe Hochspannungstechnologie** hat einen ihrer Schwerpunkte nach wie vor in der Erforschung neuer Prinzipien zur strombegrenzenden Unterbrechung von Kurzschlussströmen, aus der 1998 zwei Patentanmeldungen hervorgingen. Ein weiterer Schwerpunkt ist der Einsatz künstlicher Intelligenz für Hochspannungsleistungsschalter, letzteres in erster Linie mit Bezug auf das kontrollierte Schalten sowie die intelligente Fehlerdiagnose. Erwähnt sei in diesem Zusammenhang die Verleihung des ETG-Innovationspreises an den das Projekt ausführenden Mitarbeiter, Herrn M. Stanek.

Im 1998 wurden auch zwei neue Aktivitäten aufgegriffen. Zum einen nimmt die Fachgruppe an einem Gemeinschaftsprojekt mit EPFL, ABB Sécheron und ABB Research teil (welches auch vom PSEL gefördert wird), das zum Ziel hat, das Potential von Hochtemperatursupraleitern für die elektrische Energieversorgung abzuschätzen. Unsere Fachgruppe hat dabei die Aufgabe, die damit verbundenen ökonomischen Aspekte zu behandeln. Zum andern werden in einem neuen Forschungsprojekt, gemeinsam mit der Industrie und gefördert vom KTI, die physikalischen Eigenschaften von Maschinenisolationen auf Glimmerbasis tiefer erforscht, um einen Technologiesprung zu erzielen.

Bezüglich Infrastruktur ist zu bemerken, dass unser grosses Hochspannungslabor mit einem neuen Boden sowie einer längeren Kranbrücke erheblich verbessert wurde. Auch eine neue, mit Lichtleitern übertragene Steuerung und ein Wechselrichter für 16.7 Hz-Versuche erhöhen die Funktionalität des Labors.

Klaus Fröhlich Rainer Bacher Daniel Spreng

Zürich, im Januar 1998

GLIEDERUNG DES INSTITUTS

Ausgerichtet auf wohlumschriebene und abgeschlossene Arbeitsgebiete, gliedert sich das Institut für "Elektrische Energieübertragung und Hochspannungstechnologie" in zwei Fachgruppen: Es sind dies die

- Fachgruppe für Energieübertragungssysteme (Leiter Prof. Dr. H. Glavitsch) mit der Assistenzprofessur für Netzleittechnik (Leiter Prof. Dr. R. Bacher) und der Forschungsgruppe Energieanalysen (Leiter Prof. Dr. D. Spreng)
- Fachgruppe Hochspannungstechnologie (Leiter Prof. Dr. K. Fröhlich)

Im Aufbau dieses Jahresberichts wird die gleiche Gliederung vorgenommen.

Gemäss Institutsreglement der ETH Zürich vom 23.11.73 obliegt die Institutsleitung sämtlichen, dem Institut angehörigen, vom Bundesrat, bzw. ETH-Rat gewählten Professoren gemeinsam. Der Institutsvorsteher, Prof. Dr. K. Fröhlich, wurde von der Institutsleitung für eine Dauer von zwei Jahren bestimmt. Er ist für den Vollzug der Beschlüsse verantwortlich, die von der Institutsleitung, den vorgesetzten Hochschulorganen und den zuständigen Unterrichtsorganen getroffen werden; er vertritt das Institut nach aussen und sorgt für die Information nach innen.

FACHGRUPPE ENERGIEÜBERTRAGUNGSSYSTEME

Leitung:	Prof. Dr. H. Glavitsch	
Sekretariat:	Frau D. Metzler	(70 %)
Assistenten und	Dipl. El.-Ing. M. Bigatto	
wiss. Mitarbeiter:	Dipl. El.-Ing. A. Karpatschev	(ab 16.7.98)
	Dipl. El.-Ing. M. Leuzinger	(bis 31.12.98)
	Dipl. El.-Ing. L. Maiocchi	
	Dipl. El-Ing. E. Thaler	(30 %)

ASSISTENZPROFESSUR FÜR NETZLEITTECHNIK

Leitung:	Prof. Dr. R. Bacher	
Assistenten:	Dr. P. Bosshart	(bis 31.8.98: 60 %)
	Dipl. El.-Ing. ETH O. Meyer	(ab 1.5.98: 50 %)
	Dipl. El.-Ing. Tina Orfanogianni	
	Dipl. Ing. U. Stumkat	(ab 1.10.98)
	Dr. K. Werlen	(40 %)

FORSCHUNGSGRUPPE ENERGIEANALYSEN

Leitung:	Prof. Dr. D. Spreng	
wiss. Mitarbeiter:	Dr. B. Aebischer	(90 %)
	M. Sc. David Goldblatt	(70 %)
	Dipl. Phys. J. Schwarz	(ab 1.4.98 70 %)
	Dipl. Geogr. A. Scheller	(bis 31.1. 50%, ab 1.2.98 70%)
	Dipl. El.-Ing. L. Weber	(80 %)

Akademische Gäste	Dr. Ni Ming Southeast University, P.R.China, l5.l0.97-l7.7.98
	Frau Shonali Pachauri, New Delhi, 15.9.-30.11.98

Externer Lehrbeauftragter Dr. Dieter Reichelt, NOK Baden

Die Fachgruppe stellt über das Internet Unterlagen betreffend Lehre, Forschung und anderen Aktivitäten zur Verfügung. Die WWW Adresse ist http://www.eus.ee.ethz.ch/.

Spezielle käufliche Unterlagen sind unter http://www.eus.ee.ethz.ch/order_information/index.html (Vorlesungstexte, vollständige EPSOM'98 Konferenzunterlagen) zu finden.

Applikationsdienste (Power System Services) können unter http://www.eus.ee.ethz.ch/services/ benutzt werden.

FACHGRUPPE HOCHSPANNUNGSTECHNOLOGIE siehe Seite 2/1

1. BERICHT DER FACHGRUPPE ENERGIEÜBERTRAGUNGSSYSTEME

1.1 LEHRBETRIEB

A VORLESUNGEN

A.1 Grundstudium Elektrotechnik

2. Semester 2V/1.5U[1]
Signale + Systeme II **Glavitsch H.**

Analyse linearer Netzwerke für Gleich- und Wechselstrom, Anwendung auf Dreiphasensysteme, Stern- und Dreiecksumwandlung, T- und π -Schaltungen, Ausgleichsvorgänge in linearen Systemen mit einem oder zwei Speichern, Anwendung der Laplace-Transformation, Verhalten von linearen Systemen bei veränderlicher Frequenz.

A.2 Fachstudium - Kernfächer

5. Semester 4G (5 KE)
Energieübertragung und Hochspannungstechnologie **Glavitsch H./K. Fröhlich**

Grundlagen der Übertragung elektrischer Energie auf Leitungen und Kabeln, Dreiphasensystem: Leitungsmodell, Telegraphengleichung. Betriebs- und Störfälle am einphasigen Modell. Dreiphasensysteme. Symmetrische Komponenten. Unsymmetrische Fehler. Erdschlusskompensation. Erdrückführung.

Transiente Vorgänge im Übertragungssystem: kritische Schaltfälle, Überspannungen. Wichtige komplexe Komponenten (Leistungsschalter, gasisolierte Systeme, Kabel, Überspannungsableiter): physikalische Grundlagen, Probleme, Auswirkung auf das System. Modellbildung. Grundlagen der Isolationskoordination (Strategien, Wirtschaftlichkeitsbetrachtung).

[1] hier bedeuten: V: Vorlesung; G: Vorlesung mit Übungen

6. und 8. Semester 4G (5 KE)
Energiewirtschaft / Energieanalyse **Spreng D., Glavitsch H.**

Energiewirtschaft: Energiegewinnungsprozesse, Kostenstrukturen, Systemoptimierung für Kraftwerkskombinationen, energetische Verbundsysteme. Energieanalyse: Energieverbrauchsprozesse. Analysen und Bestimmungsfaktoren des Verbrauchs auf Stufe Länder, Verbrauchssektoren, Betriebe/Haushalte. Modelle, Prognosen, Szenarien.

7. Semester (auch für externe Hörer) WS 97/98 NF (3 KE)
Wasserkraft **Spreng D., Aebischer B., Vischer D.**

Übersicht: Was hat die Wasserkraft heute zu einem Thema gemacht? Katalogisierung der Wasserkraftwerke. Ausbau, Erneuerung und Instandhaltung: Potentiale, Kosten, mögliche technische Entwicklungen. Optimale Bewirtschaftung über das Jahr, im Wochen- und Tagesrhythmus. Ancillary Services: Reservehaltung, Frequenzhaltung. Alternative Nutzung? Konzessionen. Betriebswirtschaft: Investitionskosten, Erneuerungskosten, Finanzierung, Betriebskosten, Abgaben. Langfristige Perspektiven der Nachfrage und der Produktionsmöglichkeiten, insbesondere für Spitzenenergie. Ökobilanz, Ecological Economics. Volkswirtschaftliche Beurteilungen.

7. Semester (auch für externe Hörer) WS 98/99 NF (3KE)
Rationelle Verwendung von Energie: **Spreng D., Aebischer B.**
auf den Weg zur 2000 Watt Gesellschaft

Warum 2000 Watt Gesellschaft? Dauerhafte Entwicklung und rationelle Verwendung von Energie, die Rolle der Hochschule und die Schaffung einer Wirtschaftsplattform; *Analyse des Energiesparens*: Sparpotentiale, Kennzahlen, Hindernisse, Evaluationen; *Programme und Massnahmen:* Engagement der öffentlichen Hand und der Verbände, SIA Empfehlungen zur energetisch optimalen Planung, Energiemanagement im Betrieb, Energie 2000(+), E2000+ an der ETH Zürich, Contracting; *2000 Watt Gesellschaft:* als Herausforderung für Forschung und Wirtschaft; Ökonomische Auswirkungen; Evaluation

A.3 Fachstudium - Hauptfächer

6. Semester 4G (5 KE)
Vorlesung ETH 35-536
Modellierung und Analyse elektrischer Netze **Bacher R.**
(Power System Analysis)

The electrical power transmission system, the energy management system, requirements of the electrical power transmission (demand oriented, operationally, economically), network planning and network operation, models of N-port network components (line, cables, shunts, transformers), the p.u. computation, computer oriented network models, linear networks (solution methods direct, iterative), algorithms for the solution of non-linear sets of equations, derived from the electrical power system (Newton-Raphson), power flow

computation (problem definition, solution methods), three phase short-circuit computation, application of power flow algorithms.

7. Semester 4G (5 KE)

Vorlesung ETH 35-537

Netzleittechnik und Optimierung elektrischer Netze Glavitsch H., Bacher R.

(Energy Management Systems and Optimization of Electrical Networks)

Why power system control ? Definition of energy management systems, engineering in energy management systems (model, algorithms, real-time, computer systems, software engineering, human interaction), network control categories (topology, switching, voltage control, power generation oriented), n-1 security, planning, real-time optimization, electric utility organizations worldwide, object models, SCADA (Supervisory Control and Data Acquisition), data bases. Mathematical optimization methods, Karush-Kuhn-Tucker optimality conditions, equality constrained optimization, economic dispatch, linear programming (Simplex, Interior point), quadratic programming, state estimation, optimal power flow, optimal power generation.

8. Semester 4G (5 KE)

Dynamik von Netzen und Leitungsschutz Glavitsch H., Reichelt D.

Dynamische Eigenschaften von elektrischen Maschinen, Netzen, Verbrauchern und der damit verbundenen Systeme, Modelle von Kraftwerken und Turbinen, Turbinenregelung, Frequenz-Leistungsregelung, Energieaustausch in Netzen, Modell der Synchronmaschine am Netz, Zweiachsentheorie, transientes Modell, Blockdiagramm, Verhalten der Maschinen bei grossen Störungen, transiente Stabilität, Flächenkriterium, Modell für kleine Störungen, Spannungsregelung und statische Stabilität, Aufgaben und Konzeption des Schutzes, Fehlerverhalten des Netzes, Messgrössen, Rechenoperationen, Schutzprinzipien, ausgeführte Relais, numerischer Schutz, Selbstprüfung und Überwachung.

B STUDIENARBEITEN

Die Studenten der Abteilung Elektrotechnik müssen für die Zulassung zur Diplomprüfung im 7. und 8. Semester zwei Studienarbeiten ausführen. Jeder Student kann dabei das Fachgebiet frei wählen: in der Regel müssen jedoch die beiden Arbeiten an unterschiedlichen Instituten (Fachgebieten) durchgeführt werden. Die vorgeschlagenen Arbeiten leiten sich von aktuellen Forschungsthemen und Themen einschlägiger Gremien ab. Sie haben das Ziel, ein Forschungsgebiet zu vertiefen und Verfahren für Planung und Betrieb elektrischer Netze dem Studierenden nahezubringen.

Die Arbeiten können aus theoretischen Ausarbeitungen, Konzeptentwürfen, Computer-Simulationen und Software-Engineering bestehen. Ein Schwergewicht liegt auf der

Nachbildung von technischen und vermehrt auch wirtschaftlichen Phänomenen mit Computerprogrammen.

