ERDA PROGRAMS AND OBJECTIVES:
ENERGY CONSERVATION IN FOOD PROCESSING

JULY 1977

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DIVISION OF INDUSTRIAL ENERGY CONSERVATION

PREPARED BY
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UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

OFFICE OF THE ASSISTANT ADMINISTRATOR
FOR CONSERVATION

July 1977

To the reader:

This document describes the current ERDA Agriculture program as it relates to the research recommendations submitted by a 1976 workshop on energy conservation in the food processing industry. It is intended to reflect the ERDA Division of Industrial Energy Conservation response to the ideas and concerns of the private sector as expressed by the workshop participants.

The format of this document is based on the itemized recommendations contained in the workshop Report of Proceedings, but the content of the recommendations is not repeated herein. The reader is therefore urged to refer to the Report of Proceedings as an accompaniment to fully appreciate the context of ERDA's responses. Recommendations and responses are cross-referenced, where appropriate, parenthetically by number.

Preparation of this report necessitated a thorough internal review and evaluation of the Agriculture program objectives and activities to ascertain whether and how the workshop recommendations have been addressed. It is hoped that similar discussions will be stimulated among readers.

This report has been prepared and edited by Washington Scientific Marketing, Inc. in close cooperation with the Division of Industrial Energy Conservation, and in particular with the Agricultural and Food Systems Branch.

Sincerely,

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*Report of Proceedings of the Agriculture Processing Industry Workshop on Energy Conservation, Wash., D.C., March 1976, available from National Technical Information Service, Springfield, VA 22161, #CONF-760355 (\$5.00).

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INTRODUCTION

A Workshop on Energy Conservation in the Agriculture Processing Industry was sponsored by the ERDA Division of Industrial Energy Conservation in March 1976. 49 participants from industry and academia represented the chemicals, dairy, fruits and vegetables, grain, meats, and textiles sectors. They submitted a total of 87 conservation research recommendations to ERDA contained in the workshop Report of Proceedings as a reference for this report. This ERDA response document was prepared as part of an intensive review of the Division's Agriculture program to describe how and where the workshop project ideas have been incorporated into its ongoing and planned research and development program.

The Agriculture program is described in detail, and the reader will note that some of the workshop recommendations are being specifically addressed. Many others are included as components of broader projects. The several systems studies, for example, will examine and evaluate energy-conserving food processing alternatives such as those discussed at the workshop. The ideas carrying the greatest savings potentials, feasibilities, and likelihood of adoption by industry which result from these analyses will be considered for ERDA-supported research, development and demonstration (RD&D). Several of the recommendations are not considered priorities for funding, and the Division's explanations in these instances serve to illustrate, by way of example, the Agriculture program objectives.

Preparation of these responses stimulated considerable discussion within the Division regarding program priorities, and ERDA anticipates that this document will spur similar discussions within the private sector. Readers may wish to challenge some of the recommendations and responses, and provide program guidance by way of identifying gaps, new ideas and needed information.

A second food processing workshop is scheduled for September 1977, and will include discussion groups on dairy, fruits and vegetables, grain products, meats, oils and fats, malt beverages, bakery products, and sugars. The nature of industrial feedback generated by this document will guide the initial deliberations. At present, no ERDA Agriculture projects are underway relating to the latter four groups. These sectors are quite energy-intensive and are considered priority areas for conservation RD&D, so the advice and concerns of these discussion groups will be especially important in helping the Division identify the most significant and viable RD&D opportunities.

The 1976 workshop, this response document, and the upcoming meeting have been undertaken as a coordinated dialogue between ERDA and its industrial constituency. Maximization of private sector involvement in the conduct, review, and evaluation of the federal energy R&D program is a primary Division objective, and the success of the industrial program hinges critically upon its fulfillment. The workshop and follow-up activities provide a forum for defining the optimal federal role and for exchange of information about ongoing efforts in both the private and public sectors, and lay groundwork for eventual technology transfer.

While reading the workshop recommendations and the corresponding ERDA responses, it should be borne in mind that the major thrust of the ERDA Industry Conservation program is to demonstrate technologies that:

- Industry would not pursue on its own primarily because of the high risks involved.
- Have high potential benefit in terms of energy savings.
- Significantly accelerate energy savings.
- Promise significant savings in fragmented industry which has no research funds allocated to such effort.
- Have a return on investment which, once developed, will sufficiently attract broad scale implementation.
- Are cost-shared by the industries affected.
- Are environmentally acceptable, operationally safe, and reliable.

The Division is refining a computer model which processes specific project-related data (capital cost, operating cost, useful life, year of introduction, total market, etc.) and provides a summary ranking of project ideas. This threshold criteria technique is being used as a guideline to judgement and, since the technique does not take all related considerations into account (for example, the substitution of inexhaustible fuels for natural gas), there will be exceptions taken, i.e., projects may be supported which have received a relatively low threshold criteria ranking, but which have other critical values that dictate implementation. Systems studies, for example, do not yield energy savings per se, but are often considered priority projects to identify promising conservation R&D opportunities. Another example in the Agricultural program is crop frost protection research.

The reader may also wish to refer to the ERDA Industrial Energy Conservation Program Approval Document (PAD) which describes the objectives and activities of all the Division's programs, including those of the Agricultural and Food Systems Branch upon which this report is based. The FY77 edition of the PAD is available from the ERDA Technical Information Center (TIC), PO Box 62, Oak Ridge, TN 37830. The FY78 PAD is scheduled for release in early autumn. ERDA's comprehensive plan is set forth in A National Plan for Energy Research, Development & Demonstration. This report is updated each year, and may be purchased from the U.S. Government Printing Office, Washington, DC 20402 (#ERDA 77-1, \$2.00). Single copies are available upon request from TIC.

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OVERVIEW OF PROGRAM AREAS & SUBJECTS OF INTEREST TO WORKSHOP

Systems Studies

The Division favors systems studies as an initial effort in most industrial and agricultural sectors to evaluate the major energy loss points and identify energy conservation research needs. Optimally, the scope of work involved is broader than in energy audits, and includes identification and assessment of alternatives to conventional equipment and operations.

Purdue University is conducting an extensive study of pork and dairy processing which will involve development of baseline data, analysis of modifications, new equipment and new processes, and demonstration of an energy management program to industry (16-A, 48). Many of the workshop recommendations will be evaluated for technical feasibility, energy saving potential, and likelihood of industrial adoption during the course of this project. In the poultry sector, Georgia Tech has undertaken a similar program with particular attention to reducing hot water usage and recovering waste heat (48). It is anticipated that, thanks to significant industrial cooperation, most of the known conservation modifications can be incorporated into the demonstration plant, resulting in the most economically and energy-efficient poultry processing plant in the nation. Also, Oklahoma State University will review current beef processing methods and document the "state of the industry" regarding alternative procedures in connection with its R&D on hot beef deboning and electrical stimulation techniques (48).

Systems analyses are underway in the textiles sector to identify and demonstrate energy-saving modifications and managerial practices in wet processing and drying in dyeing and finishing plants (82, 83).

The ERDA Agriculture program is preparing a competitive procurement solicitation regarding nitrogen fertilizer production which will specify the intended federal R&D objectives. This may include a systems study of the industry to help select the most viable research opportunities.

Systems studies in the fruits and vegetables canning industry are planned (39), and similar efforts in the grain, oils and fats, malt beverages, bakery products, and sugar industries may also be undertaken.

A study of the industrial park concept is also underway (30).

Technology Transfer

This topic was discussed extensively at the 1976 workshop, and is one of the Division's primary concerns, both as a day-to-day and a long range objective. Within the Agriculture program, the nature and mechanisms of technology transfer to be pursued once successful development and demonstration is accomplished are considered in all projects. Broadly, this includes access to industry via panels which monitor work in progress, demonstration site visits arranged with the assistance of such panels and regional/national trade organizations, and workshops, publications and seminars. The USDA Cooperative State Extension Service network and the agency's Economic Research Service are also recognized as valuable channels of communication and technology dissemination.

The Division's Technology Transfer program pursues the objective of developing techniques to transfer new technologies into the industrial market, i.e., acceptance and widespread implementation by the private sector. Strategies include identifying the needs of industry regarding energy conservation (via the food processing workshop, for example), and active dissemination of current state-of-the-art conservation technology and technologically advanced energy-saving measures and research results. The integration of activities in this program with those in the Agriculture program is initiated as research projects are identified and contracts are developed so that the ultimate objective of industrial adoption is addressed throughout the entire RD&D effort.

Waste Heat Recovery and Hot Process Improvement

Several recommendations in this category were submitted by the workshop. The Waste Energy Reduction program in the Division is directed at reducing energy loss through waste energy of industrial processes by improvements in equipment that are common to many industries. Major efforts were initiated in Fiscal Year 1977 (FY77) on high temperature heat recuperators, catalytic combustion industrial boilers, boiler air/fuel ratio controls (31), and high temperature heat pumps (19). The latter program includes design and application of heat pumps in milk drying (19), textiles (77-A), and papermill bleaching operations.

