科際整合的高科技綠能產業

主講：周震煌
正同開發股份有限公司 副總經理
台灣大學生物產業機電工程學研究所 博士
地點：國立台灣大學動物科學技術學系(所)
日期：2022年5月26日(四)

大綱

- 與動科結緣
- 課程大綱與統計資料網站
- 養豬，科際整合的綠能產業
- 密閉隔熱、水簾、溫控、隧道式通風的畜舍
- 結論

72~74 年	年服兵役期間擔任戰車連隊的坦克車駕駛手，不但對履帶車輛動力產生與傳動機構的熟悉，也同時將過去零件的加工轉為設備的運轉操控。	正式接觸運轉設備
75~77 年	在國立台灣工業技術學院就讀，主修機械製造	
77 年~迄今 34 年	在正同開發股份有限公司，從事飼料添加、動物營養、飼料加工相關設備的進口業務，隨著產業型態的變遷與機械工程專業人力的投入，業務範圍擴展到水產飼料場廠、畜產飼料廠、碾米廠、麵粉廠、油脂廠等，以及原物料處理儲存相關的設備買賣。	
77~81 年	Wenger Extruder 水廠飼料加工系統。立大、中日、福壽、廣大、龍聯、立大增建新廠，幾乎每年一個廠。	水廠飼料加工
78~79 年	協助興建全國第一個產能 40MTPH 電腦化動物飼料製造廠，從進口、現場安裝到試車完成。[茂生飼料]	完整的整場訓練
81 年	開發稻穀冷藏系統，82 年 2 月 28 日與億東企業三好米簽約在西螺頂茄建立台灣第一座鍍鋅鋼製稻穀冷藏系統，開啟稻穀儲存的新頁，產品壽命一直持續到現在。總倉儲量超過十萬噸	個人對產業最大的貢獻。
84~88 年	引進豆粉掃倉機，解決容易架橋原料的架橋問題。	解決業界頭痛問題
85 年	因震動清倉系統的開發認識農機系主任蕭介宗教授，為日後的二度就學結下不解之緣。	曾經申請台灣專利
88~89 年	協助中聯油脂公司建立日耗 2500 噸黃豆的提油廠，當年只有 10 年的產業功力，加上欠缺化工術養，看到的黃豆油的製程也只限於容器和管路。但是每小時 500 噸黃豆輸送設備全台第一。	
90 年	拜全球經濟不景氣之所賜，以及每年建廠的體能轟炸，有時間回到大學時代夢想的第一志願-台大農機，選修穀物乾燥、農產品儲運、農業廢棄物處理、產業機械等與工作相關的專業課程。	帶職考進台大生機所
92~99 年	在蕭介宗教授的指導下完成［撓性振板應用於穀物清倉］碩士論文，同時應屆考進博士班，進入到以近紅外線光譜 NIRS 檢測與鑑別肉品的研究領域。在校期間更進一步研修：生物廢水處理、酸酵工程、水產養殖工程、單元操作、熱環境工程、生物產業機械、實驗設計、系統工程等和個	工作與博士班學生兼顧

	人從事的產業有高度相關的課程，服務的範圍又更擴大了。	
94~96 年	最高耐震桶槽金車麥芽倉儲工程，配合國內開發貨櫃舉揚系統。	高耐風耐震桶
96 年	成功引進膨化系統應用於飼料加工，以期能增加現有設備的產能、減少飼料的藥物濫用、和簡化加工流程，97 年台灣第一套膨化系統成功的運轉。	迄今已有 12+2 套
97 年	稻穀連續乾燥系統，終於在 98 一期稻作前試車完成，稻穀連續乾燥後再送到冷藏桶做保鮮儲存的二次乾燥理念應用在產業。	
99 年	博士班畢業，並將學習多年的 NIRS，從學校研究變成產業應用推廣。	博士班畢業。
100 年~迄今	開始將台灣成功的經驗轉移到菲律賓，包括 NIR 應用於飼料原料快速檢測、德國 KAHL 公司新開發結合調質/膨化/造粒三機一體機型、美國 Wenger 水產飼料擠出機搭配 Wenger 第一套以粗糠當燃料的乾燥機、美國 LAIDIG 粉料掃倉出倉機搭配先進先出計時啟動管理。	產業技術南向輸出
104~105 年	中聯油脂 20000 噸鐵皮桶倉搭配新型廠組式震動清倉系統，台灣最大。	
105 年	引進 3/4 型多區粉碎功能之粉碎系統應用於豆粉加工，粉碎刀片的更換由每個月更換提升到 8 個月，大幅減少停機損失和零件耗損，被譽為最高 CP 值設備。	
106 年	以三大主題，包括稻穀冷藏自動化倉儲系統之開發、振動板清倉系統應用於穀倉，和以近紅外線光譜鑑別肉品與新鮮度判別之非破壞檢測應用，獲選國立臺灣科技大學傑出校友。	當選國立臺灣科技大學傑出校友。
107 年	NIR 應用於線上即時品質參數檢測。 黃豆提油廠不銹鋼壓力容器更新，與夾雜物再利用處裡。	
108 年	膨化機應用於黃豆加工，以及顆粒飼料產能加倍應用。	
109 年	疫情期間應用網際網路完成膨化機加工系統遠端調試。 Laidig 雙螺旋架橋破壞出料器。	
110 年	密閉式畜舍智能化養豬工程。 沼氣發電與養豬廢水處理。 500 噸組合式全脂黃豆粉桶槽與雙螺旋架橋破壞出料器。	
111 年	木顆粒與 RDF 可燃廢棄物造粒。	

與動科結緣-

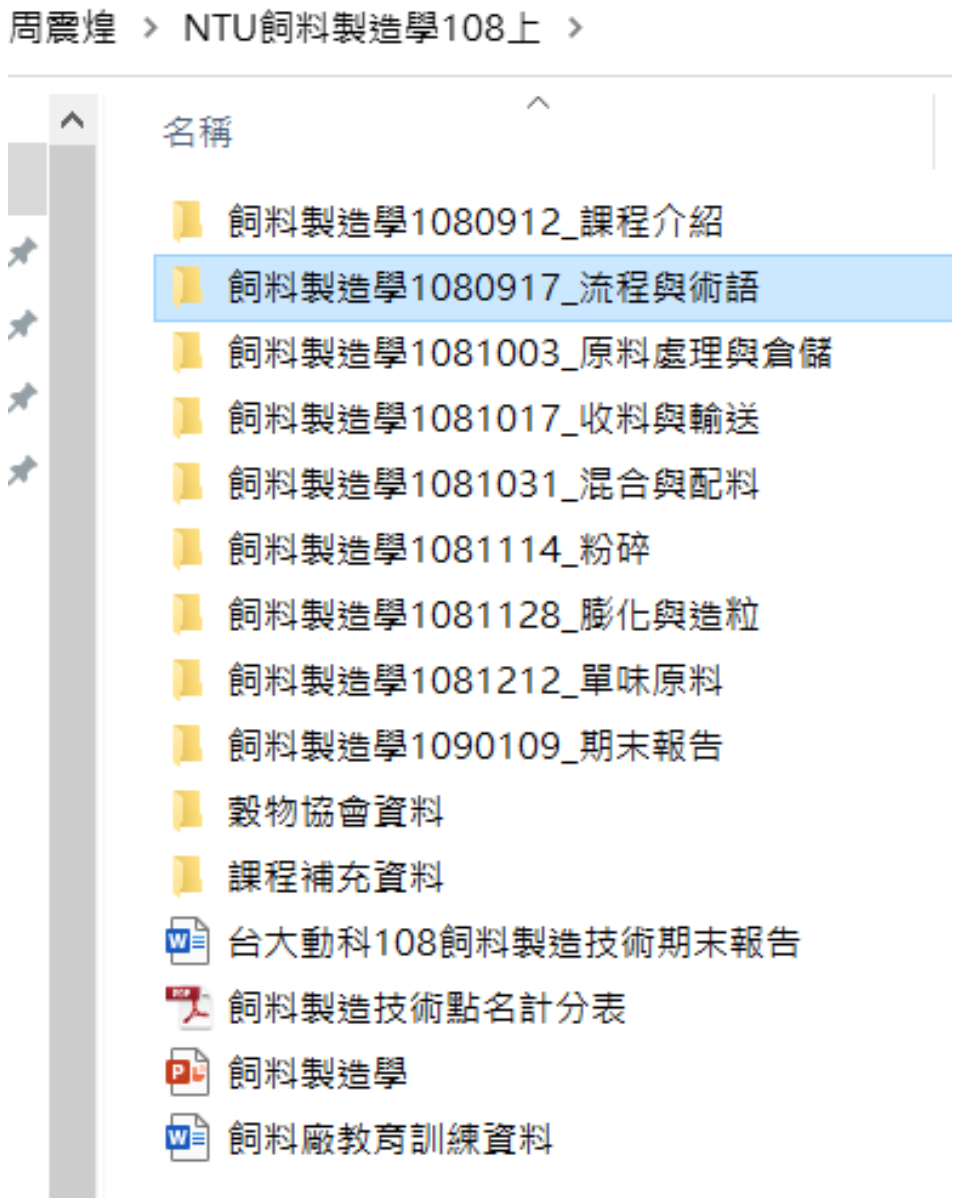
- 飼料加工研討會_全脂黃豆粉加工
- 梅納反應(Maillard Reaction)

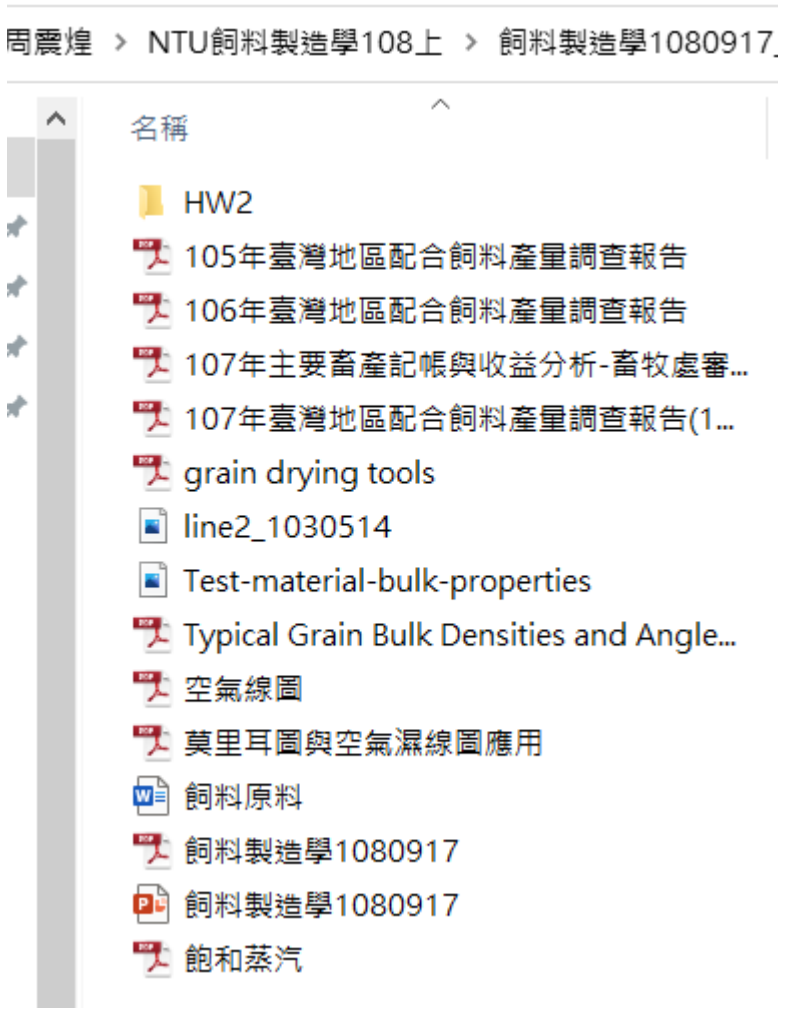
  黃豆中的碳水化合物(醣類)在高溫下裂解，所產生的酮基和醛基與胺基結合，因此降低了胺基酸的可利用率。

只相信眼睛看到的三點紅，就是不相信科學 PDI : 15~25。

~過度加工，暴殄天物~

感謝動科系給我機會


周震煌 › NTU飼料製造學108上 ›
名稱
飼料製造學1080912_課程介紹
飼料製造學1080917_流程與術語
飼料製造學1081003_原料處理與倉儲
飼料製造學1081017_收料與輸送
飼料製造學1081031_混合與配料
飼料製造學1081114_粉碎
飼料製造學1081128_膨化與造粒
飼料製造學1081212_單味原料
飼料製造學1090109_期末報告
穀物協會資料
課程補充資料
台大動科108飼料製造技術期末報告
飼料製造技術點名計分表
飼料製造學
飼料廠教育訓練資料


周震煌 › NTU飼料製造學108上 › 飼料製造學1080917_
名稱
HW2
105年臺灣地區配合飼料產量調查報告
106年臺灣地區配合飼料產量調查報告
107年主要畜產記帳與收益分析-畜牧處審...
107年臺灣地區配合飼料產量調查報告(1...
grain drying tools
line2_1030514
Test-material-bulk-properties
Typical Grain Bulk Densities and Angle...
空氣線圖
莫里耳圖與空氣濕線圖應用
飼料原料
飼料製造學1080917
飼料製造學1080917
飽和蒸汽

2020 臺灣養豬統計手冊
TAIWAN PIG PRODUCTION STATISTICS

表 3 歷年每人肉品消費量
Table 3. Per capita consumption of red meat, poultry and fish, 2012~2020

單位：公斤 / 人 (kg / person)

年別 Year	畜禽肉類 Red Meat & Poultry						魚類 Fish	合計 Total
	豬肉 Pork	牛肉 Beef	羊肉 Mutton	禽肉 Poultry	其他 Others	畜禽肉類總量 Sub-total		
2012	37.18	4.39	1.03	32.54	0.03	75.17	19.39	94.56
2013	34.94	4.84	1.04	30.63	0.04	71.50	17.89	89.39
2014	35.44	5.16	1.21	33.70	0.05	75.56	18.89	94.45
2015	37.56	5.07	1.12	34.26	0.05	78.06	14.52	92.58
2016	35.66	5.69	0.96	34.63	0.04	76.99	13.86	90.84
2017	36.50	5.88	0.97	34.26	0.05	77.67	12.39	90.06
2018 r	37.25	6.41	1.11	38.57	0.06	83.40	16.71	100.11
2019	36.84	6.83	0.94	40.16	0.07	84.84	12.75	97.60
2020	…	…	…	…	…	…	…	…

註：r 表示修正數；" …" 表示數值不明或尚未產生資料。

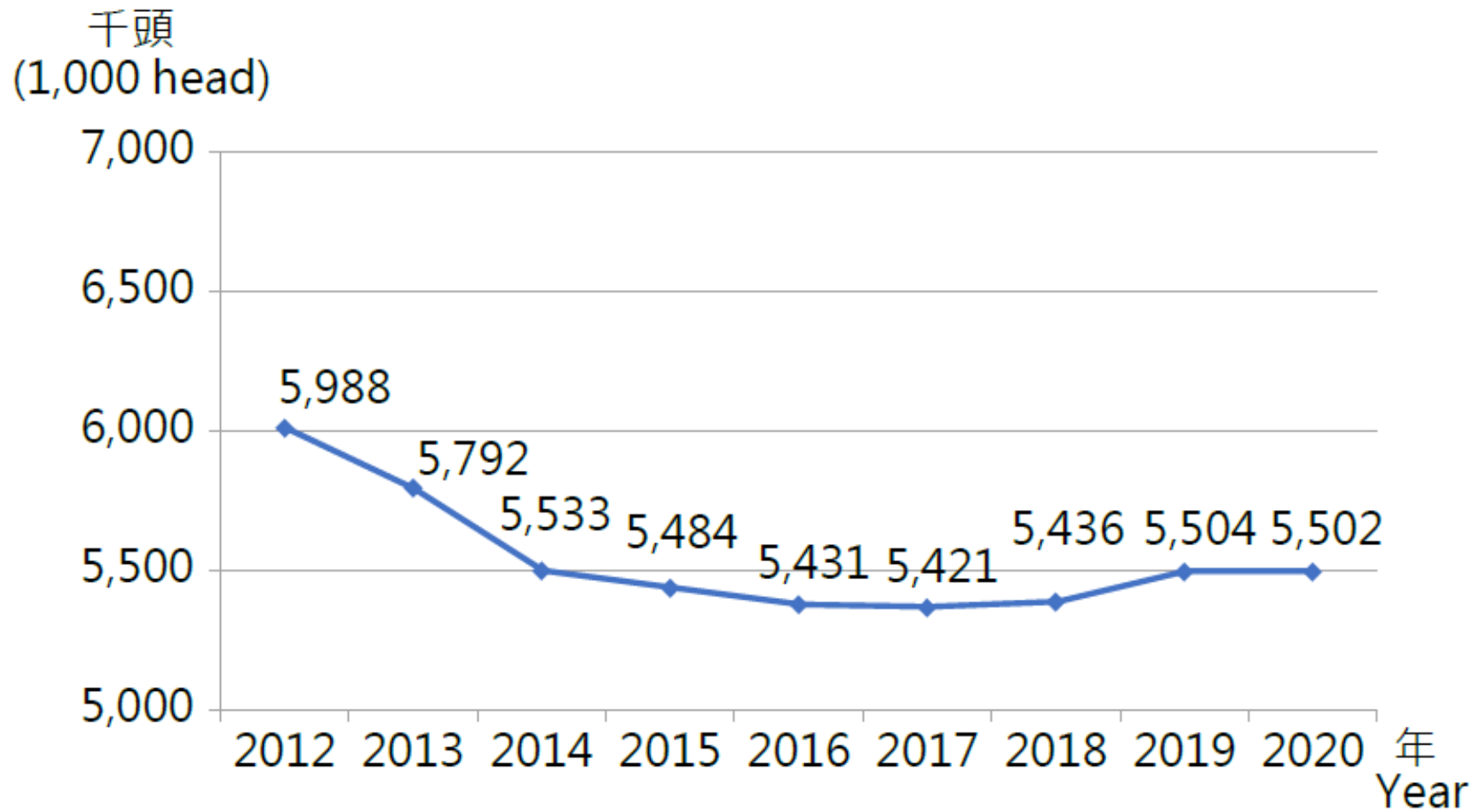
Note: " r " stands for the revised figure and " ... " stands for the unclear numeric value or no information available.