Grundlagen dafür sind die Systemtheorie, die Netzleittechnik, die Fernwirktechnik, die Zuverlässigkeitstheorie, Erkenntnisse der Systemanalyse der Netze, Ansätze des Operations Research, Kenntnisse von innovativen Komponenten (FACTS).

Bemerkung: Die beendeten Arbeiten können teilweise über das Internet eingesehen werden: http://www.eus.ee.ethz.ch/main/eus_research.html#semester_diploma_works

Die folgenden Themen wurden zur Bearbeitung ausgegeben:

Im SS 98

Urs Krüsi
Strategien zur Profitmaximierung unter unterschiedlichen technischen Randbedingungen in simulierten liberalisierten Strommärkten

Antonios Kapsalis
Informationsmodellierung zum Austausch von Daten des elektrischen Energieübertragungssystems

Im WS 98/99

Jürg Zweifel
Hydrooptimierung: Theorie und Praxis (Teil I) (in Zusammenarbeit mit NOK, Baden)

Stefan Alder
Hydrooptimierung: Theorie und Praxis (Teil II) (in Zusammenarbeit mit NOK, Baden)

Willi Rohr
Modellierung des UPFC (FACTS) im stationären Betriebszustand

C DIPLOMARBEITEN

Bemerkung: Die beendeten Arbeiten können teilweise über das Internet eingesehen werden: http://www.eus.ee.ethz.ch/main/eus_research.html#semester_diploma_works

Im WS 98/99

Patrik Schäfer
WWW basierte Simulation eines Strommarktes

D NEUE UNTERRICHTSMETHODEN - ETH-Pilotprojekt Prof. Rainer Bacher: WWW unterstützte Vorlesung "Modellierung und Analyse elektrischer Netze"

Prof. Rainer Bacher hat sich mit der Vorlesung "Modellierung und Analyse elektrischer Netze" (6. Semester, Abt. Elektrotechnik) bei einem von ca. 10 Pilotprojekten der ETH Zürich (unterstützt vom Didaktikzentrum der ETH Zürich) beteiligt. (siehe auch http://www.eus.ee.ethz.ch/~bacher/bacher_education.html).

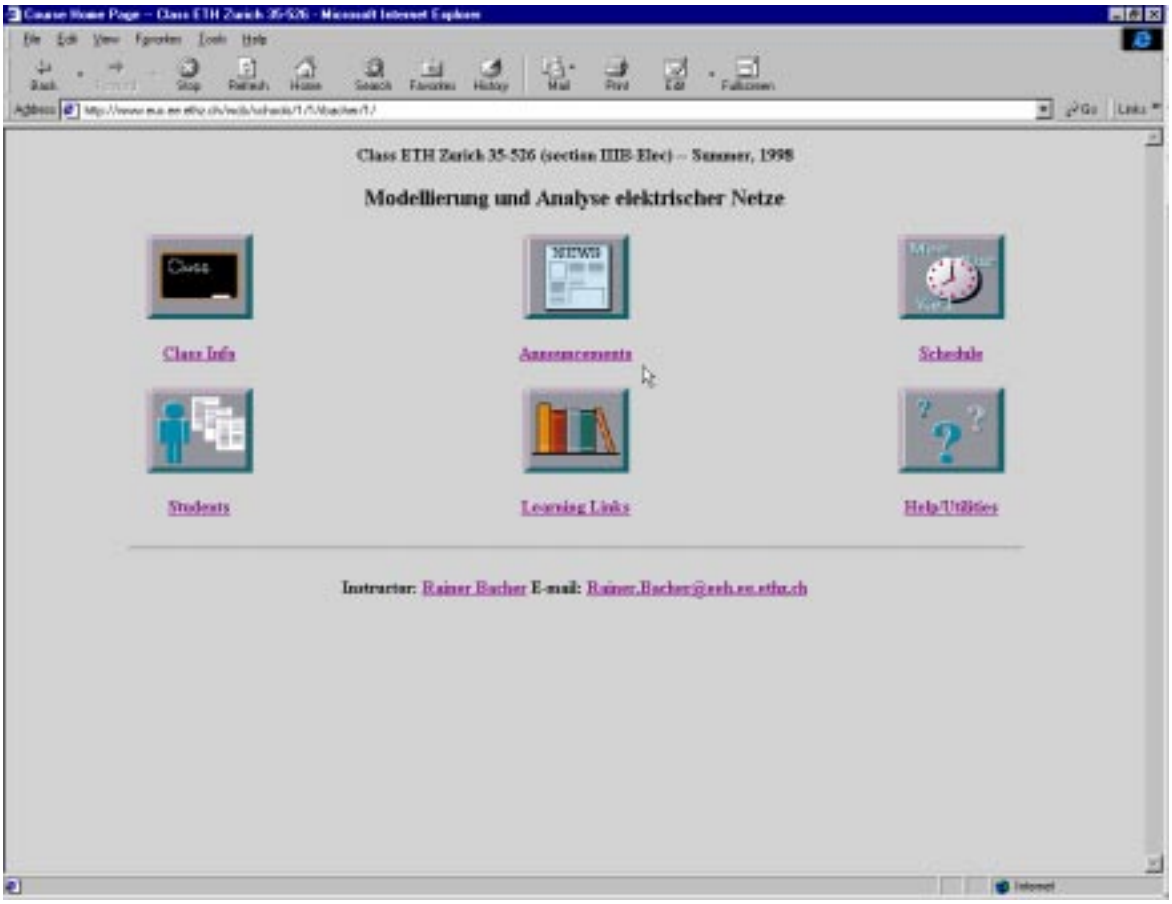


Fig. D.1: Web-Authoring System

Die vor Beginn des Projektes gesetzten Ziele waren:

- Motivation der Studierenden fördern
- Unterlagen der Vorlesung über WWW verfügbar machen
- Interaktive Simulationen über das WWW ermöglichen
- Problemlösungen via WWW geben können
- Fortschritte der Studierenden analysieren können

Bei diesem Projekt wurden zwei unterschiedliche Problem-Bereiche festgestellt: *Benutzen* bzw. *Entwickeln* von WWW-basierten Lernumgebungen.

Benutzen der WWW Umgebungen: Dies ist mit den neuesten Gratis-WWW Browsern praktische auf „allen“ vernetzten Computern möglich. Wichtig ist hier die Möglichkeit, im Unterricht jeden beliebigen Inhalt des WWW auch in Grossprojektion darstellen zu können. Speziell dieser Punkt hat das Wesen des Unterrichts verändert: Jederzeit kann flexibel auf jegliche Inhalte (Details von einzelnen Formeln, Grossübersichten) der im pdf-Format vorliegenden Dokumente (Vorlesungsskript, Übungen, Lösungen, Multiple Choice) eingegangen werden: Das pdf-Format erlaubt eine sehr feine Vergrösserungsmöglichkeit, wobei keine Schärfe verloren geht.

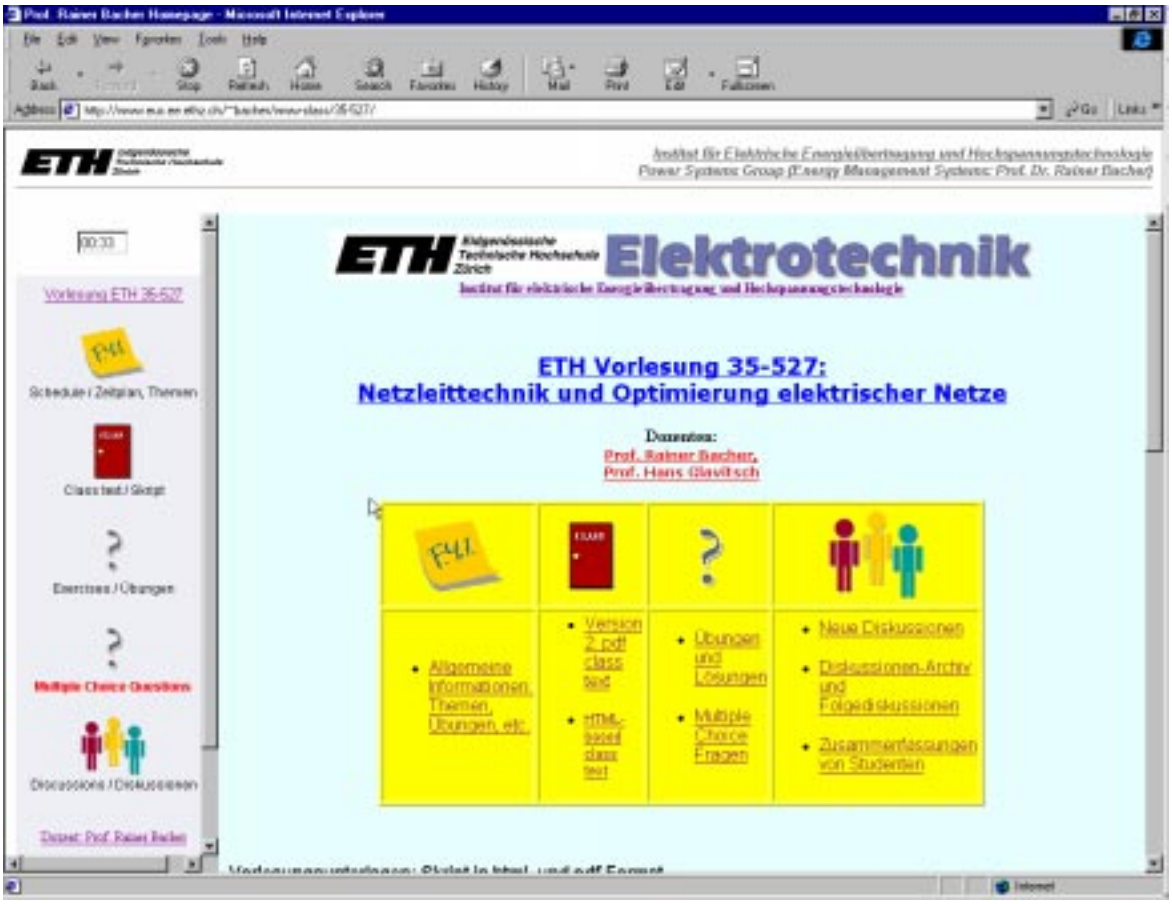


Fig. D.2: Phase II: Eigenbau einer WWW-Unterrichtsumgebung

Beim *Entwickeln* der die Vorlesung unterstützenden Umgebung sind folgende Erfahrungen gemacht worden: In Phase I wurde eine aus Canada stammende Authoring-Software (WCB) verwendet (http://www.madduck.com/wcbinfo/). Die Umgebung (Version 2) wurde verwendet, um die Vorlesung "Modellierung und Analyse elektrischer Netze" WWW-unterstützend zu gestalten. Die Umgebung erlaubt im wesentlichen Kategorien wie "Class

Info, Announcements, Schedule, Students, Learning Links, Help/Utilities" zu gestalten, siehe nachfolgende Figur. D.1
Der Hauptpunkt ist "Learning Links", wo alle Vorlesungsunterlagen mit Hyperlinks angegeben werden können. Weiters wird eine Möglichkeit angeboten, Fragen (Quizzes) zu formulieren, bei denen die Studierenden zwischen max. 3 möglichen Antworten auswählen können. Diese Möglichkeiten wurden jedoch aufgrund von technischen Unzulänglichkeiten der Umgebung nicht verwendet. Mit der WCB konnte jedoch eine Umgebung geschaffen werden, mit welcher der Unterricht wesentlich und zur vollen Zufriedenheit der Studierenden (http://www.eus.ee.ethz.ch/~bacher/bacher_studentenbefragung_ss98.html) verbessert werden konnte. Eine ausführliche Analyse (auch der anderen ETH-Pilotprojekte) kann unter http://www.eus.ee.ethz.ch/~bacher/studenten_bewertung/evaluation_eth_distance_learning.pdf eingesehen werden

Die Umgebung, das muss jedoch hier betont werden, schränkt auch die Freiheiten bezüglich des Designs von WWW-Seiten stark ein. Bei Beherrschung der unterliegenden WWW-Internet Software-Ebenen kann relativ einfach eine eigenen Umgebung aufgesetzt werden: Um die zum Teil grossen Beschränkungen zu umgehen, um nicht von Umgebungen, welche noch stark in Entwicklung sind, zu stark abhängig zu sein, wurde in Phase II eine eigenen Umgebung aufgebaut. Diese Phase II-Umgebung (Zeitpunkt: Dezember 1998) ist in Fig. D.2 dargestellt.
Die Umgebung hat ähnliche Merkmale wie diejenige der Phase I, jedoch können im Layout jetzt vollumfänglich alle Eigenschaften der neuesten Browser-Versionen angewendet werden. Die neue Umgebung bietet jetzt auch die Möglichkeit, Fragen fast beliebiger Art unterstützt durch Formeln, Graphiken, etc. zu stellen.

Die Hauptproblematik liegt im Aufbau einer WWW-Software für die Analyse der richtigen und falschen Antworten auf die Fragen. Diese Software wird im kommenden Jahr neu aufgebaut werden.