Within the Agriculture Branch, opportunities for recovery and re-use of waste heat are considered important components of the systems studies. For example, the Georgia Tech systems analysis will investigate utilization of waste heat from ice coolers and masses to heat water required for broiler processing. Also, demonstration of a fruit tunnel dehydrator using recirculated exhaust air and heat recovery heat exchangers

is underway (25). This Branch is very interested in the application of state-of-the-art heat recovery technologies to food processing needs; the potential for matching known techniques and apparatus to recover heat from waste streams in the relevant temperature ranges seems significant. Heat recovery concepts are of interest in connection with the grain drying program (41), and are being applied in textile wet processes and drying (82,82). One such project involves demonstration of a closed-cycle dyeing operation with high temperature hyperfiltration membranes.

Alternate Fuels and Processes

The Division is currently preparing a program plan for conservation research in nitrogen fertilizer production which will include consideration of alternate feedstocks to natural gas (1). Work is underway on new formulations which generate chemical heats-of-reaction used as a substitute for natural gas in drying granular fertilizer (5).

The Division's Agriculture program is interested in exploring alternatives to natural gas for direct firing applications (45).

In the fruits and vegetables sector, several demonstrations of solar collectors supplying heat to existing process needs and equipment are ongoing (25-A).

Significant conservation research on new food processes is also underway. Low energy concentration of liquid foods such as fruit juices, milk and whey is one example (36). Other efforts include hot beef deboning techniques (60), and an innovative new method of preserving solid foods (37).

Utilization of Food Processing Wastes

Recommendations on this subject were received with interest in the Agriculture program. Because no work has yet been sponsored on food processing wastes and by-products, the Division would be interested in additional comments and suggested priorities from industry in order to ascertain the magnitude and viability of energy savings that can be realized. The Division's Materials Optimization program has undertaken some work on anaerobic digestion and methane production with industrial wastes, and the Solar Division's Fuels from Biomass program is active in bioconversion of animal and plant residues (26).

Other Subjects of Interest to the Workshop

Many of the workshop recommendations dealt with refrigeration. The Division's programs have not addressed this topic, but comments and information from the food processing industry would be welcome so that the conservation potentials and technical feasibilities of new or improved refrigeration technologies and equipment could be determined.

Packaging was also a topic of interest among participants. The Division feels that packaging is so varied and product-dependent that conservation research is not justifiable unless undertaken in connection with research on the product or on new production processes of which packaging is an integral part. For example, a new sterilization-packaging process for solid foods is being studied (37). Research on packaging per se is not anticipated.

Several of the discussion groups also commented on the need for inter-agency coordination and ERDA-Industry cooperation. ERDA is actively pursuing both of these objectives. Interagency Agreements with FEA, EPA, USDA, and Dept. of Commerce are being implemented. NSF and NASA also meet regularly with ERDA. The Division has sponsored coordination meetings with state energy representatives, and with numerous specific industrial firms, and solicited the advice and opinions of the private sector at workshops with industry and academia. This particular document was prepared as part of a program to stimulate ERDA-Industry dialogue regarding energy conservation in food processing.

Chemicals

Project 1. Alternate sources of feedstocks for ammonia plants to replace natural gas with coal

The Division of Industrial Energy Conservation is planning to support conservation RD&D regarding nitrogen production for fertilizers. Details on the scope and funding level of this program will be set forth in a competitive procurement announcement expected to be released in autumn 1977. Broadly, the objectives are to conduct energy-oriented systems analyses of the nitrogen fertilizer production industry, to study methods to reduce energy used in the classic Haber process to produce ammonia, and to evaluate the feasibility and conservation potential of alternate feedstocks to replace natural gas (funding limitations will probably preclude full-scale demonstration of the latter.) The National Fertilizer Development Center of the Tennessee Valley Authority is investing about \$40 million in a demonstration ammonia plant utilizing coal gas as a feedstock, and the ERDA program may seek to tie into or supplement this effort.

Project 2. Conservation of energy during the production of phosphoric acid

The Division has no current programs or future plans relevant to this recommendation. ERDA RD&D funding will be concentrated during the next couple of years on more energy-intensive processes in the chemicals industry such as production of nitrogen fertilizers. However, as conservation gains are effected in these priority areas, funding of phosphoric acid production research and development may be actively considered.

Project 3. Use of coal as a fuel for ammonia plants instead of natural gas

The ERDA program in nitrogen production may address alternate fuel sources such as coal for ammonia plants depending upon the availability of ERDA funds and the nature of coordination sought between ERDA and TVA (1).

Project 4. Study total energy consumption of marketing systems for anhydrous ammonia versus nitrogen solution

At present the Division has no plans to support this type of study. It would be necessary for a proposal to be submitted on the strength of preliminary work indicating the magnitude of potential energy savings in order to receive active consideration for funding. If undertaken, this effort could be one component of a systems study of energy consumption in the nitrogen fertilizer industry.

Project 5. Conservation of energy in granulation plants

The National Fertilizer Development Center, Tennessee Valley Authority, is developing processes for conserving energy in the production of fertilizers in ammoniation-granulation plants under an Interagency Agreement with ERDA initiated in FY76. The 4-year project will develop new formulations which reduce moisture added in the granulation process, and utilize chemical heat-of-reaction generated by combinations of ammonia and phosphoric acid as a substitute for natural gas in drying granular fertilizer. It is estimated that fuel consumption in granulation plants can be reduced by as much as 65% by using the new formulation procedures, resulting in a cumulative energy savings of 5.8 million barrels equivalent by 1985, with first savings occurring in 1980. TVA is currently developing a pipe-cross reactor and other melt-type processes, and collecting data from ammoniation-granulation plants on energy requirements for producing fertilizers by conventional processes. Performance tests on the new formulations will be conducted in pilot plants during FY78, and demonstrations in commercial plants under actual operating conditions are planned for FY79.

Project 6. Improve heat recovery in existing ammonia plants

This specific recommendation has not been addressed, but could be undertaken in connection with the planned fertilizer conservation RD&D program (1). The Division's Waste Energy Reduction program is directed at reducing energy loss through waste energy of industrial processes by improvements in equipment and processes that are common to many industries. There are numerous avenues for the reduction of waste energy, and each will be addressed. Major efforts were initiated in FY77 on high temperature heat recuperators, high temperature heat pumps (19), and catalytic combustion industrial boilers. Research is also underway on organic Rankine bottoming cycles for re-use of recovered waste energy.

In the Agriculture program, waste heat recovery opportunities are an important part of systems studies in the meat and dairy industries (16-A, 48, 57). In the fruits and vegetables sector, a fruit dehydrator using recirculated exhaust air and heat recovery heat exchangers is being demonstrated (25). Heat recovery alternatives are also of interest to the Division in the grain industry (41, 44). Modifications to recover and re-use waste heat in textile operations are the focus of demonstrations, also (83).

A detailed handbook on waste heat recovery technologies is available, and an accompanying FEA film on the subject (44).

Project 7. Conserve energy in phosphate rock mining by extracting the P_2O_5 directly from the rock-clay matrix

The Division feels that this project would yield relatively small energy conservation at great expense, in comparison to current priorities such as reduction of energy consumed in the production of nitrogen fertilizers. Over the long term, as the ERDA agricultural production program matures, analyses and perhaps feasibility studies relating to phosphates will be undertaken. In the meantime, unsolicited proposals on this subject must evidence significant conservation potential which can be attained with reasonable cost and likely adoption by industry in order to be actively considered by the Division.

Project 8. Combine the operations of an anhydrous ammonia plant and a steel blast furnace

There are no immediate plans to support this type of project, although ERDA has reviewed unsolicited proposals regarding conversion of the carbon monoxide from blast furnaces to nitrates, and is generally very interested in the potential of utilizing byproducts from one industry in another. Preliminary work which demonstrates the viability of cascaded operations would be an essential accompaniment to such a proposal.

Project 9. Conservation of energy through minimum tillage

Research, development, and demonstration of minimum tillage practices has been ongoing at Agricultural Experiment Stations for several decades. The Division of Industrial Energy Conservation recently did not fund an unsolicited proposal on this subject because, in view of the USDA role, it is doubtful that ERDA could effectively speed adoption of minimum tillage procedures beyond present efforts.

Project 10. Improve the efficiencies of pollution control equipment to decrease energy consumption in fertilizer plants

Systems studies, if undertaken, in this industry would generate data on pollution control energy requirements (1). The resultant data could serve to focus greater attention on the development of more energy-efficient pollution control devices, perhaps with EPA assistance.

Project 11. Conservation of electrical power in granulation plants

The major granulation research project now underway at TVA will not specifically address electrical energy conservation. Electrical energy is a relatively insignificant energy source for granulation plants compared to natural gas, and is not considered a priority target for federally-supported RD&D at this time.

Project 12. Conservation of energy through efficient marketing and distribution of fertilizers and agricultural chemicals

This, as a discrete effort, carries a low priority within the Division, and there are no funding plans. As more substantial conservation gains are achieved in the processing sector of the chemicals industry over the long term, this type of effort may receive attention. Of course, proposals which demonstrate an important magnitude of potential energy savings will be reviewed with interest by the Division. This project could also be conducted as part of an overall systems study of the industry.

Project 13. Conservation of energy through the use of byproducts

ERDA is considering sponsoring a study to ascertain the feasibility and magnitude of energy conservation that can be achieved by utilizing byproducts in the fertilizer industry. If such a study indicates that significant savings can be obtained at reasonable cost, further RD&D support would be actively considered.

Project 14. Solar evaporation of potash brine to concentrate and crystallize potash

There are no plans in the Division to fund this project, which is rated as a very low priority due to the relatively insignificant conservation and high cost involved. The Division of Solar Energy reports that none of its ongoing research is specifically relevant to this recommendation, either.

