

An exploratory study on the commercialisation of heat pump-fluidised bed drying technology

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Organizational Evaluation and Adoption of Technological Innovations: an exploratory study on the commercialisation of heat pump-fluidised bed drying technology

1. Introduction
2. Objectives
3. Research methodology
4. Results
5. Conclusions



1. Introduction – Drying, Heat pump & Fluidised bed drying

- Drying & dryers
- The Concept – hybrid drying concept
- Innovation
- Adoption of technological innovation - Commercialisation



1. Introduction – Drying, Heat pump & Fluidised bed drying

- **Drying & dryers** – Drying is a thermal process in which heat and mass transfer occur simultaneously. Dryers are the equipment that facilitate the drying process

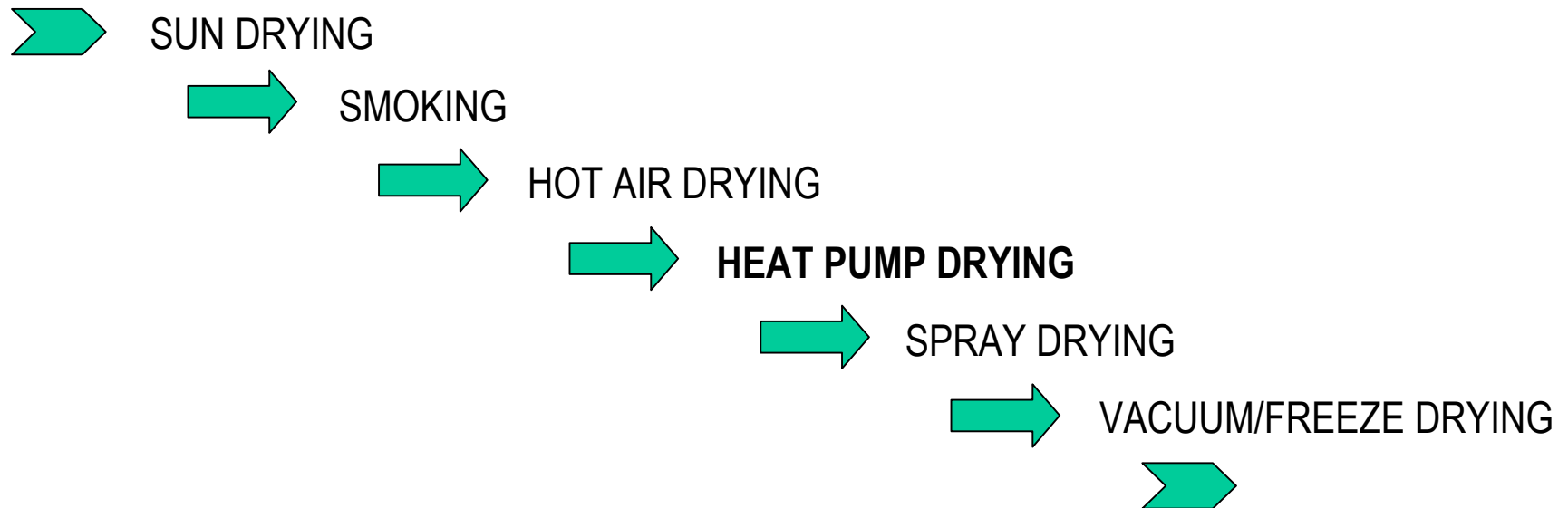
Table 1. Examples of selected dryers and typical applications

Dryer Type	Product Applications
Tray or cabinet	Fruits, vegetables, meat, confectionery
Tunnel	Fruits, vegetables
Belt conveyer	Grain, fruits, vegetables, cereals, nuts
Rotary	Seeds, grains, starch, sugar crystals
Pneumatic or flash	Starch, pulps, corps, granules, powders
Fluid bed	Vegetables, granules, grains, peas
Spray	Milk, cream, coffee, tea, juices, eggs, extracts, syrups
Drum	Milk, flakes, baby cereals, juices, purees
Puffing	Fruits, vegetables
Freeze	Flakes, juices, meat, shrimp, coffee, vegetables, extracts