Generell kann zum heutigen Zeitpunkt festgehalten werden, dass die Unterstützung von WWW basierten Techniken zur Motivation der Studierenden beiträgt: Diese schätzen einen dynamischen Unterrichtsstil, in welchem man sich - quasi nebenbei - auch mit den neuesten WWW-Internet-Technologien auseinandersetzt. Studierende und Dozenten schätzen die hervorragende Möglichkeit, Theorie - durch "interne" Links auf Dokumente, Skripts, etc. - und Praxis - durch "externe" Links zu Elektrizitätsunternehmen, Systemherstellern, Consultants, etc. - flexibel zu kombinieren.

Die Erfahrungen wurden im Rahmen der NET-Tagung 98 (ETH Zürich, 4.12.98) präsentiert. Die Präsentation kann unter http://www.eus.ee.ethz.ch/~bacher/www-class/nettagung/eth_www_unterricht_all/sld001.htm **eingesehen werden.**

E. EXKURSIONEN

Unterwerk Winkeln der NOK, Prof. Glavitsch, Dr. D. Reichelt
1.7.98

Thermisches Kraftwerk und Unterwerk Weinfelden, Dr. D. Reichelt
2.12.98

1.2 DISSERTATIONEN

Bemerkung: Die beendeten Arbeiten können teilweise über das Internet eingesehen werden: http://www.eus.ee.ethz.ch/main/eus_research.html#dissertations

"Optimal Hydro Power Scheduling under Stochastic Conditions"
Doktorand: Markus Leuzinger
ETH Diss. Nr.: 12919, 1998
Referent: Prof. Dr. H. Glavitsch
Korreferent: Prof. Dr. Karl Frauendorfer, Universität St. Gallen, IfU

"Life Cycle Inventory Analysis For Decision-Making; Scope-Dependent Inventory System Models And Context-Specific Joint Product Allocation"
Doktorand: Rolf Frischknecht
ETH Diss. Nr.: 12599, 1998
Referent: Prof. Dr. Peter Suter, Abt. IIIA
Korreferent: Prof. Dr. D. Spreng

1.3 VORTRÄGE UND REFERATE

Vorträge von Angehörigen der Fachgruppe im In- und Ausland

H. Glavitsch

ABB Workshop Vortrag:" Anforderungen an die Energieerzeugungseinrichtungen im deregulierten Strommarkt am Beispiel von Kombikraftwerken" in Baden
26.05.98

Vortrag bei der Verbundgesellschaft, Wien
17.3.98

R. Bacher

Deregulation in the electric power industry (ABB Research Center, Switzerland)
27.03.98

Server Side Web Applications (Panel at IEEE Summer Power Meeting, San Diego, CA, U.S.A.)
14.07.98

WWW-unterstützte ETH Vorlesung "Modellierung und Analyse elektrischer Netze": Praktischer Einsatz von WWW, Erfahrungen, Akzeptanz, "Distance"-Education als Erfolgsrezept? (NET-Tagung '98: Neue Informations- und Kommunikationstechnologien in der Aus- und Weiterbildung an Hochschulen: Auf dem Weg zur virtuellen Hochschule)
04.12.98

D. Spreng

”Ökoeffizienz der Elektrizitätswirtschaft”, Seminarreihe Sicherheit und Umweltschutz in der Chemie (Prof. K. Hungerbühler), ETH Zürich
20.4.98

”Anwendung von Life-Cycle-Analysis in Projekten der Alliance for Global Sustainability” Kurzvortrag an einer Tagung zur Vorstellung von vier Doktorarbeiten zum Themenbereich Ökobilanzen, ETH Zürich
26.8.98

"De l’énergie primaire aux demandes et besoins humains d’énergie", Séminaires du CUEPE, Universität Genf
29.10.98

"Externe Kosten, Natürliches Kapital, Kundennutzen: Gesucht eine umfassende Analyse”, Tagung des Forums Wissenschaft und Energie, ”Erneuerbare Energien - Konkurrenz-fähig?", ETH Zürich
30.10.98

Bernard Aebischer

"Electricité dans les services: Déterminants à long terme et vérification sur la période 1990-1997", Séminaires du CUEPE, Universität Genf
03.12.98

Andrea Scheller

"The Mapping Project", 2nd AGS Day, Alliance for Global Sustainability, Bern
09.09.98

Lukas Weber

"Strong Will, Weak Flesh? – From Awareness To Action", 2. Internationale Konferenz der European Society for Ecological Economics ("Ecological Economics and Development"), Genf
4.–7.3.98

1.4 TEILNAHME AN TAGUNGEN, NATIONALE UND INTERNATIONALE BEZIEHUNGEN

H. Glavitsch

Besuch von Herrn Stiller, Regierungspräsidium Baden-Württemberg, Tübingen
12.1.98

Besuch von Dr. Felix Bagdasarjanz, anlässlich des Seminars New Vistas
19.1.98

Besuch bei ESG Linz
10.2.98

Besuch von Prof. Stroev, Moskow Power Institute, zusammen mit Prof. Germond EPFL
23.2.98

Besuch aus Japan,
21.4.98

Kontakttreffen ETHZ-ABB, bei ABB Consulting AG, Dättwil
22.4.98

Akademischer Gast Dr. Ni Ming am Institut vom 15.10.97-17.7.98.
Dr. Ni gibt im Rahmen der Vorlesung "Dynamik der Netze und Leitungsschutz eine Präsentation über sein Forschungsprojekt "Unterdrückung von Inter-Area Schwingungen in grossen Netzen".
20.05.98

CIGRE 37. Session Paris
30.8.98-4.9.98

Konferenz Chairman EPSOM Konferenz
23.9.98-25.9.98
Teilnahme am Workshop PSEL BfE in Bern
1.10.98

Teilnahme am Seminar "Technologie Trends bei der elektrischen Verteilung" an der ETH
29.10.98

R. Bacher

Electronet Workshop-Meeting in Bürchen, VS
19.1.98-21.1.98

DFG (Deutsche Forschungsgemeinschaft) Meeting Bonn: Beurteilung und Diskussion Anträge deutscher Professoren
22.1.98

IEEE PES Winter Power Meeting, Tampa, FL, USA
1.2.98-5.2.98

PICA'99: Technical committee meeting (anlässlich IEEE PES Meeting)
5.2.98

Treffen Dr. Filippini, Wild: Socioeconomic Institute, Zürich
16.2.98

EPSOM'98 Konferenzkomitee - Sitzungen
25.2.98, 11.5.98, 17.08.98

Electronet PDT Tage in Watford, England, zusammen mit Dr. Karl Werlen
24.3.98-26.3.98

Vortrag ABB Forschungszentrum, Dättwil
27.3.98

Diskussion Hydrooptimierung bei NOK, Baden
31.3.98, 30.4.98, 10.6.98, 26.6.98, 8.7.98, 5.8.98, 18.8.98, 21.10.98

Teilnahme bei Treffen Elektrotechnik-Professoren mit ABB Management
22.4.98

Exkursion zu KW Hinterrhein, NOK (mit Herrn Senn, NOK)
19.05.98

Besuch der Herren Bergamin und Keller, EGL Laufenburg
29.5.98

Diskussion FACTS mit Dr. Westermann, ABB
10.7.98

IEEE PES Summer Power Meeting, San Diego, CA, USA
12.7.98-16.7.98

ABB Elektrogipfel, Oerlikon
14.8.98, 20.8.98

Doktorprüfung Eirik Selvik, Trondheim, Norwegen
27.8.98

Sitzung mit Herren Brüniger und Schnyder (Begleitgruppe Trendwatching)
17.8.98

Technical Chairman EPSOM Konferenz
23.9.98-25.9.98

Teilnahme am Seminar "Technologie Trends bei der elektrischen Verteilung" an der ETH
29.10.98

Teilnahme an CIGRE Tagung an der ETH
10.11.98

Review Meeting Electronet Brüssel
17.11.98

Besuch Urs Mock, Busarello & Cott AG: Installation NEPLAN
23.11.98

Teilnahme (Vortrag) an NET-Tagung '98: Neue Informations- und Kommunikationstechnologien in der Aus- und Weiterbildung an Hochschulen: Auf dem Weg zur virtuellen Hochschule
4.12.98

K. Werlen

Electronet Workshop in Bilbao, Spanien
1.3.98-4.3.98

Electronet Workshop in Trondheim, Norwegen
9.5.98-12.5.98
Teilnahme am Elektro-Gipfel bei ABB Oerlikon
14.08.98

Electronet Workshop-Meeting in Bilbao, Spanien
14.-15.12.98

D. Spreng

Annual Meeting, "Alliance for Global Sustainability", ETH Zürich
22.1.-24.1.98

Nationales Forschungsprogramm 41 (Verkehr und Umwelt). Experte an einer internen Tagung zum Thema ”Indikatoren der Nachhaltigkeit im Verkehr”, Bern
20.3.98

Jubiläumsveranstaltung ”75 Jahre Liechtensteinische Kraftwerke”
22.5.98

Energieforum Schweiz: ”Strommarktöffnung: EU/WTO”, Bern
25.6.98

Jahrestagung der INFEL, Liestal
2.7.98

Jubiläumsveranstaltung ”100 Jahre Elektra Baselland”, Liestal
27.8.98

”Bauen für das 21. Jahrhundert”, Forum der Schweizer AG, Zürich
1.9.98

"Jahrestagung Energie 2000", Bundesamt für Energie, Bern
10.-11.9.98

"Nachhaltigkeit und Energie", Energieforum Schweiz, Zürich
26.11.98

Bernard Aebischer

"Alliance for Global Sustainability. Annual Meeting", ETH Zürich,
21.-24.1.98

"Face aux énergies fossiles, quelle place pour l'énergie nucléaire?", Journée du CUEPE, Genève,
23.4.98

"Publiforum 'Strom und Gesellschaft'", Schweizerischer Wissenschaftsrat, Bern,
16.5.98

"Solidarität schafft Zukunft. Nord/Süd-Konferenz für Nachhaltige Entwicklung", Bern,
25.-29.5.98

"Investitionsprogramm Energie 2000", Bundesamt für Energie, ETH Zürich,
3.6.98

"International Workshop on Industrial Energy Efficiency Policies: Understanding Success and Failure", INEDIS/SAVE, Utrecht,
11.-12.6.98

"Jahrestagung Energie 2000", Bundesamt für Energie, Bern,
10.-11.9.98

"Improving Electricity Efficiency in Commercial Buildings", SAVE/Novem, Amsterdam
21.–23.9.98

"Conference on Sustainable Energy Development in India: EU-India Partnership for Technology Cooperation", TERI/EC-DG XVII, Brussel,
26.10.98

David Goldblatt

"Ecometrics" Workshop, Lausanne,
19.01-20.01.1998

"The 17th Congress of the World Energy Council", Houston.
14.09-17.09.1998

A. Scheller

"Alliance for Global Sustainability. Annual Meeting", ETH Zürich,
21.-24.1.98

"Nachhaltigkeit und Energie", Energieforum Schweiz, Zürich,
25./26.11.98

Lukas Weber

"Ecological Economics and Development", 2. Internationalen Konferenz der European Society for Ecological Economics, Genf
4.–7.3.98

"Umweltmanagement in Forschung und Praxis – Eine Zwischenbilanz", Institut für ökologische Wirtschaftsforschung (IWÖ/HSG), St. Gallen
29.5.98

"Improving Electricity Efficiency in Commercial Buildings", SAVE/Novem, Amsterdam
21.–23.9.98

Mitarbeit in verschiedenen Gremien

H. Glavitsch

Mitglied des Schweizerischen Nationalkomitees der CIGRE

Mitglied des Councils und Executive Board (Treasurer) der
Power Systems Computation Conference (Verein nach OR Art. 60)

Koordinator Forschungsprojekte ETHZ im Rahmen der Hauptstudie SWISSMETRO

Berater bei der Kommission "Merkur" des VSE (Vorbereitung der
Öffnung des Strommarktes in der Schweiz)

Präsident des Organisationskomitees der IEE-SEV-ETH Konferenz
"Electrical Power Systems Operation and Management" EPSOM 1998

R. Bacher

Technical (vice-) chairmanship of conferences, task forces

EPSOM'98 (CH)
Technical Chairman of EPSOM'98 (Electrical Power Systems Operation and Management), International SEV/ETH/IEE conference in Zürich, Switzerland,
23-25 Sept. 1998

IEEE PES 1998 (USA)
Chairman of IEEE PES Task force on "Symbolically assisted numeric computations for power systems software development"

D. Spreng

Mitglied der NK-UIE

Mitglied der UIE CE

Prix Eta

Energie und Wissenschaft (Vorstandsmitglied)

Studienkommission Energieperspektiven (Vorstandsmitglied)

Mitglied der Denkwerkstatt "2000 Watt Gesellschaft"

B. Aebischer

Expertengruppe der Internationalen Energie Agentur (IEA) "Co-operative Procurement of Innovative Technologies"
Begleitgruppe des BFE-Projekts "Energiemanagement in vernetzten elektronischen Systemen"

INEDIS (International Network for Energy Demand Analysis in the Industrial Sector)

1.5 FORSCHUNG UND PUBLIKATIONEN

Fachgruppe Energieübertragung (Prof. Dr. Hans Glavitsch)

SwissMetro-Power Supply for a High-Power Propulsion System with Short Stator Linear Motors, Number MLV-16 MAGLEV '98

Beitrag im Bulletin SEV/VSE 11/98 "Lastflussbezogene Netzbenutzungsgebühren im offenen Strommarkt"

Fachgruppe Netzleittechnik (Prof. Dr. Rainer Bacher)

Most up-to-date information can be found at the WWW: http://www.eus.ee.ethz.ch/~bacher/

Note: Some of the published papers and publications can be downloaded from the Internet (WWW) at http://www.eus.ee.ethz.ch/~bacher/bacher_publications.html.