Project 15. Wet grinding of phosphate rock

ERDA views conservation in the production of nitrogen fertilizers as the top priority in the fertilizer industry, and has no plans to support RD&D related to phosphates in the near future. Over the long term this sector will receive attention once significant work has been accomplished in the more energy-intensive nitrogen processes.

Dairy

Project 16-A. Systems Studies

The Purdue Food Sciences Institute will be starting a major systems study of dairy operations in July, 1977. This effort will quantify the amounts of water and energy usage and help point out areas for additional research to reduce energy consumption in food processing plants. The following tasks will be performed in one dairy and two pork plants:

1. Overall economic analysis - types and costs of energy used, labor, raw material, equipment and energy costs with labor as a constraint.
2. Description of plant processes - material flow, energy inputs, and process conditions; a baseline or "ideal" minimum energy consumption level will be calculated for each unit operation.
3. Data collection - material flow rates, pertinent process conditions, and energy supplied.
4. Determination of efficiencies of present systems.
5. Analysis of effects of equipment modification, new equipment, and new processes to determine the potential for improvement in energy efficiency.
6. Comparison of existing and alternative systems; economic analysis of whether or not a more energy efficient process generates a sufficient savings over the existing process to warrant a change.
7. Energy management program - procedures for improving energy efficiency will be demonstrated to make conservation methods developed applicable to as many processes in the food industry as possible.

This study is expected to demonstrate that energy consumption can be reduced in these industries by 10-20% with a minimum of capital expense, and 20-40% by making more expensive major changes. This would amount to a 1-2% decrease in total U.S. energy consumption when applied across the entire food processing industry. Data on actual in-plant energy utilization generated by this project will serve to target ERDA funding priorities by identifying areas of significant and viable conservation potential.

Project 16. Development and dissemination of technical educational materials and technology transfer

The Purdue study will generate needed data on energy consumption and conservation opportunities in industry operations (16-A). ERDA may then consider funding the development of a handbook of optimal dairy energy standards based upon this information, similar to but more in-depth than the reports on energy audits in the baking and meat packing industries sponsored by FEA in 1976. Manuals which identify basic, first-step conservation opportunities in plants are currently available from dairy trade organizations. USDA has developed a series of six manuals on energy in agricultural production, one of which details energy use and conservation potential in on-farm dairy operations (available mid-summer 1977 from USDA Office of Communication, Washington, D.C. 20250), and various other FEA statistical reports on energy use in the food sectors may be of some help to processors (see Technical Reports of the Federal Energy Administration from National Technical Information Service, NTISUB/C/221-402 \$5.00).

Project 17. Development of alternatives to current package sealing techniques

Food packaging is so varied and product-dependent that energy savings realized in one technique are not often widely applicable throughout the food processing industry. Packaging usually cannot be studied separately from the products involved, and in these cases it is more feasible to examine packaging techniques as part of larger RD&D projects dealing with the energy-intensive production processes of certain goods. ERDA is interested in fostering the development of new heat sealing techniques and other packaging innovations, but unsolicited proposals along these lines may tend to drop out of contention for funds when subjected to threshold criteria evaluation because they do not carry a great enough conservation potential. Currently the only packaging-related project receiving Division funds involves a new method (GASPAK) of preserving solid foods, under development at the University of Maryland (37). Packaging is also discussed under No. 35 below.

Project 18. Integrated energy systems for dried food products

There is no current ERDA project to develop integrated systems for concentration and drying of food products, however the two processes are being separately researched. The University of Arizona is under contract with the Division to design and demonstrate an optimal heat exchange and exhaust air recirculation system for reclaiming waste heat energy from fruit dehydrators (25). Also, work on low energy concentration

of fluid foods and food processing effluents has just begun at the USDA Eastern Regional Research Center. The three methods generally used to concentrate liquid foods such as fruit juices, milk, whey, and waste-effluents, etc. - thermal evaporation, freeze concentration, and membrane processes - will be studied in various combinations in order to ascertain which utilizes minimum energy at the lowest overall process cost without sacrifice of product quality (36). ERDA RD&D on heat pumps in dairy operations is discussed below in No. 19.

Project 19. Utilization of heat pumps in current manufacturing processes

The Division has recently initiated an industrial heat pump program, with the objective of recovery and utilization of low temperature waste heat (150-250°F.) for delivery of high temperature process steam (350-400°F.). One of the three projects in this category, conducted by Garrett Airesearch, will develop an open subatmospheric Brayton cycle heat pump for heat recovery from waste water and exhaust gas streams in a dry milk processing plant. The system, based on a turbocompressor and heat exchanger developed by Garrett for aerospace applications, will take ambient air and "pump" it up to levels useful for process heat applications. An important design feature is that, because the system is an air cycle (the turbocompressor uses air bearings) and no lubrication is required, the air entering the dry house will not contain any contaminants that could degrade product quality. Exceptional long life and maintenance-free operation is expected of the device, which should find widespread acceptance in other food processing sectors, and in the textiles and pulp and paper industries as well. Demonstration is scheduled for FY79 at a Knudsen Corporation plant in Modesto, California.

The other two contracts in the heat pump program deal with applications to recover heat from a waste solvent stream in a textile fibers plant (77-A), and development by Westinghouse of an electrically-driven high temperature Rankine heat pump for delivery of process steam to a papermill bleaching operation. The design concept of the latter is very similar to the current Westinghouse line of Templifier low temperature heat pumps, the main differences being top temperature levels, working fluids, and unit capacities. The resultant system is expected to be widely usable in the paper-making industry.

A recent FEA/National Bureau of Standards Waste Heat Management Guidebook may be helpful to processors (44).

Project 20. Utilization of solid wastes as an energy source

Currently, none of the Division's ongoing or planned projects deal with dairy wastes, although in the future the Agriculture

program and the Division of Solar Energy Fuels from Biomass program may explore the feasibility of a jointly-sponsored total on-farm energy study which would include utilization of solid wastes as an energy source. ERDA agricultural waste research programs are discussed in No. 26 below.

Project 21. Development of a two-to-one sterile concentrate milk beverage

Presently, ERDA is considering supporting sterile fluid milk research (24). If undertaken, this effort would probably not specifically involve examination of concentrated sterile beverages. The USDA has recently initiated work on concentration (but not sterilization) of liquid foods, including milk, in which thermal evaporation, freeze-concentration and reverse osmosis will be studied (36).

Project 22. Identification and evaluation of constraints on energy utilized by the dairy products industry

No current or planned ERDA project will explicitly attempt to identify and evaluate all constraints on energy utilized by the dairy products industry. The example given in this recommendation of code dating requirements would be treated by research on sterile fluid milk products (24), and the Purdue dairy plant system study will treat other such constraints (16-A). An analysis of the energy impact of federal, state and local health, safety and environmental regulations could best be conducted by the dairy trade associations and would not require ERDA funding.

Project 23. Improved energy efficiency of in-plant clean-up practices

The Purdue dairy plant system study will yield data on the type and quantity of energy consumed in clean-up operations from which important conservation opportunities can be identified (16-A).

Project 24. Phase I: Feasibility study of sterile fluid milk as a major conservation measure; Phase II: Development and demonstration of a pilot system

The Division is actively considering this recommendation. Production processes for sterile milk have been developed by industry and academia, and although additional engineering, microbiological, and packaging research on some of the more innovative and promising technologies is necessary, the primary thrust of future work would be to test consumer acceptability

and market feasibility. Justification for ERDA's interest and role in RD&D which is fundamentally market-oriented as opposed to technological is currently being examined within the Division, using this particular project idea as an example.

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Fruits & Vegetables

Project 25-A. ERDA Solar Program

Some of the projects underway in ERDA's Division of Solar Energy, Agricultural & Industrial Process Heat Branch are of interest to the fruits and vegetables industry. The Branch supports work which demonstrates the applicability of solar technology for provision of hot water (up to 200°F.); for drying and dehydrating operations (140-170°F.); and for generation of low pressure steam (up to 350°F.). At present, the focus of these programs is to supply solar energy to existing process needs and equipment. A demonstration is underway at a Campbell Soup Company plant in which a solar collector provides heat for can sanitizing operations. California Polytechnic State Institute has designed a 20,000 square foot collector to supply heat to a raisin and prune tunnel dehydrator. Also, Teledyne-Brown and Goldkist are cooperating in a project to use solar power as a supplement to oil and gas requirements in soybean drying operations.

Project 25. Heat recovery - gases and water

The University of Arizona is nearing completion of a project to demonstrate energy conservation in fruit dehydrators utilizing recirculation of exhaust air and heat recovery heat exchangers. Currently about 436,000 tons of fresh fruit are dehydrated in the U.S. each year. About 10 million BTU's are required to dehydrate one ton of fruit, and most of this energy is discharged as waste heat at a temperature of approximately 155°F. Preliminary tests indicated that up to a 40% reduction in energy utilization can be achieved by recycling air through a bypass damper and thermal energy recovery through the heat exchanger equipment, which is equivalent to about 300,000 barrels of oil per year. Both modified (with heat pipes) and traditional fruit dehydrator tunnels were instrumented and monitored over an entire 100-day drying season to determine relative energy costs and dehydrating performance. Superior Farming, Inc., as a cooperator in the program, has provided the facilities and cost of system modification. Final presentation of results is expected in December, 1977.