1. Introduction – Drying, Heat pump & Fluidised bed drying

- **Drying & dryers** – Evolution of Food Drying Technology

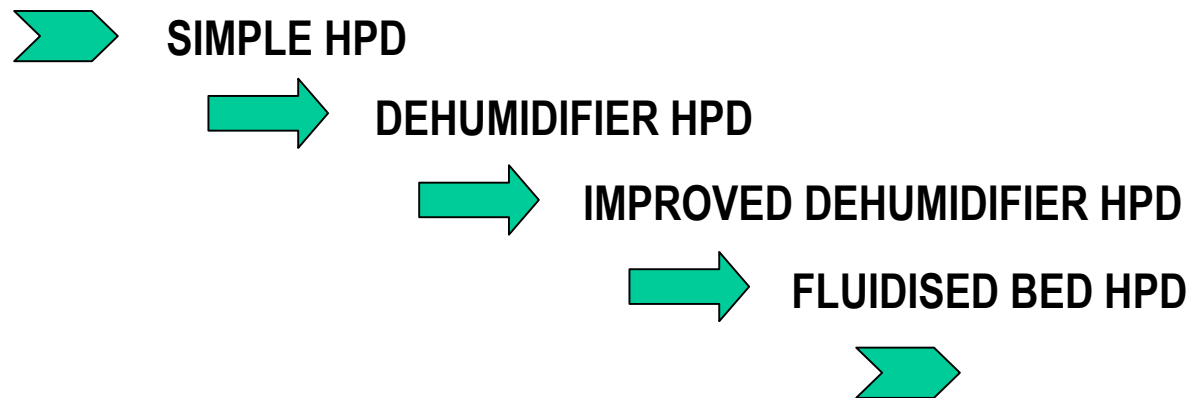
Figure 1. Evolution of Food Drying Technology



1. Introduction – Drying, Heat pump & Fluidised bed drying

- **Drying & dryers** – Heat Pump Drying (HPD) or Dehumidified Air Drying

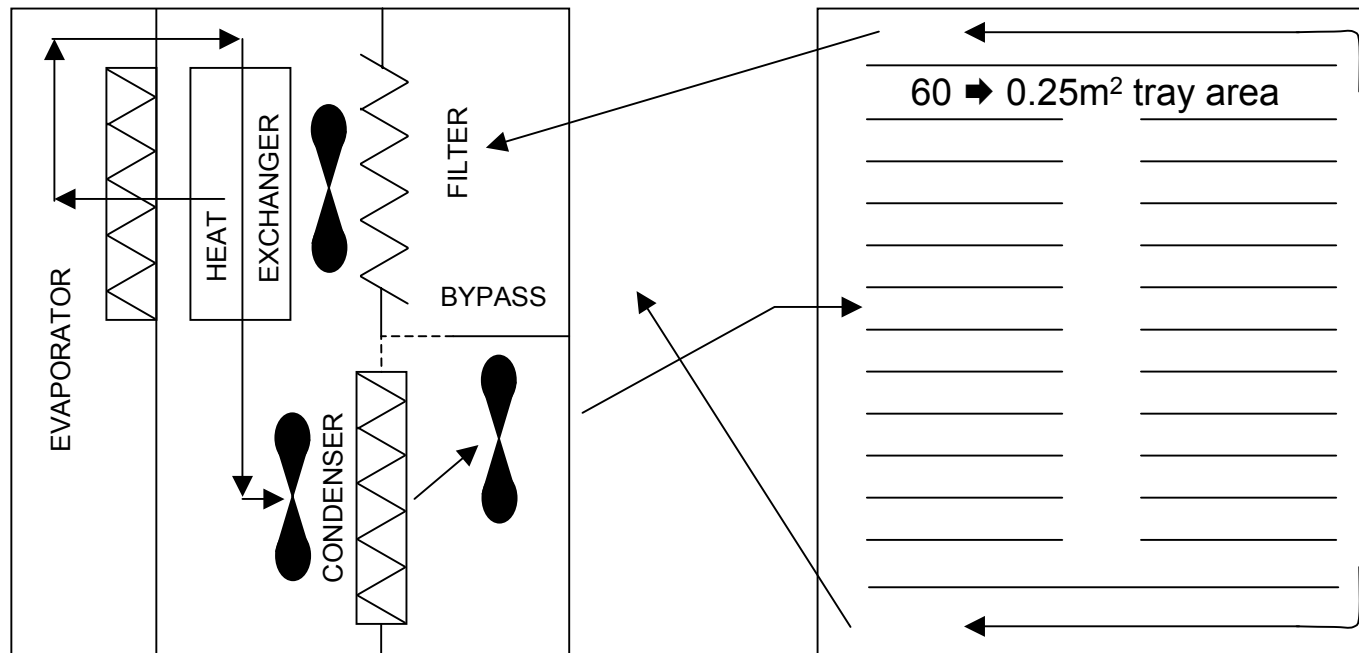
Figure 2. Various Phases of the Development of HPD Technology