資料來源：糧食供需年報，行政院農業委員會

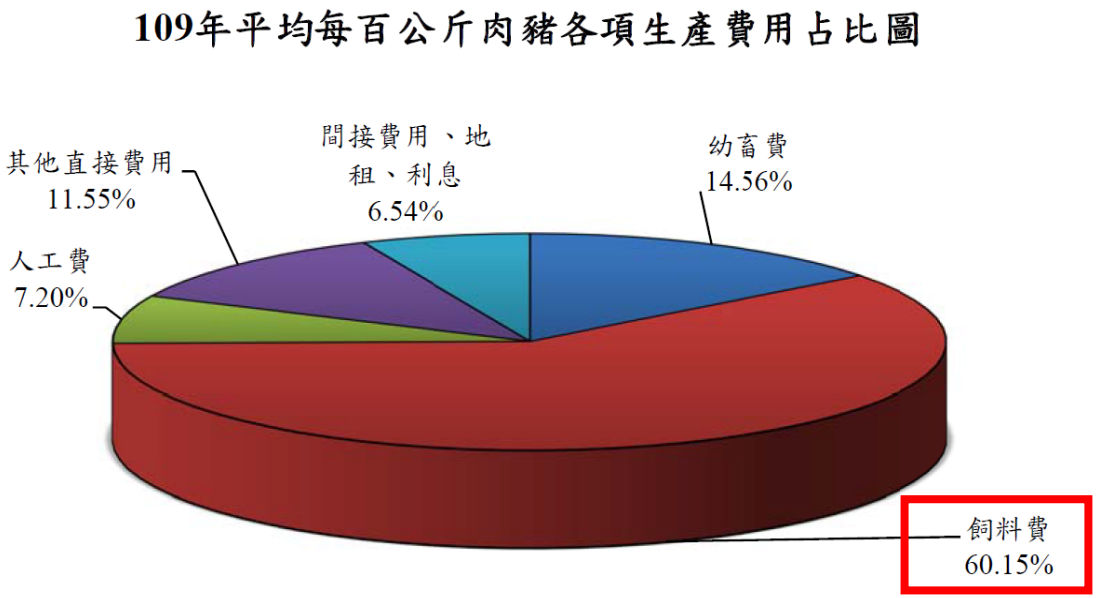
Source: Food Supply and Utilization Yearbook, Council of Agriculture, Executive Yuan.

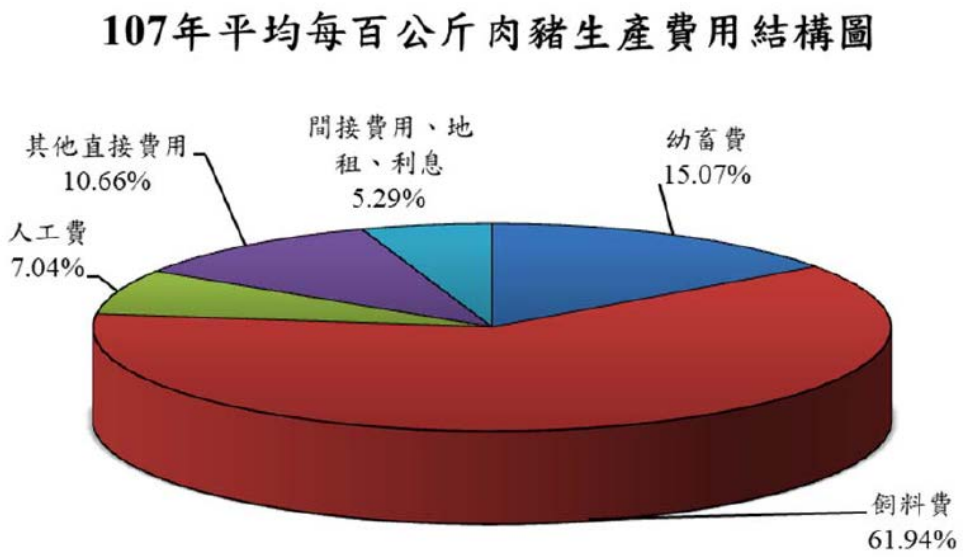
圖 5 歷年毛豬在養頭數趨勢圖

Figure 5. The trend of pig inventory, 2012~2020



生產成本中飼料費占比





https://agrstat.coa.gov.tw/sdweb/public/book/Book.aspx

109年臺灣主要畜禽產品生產成本與收益分析

飼料成本增加，農家賺款減少
養豬是不是賺錢的行業!?

109 年每百公斤肉豬收益比較表　　單位：元

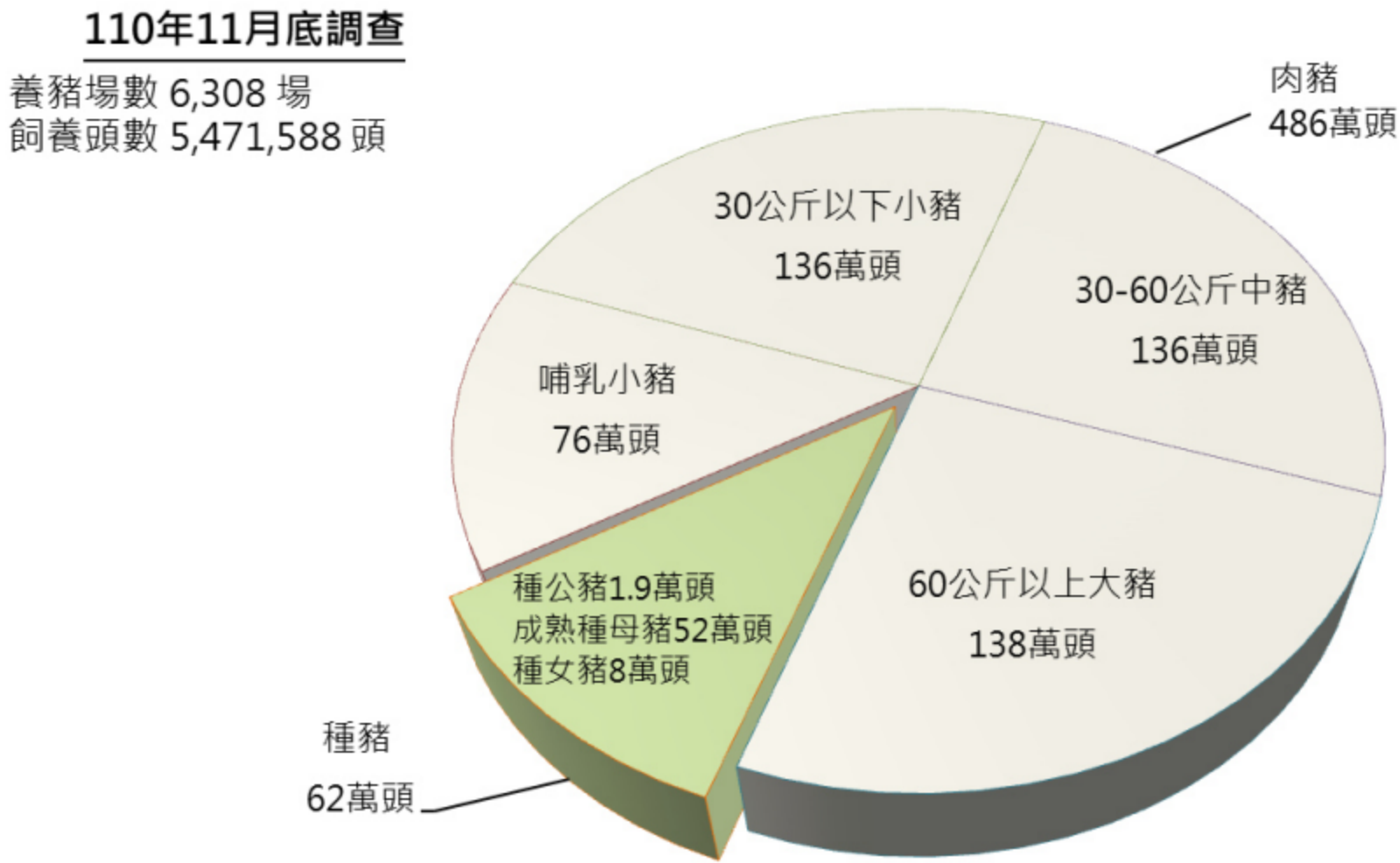
項　目	109 年	108 年	增減(%)
總生產費用	6,002	5,853	+2.55
粗收益	7,243	7,424	-2.44
損　益	1,240	1,571	-21.05
家族勞動報酬	1,549	1,865	-16.91
農家賺款	1,593	1,898	-16.08

107 年每百公斤肉豬收益比較表　　單位：元

項　目	107 年	106 年	增減(%)
總生產費用	5,552	5,476	+1.38
粗收益	7,297	8,080	-9.68
損　益	1,746	2,604	-32.96
家族勞動報酬	2,034	2,882	-29.43
農家賺款	2,065	2,911	-29.07

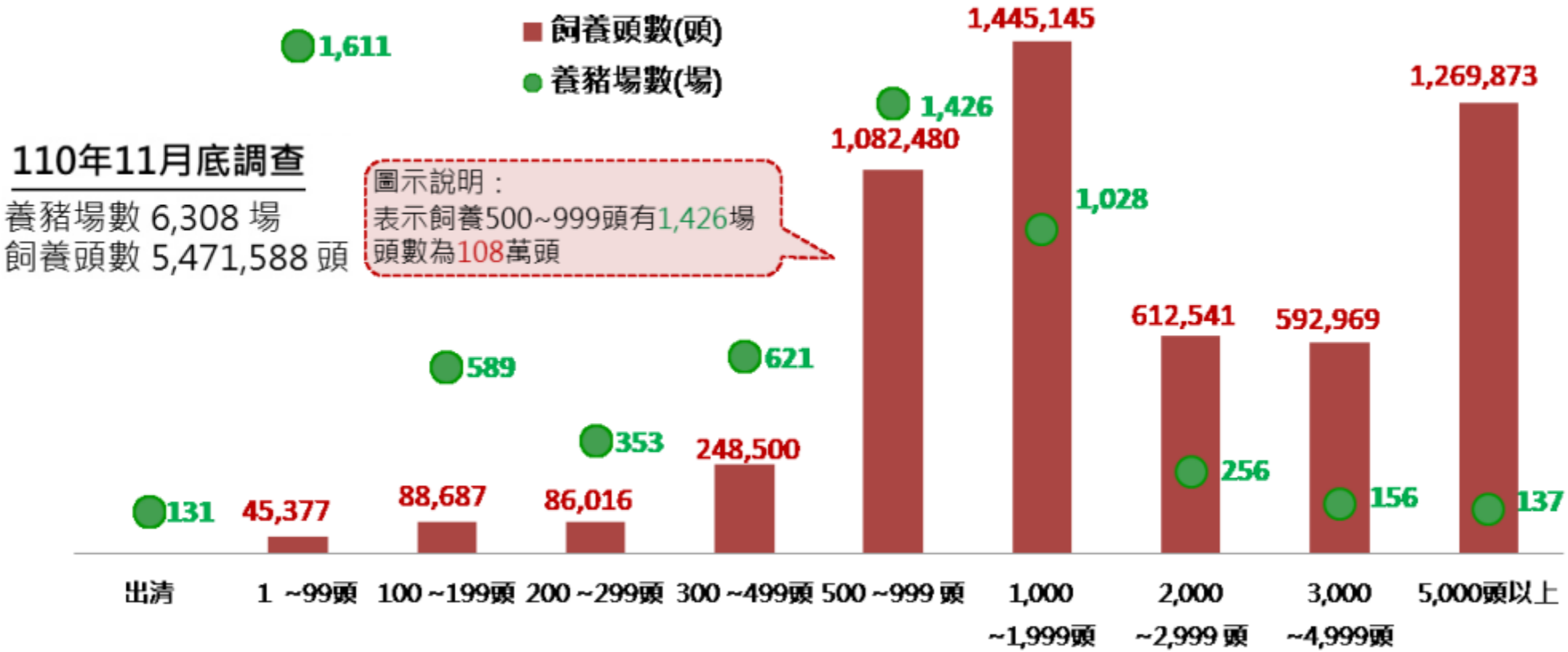
https://agrstat.coa.gov.tw/sdweb/public/book/Book.aspx
109年臺灣主要畜禽產品生產成本與收益分析

圖1、110年11月底豬隻飼養頭數



分析：110年11月底臺閩地區毛豬飼養6,308場，在養頭數547萬頭，其中種豬62萬頭(占11.2%)，肉豬486萬頭(占88.8%)；平均每場飼養規模為886頭。

圖2、110年11月底不同飼養規模別養豬場數及頭數



分析：扣除調查時暫時出清場數，飼養199頭以下場數2,200場(占35.6%)，飼養頭數占總在養量2.5%；200~999頭2,400場(占38.9%)，飼養頭數占總在養量25.9%；1千頭以上大規模場數為1,577場(占25.5%)，飼養頭數占總在養量71.7%。

https://www.naif.org.tw/upload/47/20220214_101017.93476.pdf

1988年莊焜明教授對學生的期許

運用智慧

整合科際

創新產品

造福人類

養豬，科際整合的綠能產業1/2

- 環境工程：地點選定、生物安全與環境影響評估、大氣科學、
- 土木結構工程：地質鑽探、土壤分析與畜舍建造
- 生物產業機械工程：地板、欄位、隔熱、材料、給飼、給水、 溫度濕度、通風、水簾、豬糞尿收集、流體力學、熱力學、
- 電機電子工程：供電(市電/沼氣發電/太陽能/備用電池)與控制，就是不能斷電。
- 資訊與管理工程：遠端通訊與大數據
- 動物科學：生物安全、動物營養、基因與育種.....
- 獸醫：疫苗、疾病防治與醫療

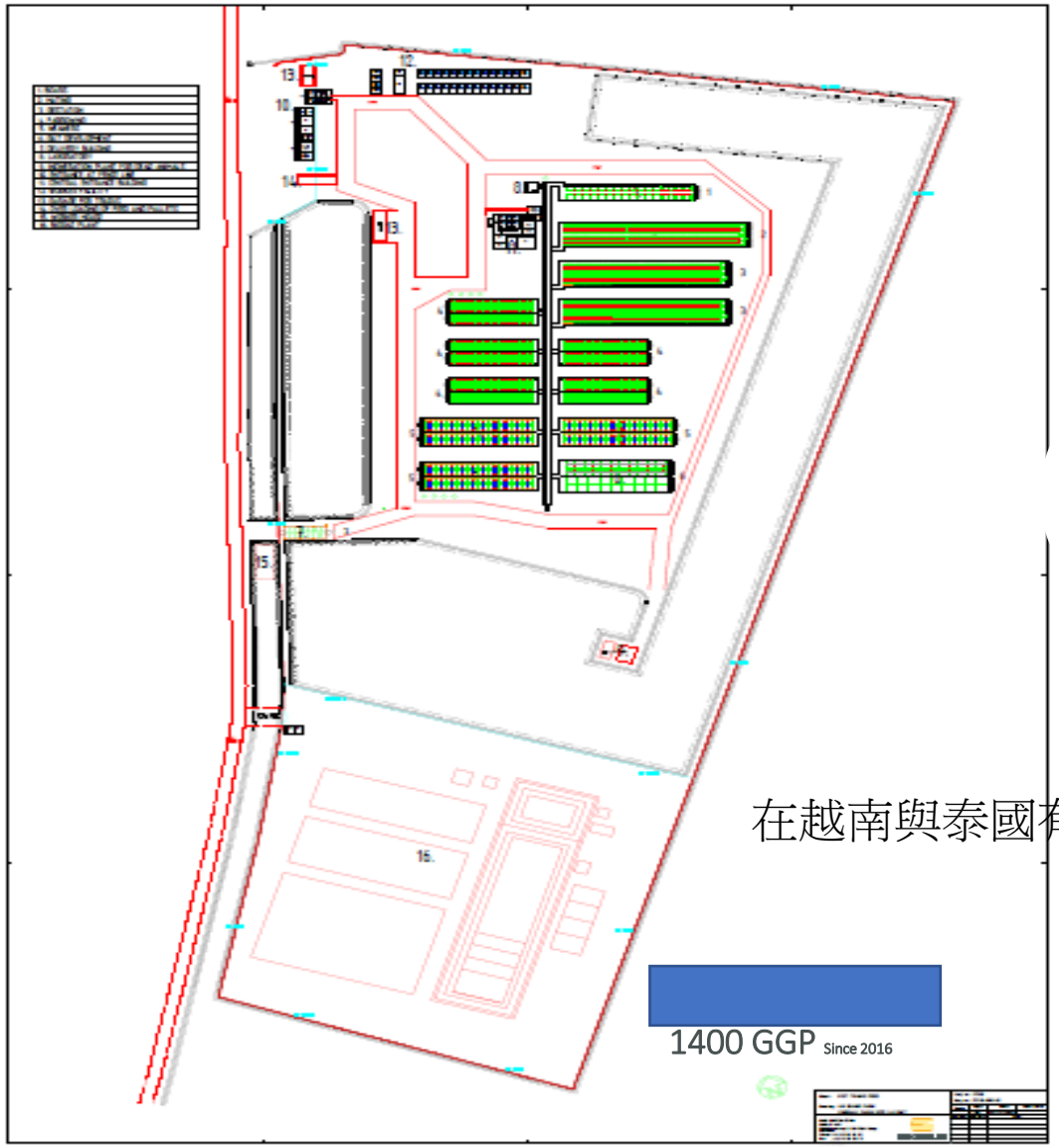
養豬，科際整合的綠能產業2/2

- 微生物醱酵工程：豬糞尿處理、沼氣發電與沼渣沼液處理
- 農藝與肥料：固肥，液肥回灌農田
- 生態工程：水處理與排放大自然
- 養殖工程：黑水虻、水產養殖、養藻、魚菜共生
- 市場銷售：活豬隻運輸與零售市場
- 肉品加工：冷凍冷藏與冷鏈運輸
- 財務金融：大量金流