A detailed energy audit in several fruit and vegetable canning plants is planned which is to include evaluation of heat recovery opportunities (39). If undertaken, researchers will employ an infrared sensor to locate sites where significant heat losses occur. Although this device does not yield quantitative information, the resultant heat loss pictures will speed analyses of where process re-design, application of insulation, or conscientious housekeeping efforts will be most productive.

A new Guidebook on Waste Heat Management is available which offers detailed descriptions of known technologies and case examples of application (44).

Project 26. Methane production and anaerobic digestion of waste

None of the Division's Agriculture projects to date have focused on anaerobic digestion of food processing wastes. Several groups at this workshop recommended that standardized "package" units be designed, in order to alleviate the investment burden of custom design and spur widespread adoption in the myriad of cases where the technique is potentially applicable in this industry. Proposals of this nature would be reviewed with interest by the Agriculture Branch, but would have to be accompanied by documentation of where in the food processing spectrum the unit could be employed, the magnitude of energy savings involved, and likelihood of adoption (based on projected capital costs, opportunity costs of using the wastes in this fashion, conservation, etc.). If such a unit were to be based on conventional bioconversion methodologies and thus little or no actual R&D were necessary, the Division's involvement might be difficult to justify. Also, R&D ideas on methane generation via fluidized bed or fixed bed gasification apparatus would tie in with the Agriculture program objectives regarding, for example, use of crop wastes for drying operations.

The Division's Materials Optimization program has two projects underway dealing with anaerobic digestion of industrial wastes. Michigan Technological University is investigating biological conversion of the organic residues available as spent sulfite liquor, the major waste product of the sulfite pulping industry, to protein and methane. Total annual production of these organic solids exceeds 2.0 million tons, which is equivalent to about 40 billion cubic feet of natural gas. The Michigan Tech effort employs ozonation to desulfonate the lignin, followed by conversion of the organic fraction into yeast protein, methanogenesis utilizing anaerobic organisms, and finally aerobic digestion. Drexel University is characterizing the properties of an array of petrochemical waste streams and known toxicants to ascertain biota effectiveness and recovery rates, and derive information so that process plants can be designed to optimize industrial anaerobic digestion applications. Regarding bioconversion, this Branch is primarily interested in technologies and configurations which are innovative and show promise of advantages over conventional methods.

The Fuels from Biomass program in the Division of Solar Energy supports projects dealing with the production of biomass (agricultural, forest, animal residues) and its conversion to clean fuel products and petrochemicals. Anaerobic digestion research includes a pilot plant (in procurement) to convert 40 dry tons/day of animal residues (approximately 300,000 scf/day SNG), 3 experimental feedlot facilities, and R&D on innovative concepts, small digestors, digester kinetics, and pretreatment, digestion and post-treatment alternatives. Other bioconversion processes being studied are fermentation to produce alcohols and petrochemicals, and biophotolysis to generate hydrogen.

Also, thermochemical conversion methods such as liquefaction, gasification and pyrolysis, and direct combustion are the focus of research, as are photochemical conversion processes such as photoelectrolysis to produce hydrogen. Biomasses under study include manure as a source of fuel gas to achieve feedlot energy self-sufficiency; carbohydrate crops (sugar cane, sorghum, sugar beets, corn) and other agricultural residues such as grasses/grains, silviculture, and cotton gin trash; and organic urban refuse. USDA is also active in research on utilization of agricultural wastes and residues for energy production, some of which is conducted at State Agricultural Experiment Stations with ERDA Biomass program funds.

Project 27. Improved steam traps

Steam traps are a source of frustration in all industrial sectors, and were mentioned at this 1976 food processing workshop by every discussion group. The problems involved (reflected in workshop recommendation No. 67) do not require ERDA-supported technological development, but rather careful attention to proper sizing and periodic checks.

The FEA/National Bureau of Standards EPIC handbook offers several energy-saving suggestions, case examples, and references for steam trap users (Energy Conservation Guide for Industry and Commerce - EPIC, Government Printing Office, Washington, DC 20402, SD Cat. No. C13.11:115, \$2.50).

Project 28. Good Management

Systems studies in the fruits and vegetables industry are currently under consideration which would address this recommendation (39).

Project 29. Systems studies of industrial parks

Honeywell is conducting a preliminary analysis of the industrial energy park concept for the Division. This effort involves examination, both theoretically and statistically, of the selection and siting of industries so as to efficiently utilize waste energy outputs of some as process energy inputs for others, as well as integration of waste materials and feedstocks. Specific industry data is being collected and analyzed, and optimal mixes of industries and technologies will be determined. Once this feasibility study is completed (by FY78), the Division will formulate plans for additional research and demonstrations.

Project 30. Fuel substitution

The ideas in this recommendation span several ERDA Divisions. The Fossil Energy program is very active in fluidized bed combustion research. One such project is the design and development of a standardized fluidized bed gasifier which is shop-assembled and capable of being shipped by rail. This "package" unit, judging from capacity plans, could be suitable for a variety of food processing needs. Full-scale operation is scheduled for FY79. Projects for technologies related to peak shaving are underway in the Division of Electric Energy Systems, and in the Energy Storage Systems Division. Bioconversion programs are discussed above in No. 26. Regarding co-generation, the Division of Industrial Energy Conservation is currently supporting component development (advanced bottoming cycles, industrial waste combustion technologies, etc.) and formulating program objectives for initiation of plant demonstrations. Once funding is received (expected for FY78), specific industry optimization and design studies, and architectural and engineering design work for demonstrations will be initiated. This program will not specifically target the applicability of co-generation to the food processing industry in its early stages, but will concentrate on sectors where the greatest energy impact can be achieved. Also, the Division of Buildings & Community Systems is involved in district heating installations, and the Division of Nuclear Research and Applications is evaluating opportunities for reactor co-generation, although this is generally on too large a scale to be relevant for food processing plants.

Project 31. Improved combustion efficiency

Exxon Research and Engineering Company has contracted with the Division's Waste Energy Reduction Program for a full scale demonstration of a unique, newly developed spectral fuel conservation system for boiler excess air control. The system integrates three discrete elements: 1) spectral flame analyzer at each burner to monitor a specific flame characteristic which accurately reflects the amount of oxygen in the fuel/air mixture; 2) flame burnout monitor to determine if the flame is fully extinguished in the upper region of the boiler; 3) in-stack pollution monitor. A microprocessor monitors inputs from the three analyzers and changes the fuel/air ratio at each burner. In this way, the excess air is reduced to nearly stoichiometric while ensuring that the pollution emissions are minimized. Retrofitting boilers with fuel/air ratio control systems could save 1-2% of their energy use. Projected cost for a four-burner boiler is approximately \$126,000, or \$87,000 if neither the flame burnout monitor nor the pollution monitor is required. The anticipated payback period on a multi-burner field erected boiler is 1-5 years, depending on fuel costs, boiler type, size and use, and the current excess air level.

This type of recommendation is also of interest to the Combustion and Fuels Technology Branch in ERDA's Division of Conservation and Technology, which is currently drawing up a program plan of R&D priorities on industrial combustion equipment. According to the present budget schedule, applied research of this nature will be initiated in FY79.

An FEA film/videotape on energy efficiency in boiler operations will be available in early autumn (contact Administrative Operations, Office of Conservation, FEA, Washington, DC 20461 for details). A new FEA technical manual on the same subject will also be compiled and made available to industry. Also, the FEA EPIC handbook contains several ideas and case studies, and a bibliography on improving combustion efficiency (26).

Project 32. Improved refrigeration equipment and processes

The Division of Buildings & Community Systems is supporting development of a more energy-efficient home refrigerator/freezer unit and improved small-scale compressors, but no projects are underway or planned in the Division of Industrial Energy Conservation relevant to this recommendation. If it can be shown that advancements in industrial refrigeration technology are feasible and could yield significant savings across the food processing sectors, proposals would be reviewed with interest.

Project 33. Bulk reduction to decrease handling, warehousing and transportation costs

Three Division projects relate to this recommendation on bulk reduction. A USDA lab has recently initiated work on low energy concentration of fluid foods which will involve examination of thermal evaporation and flavor recovery, vacuum flash freezing and reverse osmosis (36). Also, the University of Maryland is studying a new solid food preservation process that packages the product in an inert gas atmosphere in a lightweight "soft" container, and thus carries great conservation potential in subsequent handling and transport (37). Oklahoma State University is researching the technical aspects and conservation potential of muscle boning the unchilled bovine carcass (60). Removal of excess fat and bone before the edible beef portions are chilled can yield significant savings in refrigeration, materials handling, and transportation.

"Further improvements in transport vehicle performance" cited in this recommendation are the focus of RD&D sponsored by ERDA's Division of Transportation Energy Conservation. Research efforts on highway vehicles include a subsystem for diesel trucks which recovers the waste heat in the exhaust for power generation, and development of alternative combustion engines such as the gas turbine and Stirling. This Division is in the process of compiling profile data on the refrigerated trucking industry,

which will be included in a Transportation Data Book to be issued this year. To date, the RD&D ideas on new transport refrigeration systems which have been reviewed have not met funding criteria because they have not evinced significant market penetration potential due to cost and reliability factors. One project currently under negotiation in this area is development of portable instrumentation to detect energy losses in refrigerated vans.