1) Accepted refereed papers

T. Orfanogianni and R. Bacher: Using Automatic Code Differentiation in Power Flow Algorithms, Paper PE-828-PWRS-0-2-1998. Accepted for publication in the IEEE Transactions on Power Systems (1999).

P. Bosshart and R. Bacher: A domain architecture for solving simultaneous nonlinear network equations. IEEE Transactions on Power Systems, 13(3):1006-1012, Aug. 1998.

T. Dreyer, A. Azarian, R. Bacher, D. Lambrecht and D. Brown: Information Exchange Between Electric Power Systems: Achievements within the ELECTRO-NET ESPRIT IV Project. Proceedings of PDT (European Conference Product Data Technology) Days 1998, March 1998, Watford, England.

R. Bacher and T. Orfanogianni: WWW based computation services: Transfer of power system applications to the WWW. Paper accepted for publication at IEEE Winter Meeting 99, New York, Jan/Feb. 99, To be published in Proceedings of IEEE PES, Winter Meeting 99

2) Invited papers

D. Leal, I. Laresgoiti, D. Lambrecht, R. Bacher: An Open System Approach to Power Systems Information Exchange. Proceedings of EPSOM'98 (Electrical Power Systems Operation and Management) (23-25.Sept.98, Zürich, Switzerland).

3) Publications of co-workers with third-party co-authors

F. Alvarado and *T. Orfanogianni*: Efficient orthogonal factorization for constraint addition and removal in QP based Optimal Power Flows. Proceedings of EPSOM'98 (Electrical power systems operation and management) (23-25.Sept.98, Zürich, Switzerland).

P. Bosshart and R. Weiss: Eine Domänen-Architektur zur Konfiguration einer wiederverwendbaren Software-Komponente. e & i, 115. Jg. (1998), H. 3, pp. 156 – 161.

4) Publications currently in the process of editing

D. Kirschen, R. Bacher and G. Heydt (Editors): Techological Foundations for Competition in Power Systems, Proceedings of the IEEE, Special Issue on Power System Analysis. Planned for publication: March 2000 (status: accepted by IEEE Editorial board).

5) Publications currently in refereeing process

Three papers have been submitted to PSCC'99 (Trondheim, Norway), PICA'99 (Santa Clara, CA, U.S.A) and IEEE Winter Power Meeting 99 (New York, NY, U.S.A.)

Forschungsgruppe Energieanalysen (Prof. Dr. Daniel Spreng)

D. Spreng
"Energiebedarf im Elektronikzeitalter", VDI-Tagung "Rationelle Energienutzung durch Strom", Düsseldorf, Februar 1997

B. Aebischer, J. Schwarz
"Dokumentation zur Studie: Perspektiven der Energienachfrage des tertiären Sektors für Szenarien I bis III 1990 - 2030", Forschungsgruppe Energieanalysen, ETH Zürich, 1998

B. Aebischer
"Internationally Coordinated Procurement of Innovative Copiers. Project Management October 1995 - September 1997", Energy Analysis Research Group, ETH Zurich, 1998

B. Aebischer, A. Huser
"Energieverbrauch von Automaten und Energiesparmöglichkeiten", Bundesamt für Energie, Bern, 1998 (EDMZ 805.792 d)

B. Aebischer, D. Spreng
"Veränderung 1990-1997 des Energieverbrauchs in der Verbrauchergruppe Gewerbe, Landwirtschaft, Dienstleistungen (GLD): Analyse ex-post, Forschungsgruppe Energieanalysen, ETH Zürich, 1998

D. Goldblatt
"Innovations in Energy Efficiency: Perspectives, Promotion, and Policy Prescriptions in Switzerland," The 17th Congress of the World Energy Council, Houston, September 14-17, 1998

A. Scheller, F. Chevrot
"White Paper on Mobility", Mapping Project, Alliance for Global Sustainability, MIT, Cambridge, December 1998

D. Spreng
"Energienachfrage als Indikator", Schweizerische Technische Zeitschrift, Sondernummer "Nachhaltigkeit im Energiebereich", 20.4.98

D. Spreng, D. Goldblatt, A. Scheller
"Innovations in Energy Efficiency: Theory and Applications in Switzerland and Abroad", Bundesamt für Energie, Juni 1998

D. Spreng
"Ökobilanz der Elektrizitätswirtschaft", Festschrift der Liechtensteinischen Kraftwerke 1923-1998, Schaan 1998

L. Weber
"Strong Will, Weak Flesh? - From Awareness To Action", in: Université de Genève (ed.), Ecological Economics and Development: Tagungsband zur 2. Internationalen Konferenz der European Society for Ecological Economics, Geneve, 252–53, 1998

1.6 RESEARCH ACTIVITIES OF THE ELECTRIC POWER TRANSMISSION GROUP

A. COMPLETED DOCTOR THESES

Note: Some finished Dr.-theses can be downloaded from the Internet:
http://www.eus.ee.ethz.ch/main/eus_research.html#dissertations

Optimal hydro power scheduling under stochastic conditions

Candidate: Markus Leuzinger
Thesis No.: 12919, 1998
Examiners: Prof. Dr. H. Glavitsch
Prof. Dr. Karl Frauendorfer, Universität St. Gallen, IfU

The purpose of power system scheduling is to optimize operation with regard to various objects. Since there are many complicated aspects to be considered, the problem is usually subdivided into several time domains. The medium-term scheduling occupies a key position. Because of the long planning interval and the uncertain parameters, stochastic large scale nonlinear optimization problems are characteristic. Decisions of the medium-term scheduling appear as constraints in the following short-term scheduling. Therefore, model simplifications must be introduced with care. The object of the medium-term scheduling is to determine a feasible scheduling for energy in hydro units that maximizes the expected financial return, considering the entire planning interval. Most approaches ignore the uncertainties of the access to a spot market.

In order to increase the efficiency of the solution approach models have to be as simple as possible. However, the essential properties of a hydroelectric power station must be taken into account. In this thesis a linear model for the medium-term scheduling including the spot market is developed. This model is integrated into a multistage stochastic program in order to take the random variables- natural inflows, prices and the load - into account. It is explained how to solve this large scale optimization problem by stochastic dynamic programming. By applying the principles of dual decomposition, the number of states that must be calculated is reduced, and the problem can be approximated as precisely as needed. Furthermore, a parallel programming approach is presented which clearly reduces the calculation time.

The developed model is applied to the medium-term scheduling of a typical Swiss pumped storage power station. An investigation of the influences of the various random variables on results shows that energy prices are of crucial importance and that the variances are reduced. The opposite can be observed for the natural inflows because of low water levels from October to March. The load also has an effect on the financial return. But the optimal decisions for the level curves of the reservoirs are made on the basis of the price distributions. Moreover, the medium-term scheduling also has to assess the influence of an

energy contract with a fixed price on the return of the whole planning interval. In this work it is shown that also by determining an optimal policy for energy trading the prices of the spot market are the crucial factors. Finally, it is shown how the computer-based medium-term scheduling can be used to investigate the influence of planned investments - as power increases or efficiency improvements of pumps - on the expected financial return.

B. CURRENT RESEARCH PROJECTS

Transmission pricing in an open electricity market
(Marco Bigatto, Prof. Hans Glavitsch)

In the USA, several Latin American countries and in Europe the electricity market is being deregulated, resulting in an open-access market. The concept varies from country to country and is not standardized. In one case the network company acts both as wholesaler and as consumer. In another case both wholesaler and consumer can communicate directly without involvement of the network company. In all systems, independent power producers can sell services and electricity at a spot market price. In some cases, a network company buys the electric power from the generators and resells it to a retailer, whereby charges are made for guaranteeing voltage stability, constant frequency and the supply of stand-by energy.

In a liberalized market where bilateral transactions can be established, the procedure for determining the network services is not clear at first sight. Network theory provides no definite answer in this respect. However, the need for a pricing system is evident.

This project aims at determining the prices for network services provided by the network operator.

The main components are:
- charges for the use of electric circuits
- allocation of reactive power
- pricing signals for the elimination of congestions
- allocation of losses

The project is based on the simulation of an electricity market, i.e. on the assumption that bilateral transactions are carried out based on principles of the open market and are set as a result of supply and demand. Each producer calculates individual production prices and sets up prices for each produced or sold MW. The network company lays down the price for network usage. Prices for network usage differ from one node to the next and depend on the network usage which can be computed by a load flow. As a consequence the prices are dynamic. The consumers minimize their total payments, i.e. production cost payments plus network charges. However, as the decision of each consumer influences via market

mechanisms the payments of other consumers, an iterative process is started. When converged, this process results in the same marginal cost for all consumers.

To simulate this important market behavior, a "physical" load flow has been developed, which can recognize the physical origin of the energy at the load node under certain conditions. With the actual load flow the use of electric circuits and the allocation of consumer prices can be determined. It should be noted that the electricity industry currently uses the so-called "empty network principle" (only the individual load transaction is considered, all other loads are set to zero) when determining the use of electric circuits (MW-mile) by an individual load-generator transaction.

For the allocation of losses a load flow based method has been developed which determines the portion of network losses to be attributed to an individual load bus. The method uses the results of the so-called incremental power flow.

Pricing is used for the elimination of congestions whereby corrective pricing signals are to be issued by an independent system operator. Two concepts have been considered in a common study with Prof. F. L. Alvarado, University of Wisconsin, U.S.A. (visiting professor): One is based on a quadratic price structure, the other on a piece-wise linear price structure. Both concepts allow corrections of the flows in an open market.

State estimation in the distribution network
(Luca Maiocchi, Prof. Hans Glavitsch)

The purpose of this project is the development of a model able to represent the load behavior of the low voltage network. Due to the large amount of elements, the small impact of energy per element and the cost for the data collection, the state of low voltage networks cannot be monitored for economic reasons. For this reason load forecasting (LF) plays a key role in the secure and economic operation of the power system in the distribution substations at low voltage levels. Moreover the knowledge of the actual network states for the application of the Demand Side Management and the supply Side Management is indispensable. Primary element of a LF is an automatic identification of the different load components included in a series of off-line measurements. Cardinal point is the automatic identification of the basic load curve of households (BLCH). A process for the identification of the BLCH, water-heaters and illumination was developed. The identification of BLCH and water-heaters happens using artificial neural networks (ANN). The identification of the substation load components is represented in Fig. 1.

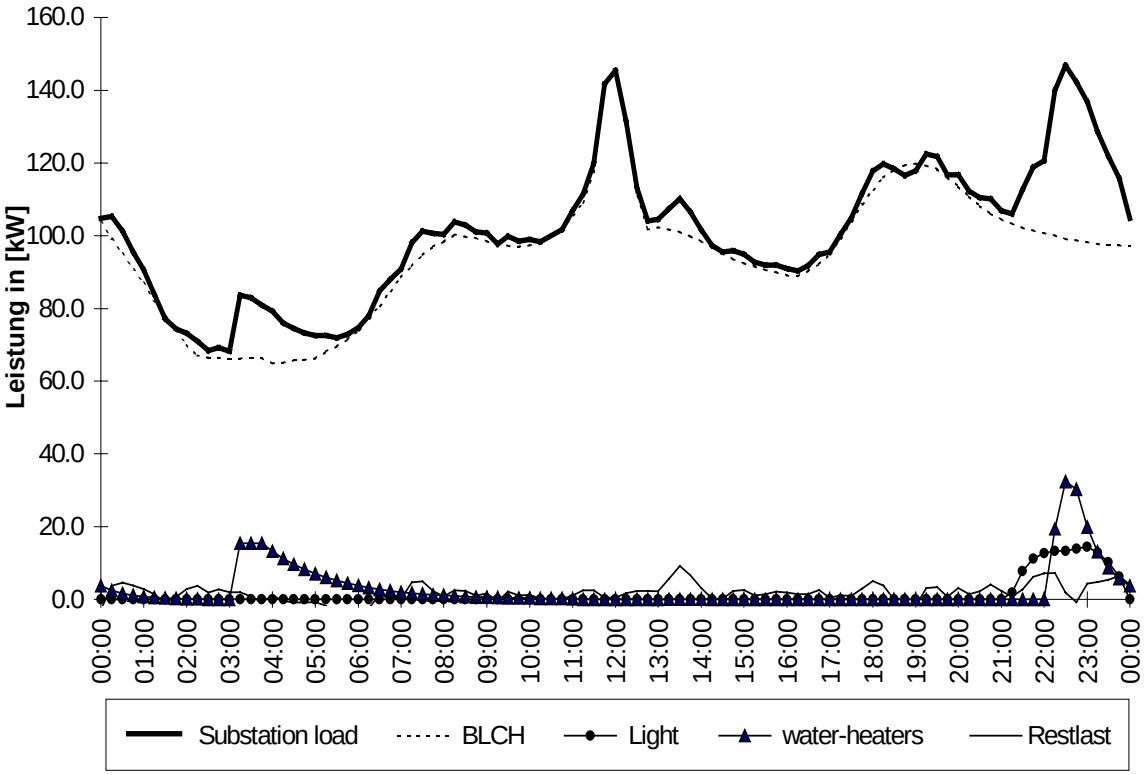


Fig. 1 Model load curve of households

Knowing the various load components it is possible to compute a synthetic load or to calculate a load forecast. Data of summer and autumn measurements are sufficient to set up a winter model. Various tests have shown that after having identified the different load component a very precise load forecast is possible.
The whole load modeling process is converted into software which is as simple as possible and easy-to-apply as a new tool for network engineering and network management.