養豬工程的啟動

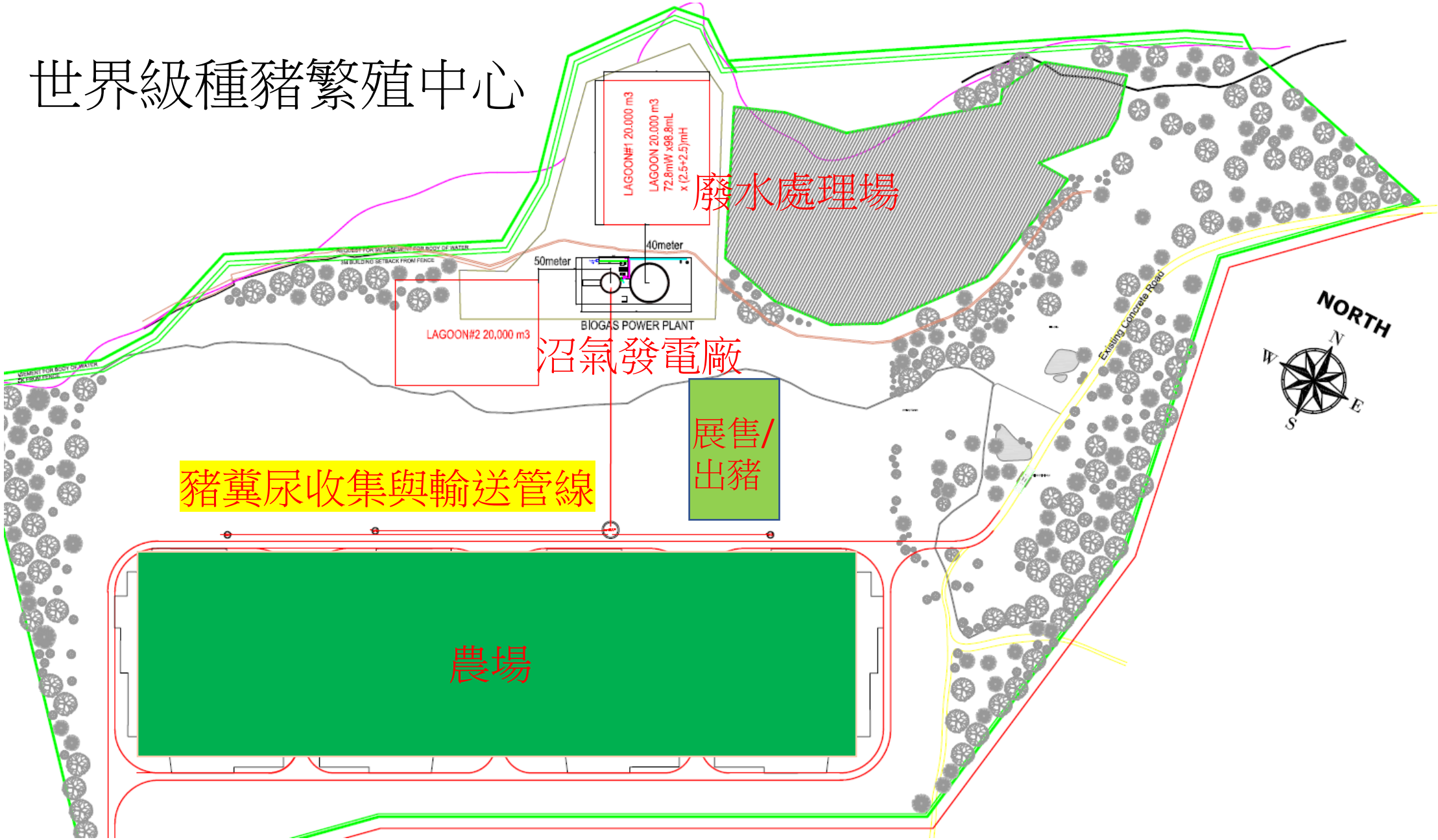
- 忠實客戶的一句話
- 周副總：我想要來養豬(2019，12，03)
- 亞洲的非洲豬瘟疫情緩和，市場肉豬剩一半
- 丹麥考察(2019，10月)剛回來
- 順水推舟，一拍即合

借將世界養豬王國 - 丹麥



在越南與泰國有經驗

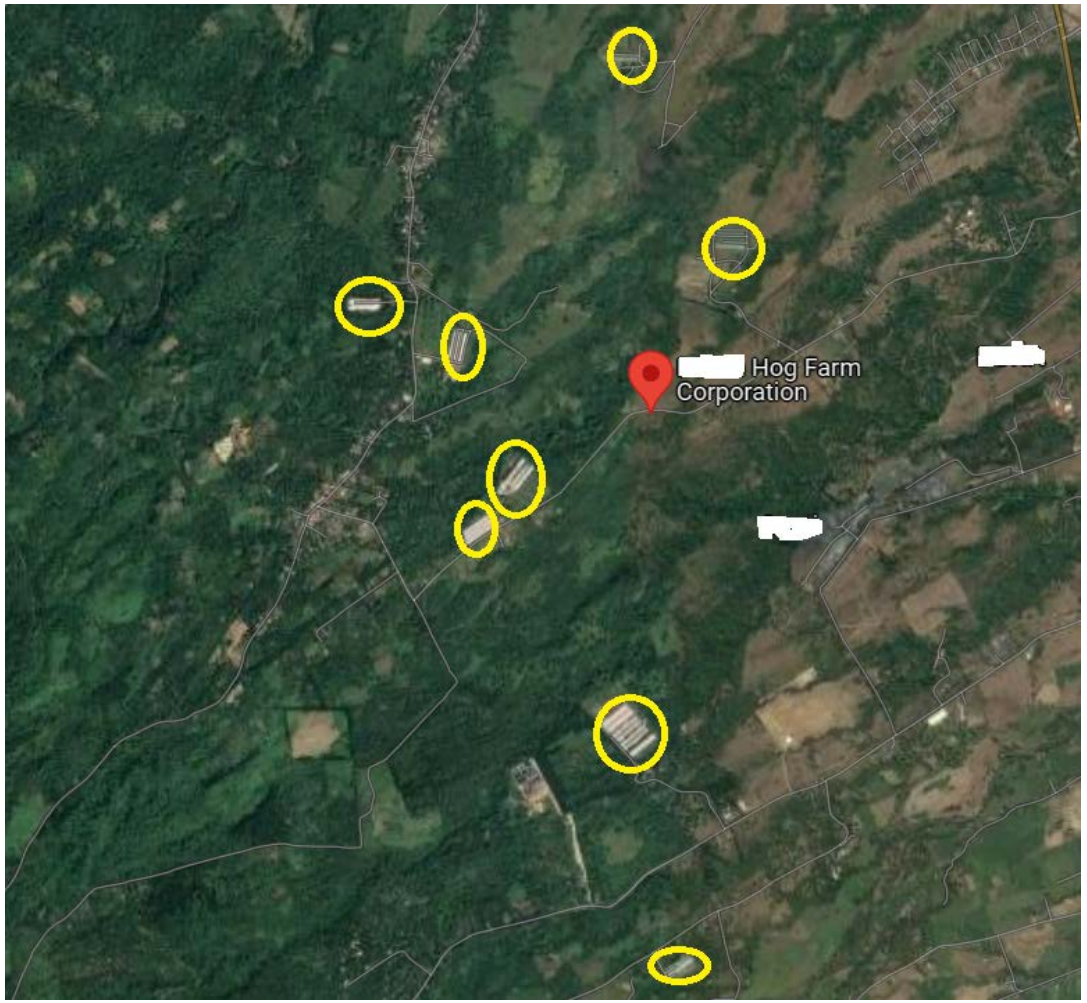
世界級種豬繁殖中心


LAGOON#1 20,000 m3
LAGOON 20,000 m3
72.8mW x98.8mL
x (2.5+2.5)mH
廢水處理場
40meter
50meter
BIOGAS POWER PLANT
LAGOON#2 20,000 m3
沼氣發電廠
展售/
出豬
豬糞尿收集與輸送管線
農場
Existing Concrete Road
NORTH
N
W
E
S


River
River
River
GPS 位置圖
農場位置
14°46 N 120°28' "E

生物安全

豬場四周有很多雞場? 有關係嗎? 還好沒有豬場。



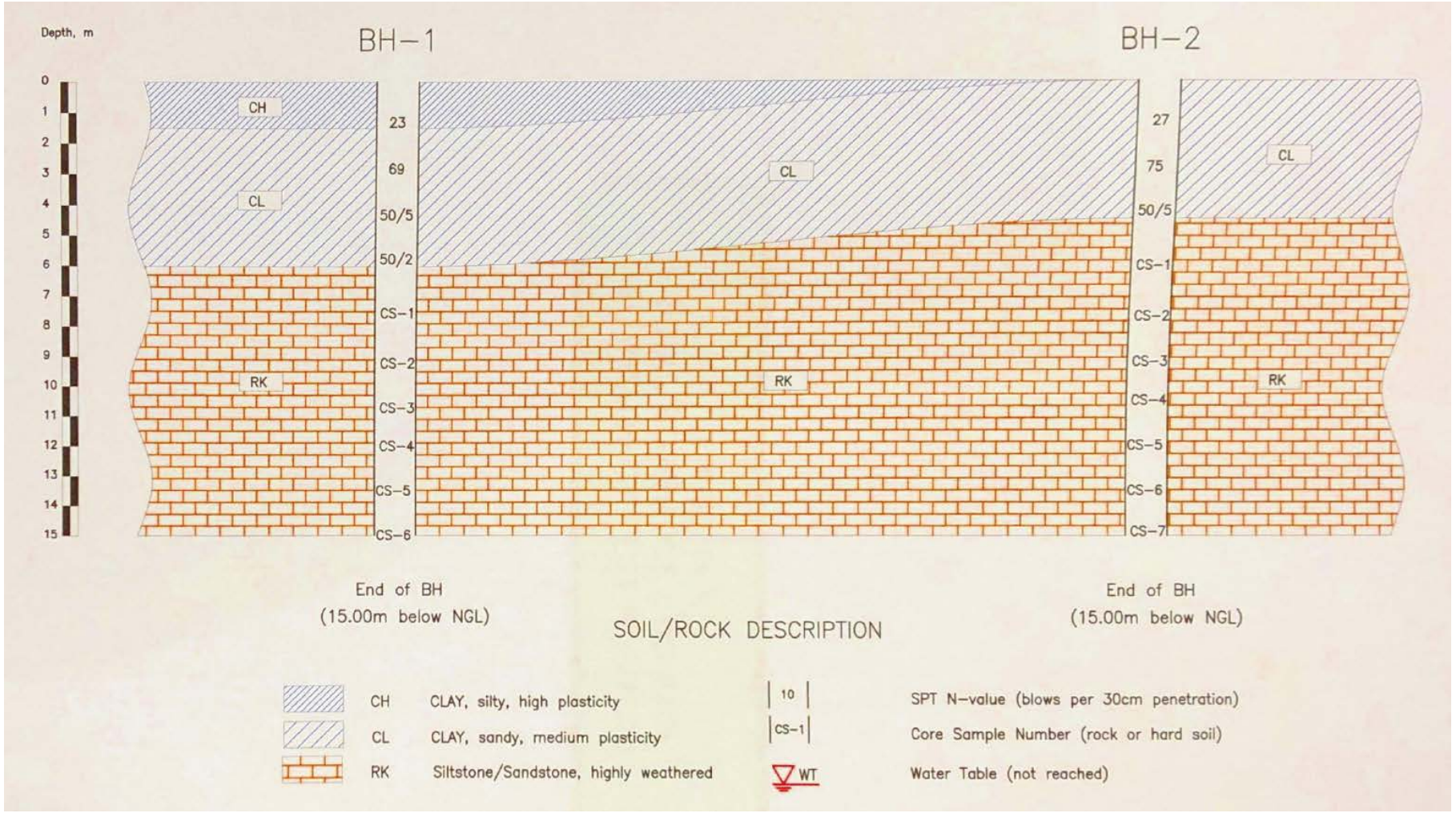
雞糞有污染的問題嗎?

還是助於豬糞尿醱酵嗎?

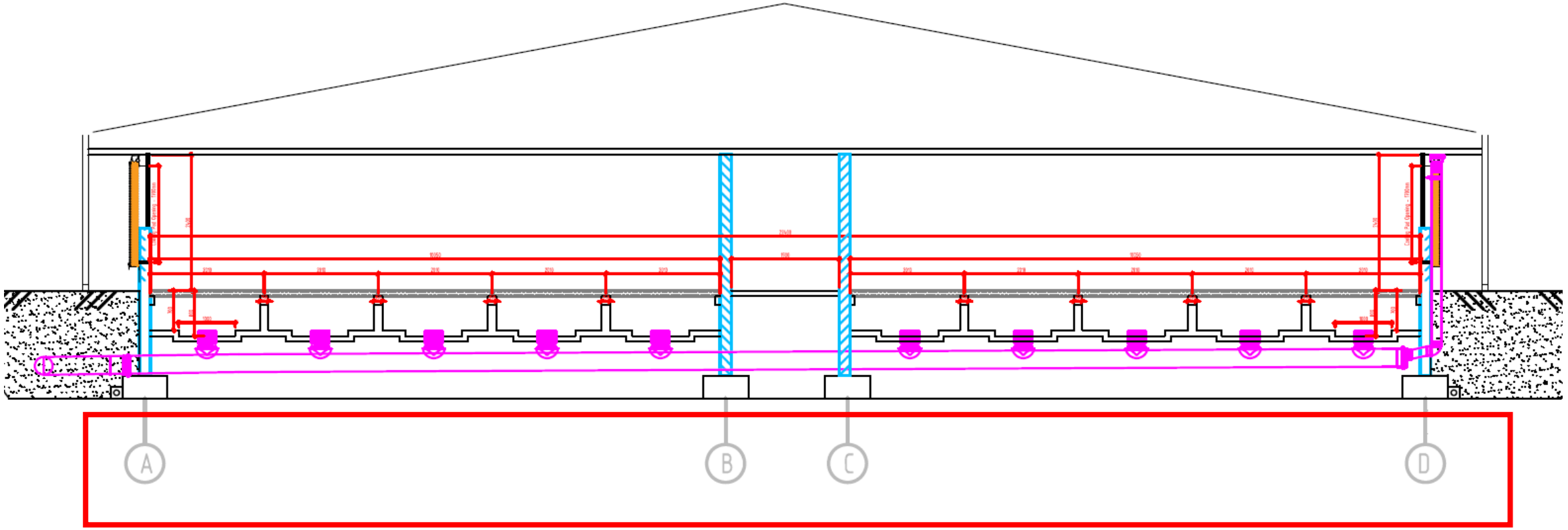
半成品飼料的當然買家嗎?