Recommendation No. 71 below also deals with conservation in refrigerated transport.

USDA has a program of R&D on efficient food product distribution (vehicle routing, city market exchange docks, inner city buying and distributing organizations, etc.) and alternatives to conventional transport refrigeration (ventilated containers on ships, bio-regulators, truck refrigerant system deriving energy from truck's movement through air, etc.).

Project 34. Earth covered and/or underground storage of cooled and/or frozen products

More data is needed on the quantity, location, energy requirements, etc. of food products in cold storage before the feasibility and conservation potential of this recommendation can be assessed. At present this is not considered a priority within the Division.

Project 35. Packaging

The Division has received unsolicited proposals related to this recommendation, but to date has not committed funds to packaging projects except for the GASPAK solid food preservation research underway at the University of Maryland (37). The "complete re-examination of packaging" recommended at the workshop is not planned at this time. In general, it is the food processor who can best study the packaging needs of his products, perhaps in cooperation with manufacturers of the relevant packaging machinery. Therefore, from the ERDA point of view it is usually only feasible to evaluate packaging processes and alternatives related to a certain product when the product itself is the focus of conservation RD&D. Specific packaging modifications targeted in unsolicited proposals to the Division must have a wide application throughout the food processing industry so that the energy savings are of a magnitude that warrants federal RD&D support. Packaging is also discussed above in No. 17.

Project 36. Water removal (and tissue gas removal)

The Division has recently completed a technical report on evaporators which contains sections on the potential for reducing energy costs, options for upgrading evaporators, correctable operating factors, moderate investment improvements, large capital investment modifications, and the changing design rationale. Vapor recompression options are discussed. Single copies, entitled Evaporation: A Prime Target for Industrial Energy Conservation are available from the ERDA Technical Information Center, PO Box 62, Oak Ridge, Tennessee 37830. A more detailed technology applications manual, Energy Conservation Tools for the Process Engineer: Upgrading Existing Evaporators to Reduce Energy Consumption has also been prepared.

A systems study of the fruit and vegetable canning industry currently under negotiation will include examination of energy-intensive water removal processes, assessing alternatives for energy efficiency and technical and economic feasibilities (39). Similarly, a study of citrus processing which may be undertaken in FY78 would address this area.

The National Canners Association performed an analysis for the Division in 1976 of the energy conservation potential of vacuum-assisted tissue gas removal from vegetables prior to canning, or vacuum blanching. Blanching, the preliminary heat treatment given raw food products prior to preservation, is the most energy-intensive step in vegetable canning (about 1% of all energy used in the food canning industry); steam or hot water blanchers are usually thermally inefficient and pollution abatement treatment of blancher effluents requires substantial energy. This study, however, indicated that vacuum blanching would conserve only 5-10% of energy utilized in the conventional process, that a 10% decrease in production rate might result, and that capital costs would run fairly high for the necessary equipment. The project was discontinued.

The Eastern Regional Research Center of USDA has recently undertaken a project on low energy concentration of liquid foods such as fruit juices, milk, whey, waste-effluents (blanch water, etc.). The current methods of liquid food concentration are (1) thermal evaporation plus volatile flavor recovery if fruit juices are being concentrated; (2) freeze concentration; and (3) membrane processes such as reverse osmosis and ultra-filtration. This project will study the application of vacuum flash-freezing to fruit juices, determining the best way of handling the aroma problem (i.e., recovery of volatiles from the water versus preconcentration by reverse osmosis before freeze concentration). Application to other liquid foods will also be demonstrated; indirect freeze concentration will be studied if the cost of this method is prohibitive. Concentration by reverse osmosis will be examined on a bench scale to determine the effect of membrane type on flux rates, flavor retention, etc. Various combinations of the three concentration

methods will then be studied to determine which combination uses minimum energy at the lowest overall process cost without sacrifice of product quality. Finally, pilot plant scale studies, including organoleptic evaluation, employing the "optimum" combination of concentration methods will be conducted with fruit juices, milk, whey, and waste effluents, and a cost/benefit analysis will be derived from the resultant data.

Project 37. Sterilization

The University of Maryland has recently contracted with the Division to conduct a feasibility study of a new method of preserving solid foods which may require as little as one-third as much energy as canning, and one-half the energy of freezing. Known as GASPAK, the technique exposes the solid food (usually diced or sliced) to a vacuum to remove oxygen from the tissue, followed by treatments with gases to reduce bacterial and spore counts to such an extreme degree as to effect substantial sterilization of the food. The product is then packaged in an inert gas atmosphere, usually nitrogen. The GASPAK process could potentially represent a major revolution in the food processing industry, and will therefore involve RD&D in biological, nutritional, and other technical areas, and also in the market research, distribution, and consumer aspects of the food system. Work is scheduled to begin in September 1977, with Phase I completion in 18 months. Demonstrations with several food products may be undertaken, depending upon the results of Phase I. Specifically, Phase I will:

1. Assess GASPAK applicability to broad categories of food products, including grains, meats, fish, fruit, and vegetables.
2. Obtain baseline energy data in solid food sectors, including processing, distribution, marketing, and consumption.
3. Develop GASPAK utilization models involving producers, procesors, wholesalers, retailers, and consumers to identify and evaluate potential energy savings.
4. Perform technical analysis on a variety of foods - engineering, chemical, microbial, flavor, shelf life, etc.
5. Investigate packaging alternatives for GASPAK foods.
6. Assess applicability of GASPAK in less developed countries.
7. Conduct benefit/cost analysis of GASPAK system; evaluate institutional barriers facing implementation.

Project 38. Equipment ratings

Trade associations have been discussing this idea for years, and more recently it has been considered for inclusion in national energy legislation. This type of effort does not really fall within the parameters of the ERDA mission, and could perhaps best be performed by industrial organizations or individual equipment manufacturers.

Project 39. Evaluation of current practices in food processing firms

The Division plans to support a 3-year systems study of fruit and vegetable processing by the National Cannery Association in cooperation with the University of California - Davis, scheduled to begin in October 1977. The project will take an in-depth look at several typical canning plants to conduct energy audits and identify institutional barriers (such as FDA and OSHA regulations) to energy efficiency. Initially, the processing of peaches, tomatoes, and spinach will be targeted because these commodities involve all of the operations common to the industry. Data collection in the first phase will cover all in-plant processes, and poor energy "housekeeping" practices which can be corrected with minimal expense and effort will be isolated. More detailed studies conducted subsequently will include additional products and focus on energy-intensive unit operations; energy-conserving process modification ideas will be identified and evaluated, and some will be implemented in participating plants during the course of the project. Demonstrations and dissemination of results will be accomplished through workshops, a variety of publications, and presentation of technical papers. Information generated in this project will help ERDA establish RD&D funding priorities for this industry.

In addition, the Division is considering providing support for a similar evaluation of conservation potentials in the citrus processing industry, which is critically dependent on natural gas. If undertaken in FY78, this project would study energy usage and efficiencies of all operations, and evaluate the feasibilities of conservation ideas for the energy-intensive processes such as solids handling, drying, concentration, extraction, pulping, pollution control, etc.

Project 40. Education of the public

"Public education" of the types mentioned in this recommendation can best be handled by the national professional, technical, and industrial associations, corporate marketing strategies, and academia (home economic departments, land grant colleges, etc.).

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Grain

Project 41. Improved heat transfer and heat recovery capability of drying systems

This recommendation is not being specifically addressed in the Division, but other efforts may yield applicable results. For example, Garrett Airesearch will develop a Brayton cycle heat pump apparatus for use in dry milk processes (19). Also, McDonnell Douglas is developing a microwave-vacuum drying process, consisting of a microwave system, vacuum chamber, condenser, and product handling system. Unfortunately however, feasibility and cost/benefit evaluations conducted during FY76 indicated that the energy savings of the MIVAC dryers were not sufficiently large to offset their high initial cost compared to the less expensive but more energy-intensive electric resistance dryers currently in use. This effort has been continued through FY77 at a lower priority. The Divisions of Solar Energy and Energy Storage Systems are supporting Lockheed's feasibility study and development of a solar regenerated desiccant crop drying facility. Work to date has shown that energy savings of up to 50% can be achieved over traditional equipment. Because the installed cost of this new equipment appears to be considerably higher than conventional apparatus, refinement of the desiccant regeneration subsystem to improve the heat and mass transfer efficiencies during regeneration is underway to reduce system size and cost.

The Division's Agriculture program may undertake an overall analysis of alternatives to conventional grain drying technologies to help identify the most promising targets of RD&D to reduce the critical dependence upon natural gas; an investigation of the economic and technical feasibility of electric heat pump grain drying is also being considered.

USDA solar crop drying research is underway at State Agricultural Experiment Stations with ERDA Division of Solar Energy funds.

RD&D ideas regarding heat transfer and heat recovery of drying systems which embody novel technological concepts and evince important conservation potentials will be reviewed with interest.

Project 42. Improved technology for process and moisture control

More data is needed on the energy conservation potential of improved technology for process and moisture control in this industry, such as an indication of the energy wasted by overdrying. If the potentials appear to be significant and attainable at reasonable RD&D cost, the Division would be interested in supporting the development of improved control

technologies. Unsolicited proposals on this subject must be supported by preliminary work which indicates the magnitude and feasibility of savings.

Project 43. Liquid concentration

A manual on energy optimization of evaporator apparatus was recently compiled by the Division (36).