1. Introduction – Drying, Heat pump & Fluidised bed drying

- **Drying & dryers** – Heat Pump Drying (HPD) or Dehumidified Air Drying

Figure 3. Simple dehumidifier heat pump dryer



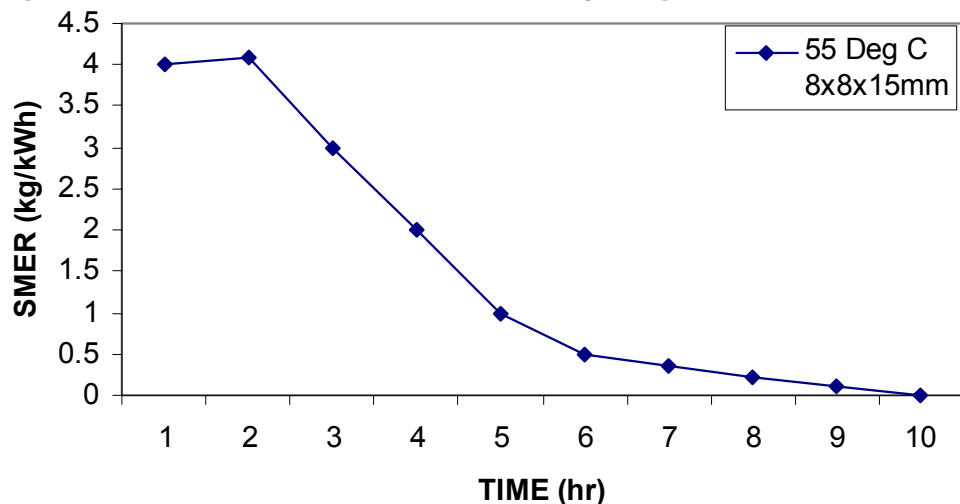
1. Introduction – Drying, Heat pump & Fluidised bed drying

- **Drying & dryers** – Heat Pump Drying (HPD) or Dehumidified Air Drying

Efficiency – Specific Moisture Extraction Rate (SMER)

$$\text{SMER} = \frac{\text{Mass of water removed from the product per unit time}}{\text{Total energy input per unit time}}$$

Figure 4. SMER versus drying time





1. Introduction – Drying, Heat pump & Fluidised bed drying

- **The Concept** – Hybrid drying concept
- **Drying & dryers** – Heat Pump Drying (HPD)

Figure 5. Two stage Fluidised Bed – Heat Pump Dryer (FBHPD)



1. Introduction – Drying, Heat pump & Fluidised bed drying

- **Adoption of technological innovation – Commercialisation**

Table 2. Comparison of performance characteristics of Single stage HPD versus Two-stage FBHPD

	3 batches of 4 hours + a larger batch of equivalent to 3 small batches for 6 hours	4 batches of 4 hours + a larger batch of equivalent to 4 small batches for 6 hours
Single stage normal batch process:		
• Time required	30 hours	40 hours
• Average SMER	1.51	1.51
Two stage drying process:		
• Time required	18 hours	22 hours
• Average SMER	2.47	2.75
Increase in Efficiency	64%	82%
Throughput increase	167%	182%
Decrease in drying time	40%	45%