聯合加工提高設備稼動率。

地質鑽探與土壤分析

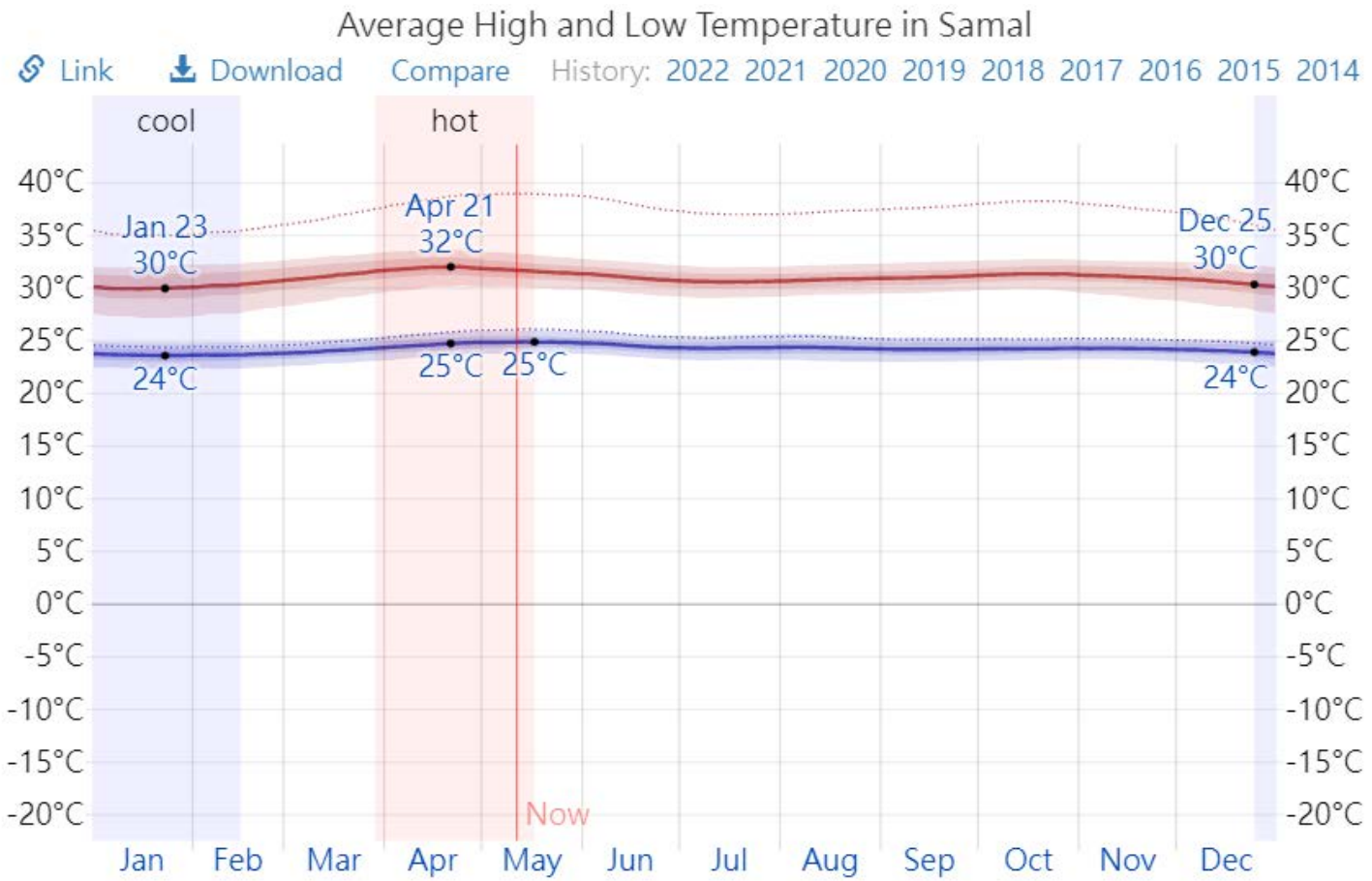

Depth, m
BH–1
BH–2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
CH
CL
RK
23
69
50/5
50/2
CS–1
CS–2
CS–3
CS–4
CS–5
CS–6
27
75
50/5
CS–1
CS–2
CS–3
CS–4
CS–5
CS–6
CS–7
End of BH
(15.00m below NGL)
End of BH
(15.00m below NGL)
SOIL/ROCK DESCRIPTION
CH CLAY, silty, high plasticity
CL CLAY, sandy, medium plasticity
RK Siltstone/Sandstone, highly weathered
10 SPT N–value (blows per 30cm penetration)
CS–1 Core Sample Number (rock or hard soil)
WT Water Table (not reached)

土壤負載



百年大業是否需要基樁、筏式基礎、四周鋼板樁等等基礎改善工程。

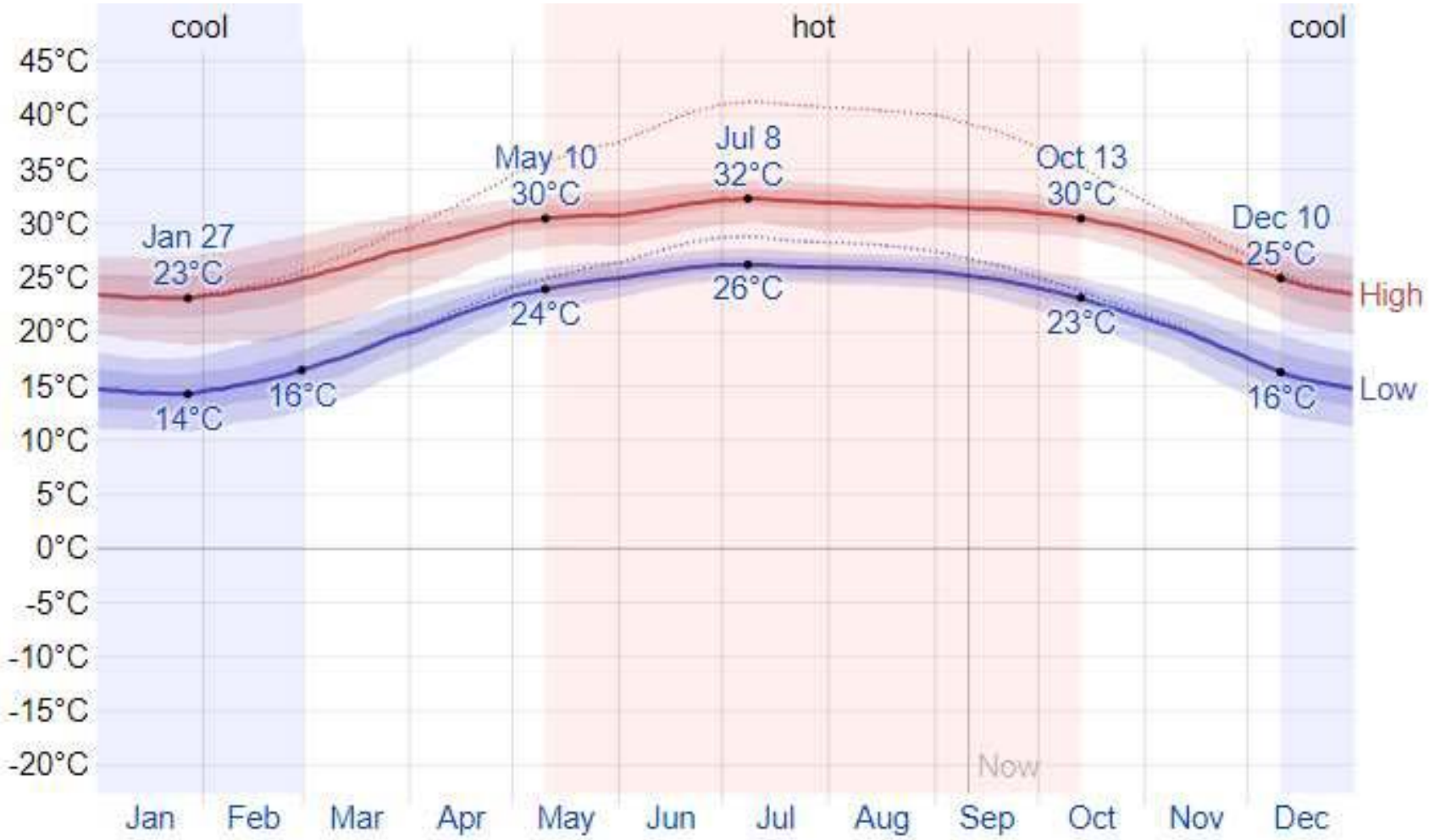
農場所在年均温度



The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

https://weatherspark.com/y/141419/Average-Weather-in-Samal-Philippines-Year-Round

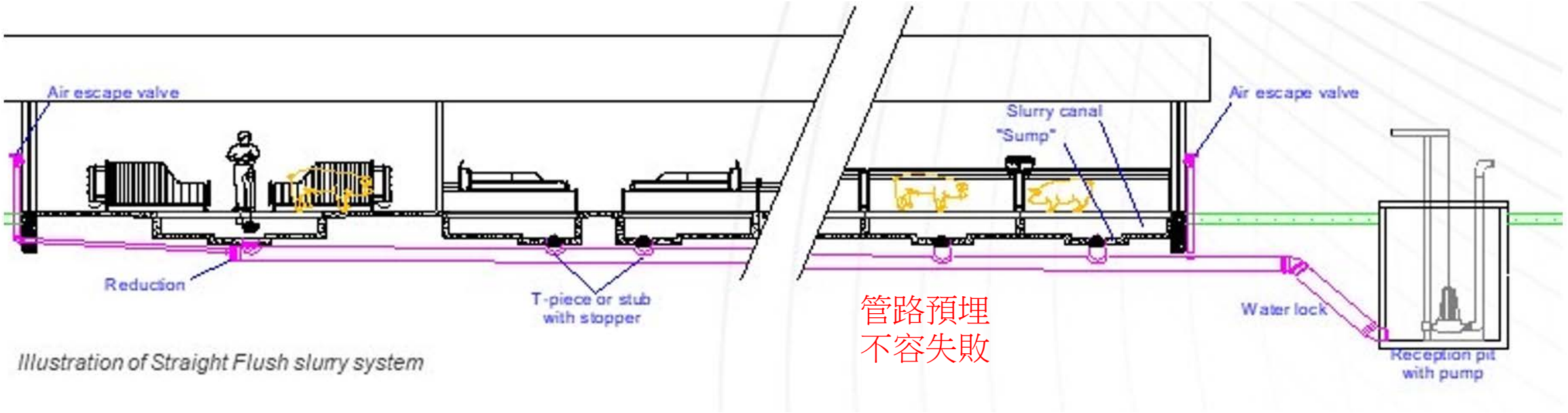
台灣台南


cool
hot
cool
45°C
40°C
35°C
30°C
25°C
20°C
15°C
10°C
5°C
0°C
-5°C
-10°C
-15°C
-20°C
Jan 27
23°C
May 10
30°C
Jul 8
32°C
Oct 13
30°C
Dec 10
25°C
High
14°C
16°C
24°C
26°C
23°C
16°C
Low
Now
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

拉沖式排污管線與豬糞尿收集

- 5/1000管路斜度
- 分區+水壓
- 通氣管口

- 50立方米收集槽
- 圓形下方進水
- 污泥攪拌機
- 污泥泵送機



管路預埋
不容失敗

豬糞尿是黑金?還是污染物?

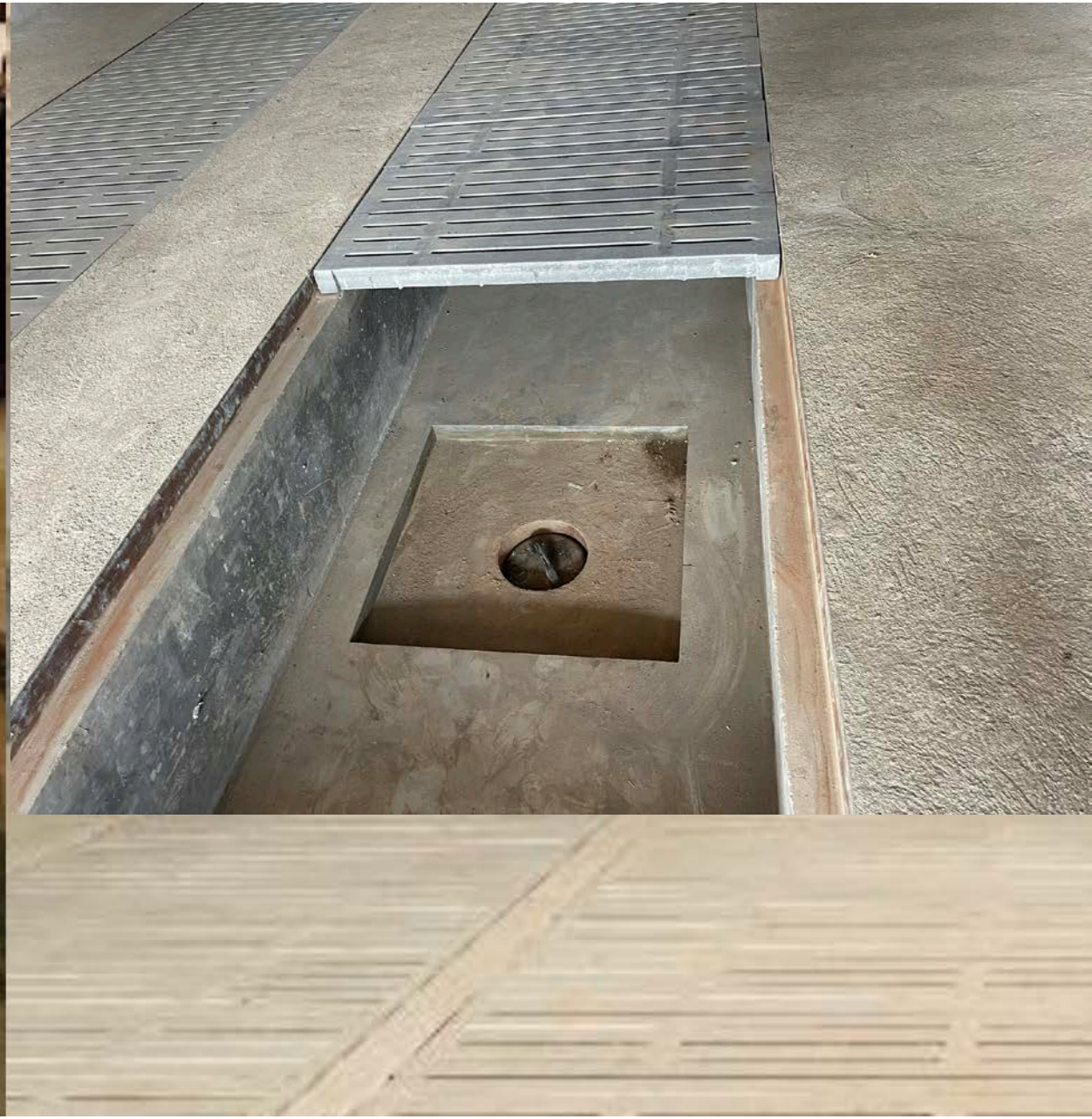
- 生機所”農業廢棄物處理工程”課程。
- 農業沒有垃圾，只有廢棄物。
- 周楚洋教授：**廢棄物：棄置不當的資源**
- 一個可以完全循環經濟的產業。

適當地處理是資源
不當的排放是污染

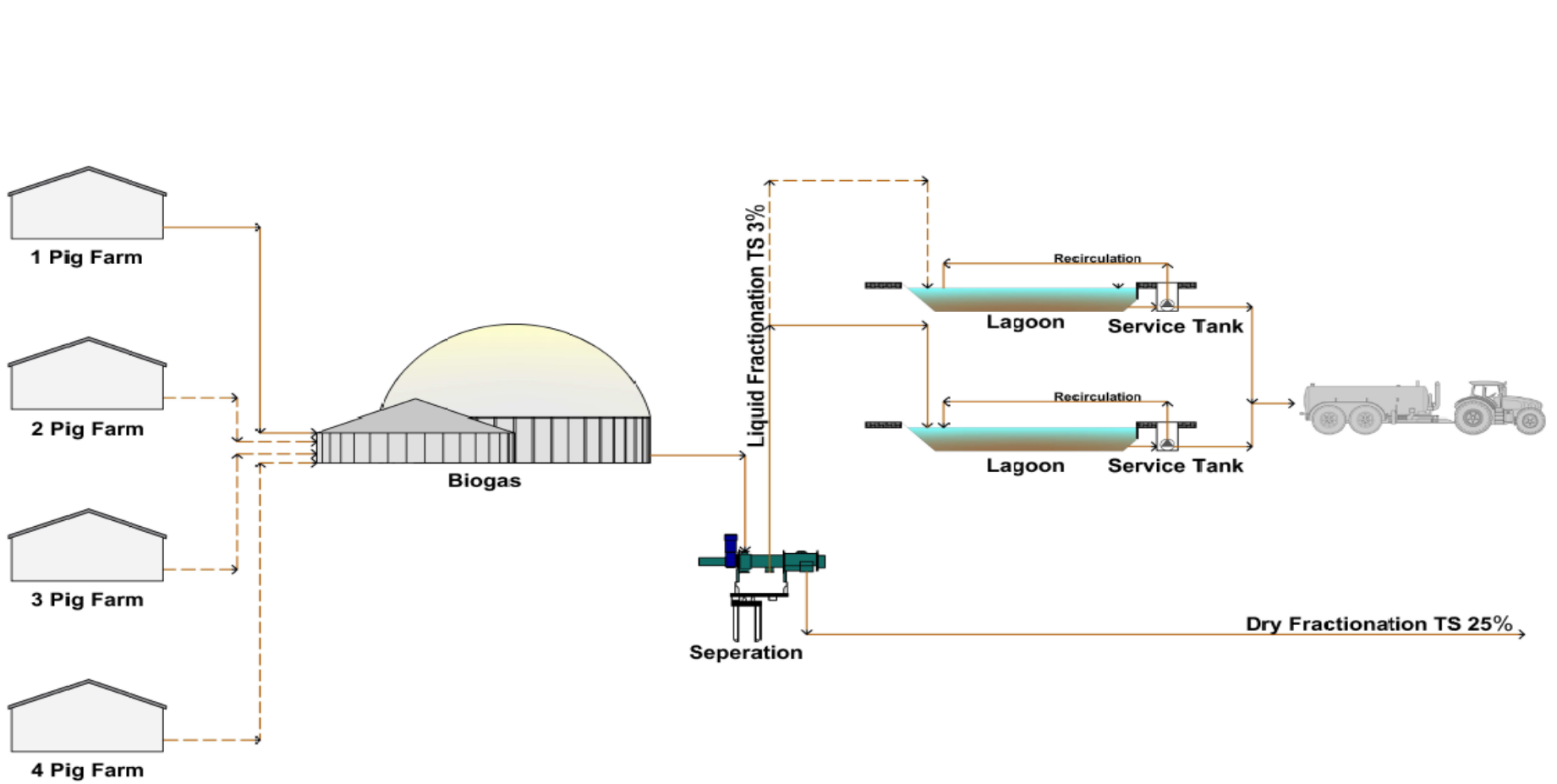
排污管線操作

多久拉一次?
壓力(水頭高)?