The Division is currently funding work on liquid concentration at the USDA Eastern Regional Research Center in which vacuum flash-freezing, thermal evaporation, and membrane processes such as reverse osmosis will be studied with fruit juices, milk, whey and various waste effluents (36).

Project 44. Improved heat recovery systems

A project on recirculation of exhaust air and heat recovery heat exchangers for fruit dehydrators at the University of Arizona relates to this recommendation (25). Also, innovative, viable ideas regarding improved heat recovery in grain drying processes would be reviewed with interest. The Division's Waste Heat Reduction program is sponsoring research on high temperature heat pumps (19), high temperature heat recuperators, and Rankine bottoming cycles for re-use of recovered waste energy. The Agriculture program is interested in exploring applications of state-of-the-art heat recovery technologies and equipment in the food processing industry.

An FEA/National Bureau of Standards handbook, Waste Heat Management offers detailed information about current options in waste heat recovery, and contains 14 actual case studies of companies that have recently installed waste heat recovery systems and profited. They represent major commercial options in waste heat recovery equipment and various industrial applications. (Government Printing Office, Washington DC 20402, GPO #003-003-01669-1, \$2.75). An FEA film, "Waste Heat Management - Energy Utilization for Profit" may also be of interest to industrial managers (Administrative Operations, Office of Conservation, FEA, Washington DC 20461).

Project 45. Alternate fuels to replace natural gas

Since the food industry is so dependent upon the tightening supplies of natural gas as a clean-burning fuel for direct firing applications, ERDA is very interested in exploring fuel substitution alternatives. An initial step may be to conduct an overall study of substitute fuels, indirect firing systems, and the more innovative new technologies to ascertain energy and capital costs, problems resulting from impurities, effects on

production capacity, and technological feasibilities. If undertaken, this type of study could provide vital data and guidance for the Division in formulating its future funding plans. Small-scale demonstrations of direct-firing with fuel oil in food processing, followed by trace tests on the product, would also be of interest.

Project 46. Alternate processing and formulation methods to reduce energy consumption

The Division is interested in supporting systems studies in the energy intensive areas of the grain industry, similar to those underway in the meat, dairy, and fruits and vegetables processing sectors. This type of effort would serve to identify energy savings such as those mentioned in the recommendation which can be obtained at low cost to plant operators, and highlight RD&D opportunities with significant conservation potentials which are gaps in the current ERDA program. Sectors of particular interest to ERDA (i.e., those which are most energy-intensive or critically dependent upon a diminishing fuel supply) are wet corn milling, malt beverages, and bread and cake products. RD&D in less energy-consumptive sectors such as soybean oil milling and prepared feeds will come under consideration later in the Division's agriculture program, perhaps in FY79.

Also relevant to this recommendation is a proposal which is currently being evaluated by ERDA, dealing with an alternative to wet milling of corn, the second most energy-intensive operation in the food processing industry. The radically new direct enzymatic extraction process would bypass conventional wet milling operations altogether.

Project 47. Improved equipment design for energy conservation

Proposals for improved equipment design which can be achieved with reasonable levels of support and pose important conservation opportunities for the food processing industry will be reviewed with interest by ERDA. One such idea currently being examined is a low temperature radiant oven which is applicable to both home and commercial needs, minimizes preheating, and reduces cooking times.

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Meats

Project 48. Systems analysis of energy use in the meat industry

Purdue University is under contract to conduct an evaluation of energy conservation potential in two pork processing plants and one dairy plant, starting in July 1977. As recommended during the workshop, this systems study is much wider in scope than the Johns-Manville energy audits compiled for FEA (A Study of Energy Conservation Potential in the Meat Packing Industry, Government Printing Office, #041-018-00118-2 (\$3.40). It will incorporate an analysis of the effects of equipment modification, new equipment, and new processes for energy-intensive unit operations, and a cost/benefit and energy comparison of existing and alternative systems. It is estimated that 20-40% of the 189.6 trillion BTU's consumed annually by the milk and meat processing industries could be conserved from the results of this study. The tasks involved are detailed in 16-A.

The Georgia Tech Research Institute has begun a 1-year examination of energy conservation in the poultry processing industry. An energy balance and optimization analysis will be performed for a Georgia poultry processing facility, followed by economic analyses of energy-using processes, and identification and refinement of modification designs for energy-saving process units. This effort will make it possible to demonstrate some of the more sophisticated and expensive conservation measures which can recover large amounts of rejected heat. For example, recovery of the condenser heat from the ice-making refrigerator unit by preheating makeup water for processing is especially attractive because of its effectiveness in saving natural gas.

Oklahoma State University, in connection with its hot beef deboning project will review current processing methods at various capacity beef processing plants and document the "state of the industry" regarding alternative procedures (60). The impact of the new muscle-boning technique on facility design, material handling systems and equipment, and transportation will be studied in-depth.

Project 49. Automatic air/fuel ratio control for small boilers

Major sources of inefficiency in industrial boilers are equipment design, constantly varied loads requiring instant changes in burner fuel/air ratios, and the necessity of operating at excess air levels to guarantee complete combustion thus minimizing hydrocarbon emissions. A project is underway at Exxon to demonstrate an automatic fuel/air ratio control system during which capital costs and expected payback for retrofit of small boilers will be determined (31).

Project 50. Recycle waste water effluents through reclamation system to produce crystal clear potable water certifiable by U.S. health department laboratories

The Division is interested in conservation of energy in plant clean-up operations, and considers the environmental effects of all its projects. However, this specific recommendation may be more relevant to EPA R&D programs and objectives; also, the savings estimate cited seems unreasonably high. One major water recycling project underway in the textile industry is described in No. 82 below.

Project 51. Re-use of hot and/or tempered water through filtration

The Purdue and Georgia Tech meat processing studies will address this recommendation (48). Purdue will measure water and energy flow rates, deriving data on energy needs and waste so that the feasibility of re-use can be ascertained. If viable ways can be identified to recycle this water, the Division would be interested in evaluating them (although it may generally be more feasible to focus on heat recovery concepts). This type of recommendation is within the scope of both ERDA and EPA interests. Hyperfiltration of textile dyeing and finishing waste streams is one such joint project currently in progress which may yield results applicable to the food sector (82).

Project 52. Reduce energy used in beef and hog viscera inspection tables

The Purdue study will address this recommendation by identifying and evaluating technologically viable alternatives to conventional processes (48).

Project 53. Reduce energy used in high pressure and high temperature water beef carcass washer

Again, the meat processing systems studies will examine the feasibility of conservation ideas for washers (48). USDA regulations closely govern these operations, and may preclude savings of a magnitude to justify federal RD&D support.

Project 54. Substitution of sanitation for refrigeration energy to reduce energy use in chilling red meats

The conservation potential cited in this recommendation is fairly low, and this effort is not a current Division priority. The USDA Agricultural Research Service is performing some decontamination experimentation.

Project 55. Elimination of after-burners by use of filters, closed systems, and possibly chemicals

The prevalence of process oven after-burners suggests that opportunities for heat recovery are in abundance, yet the magnitude of savings in these cases (even when the RD&D cost estimate is discounted to a more realistic level than that in the recommendation) does not appear large enough to warrant federal funding. If, however, it can be shown that important conservation opportunities exist and perhaps would be applicable in other food sectors, the Division would be interested in research ideas. Potential conflicts with local regulations would have to be thoroughly examined before such a project could be undertaken to ensure adoption of results by industry.

Project 56. Investigate use of outside winter air for refrigeration in northern plants

This recommendation does not seem to carry conservation potential of a magnitude to justify its federal cost. Filtration and decontamination problems inherent in this idea could be significant.

Project 57. Recovery of lost heat escaping plant in waste effluent

The Purdue project to evaluate conservation potentials in pork processing plants and the similar effort by Georgia Tech in poultry operations will focus on recovery and re-use of waste heat (48). Resultant information on alternatives will guide the Division in establishing more specific funding priorities for the future. Because of the myriad of regulations which impact on meat processing operations, the Division is generally more interested in recovery and use of the heat from waste streams than in tackling the more difficult and costly problems inherent in recycling schemes. Conservation potentials of heat recovery are significant, and viable proposals along these lines could receive a high priority. A handbook on Waste Heat Management, compiled by FEA and the National Bureau of Standards, provides explanations and case studies of heat recovery techniques and apparatus (44).

Project 58. Reduce natural gas consumption in the operation of singeing hogs

Conservation ideas relevant to this suggestion will be considered in the course of the Purdue systems studies (48).

Project 59. Develop means of eliminating condensation on plant ceiling that is less energy-intensive than current procedure

The very low energy savings of this recommendation and the high RD&D costs involved make this an unattractive investment for ERDA. Although there may be some application to other food sectors, several refrigeration or freezing applications would involve packaged foods so condensation on the plant ceiling would be less critical.

Project 60. Hot deboning

Oklahoma State University began work in June 1976 on energy conservation in the meat processing industry from muscle boning of the unchilled bovine carcass. Removal of fat and bone prior to refrigeration, a technique adopted several years ago in pork plants, conserves about 9,400 BTU's per carcass in chilling, or 30%. Energy savings from the mass reduction are further realized in redesigned process facilities (3.31×10^{11} BTU/year), and transportation (12.9×10^6 gal. fuel/year). This project involves systems studies of conventional processing and handling operations in several Midwestern beef plants (small, medium and large) to identify energy conservation potential and the technical and economic feasibility of the alternative pre-chill deboning. Electrical stimulation processes and equipment will be developed and demonstrated, and the effects on meat quality and quantity, and requirements for energy, physical space, material handling, and manpower will be documented. Representatives of the meat packing and equipment supply industries are monitoring the project.