2. Objectives

- **Overall objective:** Identify and analyse the critical issues associated with the diffusion of new drying technologies in the Queensland and Australian food industry
- **Specific objectives:** To develop a commercialisation strategy for the Fluidised Bed-Heat Pump Drying (FBHPD) technology

3. Research methodology

- Literature search
- Establish a framework for industrial setting – modelling
- Field Study



3. Research methodology

- Literature search
 - Extensive literature search on the diffusion of innovations and critical assessment

3. Research methodology

- Establish a framework for industrial setting – modelling
 - Establish a framework that can be used as the basis for analysis the practical issues involved in the adoption and diffusion of technological innovations in industrial setting.



3. Research methodology

- Field Study

- A questionnaire was designed along the line of the findings of one of the recent studies. The questionnaire was pilot tested with one machinery manufacturer/food technology consultant and one food processing company and was further refined accommodating appropriate improvement.
- 42 relevant individuals and organizations were short listed after initial contacts using one of the channels; phone, fax, mail and face-to-face meetings.
- 21 individuals representing small to medium/large size businesses were interviewed face-to-face and 3 participants were interviewed over the phone. Questionnaires were sent to another 18 participants.
- The model developed in the desktop research was used as the basis for structuring interviews.

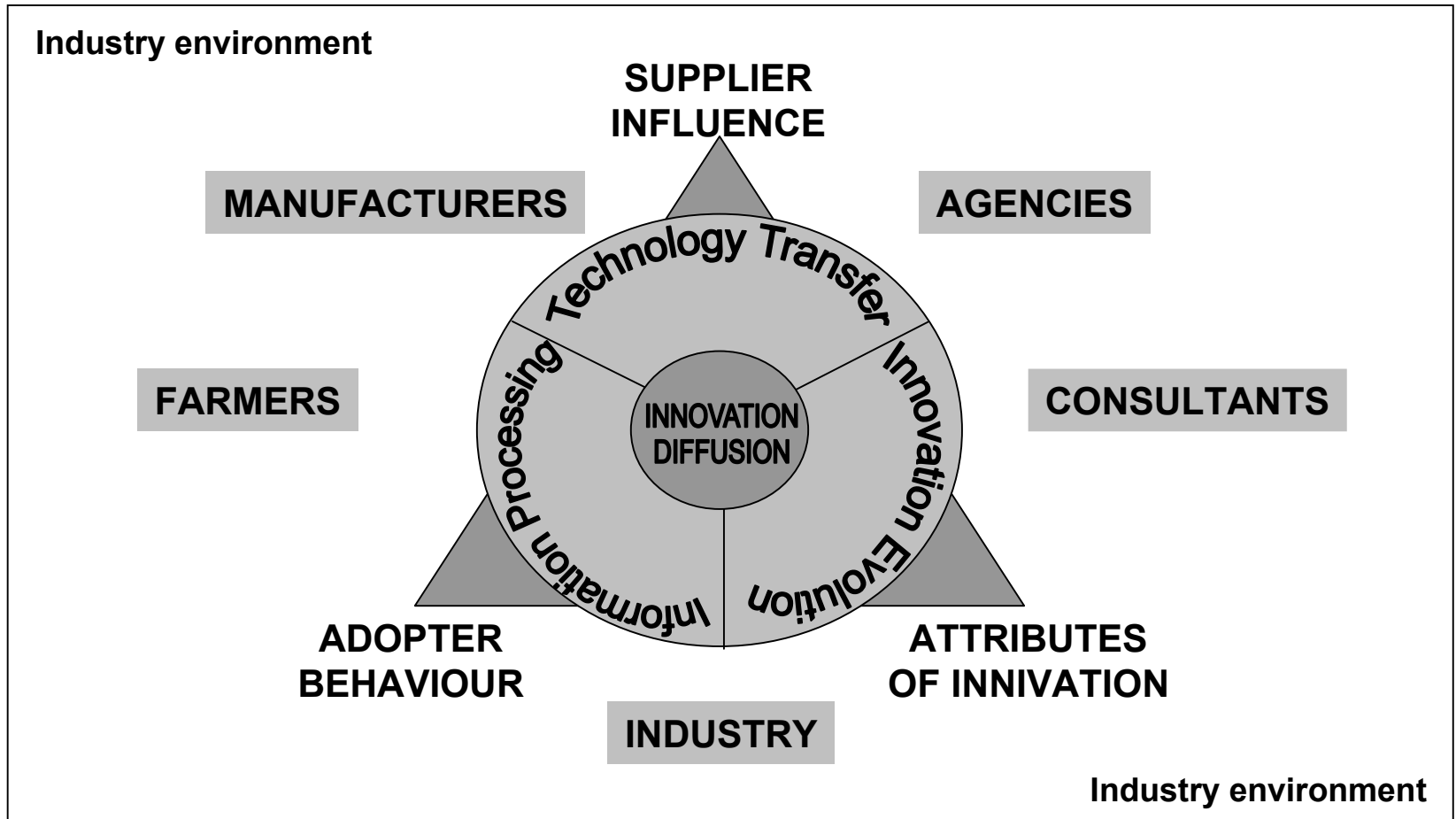


4. Results and discussion

- The Model
- Summary of respondents information
- Summary of field study findings

4. Results and discussion

- The Model



4. Results and discussion

- Summary of respondents' information
(32 Respondents)

Type of Business	Private	29
	Government	01
	Industry Association	02
Products & Services	Grain & Maize	09
	Edible Tree Nuts	06
	Fruit & Vegetable	03
	Meat	02
	Other (Eq. Herbs)	04
	Consultancy	03
	Machinery manufacturer	05
Markets	Local	04
	National	17
	International	11
Respondent's Position	Senior Management	20
	Middle Management	11
	Operational	01

4. Results and discussion

- Summary of field study findings

Drying Technologies Used

Hot Air Drying (Gas or Oil fired) including steam	16
Simple Heat Pump Drying	4
Dehumidifier Heat Pump Drying	3
Microwave Drying	1
Fluidised Bed Heat Pump Drying	Nil

Summary of Important Field Study Findings

	LOW	MEDIUM	HIGH