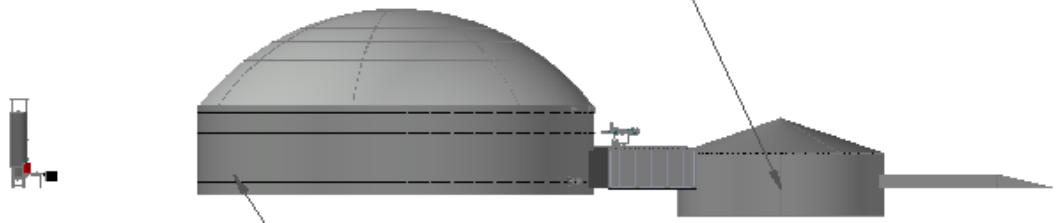
黑金?還是污染物?



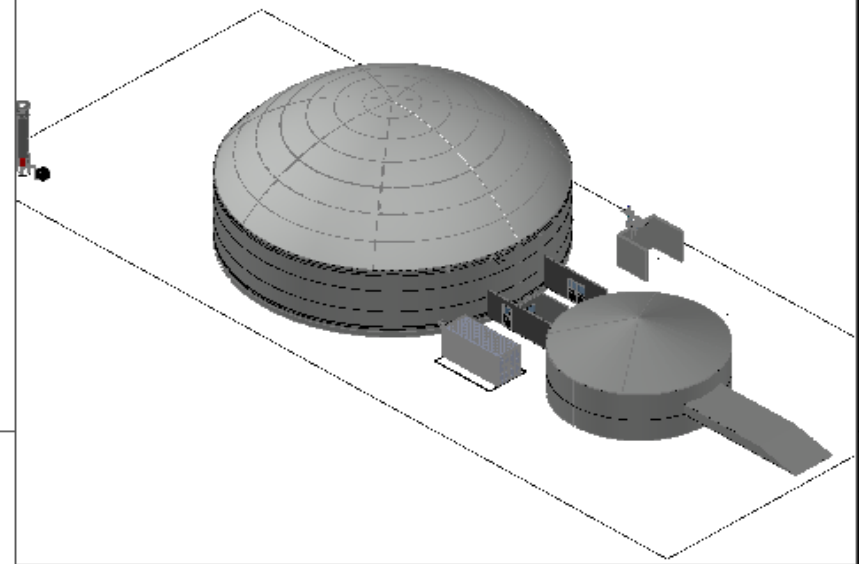
沼氣發電流程


1 Pig Farm
2 Pig Farm
3 Pig Farm
4 Pig Farm
Biogas
Liquid Fractionation TS 3%
Recirculation
Lagoon
Service Tank
Recirculation
Lagoon
Service Tank
Seperation
Dry Fractionation TS 25%

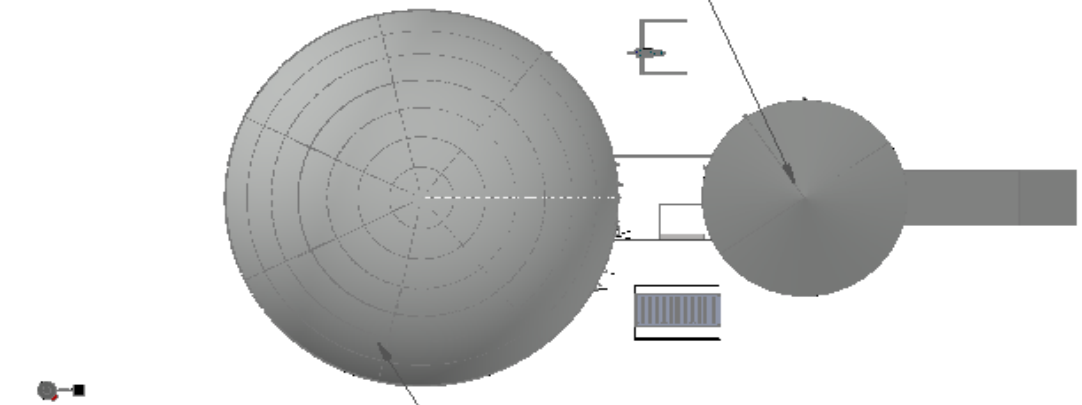
Drawing:
88.001-101-CM20.1
Mixtank tank dimension /connections



Drawing:
88.001-101-CM30.1
Primary digester tank dimension /connections



Drawing:
88.001-101-CM20.1
Mixtank tank dimension /connections



Drawing:
88.001-101-CM30.1
Primary digester tank dimension /connections

Filename: 88.001-100-CM20.1+CM30.1		Project no.: 88.001	Scale: 1:350
Draw. no.:	88.001-100-CM20.1+CM30.1	Description: CM20.1 mixtank+CM30.1 primary digester Layout	
Rev. no.	0		
Init.:	KK		
Date:	2021-01-20		
Project:	88.001 Denka farm -		

預混槽、厭氧槽、曝氣池

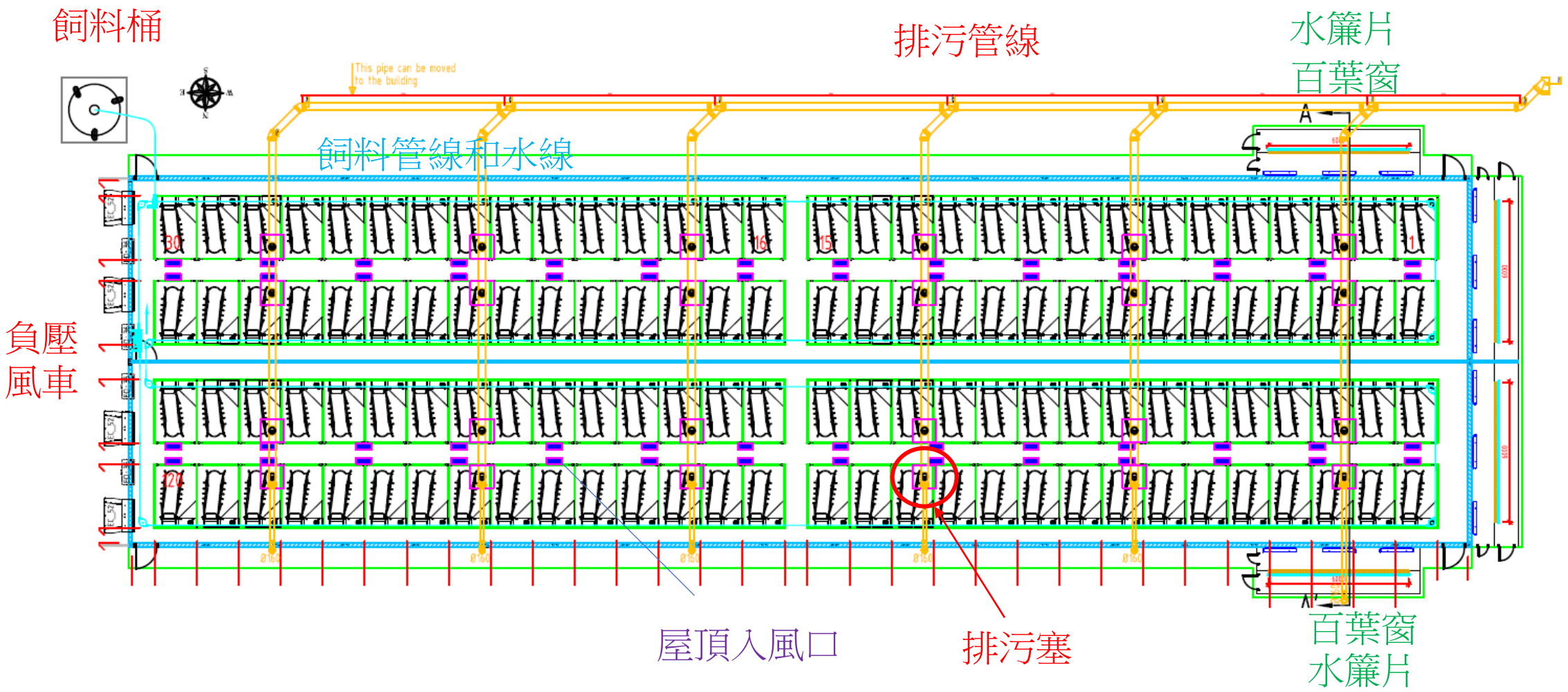
有機肥料 - 固形廢棄物

規劃+施工+試車=兩年完工

現代化的畜舍

- 密閉隔熱
- 水簾降溫
- 溫度控制
- 濕度監測
- 隧道式通風

產房(分娩舍)設備排列


飼料桶
排污管線
水簾片
百葉窗
This pipe can be moved to the building
飼料管線和水線
負壓
風車
屋頂入風口
排污塞
百葉窗
水簾片

輕型鋼結構畜舍與隔熱

- 高張力型鋼材質
- 專利多層結合方式
- 螺桿與螺釘並用
- 消除焊接應力與防止生鏽
- 多層次隔熱防冷凝水設計

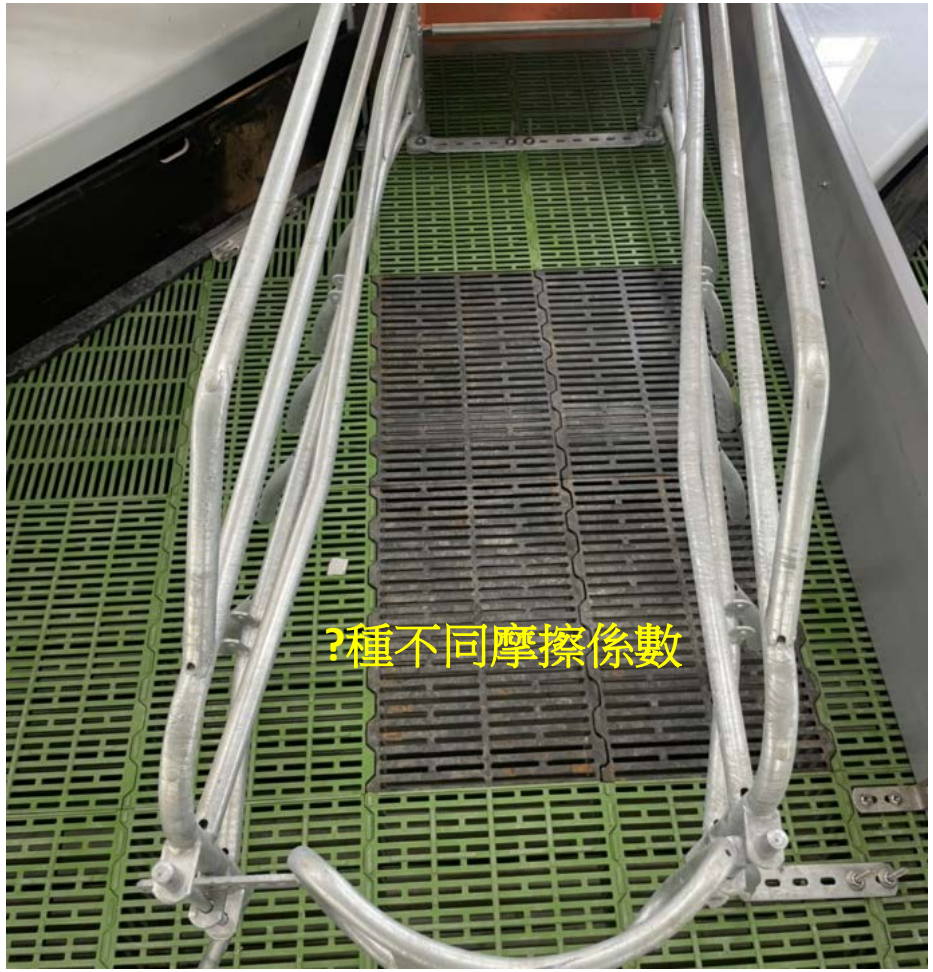
負壓、熱對流、水簾

大氣自然對流
舍內完全氣密
水簾防蟲鳥罩

Fr: www.unitedivory.com

Designed by: United Ivory

好的設計也要有好的施工



不鏽鋼自鎖螺帽

常用材料特性

	溫度℃	密度g/cm³	比熱 J/g℃	導熱係數W/m-K
水	20	1	4.184	0.6
水泥	20	1.9-2.3	0.88	0.8-1.4
鑄鐵	20	7.28	0.461	48
PVC	20	1.35-1.45	0.84-1.17	0.13-0.29
*BMC	25	1.87-1.90	0.846	1.52
矽橡膠	20	0.97	1.6	0.2

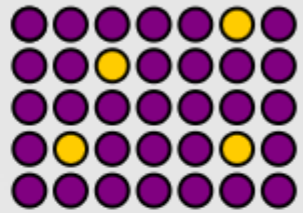
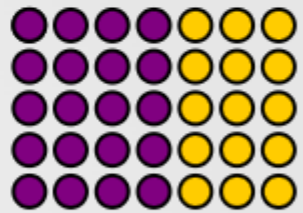
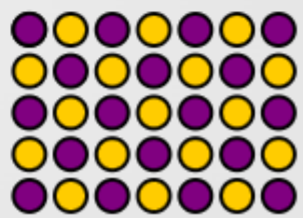
https://heater.heat-tech.biz/tc/infrared-panel-heater/science-of-the-infrared-rays/7747.html

*https://www.materialdatacenter.com/ms/en/BMC/Bulk+Molding+Compounds,+Inc/BMC+350/10a99946/498

*BMC 940-14868C在25℃的比熱是0.846，導熱係數13.4。

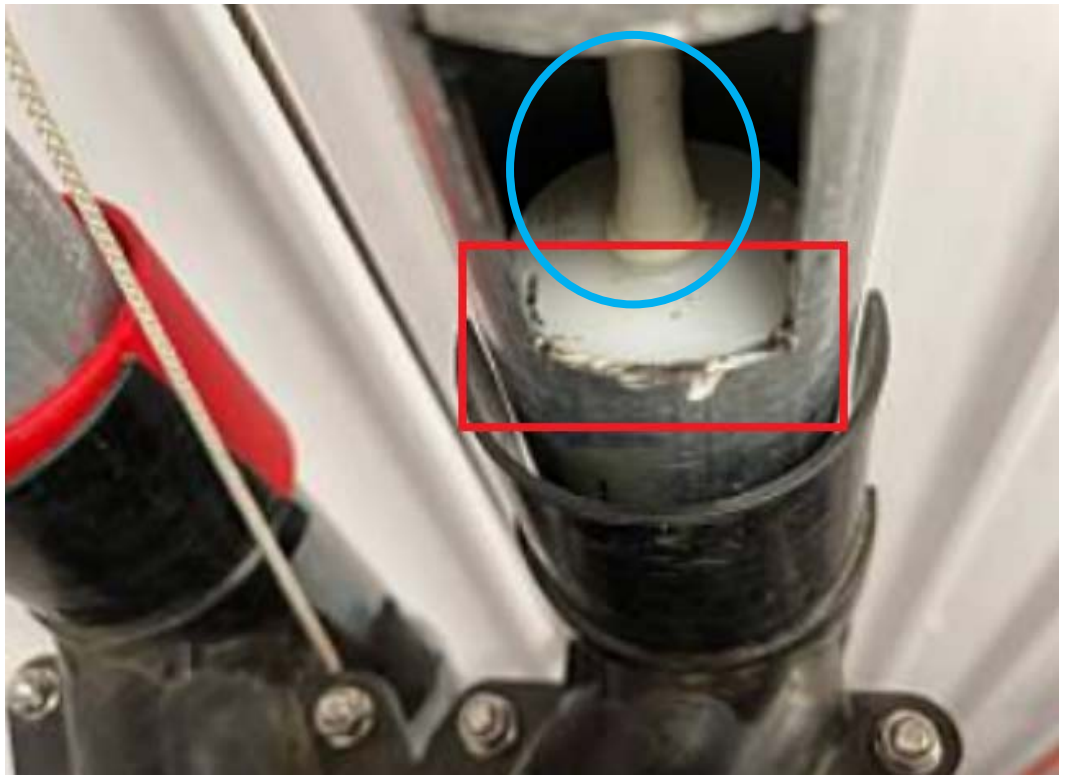
空氣:0.0267W/m-k

Terms & Definitions

Alloy	combination of **elements** (at least 1 metal) in **solid-solution** with overall **metallic properties**	
Composite	combination of other **materials**, where the **mixed** materials **remain physically distinct**	
Compound	combination of elements with **chemical bonds,** with very different properties from it's base elements	

https://msestudent.com/the-difference-between-alloys-and-composites-and-compounds/