Project 61. Industrial boiler system (to burn trash)

This project is not a high priority in the ERDA Agriculture program, because of the high federal RD&D burden to achieve relatively small savings. The Materials Optimization program in the Division is concerned with utilizing wastes as chemicals and feedstocks, and when other alternative uses for the wastes are less economical, as fuel in innovative boiler designs with high combustion efficiencies or in novel bioconversion processes. The animal wastes cited in this recommendation could perhaps be more economically converted to methane via known anaerobic digestion methods. Presently, the food industry has not been addressed, but the Materials Optimization program plans to examine agriculture processing waste utilization opportunities in the future. One example of a project that might be undertaken is use of animal inedible fat wastes as a detergent base.

Project 62. Minimize packaging material for meat

Except for the minimized packaging requirements of hot deboned beef (60) this recommendation is not currently part of the Division's program. Package size standardization efforts would not logically require federal RD&D support, but rather would depend critically upon the commitment of industry. Proposals to develop stronger, recyclable packaging materials must be supported by detailed projections of the conservation potential and obstacles to implementation.

Project 63. Development of alternate methods of chilling carcasses

Hot beef deboning research underway at Oklahoma State University is expected to yield a 30% decline in energy consumed in refrigeration operations (60), Purdue will measure amounts of energy used in chilling operations, and survey alternatives which show promise of energy savings (i.e., conveyORIZED systems, faster chilling, slower chilling, etc.) (48). Proposals on chilling technology RD&D which indicate significant savings potential attainable with reasonable federal cost and likelihood of adoption by industry, and do not pose major problems regarding meat quality or USDA regulations would be reviewed with interest.

Project 64. Develop alternate method of removing water from material to be rendered inedible

The Purdue and Georgia Tech systems studies will develop information about alternatives to conventional evaporation techniques, and their engineering, economic, and conservation feasibilities (48).

Project 65. Better ammonia and freon refrigeration systems and controls for defrosting

Alternatives to time-controlled defrost cycling are already available which provide constant monitoring of frost buildup via sensing of temperature differential across freezer evaporator coils to gear the defrost cycle to defrost needs. Refrigeration is also discussed above in 32.

Project 66. Raise low pressure (5 psig) steam to 100-125 psig level by compression cycle

MTI is developing an open cycle heat pump using steam as the working fluid (77-A). Low pressure steam (0-5 psig) will be generated from a textiles waste stream and compressed to a higher and usable pressure level (100 psig) via a high speed

turbine drive with a high efficiency centrifugal compressor. An important part of this effort will be to examine other potential applications for the system. Regarding evaporators, a recent ERDA technological report for industrial users discusses vapor recompression options for increased energy efficiency (36).

Project 67. Elimination of steam traps with introduction of a sump at lower physical level and pumping of condensate under pressure to steam generator

Steam traps are discussed above in No. 27. This particular recommendation is not a candidate for Division funds because the technology is known and does not require additional development/demonstration that is too burdensome and risky for the private sector to undertake.

Project 68. Improving scalding and de-hairing methods for hogs, on-line with mechanical equipment and chemicals

The Purdue pork plant systems studies will include a discussion of this type of project (48). The conservation potential given in this suggestion is much too small to justify the suggested level of federal support for the recommended RD&D.

Project 69. Microwave for processing - new construction

Previous RD&D of microwave applications has been somewhat disappointing in that this technology involves high installation investments and is not as energy-conserving in large scale, continuous operations as originally believed. This particular project idea calls for generous federal support to achieve relatively insignificant energy savings, and therefore is not a likely candidate for funding. Preliminary work documenting the conservation potential in special applications where microwave processing is attractive (such as pre-cooking of ground meats before chilling) would have to accompany any proposals of this type.

Project 70. Pressurize meat processing smoke houses

The Purdue pork processing study will assess conservation opportunities in smoke houses (48).

Project 71. Reduce energy use in refrigerated transport

The Division of Transportation Energy Conservation at ERDA is oriented to technology and hardware rather than the distributional aspects of transportation. In this sense, RD&D on improved vehicles and refrigeration systems is of interest to the Division, but work on vehicle routing, loading patterns,

maintenance, etc. is not within the scope of the present program. The current state-of-knowledge regarding these latter ideas is well developed and does not require additional ERDA-supported research. Transportation research is also discussed in No. 33 above.

Project 72. Demonstration of energy conservation measures

The Division is extremely concerned that the new knowledge and technologies developed with its support are rapidly and widely disseminated to the relevant audiences. The success of the federal energy RD&D program will ultimately be determined by the fulfillment of this objective. For this reason, major projects are usually monitored by an industry oversight group which provides invaluable expertise and experience throughout the research period, and access to the industry for technology transfer purposes. Georgia Tech, for example, will be working closely with a 20-member panel of poultry industry leaders from the major producing regions throughout the country in its study of plant operations. Dissemination of results to the entire industry is planned via trade publications and formal reports and short courses presented in cooperation with Agriculture Cooperative Extension Services in poultry producing states. Purdue's pork project includes a demonstration phase to illustrate procedures for improving energy efficiency, enabling other meat processors to apply this energy management program to evaluate their operations and calculate the economics of energy conservation measures or changes (48). Oklahoma State University research on hot beef deboning is assisted by a 10-member meat industry oversight committee (60). Past experience with such panels has been excellent in that their real-world orientation helps to keep RD&D directed toward solutions that are most acceptable for industry implementation.

The USDA Economic Research Service and Cooperative State Extension Service are also important channels for technology transfer.

Another trend in project management is for trade associations to submit proposals and act as the major contractor, working on a day-to-day basis with member companies conducting some or all of the actual RD&D involved.

Upon completion of the ERDA-sponsored meat industry systems studies, compilation of the resultant data into handbooks for dissemination to plant operators and researchers would be a logical function of these organizations. Other technology transfer activities such as site visits and magazine articles might also be arranged with their assistance.

See No. 48 above for reference to an FEA report of energy audits in the meat packing industry. Poultry and livestock production conservation opportunities are addressed in a new series of USDA handbooks, similar to the FEA EPIC manual.

Project 73. Vacuum chilling and storage of red meat

Preliminary work which documents conservation potential, marketability, and engineering and economic viability must accompany any proposal to the Division of this nature.

Project 74. Immersion chilling of red meats

The Division is interested in the development of alternate methods of chilling carcasses (63). Regarding this specific recommendation of immersion chilling, it is unlikely that an important magnitude of savings would result, given the types of spillover requirements that might be imposed on such an operation. Pre-chill packaging also presents problems, and proposals on alternate chilling methods must address these issues and demonstrate that they can be resolved at reasonable RD&D cost.

Project 75. Reduction of the amount of water used in all meat and poultry processing plants

The meat processing systems studies will address this recommendation by emphasizing measurement of water used throughout the plants, and considering ways to use less water in processing yet still fulfill environmental and USDA requirements (48). Ideas which appear feasible and carry significant savings potentials may be considered for RD&D.

Project 76. 4-day, 40-hour work week effect on energy consumption and effect on economies of various plant capacities

An exploration of the energy effects of a 4-day work week would certainly be of broad interest and application to American industry and the general population. This type of study would probably not be undertaken by ERDA, however, but could be more appropriately handled by private or public socio-economic research organizations.

Textiles

Project 77-A. Miscellaneous research

One effort which deserves mention in this discussion of conservation RD&D in the textiles industry does not relate to any of the workshop recommendations. The Division's high temperature heat pump program supporting development of a system to produce process steam in a textile fibers plant. Mechanical Technology, Inc. (MTI) will design, develop and demonstrate an organic Rankine bottoming cycle as a power source for an open cycle heat pump compressor, which utilizes steam as the working fluid. The equipment will recover heat from the waste stream generated during the extrusion of acetate fiber in a Celanese Fibers Company plant to produce steam and the power to compress the steam to usable levels. Demonstration is scheduled in FY79; the unit is capable of delivering about 16,000 pounds of steam per hour, and is expected to save a net annual amount of 36,000 barrels of oil equivalent in the demonstration plant. The system is suitable to a wide range of steam pressures, and other potential applications such as in chemicals and refinery operations, will be examined by MTI on a national basis, and in cooperation with the New York State Energy Research and Development Authority.

The USDA supports cotton research projects at its Agricultural Research Service ginning laboratories, some of which are: cotton fiber distribution system for open-end spinning; cotton textile finishing techniques to optimize fabric properties while minimizing pollution; cotton materials handling, collection, and disposal in stripper cotton areas; and materials handling and pollution control at Midsouth gins. This work was not undertaken with energy conservation as the primary focus of RD&D, but additional ERDA-supported efforts along these lines were recommended by the textile participants at the 1976 processing workshop.

Project 77. Conversion from pneumatic to mechanical materials handling at gins

There are no plans in the Division to undertake this sort of work. The conservation to result in the ginning sector appears to be small. In order for such a proposal to justify ERDA support, the results must be widely enough applicable throughout industry so that savings are more significant and in more reasonable proportion to the level of funding required.