Concern for Quality	Nil	Nil	100%
Inter-Organisational Communication	30%	50%	20%
Exposure to New Technologies	70%	20%	10%
Responsiveness to Industry/Environment Trends	30%	35%	30%
Formality of Evaluation Processes	40%	30%	30%
Perceived Satisfaction with Current Processes	10%	30%	60%

	YES	NO
Brand/Manufacturer Preference	Nil	100%
Final Purchase Decision taken by CEO	100%	Nil
Involvement of Engineering/Production in Decision Process	65%	35%
Involvement with Consultants	55%	45%
Aware of Fluidised Bed Heat Pump Technology	30%	70%



5. Conclusions

1. Compared to other industries, adoption and diffusion of innovations in the Australian food drying industry was seen as relatively low.
2. Adoption and diffusion of innovations in this industry sector is largely determined by industry characteristics and market requirements. The evaluation process employed by businesses is basically a judgmental process. Lack of familiarity with the new technologies keeps people away from categorization of products and processes. At the same time, forming evaluative criteria is limited by lack of information on new products and processes. DPI as a premier R&D organization representing this industry sector has a key role to play in stimulating adopter behaviour.



5. Conclusions (continued)

3. Finding of the field research showed that neither information-processing approach nor the hierarchy of effect approach of innovation evaluation could be successfully applied (in isolation) to analyse the whole range of issues affecting the diffusion of industrial innovations. Rather, an integrated approach would cover most of the issues. This study could be effectively used to develop a more comprehensive model of adoption and diffusion of technological innovations with a wider coverage to include other industry sectors as well.



5. Conclusions (continued)

4. Throughout the field study, it was observed that most businesses are localized or isolated in the sense that they had little or no interaction with other sectors of the industry and the environment. The communication flow through the social system seemed to be extremely slow, and because of these reasons the dynamism within this part of industry was seen almost lost. Under these circumstances, the important of the DPI's role becomes even more important. If Food Technology is to become the market leader in technical consulting and R&D services in this market segment, it is obvious that it should take this aspect seriously and penetrates into this market with a more proactive approach.