配種舍飼料管線切口

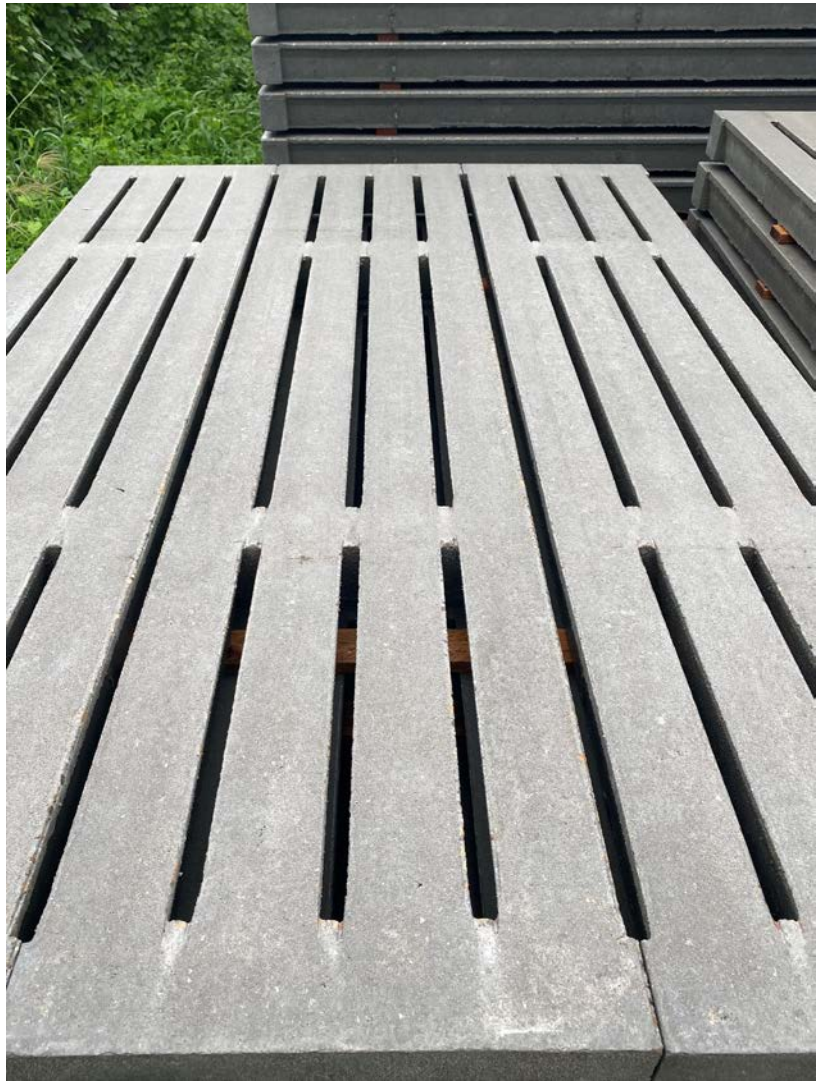


鍍鋅鋼的隱藏風險

飼料桶

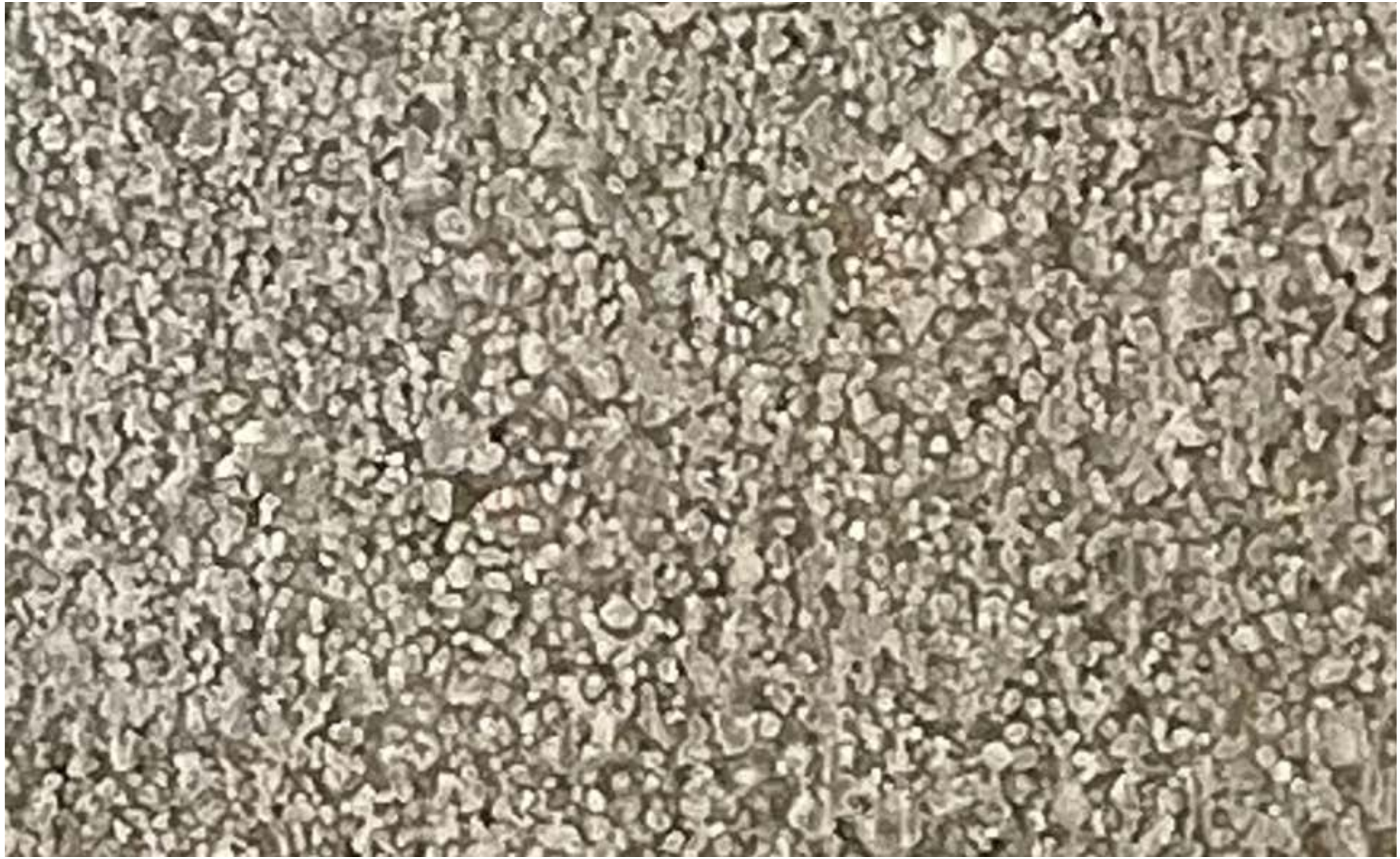
- 特殊低摩擦係數材質橢圓形料桶本體，粉粒料不易黏著。
- 特殊桶槽強化環，耐豬隻衝撞，兼具減小飼料與桶壁內側摩擦力，避免架橋度。
- 桶內鍍鋅材質分隔板，造成不架橋的90度桶壁，且強化飼料桶側向防撞力。
- 中間分隔板自然形成非幾何對稱桶型，破壞對稱型的架橋結構。
- 調整下料間隙的不銹鋼軸，豬隻進食時撞擊黑色分料器，產生的震動有助破壞架橋。
- 黑色分料器裝有可旋轉的垂直刮板，刮除錐斗底部飼料卡壁而讓流料順暢不架橋。
- 先進先出不卡料，飼料新進新出，豬隻都吃新鮮的飼料。

水泥不只是水泥



給牠舒服一輩子

不怕滑倒、不怕擦傷



animals

MDPI

Article

Effect of Slat and Gap Width of Slatted Concrete Flooring on Sow Gait Using Kinematics Analysis

Nicolas Devillers [1,*], Emmanuel Janvier [1], Farhoud Delijani [2], Steve Méthot [1], Kristopher J. Dick [2], Qiang Zhang [2] and Laurie Connor [3]

1 Agriculture and Agri-Food Canada, Sherbrooke Research and Development Centre, 2000 College Street, Sherbrooke, QC J1M 0C8, Canada; e.janvier@groupe-esa.net (E.J.); steve.methot@canada.ca (S.M.)
2 Department of Biosystems Engineering, University of Manitoba, Winnipeg, MB R3T 5V6, Canada; umdelija@cc.umanitoba.ca (F.D.); Kristopher.Dick@umanitoba.ca (K.J.D.); Qiang.Zhang@umanitoba.ca (Q.Z.)
3 Department of Animal Science, Faculty of Agricultural and Food Sciences, University of Manitoba, Winnipeg, MB R3T 2N2, Canada; Laurie.Connor@umanitoba.ca
* Correspondence: Nicolas.Devillers@canada.ca

Received: 4 April 2019; Accepted: 26 April 2019; Published: 30 April 2019

check for updates

水泥地板的間隙對於背部角度、步幅長度、腿長、以及前肢腕關節和後肢跗關節角度有顯著影響。水泥條的寬度則對腿長、前肢腕關節和後肢跗關節角度有顯著影響。結果顯示，在不同水泥條寬度和水泥地板間隙的組合中，以寬度為105-125 mm的水泥條和間隙為19-22 mm的組合，對於新女豬和母豬的步態影響最小。

負壓畜舍成敗的關鍵

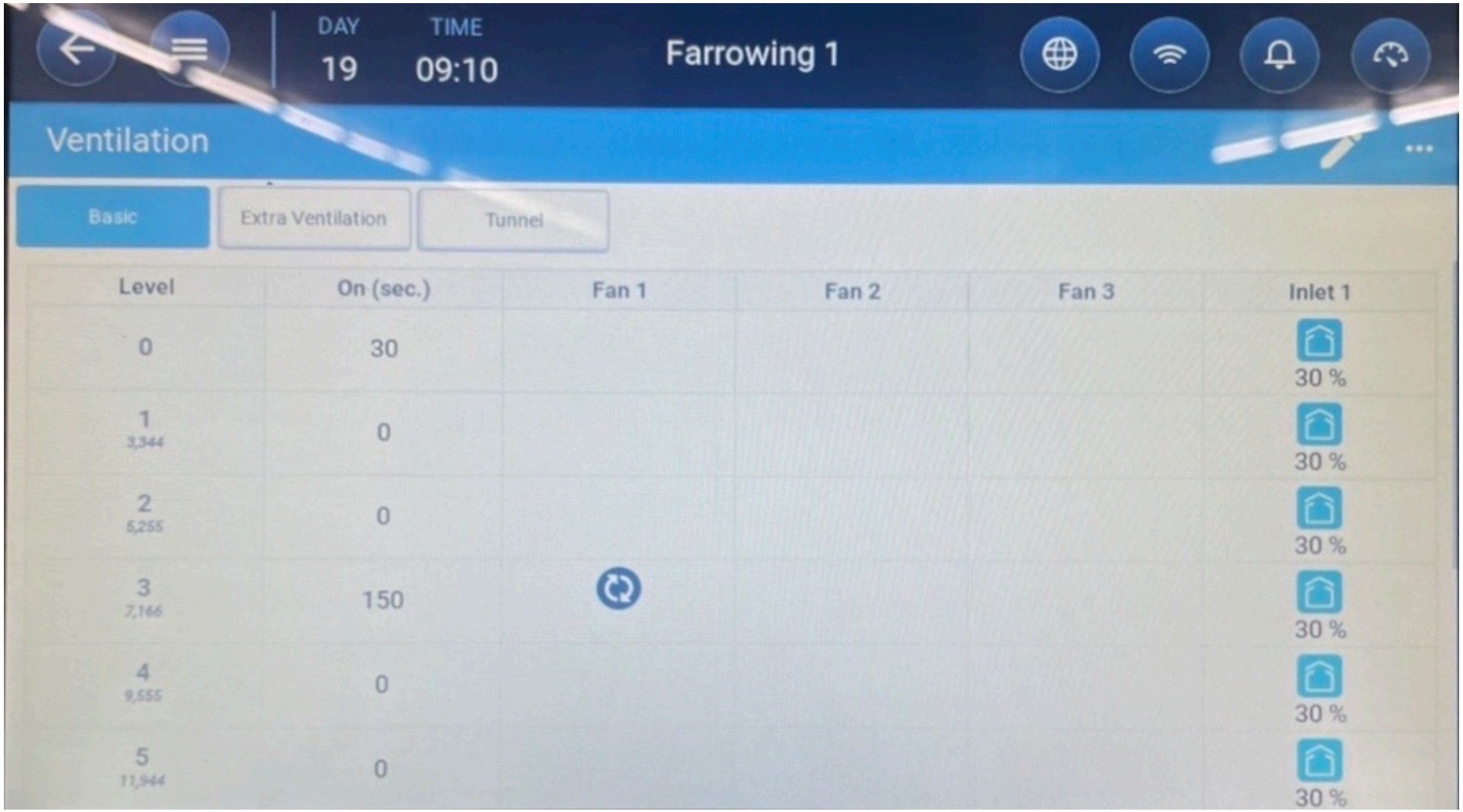
氣密性，不能漏氣

適當的風壓

適當的風量

正確的安裝位置

通風設定(台南)_基本換氣

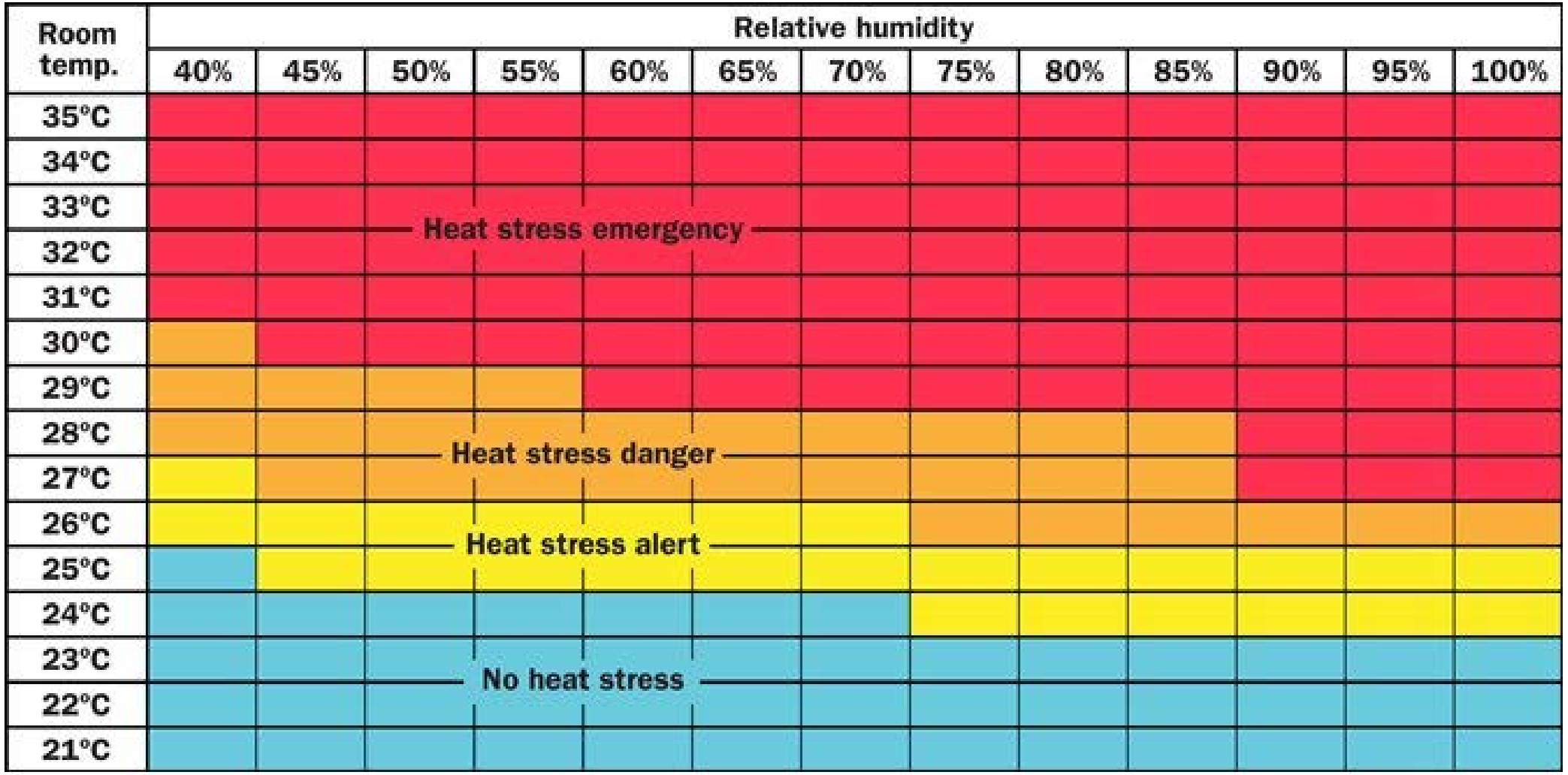

DAY
19
TIME
09:10
Farrowing 1
Ventilation
Basic
Extra Ventilation
Tunnel
Level
On (sec.)
Fan 1
Fan 2
Fan 3
Inlet 1
0
30
30 %
1
3,344
0
30 %
2
5,255
0
30 %
3
7,166
150
30 %
4
9,555
0
30 %
5
11,944
0
30 %