Maximization of network loadability with an optimal power flow using FACTS as additional control variables
(Tina Orfanogianni, Prof. Rainer Bacher)

The optimal power flow problem can be formulated as follows:

$$\text{Min.} \quad f(\mathbf{x})$$

$$\text{s.t.} \quad \mathbf{g}(\mathbf{x}) = \mathbf{0}$$
$$\mathbf{l} \leq \mathbf{h}(\mathbf{x}) \leq \mathbf{u}$$
$$\mathbf{bl} \leq \mathbf{x} \leq \mathbf{bu}$$

where $f(\mathbf{x})$ is the objective function, $\mathbf{g}(\mathbf{x}) = \mathbf{0}$ the equality (modeling) constraints, $\mathbf{l} \le \mathbf{h}(\mathbf{x}) \le \mathbf{u}$ the inequality constraints and $\mathbf{bl} \le \mathbf{x} \le \mathbf{bu}$ the bounds on variables (operational constraints). $f(\mathbf{x})$ represents the mathematical formulation of the goal and in traditional OPF problems is a function of the (total) MW losses or (partial) MW losses in a certain area.

The purpose of the current work is the creation of an OPF software tool where the software developer can easily insert new features and where the user can choose between different objective functions:

- MW power flowing in or out of an area
- MW power exporting from one area to another
- MW load at a certain bus

By defining the above functions one can maximize the power that a network area exports or the power that can be transferred *through* a part of a network.
In the context of the above goals certain relevant transmission constraints have to be included. These are:

- Current or MVA ratings of the transmission elements
- Voltage drop limitations
- Angle difference limitations
- Taps limits

The above limits are only a subset of the set of constraints that includes limitations on the absolute values of bus voltages, reactive power limits of generation, fixing of MW area export and area exchange and active or reactive power flow control with regulating transformers.

The *insertion of FACTS* devices in the electrical network adds degrees of freedom in the optimization problem. This translates to an increased number of variables: In the case of series FACTS elements (e.g. TCSC) the new variable is the effective reactance of the element.

The expansion of the OPF code to include the new objective functions and constraints was relatively easy thanks to the combined use of black box optimization and differentiation tools:

- ADIFOR (Automatic Differentiation for Fortran) is a tool that generates code (Fortran77) for calculating first order derivatives of an (input) subroutine. ADIFOR can handle large scale, sparse code and respects the structure of the input code (if-statements, do- loops etc.) and therefore is ideal for power system problems.

- MINOS is a Fortran based package, capable of solving large-scale nonlinear optimization problems, where non-linearities can occur both in the objective function and in the constraints. MINOS is used as a black box but in order to increase the robustness and execution speed the developer provides the *first* derivatives for the nonlinear parts. This part is taken over by ADIFOR. The evaluation of the derivatives and the functions is invoked with one subroutine call.

The next step will be the inclusion of FACTS - series voltage source models and assessment of their impact in network loadability and capability of power flow redirection.

The line of research in this project should lead to a very flexible software tool with the following capabilities:

- Easy and fast adaptation to market driven economic goals such as Power Exchange (PX) functions, power pools, Independent System Operators (ISO) security goals, Ancillary services pricing.
- Easy and fast adaptation to new models and system objectives coming from the field of power electronics (FACTS: TSCS, UPFC).
- Possibility to make problem studies with concrete large networks such as the UCPTE and the above mentioned problem areas.

Esprit IV ElectroNet Project No. 22297: Information Exchange for and Open Access to Power System Information
(Karl Werlen, Oliver Meyer, Prof. Rainer Bacher) http://www.eus.ee.ethz.ch/electronet/

In the traditional power system application software development most existing software products employ their own strategies for storing data files and modeling the installed equipment. Many of these data files use formats which are still based on the old punch cards, i.e. 80 characters per record, etc. Each network data set is stored on a separate ASCII file and is limited to a minimum set of attributes needed for a particular application.

Modern data structures are based on a relational data base approach. Any type of data coming from different power systems can be stored in a single data base. When using SQL (Structured Query Language), any types of attributes can be accessed for different applications. Data exchange can, however, still be carried out using ASCII files.

As the object oriented approach becomes more and more important in software development, in the future a similar development with all its benefits can be predicted in data base technology. The object-oriented approach should lead to a very flexible and generic database which will contain all the information owned by an organization, the so-called *„data warehouse“*.

The present situation makes it very difficult to exchange and to share data and software modules among the utilities. The same information has to be input several times which leads to redundancy and inconsistency problems. On the other hand the opening of the electricity market and the expansion of the interconnected networks increase the need for the electrical utilities to exchange data for joint studies.

In the ElectroNet Project an approach is taken to solve these problems by creating and standardizing a neutral representation of data for power systems application software. ElectroNet consists of a consortium of 14 partners form 7 European countries, including research centres, universities, industries and electrical utilities. The project started in October 96 and is due to finish in September 99. The ElectroNet project is funded partly by the E.C. The ETH contribution of the project is sponsored by the BBW (Bundesamt für Bildung und Wissenschaft), Bern, Switzerland (BBW Project No. 95.0840).

ElectroNet applies the so-called STEP technology (**ST**andard for the **E**xchange of **P**roduct data). STEP is a comprehensive ISO standard (ISO 10303) that describes how to represent and exchange digital product information. The data must contain enough information to cover an entire life cycle of an equipment, from design to analysis, manufacturing, quality control testing, inspection and product support functions. The STEP approach is currently used by multinational companies such as car manufactures (e.g. BMW) and large utilities in the field of the process industry (e.g. Shell). Hence, adopting the STEP approach guarantees compatibility with current technological developments in the field of international standards in information modelling.

The two main objectives of ElectroNet are:

A) To create an open market for software vendors
The users of power application software want to avoid dependency from one single software vendor. They would like to have open systems, i.e. they wish to replace software components by equivalent modules from different providers, without replacing the whole package. Such „plug-compatible“ applications not only increase the competition among software developers but also provide their chance to establish new markets.

B) To facilitate the exchange of network data for studies and operational use
The opening of the electricity market increases the need for the electrical utilities to exchange data for joint studies and for improved operation. There is an increasing demand in particular among neighbouring countries and also with respect to a future expansion of the interconnected network such as the expansion of the UCPTE network towards Eastern Europe and Northern Africa.

By November 1998 a complete information model has been created. The consortium is now developing a demonstrator software including converters for some major data formats.

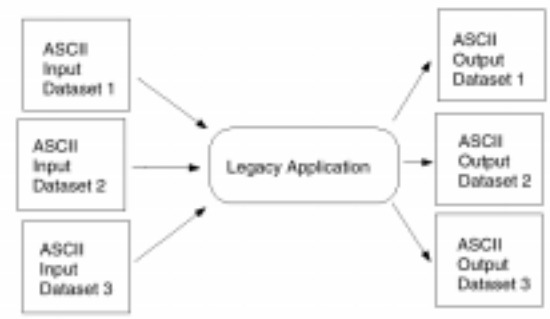
At ETH we are currently developing a prototype software, which will allow us to convert data from the IEEE- and UCPTE-data formats to the neutral ElectroNet STEP-format. In a second step we will integrate our advanced applications such as WWW based Power Flow and Optimal Power flow, Short-term Hydro Optimization, Power Market Simulators programs directly to the ElectroNet data base.

WWW based market simulator (Power Exchange and Independent System Operator)
(Several student groups, Prof. Rainer Bacher)

Different aspects of this project have been studied by several student groups as part of semester and diploma works. Some of the reports can be downloaded from the internet at http://www.eus.ee.ethz.ch/main/eus_research.html#semester_diploma_works. Parts of this project are: I) Simulation of a power exchange (PX) place, i.e. a power pool where bids are accepted from generators and load aggregators. These bids are matched by the power pool in such a way that the total power profits of all market participants are maximized (i.e. simulation of the economics of pool). II) The function of the independent system operator: This market entity is based on bids for power adjustments to the pool result of I): Minimal adjustments are done in order to satisfy the security limits (i.e. simulation of the technical feasibility of an electric power dispatch). III) Cost structures must be predefined for generators and loads: Different types of generators and loads must be created. IV) A database containing all parameters for such a simulation; mechanisms to enter and retrieve data from this database. V) The WWW-pages which allow entry and manipulation of all necessary input and output data from any WWW-browser connected to the Internet. VI) Selection of open market paramterers: What data should a participant know from the other participants ? VII) Setup of all relevant data communication between WWW-client and WWW-server, between the server and the data base, between the data base and the market simulation modules (PX and ISO). VIII) Set up of winner/looser scenarios, i.e. allowing participants to see, if they succeed with their electric power buying and selling strategies. The goal is the establishment of an environment where students and industry can participate as market players with the goal to learn about the new, coming electric power markets.

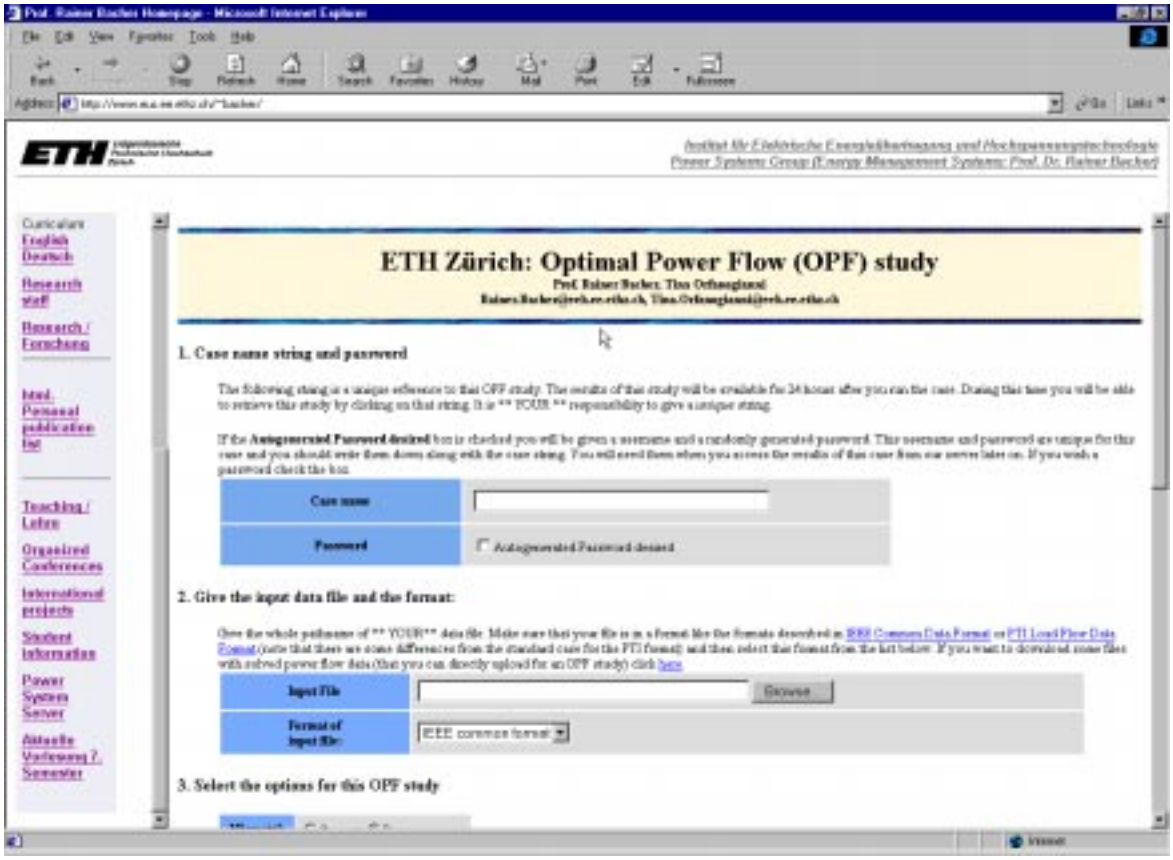
Power System Services over the Internet (WWW)
(Prof. Rainer Bacher, Tina Orfanogianni)

This project includes an analysis of the complexity of the software engineering and development steps and the realization of a transfer of "legacy" power system applications, i.e. an ASCII input file and output file based program without user interactions, to the World Wide Web (WWW).