**DIFFUSION OF DRYING TECHNOLOGIES IN THE AUSTRALIAN FOOD DRYING
INDUSTRY [INDUSTRY SURVEY – QUESTIONNAIRE]**

This questionnaire is focused on the process of *innovation evaluation*, which is considered as a critical component that constitutes the *persuasion* and *decision* stages of the innovation decision process. It aims to look at how do potential adopters evaluate new products and processes before they make a commitment to use them. Please tick the most appropriate answer (s) to each question. Feel free to provide comments where possible.

PART A: BACKGROUND INFORMATION

1. What types of drying processes are currently being used in your company?

- 1 Hot Air Drying 2 Dehumidifier Heat Pump Drying
 3 Freeze Drying 4 Other.....

2. How long have you been using these processes?

- 1 More than 10 years 2 10years > 6 years
 3 6 years > 4 years 4 Less than 2 years

3. What brands/manufacturers do these processes belong to?

.....

4. Do you have a preference to this brand/manufacturer over the others?

- 1 Yes 2 No.

5. If Yes, what are the specific reasons (if any) for that preference?

.....

6. How effective are the existing plant & equipment and processes in achieving the desired outcomes?

- 1 Unsatisfactory 2 3 4 5 Excellent

7. How often do you review/update your processes and technologies?

- 1 Not at all 2 3 4 5 As an ongoing activity

8. Usually what procedures does your company follow in the acquisition of plant and equipment?

- 1 Informal ad-hoc decisions 2 3 4 5 Formal organizational procedures

9. Who is involved in the purchasing/adoption decision process?

- 1 Proprietor/ Company CEO 2 Evaluation Committees
 3 Production Manager/Engineer 4 Other (Eg. Purchasing Manager).....

10. Who makes the final decision to acquire capital equipment?

- 1 Proprietor/Company CEO 2 Evaluation Committees
 3 Production Manager/Engineer 4 Other.....

11. How important is the quality of your end product to your business?

- 1 Not at all 2 3 4 5 Very Important

12. How do these processes and technologies affect the quality of your products

- 1 Not at all 2 3 4 5 Complete dependence

PART B: CURRENT PROCESSES/TECHNOLOGIES

1. How do you rate the following attributes of the existing plant/equipment and processes/technologies in terms of their importance to your business?

- **Capital intensity of plant and equipment**
 1 Least important 2 3 4 5 Most important
- **Labour intensity of the processes/technologies**
 1 Least important 2 3 4 5 Most important
- **Size of the plant and equipment**
 1 Least important 2 3 4 5 Most important
- **Ease of handling, operation and maintenance**
 1 Least important 2 3 4 5 Most important
- **Contribution to the enhancement of product quality**
 1 Least important 2 3 4 5 Most important
- **Overall efficiency of the plant and equipment**
 1 Least important 2 3 4 5 Most important
- **Overall economy of the processes and technologies**
 1 Least important 2 3 4 5 Most important

2. What are the attributes that you most like with your current processes?

- 1 Ease of Operation 2 Economy/Efficiency
 3 Size 4 Other.....

3. What are the attributes that you do not like at all with your current processes?

- | | |
|---------------------------------------|---|
| <input type="checkbox"/> 1 Complexity | <input type="checkbox"/> 2 Economy/Efficiency |
| <input type="checkbox"/> 3 Size | <input type="checkbox"/> 4 Other..... |

PART C: NEW PROCESSES/TECHNOLOGIES

1. How do you come to know about new processes and technologies that are being introduced into the industry?

- | | |
|--|--|
| <input type="checkbox"/> 1 Industry Contacts | <input type="checkbox"/> 2 Mass Media |
| <input type="checkbox"/> 3 Consultants | <input type="checkbox"/> 4 Other (Eg. Internet)..... |

2. What types of relationships do you have with other companies operating in your industry?

- | | |
|--|---|
| <input type="checkbox"/> 1 No relationship at all | <input type="checkbox"/> 2 Limited informal contacts |
| <input type="checkbox"/> 3 Regular interactive relationships | <input type="checkbox"/> 4 Other (Eg. Industry Forums)..... |

3. Do you usually hire consultants or seek advice from external experts in solving your technical or managerial problems?