通風設定_依溫差需要LEVEL 1-14

通風設定_隧道式通風


DAY
19
TIME
09:11
Farrowing 1
Ventilation
Basic
Extra Ventilation
Tunnel
Level
Diff
Fan 1
Fan 2
Fan 3
Tunnel 1
T1
49,000
0.0 °C
100 %
T2
66,200
1.5 °C
100 %
T3
98,000
2.0 °C
100 %
T4
115,200
3.0 °C
100 %

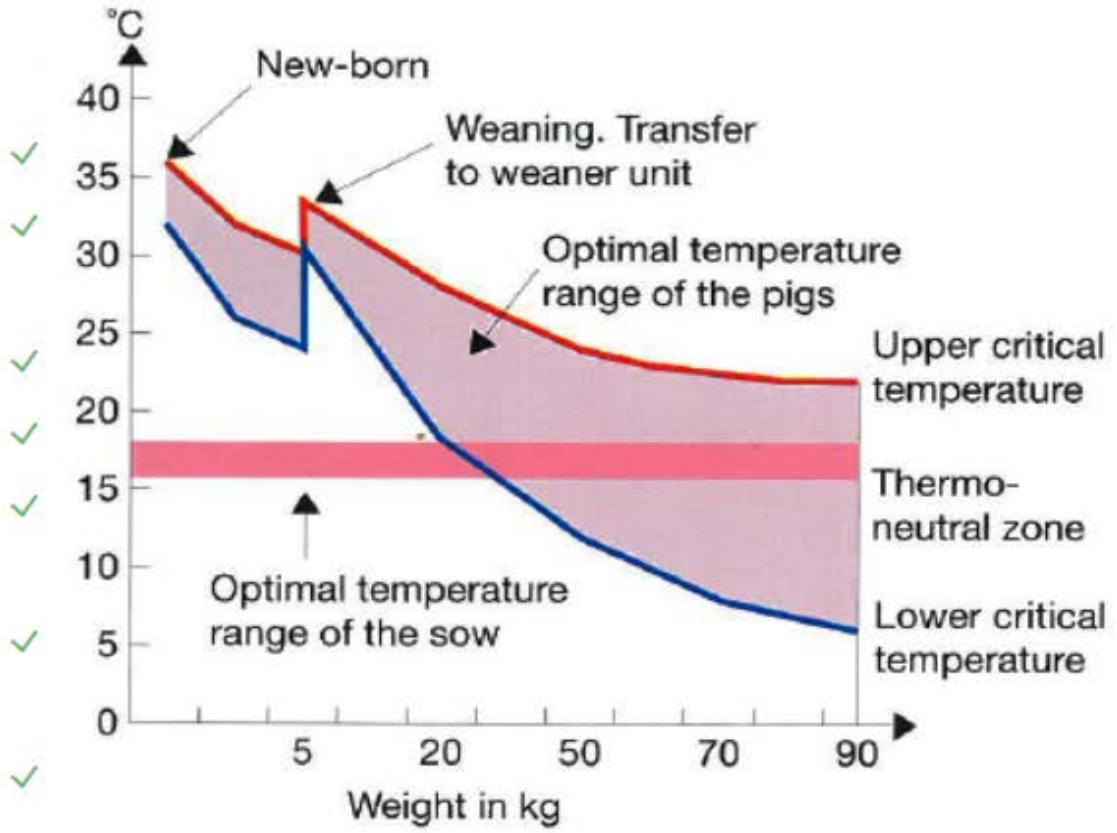
生長-肥育豬的熱緊迫指數



https://onswine.wordpress.com/2019/07/15/avoid-production-losses-in-swine-due-to-heat-stress/.

不同年齡的豬有不同溫度需求：

- ✓ Piglets in the farrowing unit requires 35°-28° Celsius depending on age and house design
- ✓ Weaners require from 28° to 20° Celsius depending on weight
- ✓ Finishers require from 22°-16° Celsius depending on weight and floor layout



The impact of heat stress on finishers:

Increasing respiratory rate

Extending body contact to the floor (for cooling)

Drinking more water

Inactive

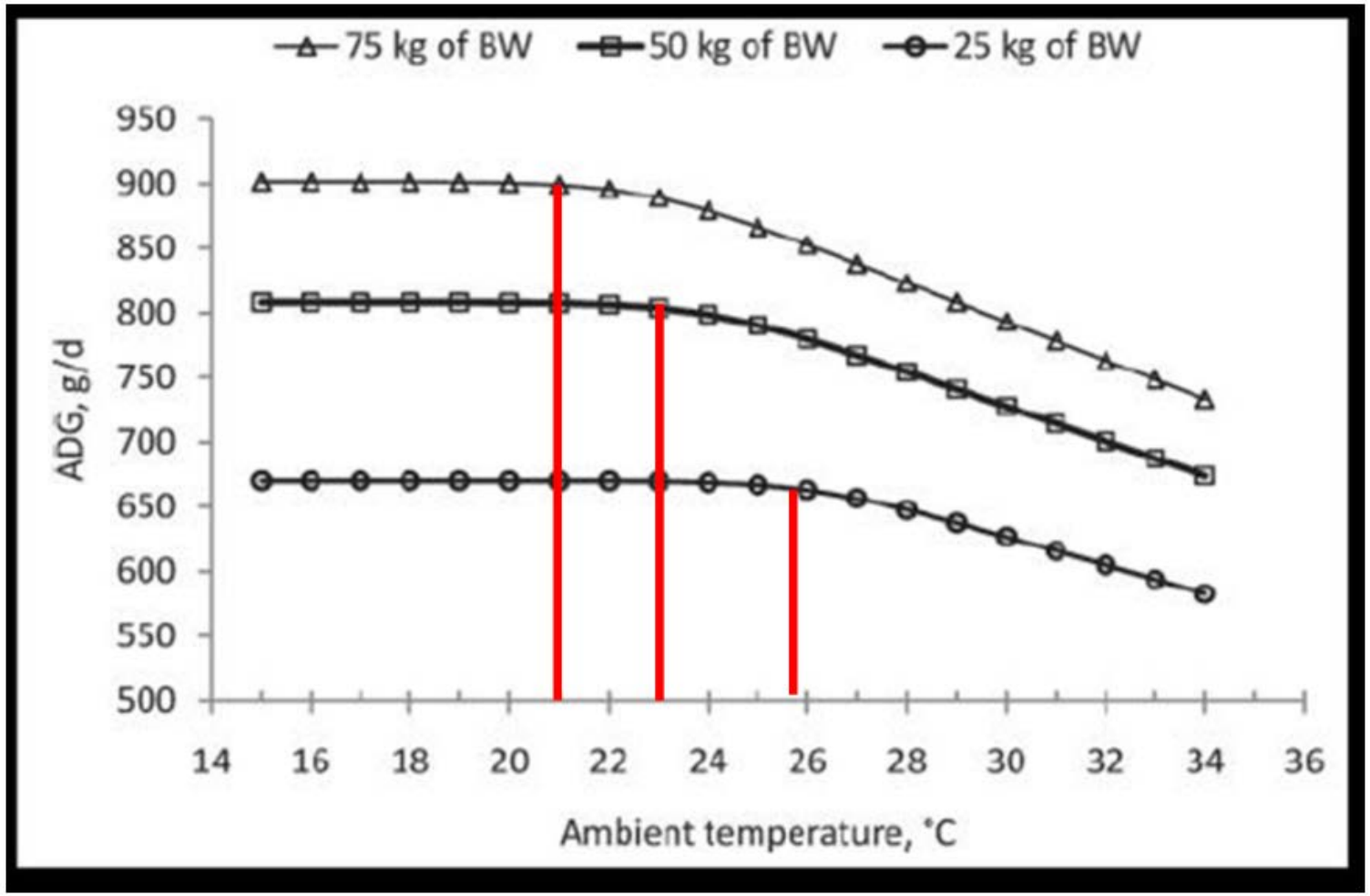
Avoid physical contact with other pigs

Increase evaporative heat loss by wallowing behaviour

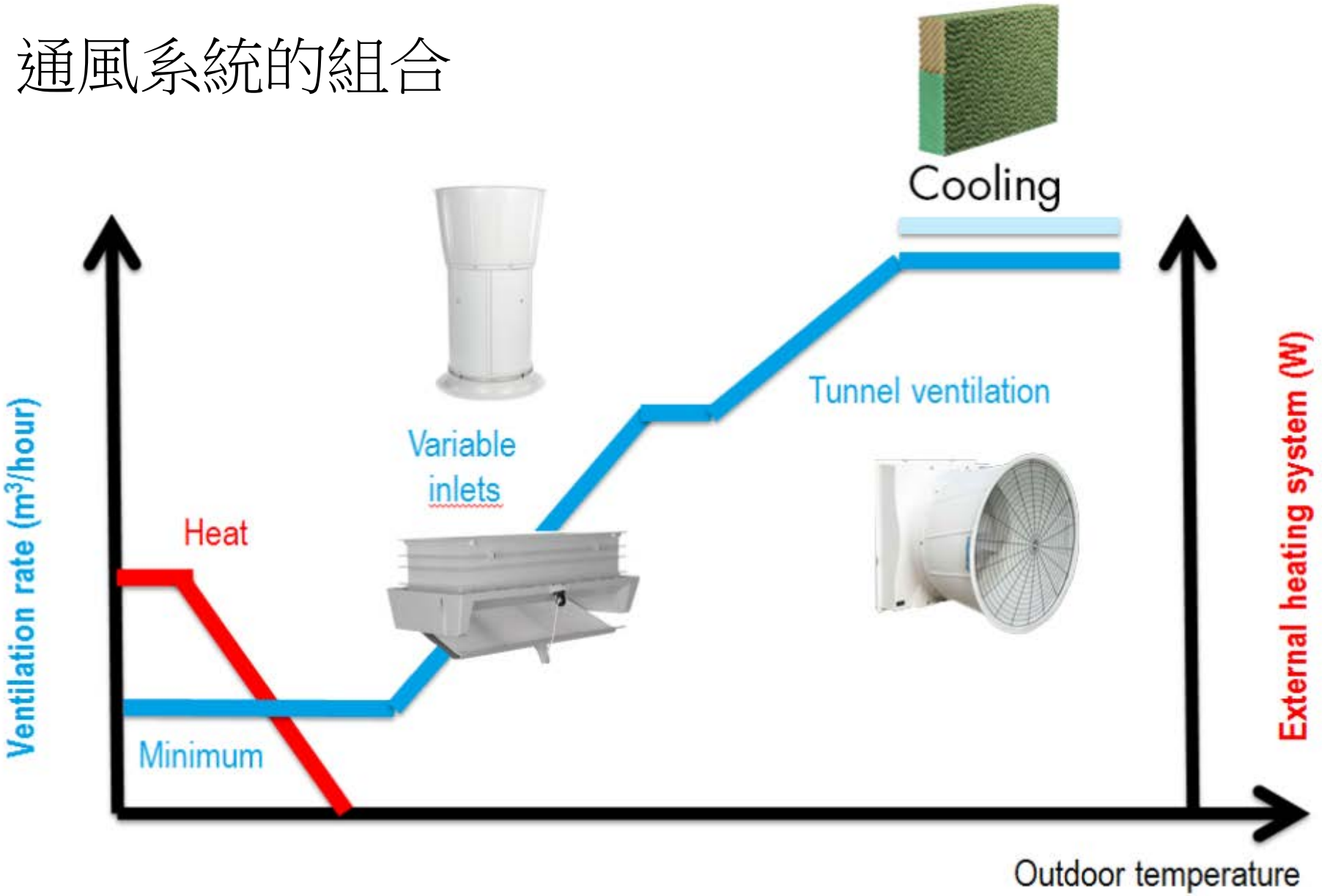
Feed intake declines

熱緊迫會轉換成生產損失:

- ✓ 35% of feed energy is used for growth (!)
- ✓ 20% for maintenance, 20% for heat and 25% for urine and faeces.
- ✓ When feed intake declines, it has a big impact on average daily gain (ADG):

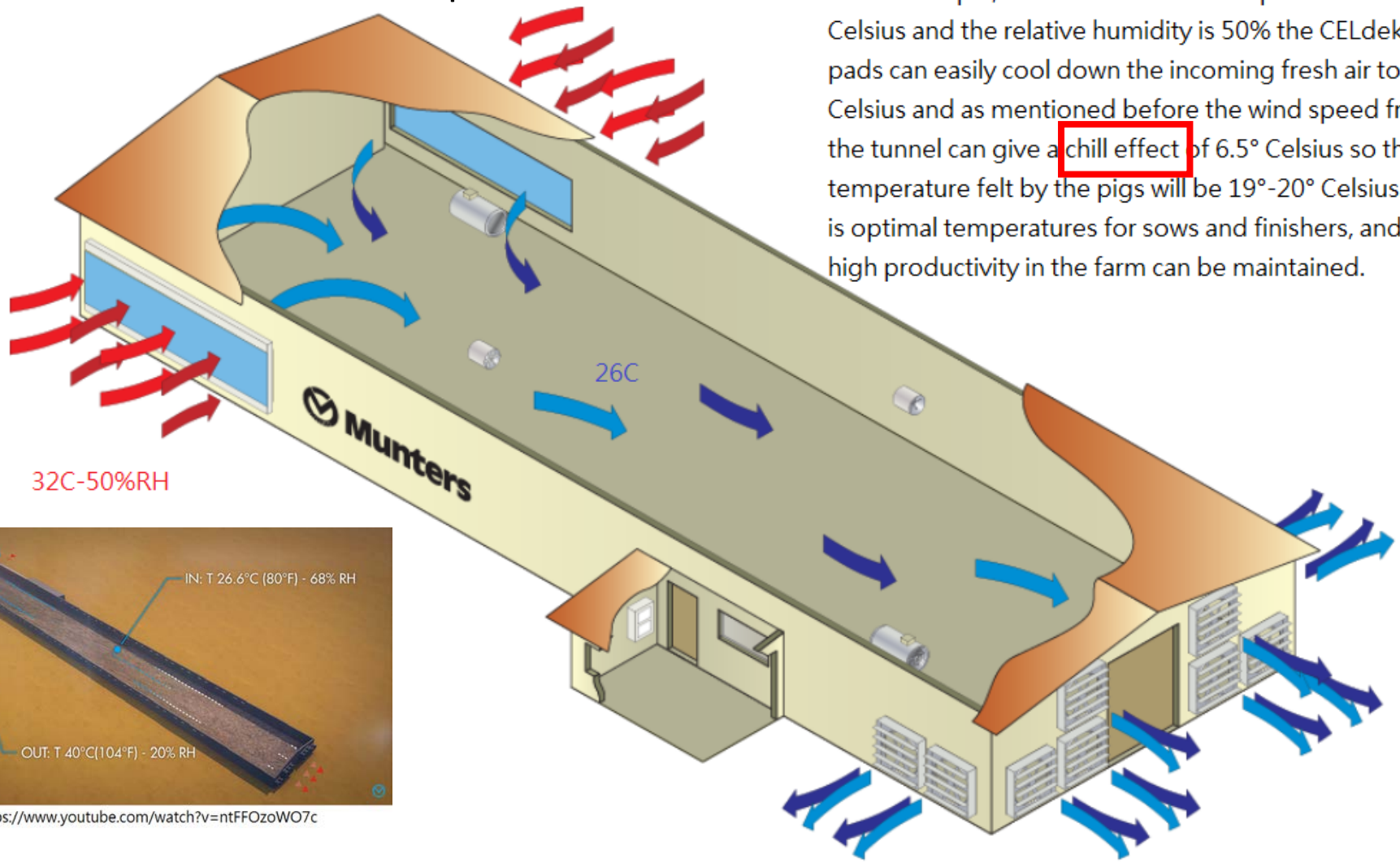


通風系統的組合


Cooling
Tunnel ventilation
Variable
inlets
Heat
Minimum
Ventilation rate (m³/hour)
External heating system (W)
Outdoor temperature