An Optimal and an a Regular Power Flow (OPF) program are currently available on the internet as examples of such "WWW-upgraded" "legacy" applications. This project includes development efforts on the WWW-client and on the WWW-server side.

Certain minimal changes to an existing OPF code are necessary: the efforts are discussed in a paper submitted for the IEEE Winter Meeting 99 Proceedings, New York available at



http://www.eus.ee.ethz.ch/~bacher/bacher_publications.html.

The paper discusses the complexity of WWW server and client side development efforts together with advantages and disadvantages of the approach both for the WWW-OPF developer and the WWW-OPF user.

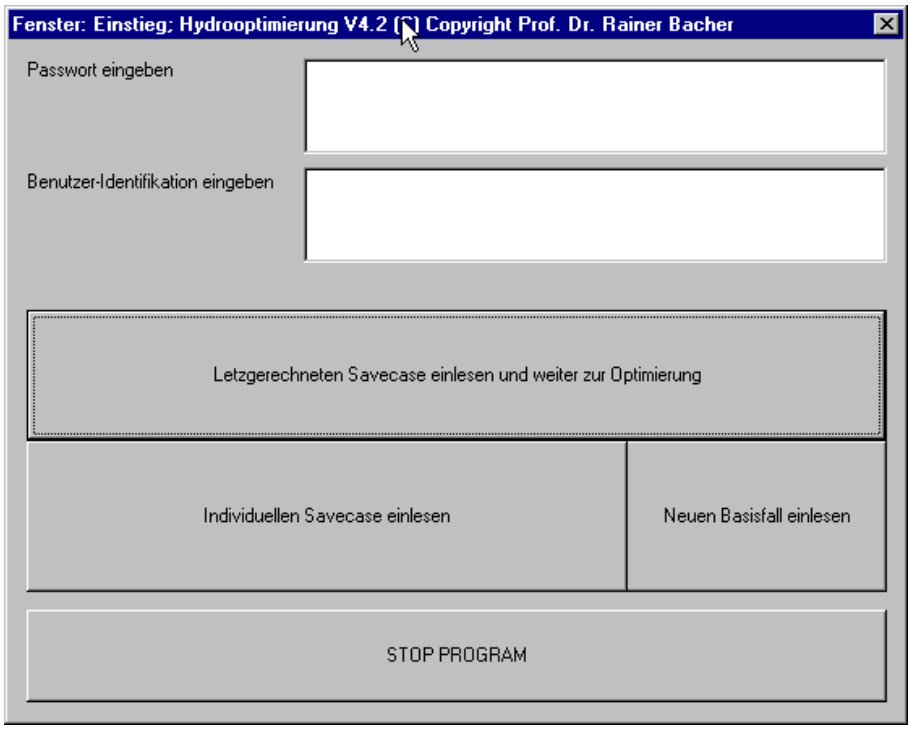
The current internet version of a power flow (PF) and an optimal power flow (OPF) can be tested at http://www.eus.ee.ethz.ch/services/. Currently only the loss minimization objective function can be used. These services will soon be extended to other problems and objectives such as market simulators, power exchange functions, Independent system operator (ISO) security achievement, use of FACTS for transmission usage maximization, maximum network loading determination, etc.

Short-Term hydro optimization environment including electric power market aspects
(Prof. Rainer Bacher, Dr. Karl Werlen)

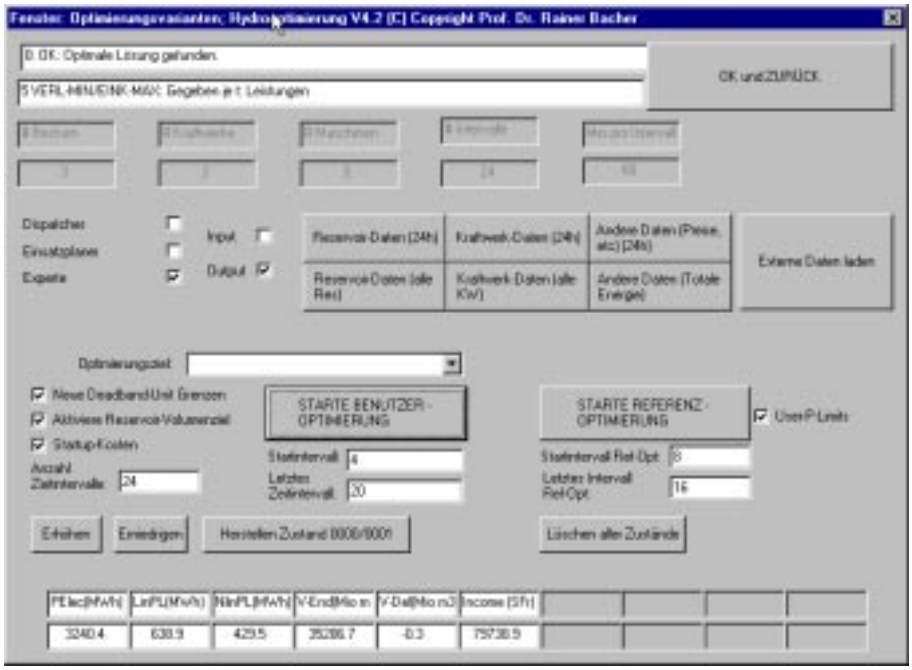
In the last fours years, a program has being developed for the simulation of an optimal scheduling of a short-term hydro power generation system. The main features of the current program version are:

- Up to 40 Hydro power generators and reservoirs with a user definable hydro topology between generators and reservoirs.
- Simulation of up to 48 time intervals with user definable interval time.
- Simulation of past (i.e. comparison of computer model with past user behavior) and future scenarios.
- Unit startup costs.
- Market prices per interval.
- Reservoir start and desired final volumes.
- Time delays for water from a generator to the next reservoir.
- Hydro generator deadbands: No operation between zero and a user definable minimum power generation.
- Several generator units within a hydro generator power stations.
- Limits for generator powers, hydro power waterway limits (m^3/s), hydro reservoir volume limits
- Choice of one of five objective functions: Minimum energy usage, Maximum energy usage, Maximum profit with given total energy for the simulation period, Maximum efficiency (i.e. minimum losses) for a given total energy per interval, mixed mode optimization
- Highly interactive use: Advanced graphical user interface including MS©Excel - interface for input and output data.
- Fast execution times, i.e. efficient optimization code.

Typical user interaction screen are as follows: Entry-Screen:



The main interaction screen with the optimization:



The current program version (December 1998) is V4.2. Future versions will include further market features including risk management based on stochastic optimization.

Increased Optimal Power Flow (OPF) development efficiency by integration of general purpose optimization and derivative computation tools
(Tina Orfanogianni, Prof. Rainer Bacher)

This projects deals with a new approach for developing OPF code and solving OPF problems, using a combination of "black-box" tools for optimization and automatic code-generation for first order derivatives.

The OPF is in general a nonlinear optimization problem with non-linearity both in the objective function F(x) and g(x), h(x). The exact formulation of the problem and the selection of variables will determine the degree of non-linearity, while the number of constraints can be very large even for medium size networks. The mathematical challenge does not stop here. Every constraint is a function of only a small subset of the variable set (partially separable functions), therefore there is a large benefit to consider the problem as sparse.

For these reasons the OPF is solved as a large-scale sparse nonlinear optimization problem. The solution process usually involves solving the optimality (Karush-Kuhn-Tucker) conditions for nonlinearly constrained optimization that contain first and second derivatives of the objective and constraint functions. A number of algorithms (augmented Lagrangian, sequential quadratic programming, reduced gradient) can be applied for its solution. If Jacobian and Hessian matrices of constraints and gradient and Hessian of objective are hand-coded then the resulting code can be fast (execution time). However the insertion of a new feature from the software programmers point of view is not trivial. Correct and exact programming requires keeping track of the interdependence of variables and having thorough knowledge of the sparsity structure of the derivatives. Calculation as well as positioning of the Jacobian terms while adding new variables or new equations, is a particularly error-prone programming task.

The objectives of the traditional OPF have been minimum production cost and minimum-loss operation. With the open energy market environment the motivations have changed. Minimum-loss and secure operation of networks is still desired, but the focus of planning has been shifted to more economic, flexible and controllable operation. Maximum power transfer between regions, elimination of loop flows or setting of the active power flow along desired paths are some examples of new possible goals under the new conditions. At the same time FACTS controllers allow more flexibility in the power grid by providing smooth and rapid control over certain network elements. This flexibility amounts to an increased number of control variables in optimization (series impedance with series FACTS devices) and less strict constraints (increased line ratings).

Under these conditions there is a motivation in an academic environment (and also in an industrial software development environment) to create an optimization software tool that offers a flexible and easy-to-augment code, where the new features (new device models, adding or elimination of constraints, changing a parameter to a variable etc.) can be easily inserted. Ideally the developer should be relieved from the tiring task of reconsidering the

sparsity structure of matrices (dependent on the order of variables and equations) every time a new feature is added.

A paper has been submitted to IEEE PICA'99 (Santa Clara, CA, U.S.A, May 1999). This paper presents an environment for solving OPF problems having the properties described above, by using a combination of a general-purpose optimization package (MINOS) and an automatic code differentiation (AD) tool (ADIFOR). The approach is compared to hand-coding (HC). The efficiency of the presented code is evaluated in terms of certain software quality properties as follows:

	FL	MN	CPU	DS
OPF/HC	+	+	+++	+
OPF/MINOS	++	+	++	++
OPF/MINOS/AD	+++	+++	+	+++

OPF: Optimal Power Flow; HC: Hand-coding; MINOS: General purpose non-linear optimization tool; AD: Automatic Differentiation; FL: Flexibility; MN: Maintainability; CPU: Execution Speed; DS: Development Speed

- Flexibility (FL): The ability in an OPF code to switch between different optimization algorithms or experiment with alternative formulations of functions.
- Maintainability (MN): The ability to easily extend, modify and reuse parts of an existing code (e.g. inserting a new constraint or objective function, change parameters, bounds, variables etc.
- Speed: We distinguish between development (programming) speed (DS) and execution (CPU time) speed (CPU)

Clearly, the chosen approach (OPF/MINOS/AD) leads to great advantages related to much higher problem flexibility and related to the much faster speed of new code developments at the price of slightly slower program execution time as compared to hand-coded programs.

Profit maximization in uncongested power pools
(Several student groups, Prof. Rainer Bacher)

Bidding based electric power markets allow market participants to bid linear or piecewise linear incremental cost curves. In this project profit maximizing aspects of bidding curves in a market without any network congestion are analyzed. The market framework and associated optimality conditions allow that each market participant can maximize its own profit by strategically bidding cost curve parameters based on knowledge of the market behavior and its own "true" incremental cost curve parameters. The optimality conditions for a pool based power market are derived where one or more participants use this same profit maximization strategy. The theory is validated with several simulation examples.

Projections of energy demand in the service sector
(Bernard Aebischer, Jürg Schwarz, Daniel Spreng; in collaboration with Amstein + Walthert AG, Consultant Engineers, Zurich)

The research project is planned as a long-term service task for the Swiss Federal Office of Energy. A continuous evaluation of the results together with a steadily enlarged and updated data base will help to improve the model.

Long term energy demand perspectives: The two "bottom-up" models of energy and electricity demand in the service sector, which were developed in 1993 and 1994, were used in 1995 and 1996 to describe future energy demand supposing today's energy policy (scenario I) and the planned energy policy with and without a CO_2-tax scenario (IIa and IIb) and to evaluate two legal referenda: the "Energy and Environment Initiative" and the "Solar Initiative" (scenarios IIIa to IIId). In 1997 we were requested to do a much more theoretical investigation: studying the technical possibilities to reduce drastically the energy induced CO_2-emissions and proposing policies and measures to achieve this goal. This investigation was published as scenario IV, but it is not based on a well specified scenario like the earlier studies. It is rather an explorative sketch of a scenario describing a possible way to reduce CO_2-emissions well below targets discussed today.

This year we finished the documentation of the models and scenario-calculations. The report [Aeb 1998] is published as a collection of appendices to the earlier studies.

Ex-post analysis: The evolution of the energy demand 1990-1997 could be reproduced in a satisfactory way [Aeb 1998/2]. The observed variations are compared in table 1 to our calculations. Short term variations due to different climatic conditions are important in the heating sector only. The growth of the occupied area is decisive for the longer term evolution of electricity demand; in the heating sector this factor is compensated by a more efficient use of energy. A rough estimation of the influence of recently introduced policy measures at the end of 1997 gave energy savings of 3% in heat consumption and 2% in electricity use.

	Heating energy		Electricity	
	1990/97	1996/97	1990/97	1996/97
Observation	2.6%	-6.1%	11.5%	0.6%
Area	13.3%	1.4%	13.2%	1.4%
Structural change *)	0.6%	0.1%	0.0%	-0.1%
Use of energy *)	-16.0%	-2.4%	-2.0%	-0.4%
Climate+days	1.9%	-9.3%	-0.3%	-0.9%
Energy price	1.2%	-0.5%	-0.8%	0.1%
Calculation (all factors)	0.9%	-10.7%	10.1%	0.1%

Table 1: Variation of heating energy and electricity between 1990 and 1997 and from 1996 to 1997. The calculated variations are allocated to different driving factors. Two of them, highlighted by *), are aggregates of more specific factors: "Use of energy" is the result of the autonomous technical change and the policy induced evolution; in the electricity sector, we distinguish the structural change on the level of the economic sectors and the structural change within the economic sub-sectors.