- | | |
|--------------------------------|-------------------------------|
| <input type="checkbox"/> 1 Yes | <input type="checkbox"/> 2 No |
|--------------------------------|-------------------------------|

4. Are you aware of any alternative drying technologies that you have not fully investigated?

- | | |
|--------------------------------|-------------------------------|
| <input type="checkbox"/> 1 Yes | <input type="checkbox"/> 2 No |
|--------------------------------|-------------------------------|

5. How do you rate the following technologies in term of their appropriateness to your product and other business needs

- > **Fuel fired hot air drying**

<input type="checkbox"/> 1 Least appropriate	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5 Most appropriate
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- > **Simple heat pump drying**

<input type="checkbox"/> 1 Least appropriate	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5 Most appropriate
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- > **Dehumidifier heat pump drying**

<input type="checkbox"/> 1 Least appropriate	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5 Most appropriate
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- > **Fluidized-bed heat pump drying**

<input type="checkbox"/> 1 Least appropriate	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5 Most appropriate
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- > **Freeze Drying**

<input type="checkbox"/> 1 Least appropriate	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5 Most appropriate
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- > **Microwave Drying**

<input type="checkbox"/> 1 Least appropriate	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5 Most appropriate
--	----------------------------	----------------------------	----------------------------	---

6. Are you aware of fluidised bed heat pump drying process?

- | | |
|--------------------------------|-------------------------------|
| <input type="checkbox"/> 1 Yes | <input type="checkbox"/> 2 No |
|--------------------------------|-------------------------------|

7. If yes, what do you like most about this process?

- | | |
|--|--|
| <input type="checkbox"/> 1 Economic gains/Operating cost | <input type="checkbox"/> 2 Contribution to product quality |
| <input type="checkbox"/> 3 Capital/Investment cost | <input type="checkbox"/> 4 Increased throughput |
| <input type="checkbox"/> 5 Other..... | |

8. What do you not like at all about this process?

- | | |
|--|--|
| <input type="checkbox"/> 1 Economic gains/Operating cost | <input type="checkbox"/> 1 Contribution to the product quality |
| <input type="checkbox"/> 3 Capital/Investment cost | <input type="checkbox"/> 4 Uncertainty of the outcomes |
| <input type="checkbox"/> 5 Other..... | |

9. Other external factors that affect your choice of new technology and processes

- | | |
|--|--|
| <input type="checkbox"/> 1 Industry competition | <input type="checkbox"/> 2 Societal concerns (Environmental Impact). |
| <input type="checkbox"/> 3 Regulatory requirements | <input type="checkbox"/> 4 Other..... |

PART D: OTHER COMMENTS

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.....

1. Type of business:

- | | | | |
|-------------------|--------------------------|-------------|--------------------------|
| Private | <input type="checkbox"/> | Public | <input type="checkbox"/> |
| Sole Proprietary | <input type="checkbox"/> | Govt. Dept. | <input type="checkbox"/> |
| Limited Liability | <input type="checkbox"/> | Agency | <input type="checkbox"/> |
| SMI | <input type="checkbox"/> | Institute | <input type="checkbox"/> |

2. Products and Services:

Product Mix

.....

3. Markets:

- | | |
|-----------------|--------------------------|
| Local | <input type="checkbox"/> |
| State-wide | <input type="checkbox"/> |
| Interstate | <input type="checkbox"/> |
| Regional/Global | <input type="checkbox"/> |

4. Company history

- Year of Inception
- No. of Employees (initial/current)
- Initial Investment/Assets

5. Financial performance

- Sales
- Gross profit
- Total Assets

6. Current competitive position

Threats

.....

Opportunities

.....

Estimated market share

.....

7. Respondent's position in the Company

- | | |
|-------------------|--------------------------|
| Senior Management | <input type="checkbox"/> |
| Middle Management | <input type="checkbox"/> |
| Operational | <input type="checkbox"/> |
| Other..... | <input type="checkbox"/> |