Project 78. Ginning waste as a substitute fuel for drying;
Project 79. Generation of power for cotton gins by using gin waste

Background information on the scope and results of work already accomplished, details on the technical, conservation, and economic viability of the idea, and assessment of the possible barriers to industrial adoption (capital costs, environmental regulations, etc.) are needed before the relative priority of these recommendations could be established.

Project 80. Compression process (of cotton bales) using hydraulic power instead of steam power

At present this is not part of the Division's program. Preliminary work, which could perhaps be performed by an Agricultural Experiment Station, indicating the energy savings and feasibility of the idea would be a prerequisite to consideration for funding.

Project 81. Reduction of energy consumption in wool scouring

This recommendation probably does not pose a significant enough conservation potential to stand alone in competition for ERDA funds, unless it is shown to be so critical a process to the industry and so critically dependent upon a scarce energy source that conservation in terms of BTU's or barrels per se is of secondary importance. However, similar purposes will be accomplished by the Riegel-La France demonstration of membrane separation for closed-cycle operation of a cotton-containing textile dyeing process (82). Hot water and chemicals required in dyeing and finishing will be separated via membrane for re-utilization. In addition, energy savings in pollution control will result from accumulation, monitoring, and periodic blowdown of toxic materials (such as pesticides from the scouring process) in a manageable volume of wastewater.

Project 82. Reduction of hot water usage in wet processing of cotton-containing textiles

This recommendation is addressed in the Division's programs. The Georgia Tech Research Institute is working to define, design and demonstrate process modifications to increase energy efficiencies of textile wet processes (thermal processes to clean, dye and finish). This project is directed to development of modifications to existing processes and equipment rather than novel systems; potential improvement of conservation via process modification is significant (10-14 million barrels oil equivalent annually) and lower capital investment requirements will speed rapid adoption. Initially, a detailed profile of energy use in the industry was compiled from which major energy

intensive and inefficient processes were identified for further in-depth research on process modifications. These modifications are undergoing laboratory tests on pilot scale textile wet process equipment to evaluate the desired benefits and provide a basis for estimating the cost of change. Sparging systems, for example, can be made more efficient simply by improving the heat transfer coefficient between injected steam and bath water with modified steam bubble diameter. 20-50% savings are possible via reuse of hot dye water for consecutive batch dye cycles, a technique being refined by Georgia Tech in which hot exhausted dye liquor is spectrophotometrically analyzed and chemically reconstituted. Energy intensive wet thermal treatments such as drying, resin curing, heat setting, and dye fixation are closely scrutinized, especially for waste heat recovery and re-utilization opportunities. This work is scheduled for completion in FY77; in-plant demonstrations of selected modifications may result.

Clemson University has undertaken a project to develop guidelines for optimizing energy usage in fabric dyeing in batch operated dye becks. (A second major focus of this work, tenter frame drying, is described in No. 83 below.) Specifically, a mathematical model of a dyehouse will be devised to keep the beck cycles evenly spaced so that there is a constant workload and a relatively constant rate of hot water generation and demand. The resultant increased fabric dyeing capacity at lower manning levels with decreased energy consumption will be documented under actual mill operating conditions. Preliminary studies indicated that a 100% increase in dye machine production efficiency is possible. The model will then be used to design a computer program that can automatically direct the optimal operation of a dyehouse.

Riegel Textile Corporation will design, install and operate a full-scale membrane system to achieve closed-cycle operation of a textile dyeing operation. Renovation and complete reuse of industrial wastewater can have a major impact on both resource conservation and pollution abatement, hence this demonstration is jointly sponsored by ERDA, the Department of Interior and EPA. The textile industry bears costs of over \$1 billion annually for treatment of wastewater to the quality required for disposal, and many of the "pollutants" are residuals of expensive process materials. The separation via high temperature hyperfiltration membranes and corresponding concentration of these solutes may yield both purified product water and extremely concentrated chemicals that are directly reusable still at or near full process temperature. Conservatively, it is estimated that wide-scale application of closed-cycle operation will permit conservation of the majority of energy necessary for hot water in textile dyeing and finishing, or an estimated 2.5×10^{12} BTU's annually. The actual energy savings, however, will be quite different for continuous versus batch dyeing operations. To make a choice between focusing on the continuous range or atmospheric becks for the closed-cycle

demonstration, field evaluations of membrane equipment, process modifications, and recycle will be completed for each. Conceptual, closed-cycle system configurations will be developed with estimated savings for each to ensure that the energy savings in hot water for the process selected are not offset by an increase in electrical power consumption. Efforts will be made to determine cleaning procedures, operating parameters of velocity and pressure, and pretreatment (filters and/or pH control) to optimize membrane operating costs and productivity. The 12-month full-scale demonstration in closed-cycle at La France Industries, scheduled for 1979, will establish the feasibility of closed-cycle operation based on product quality, the practicality of membrane separation at point sources, the environmental, toxic emission, energy benefits, and capital and operating costs.

ERDA's Solar Energy Division, Agricultural & Industrial Process Heat Branch also has a project underway relevant to this recommendation, in which a 10,000 square foot solar collector is being designed by General Electric to heat water for a dye vat in a Riegel Textile plant.

Project 83. Elimination of drying processes in wet processing of cotton-containing textiles

Two Division projects are underway on conservation in drying operations. Georgia Tech's research on wet process conservation will identify and test modifications for thermal treatments in textile finishing (i.e., drying, resin curing, heat setting, and dye fixation). The hot air systems utilized for all of these high temperature processes are basically the same in design and operation, and all rely almost totally on natural gas as the energy source. Energy is wasted in the form of heated air with typical exhaust energy fluxes of 2-4 million BTU/hour commonly experienced with many pieces of drying equipment. Energy can be recovered from these exhausts and used to heat make-up air or water for other processes; it is estimated that approximately 25% of the energy currently wasted can be recovered for reuse. This project is not intended to focus on new or novel technologies such as some mentioned at the 1976 workshop, but rather to assess and demonstrate modifications to existing processes and equipment. Systems studies conducted earlier in the effort indicated where conservation opportunities in drying operations are most significant and feasible.

Clemson University is working on guidelines for optimizing energy usage in tenter frame drying. Preliminary studies demonstrated that fuel consumption may be decreased by 25-50% and tenter frame capacity can be increased more than 50% by analyzing and optimizing tenter frame control variables, without

making any significant modifications to the equipment. Studies are underway to determine the effects of exhaust rates, tenter air flow patterns, damper adjustments, blower speed, and other variables so that an efficient control strategy can be developed which will allow further reductions in the exhaust rate. These guidelines are being developed using experimental data from a laboratory dryer and from several commercial dryers operating in textile finishing mills, in conjunction with a mathematical model of the drying operation. One textile firm cooperating in the study has already reported a 49% decrease in tenter frame energy consumption. Completion is expected in autumn 1978.

The Division's Waste Energy Reduction program is supporting a demonstration by Garrett Airesearch of an open Brayton cycle heat pump for recovery of waste heat from waste water and exhaust gas streams for re-use in a dry milk operation, completely replacing the natural gas normally required for the drying process (19). The system should find widespread acceptance in other industries such as pulp and paper, textiles, and food processing.

The Solar Energy Division also is sponsoring design and demonstration of a solar collector by Honeywell to provide hot steam energy for a drying drum in a slasher operation at a West Point Pepperell textiles plant.

The FEA/National Bureau of Standards Waste Heat Management Guidebook may be useful to textiles processors (44).

Project 84. New fiber-to-yarn techniques for agricultural fibers

There are no plans to support this type of project. The energy savings involved do not seem large enough to justify the ERDA RD&D expense.

Project 85. Field cleaning of seed cotton

There are no plans to undertake this project. The conservation potential is relatively small, so criteria such as critical dependency on natural gas, fuel costs as a percentage of operating costs, etc., would be paramount in consideration for funding. Initially, a detailed explanation of why Texas growers use stripper harvesters instead of more energy-saving methods would be necessary. Preliminary work which demonstrates the viability and energy impact of the RD&D ideas, a capital costs of equipment to be developed, etc. are particularly important components of proposals of this type.

Project 86. Improved lint cleaning at gins

This is not currently part of the Division's program, and more information would be needed before the idea could be evaluated for priority rating in textiles conservation research. Industry data on the energy required to comply with OSHA regulations and the impact on this sector, and other information such as that described above in No. 85 must accompany proposals for RD&D in this area. Also, the EPA RD&D objectives encompass this type of work and might be a more likely source of support.

Project 87. Improve efficiency of gin seed cotton dryers

This recommendation has not been specifically addressed in the Division's programs.

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American Textile Manufacturers Institute
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Biscuit & Cracker Manufacturers Association
Cereal Institute
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Dairy & Food Industry Supply Association
Dairy Research Incorporated
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Evaporated Milk Association
Fertilizer Industry Round Table
Food Processing Machinery & Supplies Association
Institute of Shortening & Edible Oils
International Apple Institute
Malting Barley Improvement Association
Milk Industry Foundation
Millers National Federation
National Agricultural Chemicals Association
National Broiler Council
National Canners Association
National Cheese Institute
National Coffee Association
National Confectioners Association
National Cotton Council of America
National Cotton Seed Products Association
National Fertilizer Solutions Association
National Frozen Foods Association

National Grain & Feed Association
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National Soybean Processors Association
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