Influence on electricity demand of the internal structural change: The "bottom-up" model for electricity demand is based on the observation that structural changes occurring within the sub-sectors of the service sector were important driving forces for the increase of electricity demand in the City of Zurich during the eighties. In a new research project we have started to investigate whether this is also the case in the nineties, which are characterised by a much lower economic growth. In order to get a more representative sample, we will include statistics for the Canton of Geneva.

[Aeb 1998] B. Aebischer, J. Schwarz, "Dokumentation zur Studie: Perspektiven der Energienachfrage des tertiären Sektors für Szenarien I bis III 1990 - 2030", Forschungsgruppe Energieanalysen, ETH Zürich, 1998

[Aeb 1998/2] B. Aebischer, D. Spreng, "Veränderung 1990-1997 des Energieverbrauchs in der Verbrauchergruppe Gewerbe, Landwirtschaft, Dienstleistungen (GLD): Analyse ex-post, Forschungsgruppe Energieanalysen, ETH Zürich, 1998

Financial support: Federal Office of Energy (BFE)

Promotion of rational use of energy in information technologies and home electronics
(Bernard Aebischer)

The first aim of this project is to collect, present and propagate information on energy use of information technology and home electronics. The research activity is oriented in two directions:

1 understanding and evaluation of national and international promotion activities and programs
2 exploration and application of new marketing strategies

Up-to-date know-how is acquired by an active follow-up of national and international activities. The crucial task is to select and pass on relevant information for research, government and industry (users and producers of equipment) both in Switzerland and abroad.

Last year a new research area was investigated with a survey of international literature and a concept for further investigations in the field of energy consumption by "machines". Within the domain of energy-consuming devices, "machines" (Automaten in German) have scarcely been studied at all, except in the household and in offices. This year the research-concept was applied to cooled vending machines in Switzerland. The methodology proved to be useful, but the resources needed were found to be rather high.

If we exclude common brown and white goods in households and office equipment, cold drinks vending machines are consuming by far the largest amount of electricity of all the "machines" which have been investigated in detail until now (table 1). In order to get an idea of the importance of other "machines", we looked at four typical objects of the service sector: a railway station, a hospital, a warehouse and a school. The electricity consumption of all "machines" (office equipment and cooling equipment in the warehouse were excluded) was for all four objects between 1% and 4% of the total electricity consumption. A report was published this summer [Aeb 1998/3].

Type	No. of machines	Energy consumption (GWh p.a.)	Source	Remarks
Automatic teller machines	3,233	8.4	(Con 1994)	
Ticket vending machines	5,000	7.3	(Hus 1996)	
Scanner cash registers	2,000	2.3	(Mos 1993)	status, 1990
Other electr. cash registers	23,000	3.4	(Mos 1993)	status, 1990
EFT/POS devices	7,000	0.5	(Ebe 1993/2)	point of sale with payment by card
Refrigerated beverage machines	13,000	42.7	(appendix 4)	included in this study
Automatic snack machines	1,200	1.8	(appendix 4)	” ”
Refrigerated goods machines	1,700	5.5	(appendix 4)	” ”

Table 1: Energy consumption of selected automatic machines in Switzerland

[Aeb 1998/3] B. Aebischer, A. Huser, "Energieverbrauch von Automaten und Energiesparmöglichkeiten", Bundesamt für Energie, Bern, 1998 (EDMZ 805.792 d)
(The report, including an English summary, can be downloaded from the Internet at: http://www.energieanalysen.ethz.ch/literatur/automaten.pdf)

Financial support: Federal Office of Energy (BFE)

Co-operative procurement of innovative copiers
(Bernard Aebischer)

On invitation of the International Energy Agency (IEA), we assumed from 1995 to 1997 the responsibility for a procurement project for innovative energy efficient and environmental friendly copier machines. Co-operative procurement refers to the activity of a group of buyers who jointly assess, determine and publish the requirements for new products, test products and purchase products using the defined requirements.

The goal of the "copier project" is to test and demonstrate the feasibility of a procurement activity at an international level in the field of standardised products with new buyer groups from the office sector. If successful, technology procurement could become a powerful instrument to promote energy efficiency also in other fields of consumer items.

In the past two years, we have defined a strategy accepted by the officially participating countries (Finland, the Netherlands, Korea, Sweden, UK, USA). On our initiative, a copier working group – composed of important copier purchasers, representatives of copier manufacturers and institutions – was organised by ö b u, the Swiss Association for Environmentally Conscious Management. Requirements for the innovative copier, originally concentrated on the ZESM-concept (zero energy standby mode) and on paper saving features, were extended to other ecologically relevant aspects. Four important companies from the banking, insurance and retail sector agreed to be the first "Leading Buyers", which means that the company declares in public that they will explicitly consider the innovative copier in future purchasing activities. ö b u and the section "Services" of the Energy 2000 Program agreed to act as "Supporter" of our procurement project. Similar activities are expected to happen in the other countries. Selected copier manufacturers were involved since the beginning of the project and recently the global copier industry participated in a meeting to discuss the specifications of the next-generation copier. In order to ensure the longer term funding of the project, the project management was handed over to the US-EPA (Environmental Protection Agency) in autumn 1997.

In 1998 a report was published describing in more detail our activity between 1995 and 1997 [Aeb 1998/4]. In September 1998 the competition of the innovative copier was officially launched. The corresponding documentation can be found on the internet at: http://www.epa.gov/appdstar/esoe/techpro.html . Included is a "Declaration of Support by the Swiss Leading Buyers and Supporters" which was prepared by the author.

[Aeb 1998/4] B. Aebischer, "Internationally Coordinated Procurement of Innovative Copiers. Project Management October 1995 - September 1997", Energy Analysis Research Group, ETH Zurich, 1998
(The report can be downloaded from the Internet at:
http://www.energieanalysen.ethz.ch/literatur/Copiers_F.PDF)

Financial support: Energy Analysis Research Group, International Energy Agency (DSM Agreement, Annex III), Federal Office of Energy (Energy 2000 Program, Research Program "Electricity"), Utility of the City of Zurich (EWZ, Stromsparfonds), Lawrence Berkeley National Laboratory

Indicators of energy consumption in Switzerland 1960-1997
(Bernard Aebischer)

Currently, no comprehensive indicator system has been published for energy consumption in Switzerland. In order to compare energy consumption in Switzerland with other countries we are updating a collection of indicators developed ten years ago and adapting them to indicators used by the International Energy Agency for the USA and Japan. A summary [Aeb 1998/5] of an intermediate report was prepared and annexed to the project proposal that was submitted in August 1998 to the *Alliance for Global Sustainability*.

[Aeb 1998/5] B. Aebischer, "Energy Consumption Indicators in Switzerland 1960-1995/97. Highlights of the Intermediate Report, May 1998", Energy Analysis Research Group, ETH Zurich, 1998

Financial support: Energy Analysis Research Group

Innovations in Energy Efficiency
(David Goldblatt, Daniel Spreng)

This project undertook a broad review of innovation theory and policy and in this context looked at the place of innovations in energy efficiency in both Switzerland and other developed countries. The report consisted of a literature review; results of interviews with experts; hypotheses regarding innovations in energy efficiency; presentation of an example of energy efficiency in Switzerland; and suggestions for future research in this area.

In 1998, we made final changes and additions to the report based on comments we received from reviewers, interviewees, and others; incorporated an illustrative graph; and added a preface, summaries in both English and German, and highlights of policy and research recommendations.

D. Goldblatt prepared a shorter paper based on the innovation study as a contribution to the student program of the 17th Congress of the World Energy Council. It is a

concentration, crystallization and partial reformulation of the specifically energy-relevant sections of the larger report.

D. Goldblatt, D. Spreng, "Innovations in Energy Efficiency: Theory and Applications in Switzerland and Abroad," Federal Office of Energy, June 1998

D. Goldblatt, "Innovations in Energy Efficiency: Perspectives, Promotion, and Policy Prescriptions in Switzerland," The 17th Congress of the World Energy Council, Houston September 14-17, 1998

Financial support: Federal Office of Energy (BfE)

Characteristics of environmental indicators and environmental sustainability indicators
(David Goldblatt)

This research was conducted as support and background for the AGS Indicators Project. One of the project's objectives is to expand the information that energy consumption indicators convey about the sustainability of levels and rates of energy consumption to incorporate environmental and possibly economic or social dimensions as well. To this end we researched characteristics of good ecological/environmental indicators and candidates for indicators of sustainable development for application to the enhancement of existing energy consumption indicators or the construction of new ones.

Two documents were prepared. One is an extended abstract and compendium of works on environmental indicators and environmental sustainability indicators. It concentrates on conceptual and structural aspects of these indicators. The other is a paper based on the abstract that covers general issues, desiderata for environmental and sustainability indicators, pressure-state-response indicators, and other issues. We will apply some of the findings here to future tasks of the Indicators Project.

D. Goldblatt, "Literature review of conceptual and structural aspects of environmental and sustainability indicators: Notes, abstracts, and comments thematically arranged," June 1998

D. Goldblatt, "Characteristics of environmental indicators and environmental sustainability indicators," August 1998

Financial support: AGS

Ex Ante evaluation of energy projects for the 2000 Watt Society Program
(Daniel Spreng, David Goldblatt)

This small project sets out and illustrates guidelines for evaluating the potential energy impacts of future projects proposed for the 2000Watt Society program. The general

guidelines explain how to submit proposed energy-saving technologies and measures to self-evaluation and scenario analysis that keep a wide perspective on historical and currently related technological and socio-economic developments. Several illustrative case studies are presented, including an extended one on the introduction of electric-assist bicycles in cities of the developing world. The report is forthcoming.

Financial support: AGS, Wirtschaftsplattform der Strategie Nachhaltigkeit der ETH Bereichs

Researchers' perception and use of indicators
(Andrea Scheller)

The study about researchers' perception and use of indicators in their own research projects is one part of "The Indicator Project", an interdisciplinary project on sustainability indicators funded by the Alliance for Global Sustainability (AGS).

The study seeks to investigate the thinking of researchers from various disciplines with regard to their use of indicators and with regard to the usefulness of some of these indicators for measuring increases and decreases in sustainability. Ultimately, it aims to contributing to the development of recommendations for constructing useful context-specific indicators of sustainable development. The task includes both the study of personal indicators used by researchers and indicator workshops with AGS researchers.

A first round of four in-depth interviews was conducted this summer at MIT in Cambridge and a second round was later conducted with an updated script at ETH. The main topics of the interviews were indicators in general and in the researchers' projects, indicators of sustainability and indicators for the quality of results.
In the interviews, the need for context-specific construction and use of *indicators* was strongly emphasized, confirming one of the basic assumptions of this project. Researchers have variously defined an indicator to be "any number that is used to convey information about a level of good or bad," "some signal that an observer uses to monitor the performance of a system in which she or he has an interest," and "an agreed-upon measure for a standard of performance." *Sustainability* indicators were not viewed uniformly either. For example, one interviewee agreed that some of his working indicators (e.g. CO_2 emission) could be considered sustainability indicators. Another understood sustainability indicators as aggregated indicators and did not consider them applicable or useful for his work. A third rejected sustainability indicators altogether, claiming that we do not know what sustainability is and therefore cannot measure it either. In judging the *quality* of their research, researchers seem to rely on their disciplinary peers, even in interdisciplinary projects. The evaluation of the research process is still very much conducted by peer reviews. Researchers disseminate their findings within their research communities and publish articles in disciplinary journals.

The next year will be dedicated to a third round of interviews at University of Tokyo, the analysis of the interviews and the organization of a workshop.

Financial support: Alliance for Global Sustainability

Mapping Mobility

(Andrea Scheller)

In January 1998 the co-ordinators of the Alliance for Global Sustainability (AGS) initiated a mapping project of AGS activities in its six "pathways of sustainability": Energy, Mobility, Urban Systems, Cleaner Technologies, Natural Resources, and Global Environmental Change. The purpose of the project is to identify needs and priorities in each of these AGS sustainability pathways.

A team of graduate students based at MIT were hired for the summer to write white papers on each of the sectors. They were to interview principal investigators and review related literature to identify the products of AGS research thus far, major questions and knowledge gaps, and other programs for overlaps and synergies.

Since A. Scheller was familiar with most of the AGS project material from her own work in "The Indicator Project" (see above), she was well-suited to join the students' team as the representative from ETH. She spent June and July at MIT investigating the mobility sector. After the two months, she transferred the draft of the white paper on mobility to an MIT graduate student for completion.

Financial support: Alliance for Global Sustainability

A. Scheller, F. Chevrot

"White Paper on Mobility", Mapping Project, Alliance for Global Sustainability, MIT, Cambridge, December 1998

Forecast system for longer-term electricity demand in the supply area of smaller and medium-sized electric utilities

(Jürg Schwarz)

Today the energy market is changing. In the future, energy demand may fluctuate, stagnate, or even decrease. In addition, deregulation of the electric industry is evolving faster than expected. Enhanced knowledge of the future energy consumption is therefore required. In addition, electric utilities need a stronger orientation toward their customers and an improvement of their internal communication processes. A longer-term energy forecast tool can help meet these challenges as it refers both to the changing pattern of energy consumption and to the efforts towards demand-side management. Forecasts of the energy demand for a whole country, which were formerly used to assess the security of energy supplies, are probably not well suited to the tasks of an electric utility.

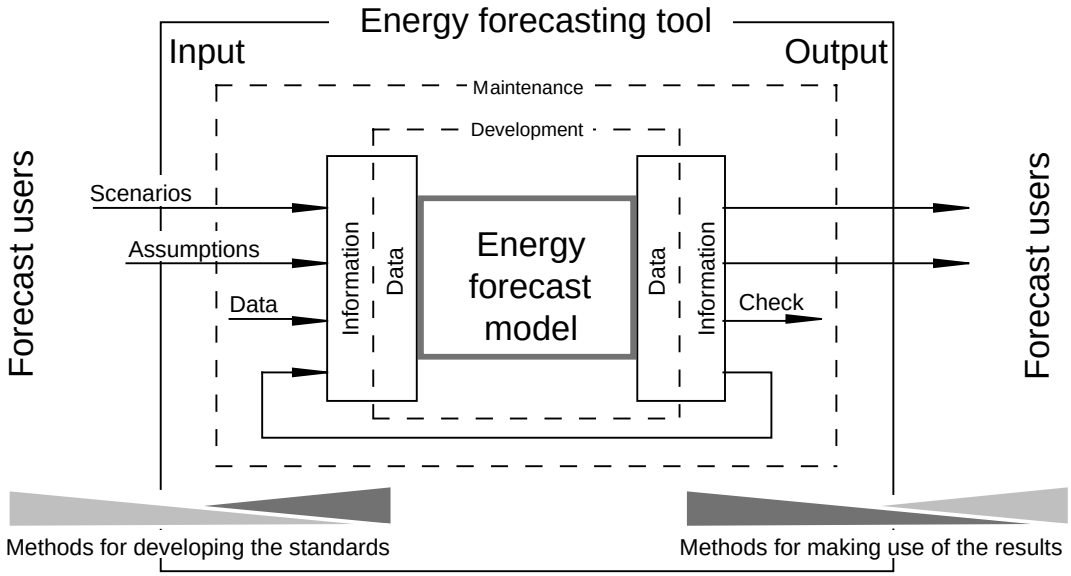


Figure : Block Diagram of the Energy Forecasting Tool. Three types of Interfaces are differentiated: Developer Interface, Maintainer Interface and User Interface

The prior experience with the electric utility Elektra Birseck Munchenstein (EBM) near Basle was motivated by the question: ”How much awareness do the various departments have of the future development of electricity output?” This experience made clear the need for an energy-forecasting tool that provides the utility with a shared database and makes it consider future requirements. The current project addresses these needs.
The ongoing diffusion of natural gas into the supply area of electric utilities requires enhanced planning for future supply strategies. Therefore the potential to address the question of substitution and regional development is important.
The forecasting tool should consist not only of a model (or algorithm) for the computation of figures, but above all of some powerful tools for future users. On the input side, the user should be able easily to manipulate data inputs and scenarios. On the output side, easy-to-use tools should enhance the usefulness of the results. For this reason three types of interfaces are to be defined (see figure above).
Currently, the project is at the stage of implementing a bottom-up energy model in a spreadsheet environment on a PC. The energy consumption of four sectors (residential, services, industry and top ten) covering the whole supply area can be calculated for the years from 1995 to 2030. The model takes into account electricity, gas, oil, solar energy, wood and district heating. Natural gas substitution for electricity is accounted for with statistically derived parameters.
In each sector, up to seven subsectors are differentiated: for example, single and multiple family houses in the residential sector. Up to six applications are distinguished in each subsector (space heating, water heating, infrastructure, process heating, process drive, and equipment), and within the application equipment up to ten devices can be taken into

account. For example, in the residential sector the electricity consumption of the following classes is calculated: cooking, cooling, washing, drying, communication, lighting and rest. Each of the 48 communities within the supply area of the energy utility can be assigned to one of five regions, each evolving according to its own regional development.
In its current state the forecasting tool allows the simulation of different scenarios of energy consumption in the supply area of the electric utility.

Financial support: Projekt- und Studienfonds der Elektrizitätswirtschaft (PSEL) and Elektra Birseck Münchenstein (EBM), 1995-1997

Energy-Relevant Decisions in Office Buildings
(Lukas Weber)

A study is done of the evolution of electricity consumption 1986–96 in 100 Swiss office buildings in order to analyse energy-relevant decision-making. The results empirically build on electricity bills, energy audits and interviews with technical staff and managers in firms. The aims of the study are:

- to determine typical trends in the evolution of electricity consumption,
- to identify crucial changes in technical equipment and installations and evaluate their impact on electricity consumption,
- to identify energy-relevant decision-makers and assess their opportunities to take more sensible decisions,
- to determine the role of energy efficiency in energy-relevant decision-making and evaluate the impact of energy-saving measures,
- to evaluate the impact of organisational prerequisites and management attitudes in firms on energy efficiency.

An electricity analysis was made in 100 office buildings selected at random. The recent consumption was divided into usage groups (e. g. lighting, cooling, office equipment), and the annual consumption 1986–96 was graphically presented. Within the buildings, an empirical analysis was made in 92 firms, where 350 energy-relevant events (i. e. changes in installation and equipment) were determined and analysed. For each event, the year, the causal reason, the decision-makers, the assumed impact on energy consumption and the status of energy efficiency were determined in interviews with technical staff and managers in the firms.

First findings show that 80% of electricity in office buildings is used by technical installations, such as cooling, ventilation, lighting and mainframes. The rest is consumed by technical equipment. Changes in technical installations are relatively rare, but they dominate the evolution in electricity consumption. Were these changes to be decided upon with respect to energy efficiency, a considerable amount of energy could be saved.

The decisions behind energy-relevant events were found to be decisions on investment usually taken without considering energy consumption. The nominal decision maker is the management, yet energy-related decisions are actually taken by specialists inside the firm

(e. g. operation service, computer acquisition group). If they were to take energy consumption into consideration when they planned new installations and equipment, much energy could be saved.

The results will be published in detail in spring 1999.

The study is realised in co-operation with a private engineering company (*Amstein + Walthert AG*) and the German *Fraunhofer Institut für Systemtechnik und Innovationsforschung Karlsruhe*.

Lukas Weber, "Strong Will, Weak Flesh? - From Awareness To Action", in: Université de Genève (ed.), Ecological Economics and Development: Tagungsband zur 2. Internationalen Konferenz der European Society for Ecological Economics, Geneve, 252–53, 1998

Financial support: PSEL, ETH, EWZ, VSE (1/1997 – 9/1999)

1.7 EPSOM'98: Electrical Power System Operation and Management (International Conference, ETH Zürich, 23-25. Sept. 1998)

EPSOM '98
International Conference on
Electrical Power Systems Operation and Management

ETH Zürich, Switzerland, 23rd - 25th September 1998

Organisierende Institutionen:
SEV Schweizer Elektrotechnischer Verein
ETHZ Eidgenössische Technische Hochschule Zürich
IEE Institution of Electrical Engineers

Die EPSOM'98 (Electrical Power Systems Operation and Management) Konferenz fand vom 23.-25. September 1998 an der ETH Zürich im Elektrotechnik Hauptgebäude statt. Die Konferenz wurde wie folgt organisiert:

Conference chairman: Prof. Dr. Hans Glavitsch, ETH Zürich
Technical chairman: Prof. Dr. Rainer Bacher, ETH Zürich

Organizing Committee: Rangie Amitirigala, ABB Network Partner AG; Philippe Burger, SEV; Iain K. Campbell, IEE Switzerland; David Goudie, Consultant; Karl Imhof, ATEL;
Venkat Narayan, Netzconsult Ingenieure; Gerhard Schaffer, KEMA-ECC/Europe; Nisheeth Singh, ABB Network Partner AG
Die Leitlinie dieser Konferenz wird durch den Konferenznamen wiedergeben. Bei EPSOM'98 wurden Schwerpunkte auf drei Themen gesetzt: A) Elektrischer Strommarkt (Marktformen, Optimierung von Speicherenergie, Software-Werkzeuge), B) FACTS (Flexible AC Transmission Systems) (Bedürfnis, Systemaspekte, Komponenten), C) Innovative Technologien und Techniken (Kommunikation, Informationsmodellierung, Qualität, Visualisierung, Internet, Künstliche Intelligenz). Die Konferenz wurde so organisiert, dass 17 internationale Experten eingeladen wurden, über vom EPSOM'98-Komitee initiierte Hauptthemen zu referieren. Diese Themen wurden von den geladenen Experten bearbeitet, an der Konferenz präsentiert und in Form von ausführlichen Papieren in den EPSOM'98 Proceedings publiziert.

Zusätzlich zu diesen "invited Papers" wurden 42 vom Komitee ausgewählte, zu den erwähnten Themengebieten A, B und C passende, Papiere von Autoren aus 19 Ländern an der Konferenz in Form von Posters präsentiert.

Ca. 150 Konferenzteilnehmer haben dazu beigetragen, dass diese Konferenz als grosser Erfolg bewertet werden kann. Speziell zu erwähnen sind die folgenden Punkte:

- Diese internationale Konferenz wurde erstmalig gemeinsam von SEV wie auch IEE finanziell abgesichert und unterstützt.
- Diverse Sponsoren (ABB Partners Ltd., Alstom Ltd., ATEL Aare-Tessin AG für Elektrizität, BKW Bernische Kraftwerke AG, Rockwell Automation AG, Siemens AG) haben namhafte finanzielle Teile der Konferenz übernommen. Diese Firmen konnten während EPSOM'98 in Form einer Ausstellung Ihre Produkte ausstellen und Dienstleistungen präsentieren.
- Praktisch die gesamte Konferenz-Administration inklusive Handling der technischen Papiere, Präsentationsmaterial, etc. wurde – von der ETH organisiert - über das Internet abgewickelt (Email, WWW, ftp). Man kann feststellen, dass – obwohl nicht ohne grossen Initialaufwand - dieser Prozess funktioniert und aufgrund von Standards wie html, pdf zu Dokumenten führt, welche jedermann auch digital abrufen und einsehen kann.
- Das gesamte Konferenzmaterial liegt neben den Proceedings in digitaler Form sowohl auf CD-ROM wie auch auf dem Internet (http://www.eus.ee.ethz.ch/epsom98/) vor.
- Durch Festlegung eines speziellen Konferenztarifs für Studenten, welcher weit unter den üblichen Gebühren für Konferenzen dieser Art liegt, konnten auch viele Studenten und Doktoranden zum Besuch dieser Konferenz gewonnen werden.
- Durch das Sponsoring der erwähnten Firmen konnte ein interessantes "Social Program" angeboten werden, welche es allen Teilnehmern in ungezwungener Atmosphäre erlaubt hat, neue Kontakte untereinander und zu den geladenen Experten zu knüpfen.

Inhaltlich wurden von den "invited speakers" hervorragende Präsentation auf höchstem technischen und inhaltlichen Niveau geboten. Es wurden Aussagen und Hinweise zu den hochaktuellen Themen des Strommarktes, des Einsatzes von FACTS und der Bedeutung der Informationstechnologien gebracht. Man kann festhalten, dass die äusserst komplexen systembezogenen Themen hervorragend didaktisch und im Tutorial-Stil präsentiert wurden. Die Qualität der Poster-Session Papiere und Posterpräsentationen wurde gemäss einer Umfrage bei den Teilnehmern ebenfalls praktisch durchwegs als hervorragend beurteilt und kann als voller Erfolg gewertet werden.

Alle EPSOM'98-Papiere können entweder in Form von Proceedings oder als CD-ROM beim SEV bestellt werden. Das gesamte EPSOM'98-Material kann auch über das Internet bei http://www.eus.ee.ethz.ch/epsom98/ bezogen werden.

Prof. Dr. Rainer Bacher
Technical Chairman EPSOM'98 (23-25 September 1998)

Der Jahresberichts-Textteil der Fachgruppe Hochspannungstechnologie (Prof. Fröhlich) kann bei folgenden Adressen bezogen werden:

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3. KOLLOQUIUM: Aktuelle Probleme der Energietechnik

Fachbereich ELEKTRISCHE ENERGIETECHNIK,
Proff. Dr. R. Bacher, Dr. K. Fröhlich, Dr. H. Glavitsch, Dr. J. Hugel,
Dr. K. Reichert, Dr. D. Spreng,
in Zusammenarbeit mit der "Energietechnischen Gesellschaft ETG/SEV"
(Alle Kolloquien WS 97/98 und SS 98)

Advanced State Estimation in Power Systems
Dr. Lamine Mili, Virginia Tech, Blacksburg VA 24061, USA
15.10.98