Tunnel ventilation + CELdek® pads

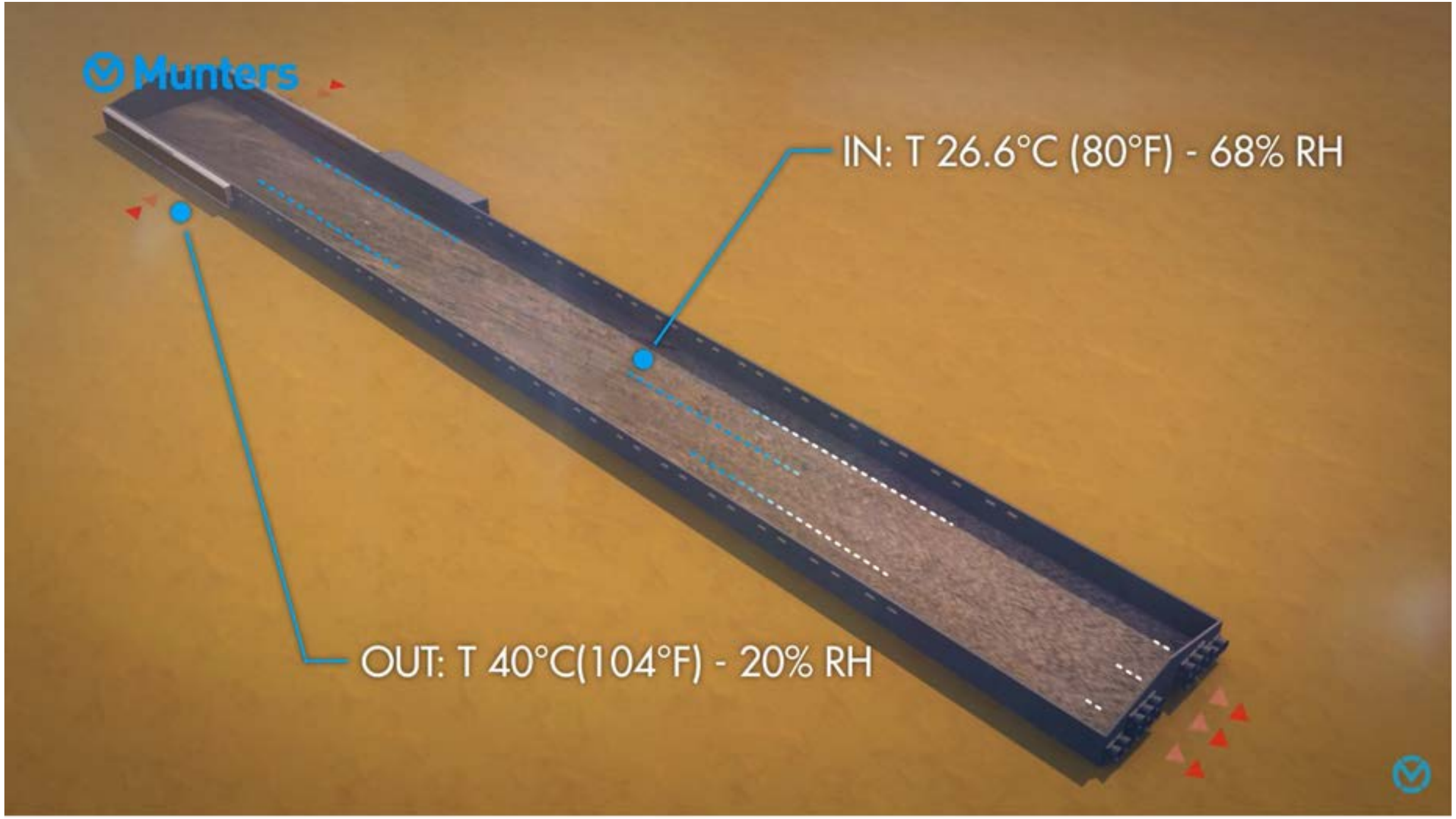
As an example, when the outdoor temperature is 32° Celsius and the relative humidity is 50% the CELdek® pads can easily cool down the incoming fresh air to 26° Celsius and as mentioned before the wind speed from the tunnel can give a chill effect of 6.5° Celsius so the temperature felt by the pigs will be 19°-20° Celsius. This is optimal temperatures for sows and finishers, and the high productivity in the farm can be maintained.



https://www.youtube.com/watch?v=ntFFOzoWO7c

When the room temperature is 26° Celsius the air speed created by tunnel ventilation will reduce the effective temperature felt by the pigs with 6,5° Celsius. That means the temperature felt by the sows and finishers will be 19°-20° Celsius, ensuring the optimal production results.

https://www.munters.com/fr/campaigns/aghort-campaigns/combi-tunnel-ventilation/



https://www.youtube.com/watch?v=ntFFOzoWO7c

WBD Table

	24	26	28	30	32	34	36	38	40 °C
50 %	7	7.39	7.78	8.16	8.54	8.91	9.27	9.62	9.96
55	6.23	6.57	6.92	7.25	7.58	7.91	8.22	8.53	8.82
60	5.47	5.77	6.07	6.37	6.66	6.94	7.21	7.47	7.72
65	4.73	4.99	5.25	5.51	5.75	5.99	6.22	6.44	6.65
70	4.01	4.23	4.45	4.67	4.87	5.07	5.26	5.44	5.61
75	3.3	3.49	3.67	3.85	4.01	4.17	4.33	4.47	4.6
80	2.6	2.75	2.9	3.04	3.18	3.3	3.41	3.52	3.61
85	1.92	2.04	2.15	2.26	2.36	2.44	2.52	2.59	2.65
90	1.25	1.33	1.41	1.49	1.55	1.61	1.65	1.69	1.72
95	0.59	0.64	0.69	0.73	0.76	0.79	0.8	0.81	0.8
100	0	0	0	0	0	0	0	0	0

WBD (Wet Bulb Depression) = dry bulb Temperature – wet bulb Temperature

$$\Delta T = WBD * Efficiency$$

註：本論文建模於溫室應用。

Pad&Fan在台灣仍有發揮空間

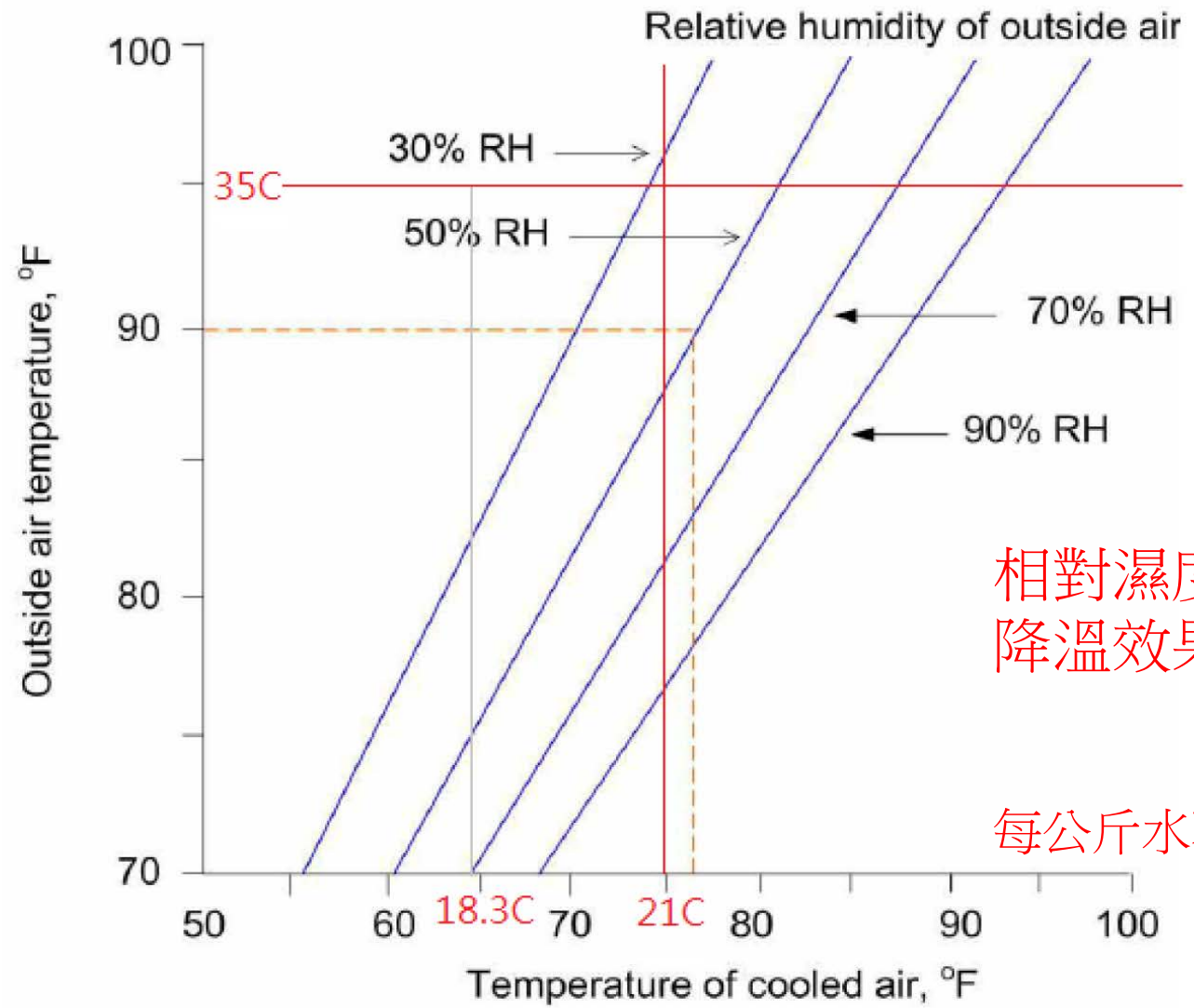
Probability of occurrence for the selected locations of Taiwan.

City (location in Taiwan)	T≥30°C	RH≥80%	T≥30°C & RH≥80%
Taipei (Northern tip)	11.43 %	50.12 %	0.092 %
Hualien (North of East coast)	6.72	48.83	0.31
Ilan (North of East coast)	7.45	69.25	0.45
Tainan (South of west coast)	11.80	51.68	0.45
Kaohs			0.38
Chiayi (South of west coast)	8.81	67.40	0.12
Taichung (Center of west coast)	10.39	48.31	0.01
Alishan (mountain area)	0.00	73.32	0.00
Taitung (South of East coast)	9.65	30.07	0.25
Wuchi (Center of west coast)	8.79	47.95	0.39

∴高溫與高濕不同時存在

92年度生機與農機論文發表會 溫室蒸發冷卻設計軟體之建立 台大生機系-方煒教授

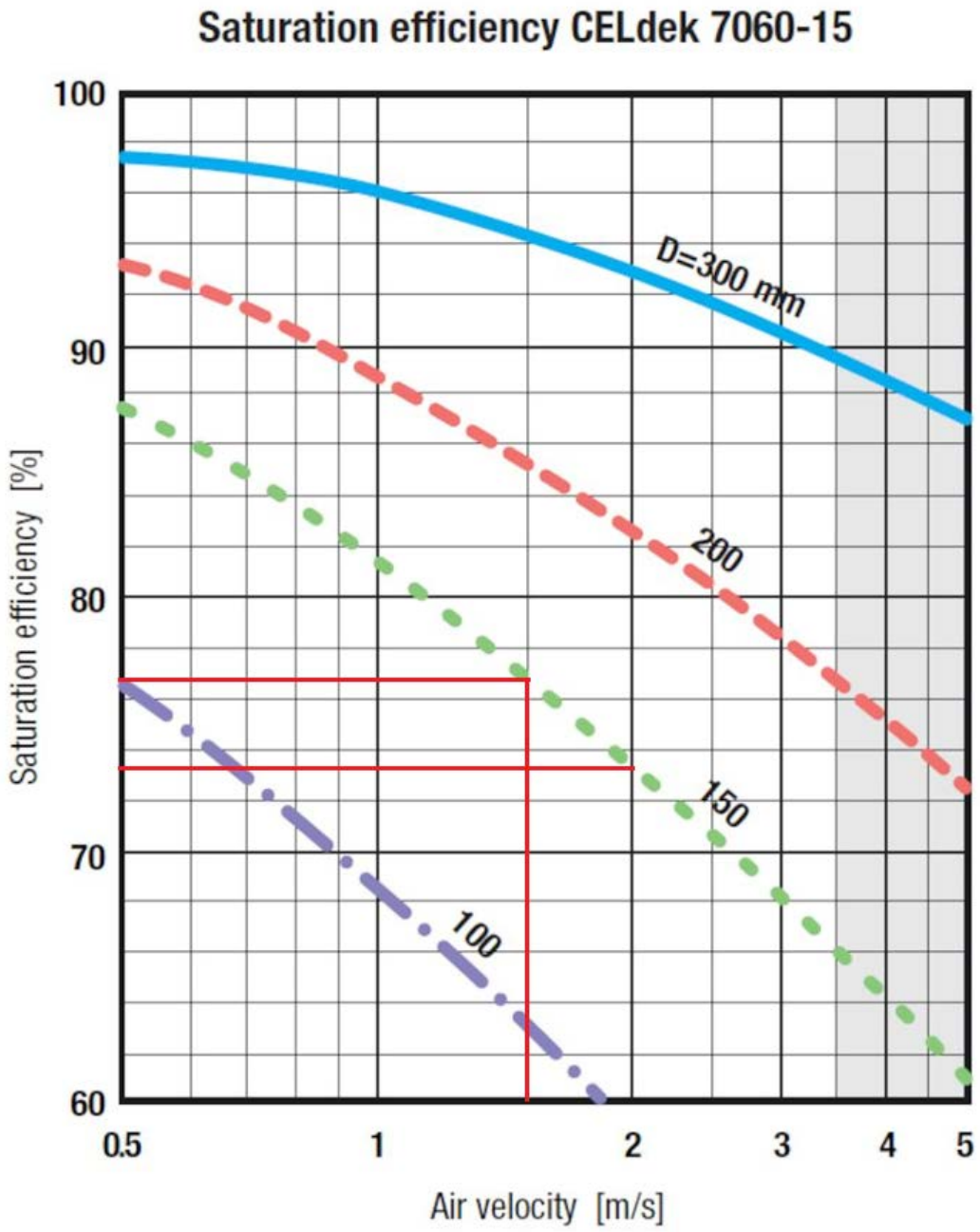
Air temperature drop thru a Cooling Pad



相對濕度越低
降溫效果越好

每公斤水蒸發吸收539Kcal熱量

https://www.researchgate.net/figure/Cooling-potential-of-85-efficient-evaporative-cooling-systems_fig4_237365768



Delta T@[150 -1.5m/s]
=(40-22)*76.4%
=13.75degC

Temp in house=40-13.75=26.3degC

Effective Temperature for Poultry and Pigs in Hot Climate

Abstract

Existing knowledge on the relative significance of air temperature, humidity, and velocity in a hot environment for housed pigs and poultry is reviewed and synthesized in an effective temperature (ET) equation. The suggested unit has an easily perceivable scale where ET is equal to air temperature if the relative humidity is 50% and the air velocity is 0.2 ms^{-1}. The included method to determine the relative significance of air temperature and humidity is similar to the way it is done in the Temperature Humidity Index. Several authors have suggested different Thermal Humidity Indices for different categories of animals, but this chapter found no evidence that the relative importance of temperature and humidity is different for pigs than for poultry or for large than small ones. The suggested ET equation includes a separate velocity term, which assumes that the chill effect is proportional to the **air** velocity or to the square root of the **air** velocity and that the chill effect declines linearly with increased **air** temperature until it becomes insignificant as the **air** temperature approaches the animal body temperature.

Keywords: effective temperature, heat stress, thermal humidity index, air velocity, poultry and pig production

Effective Temperature on Animal in barn with tunnel ventilation

Meassured dry bulb temp:	Tdb	26.5	Link to Omni claculator for webbulb temp:
Meassured Relative Humidity:	RH	86%	https://www.omnicalculator.com/physics/wet-bulb
Wet bulb temp From Table:	Twb	24.6	19.3 RH=50%
Constant of Eq.	c	0.7	
Constant of Eq.	d	43	
Constant of Eq.	e	0.5	
Meassured/Designed:	v	1.5	m/s air velocity
Original Equation:	ET=	0.794*Tdb + 0.25*Twb + 0.7	
Calculation:	ET=	26.6	while RH=50% for equation check
Modified Equation:	ET=	0.794*Tdb + 0.25*Twb + 0.7 - c*(d - Tdb)*(v^e - 0.2^e)	
Calculation:	ET	18.91	degC temp felt under air velocity v(m/s)

Reference:

Effective Temperature for Poultry and Pigs in Hot Climate
http://dx.doi.org/10.5772/intechopen.72821

dependency with velocity (e = 1 or 0.5). The best quadratic correlation (r-square value of 0.97) was obtained at c = 0.7, d = 43°C, and e = 0.5

$$ET = 0.794t_{db} + 0.25t_{wb} + 0.70 - c(d - t_{db})(v^e - 0.2^e) \quad (7)$$

2950 Niles Road, St. Joseph, MI 49085-9659, USA
269.429.0300 fax 269.429.3852 hq@asabe.org www.asabe.org

An ASABE Meeting Presentation
DOI: 10.13031/aim.201700631
Paper Number: 1700631

Modeling skin temperature to assess the effect of air velocity to mitigate heat stress among growing pigs

ABSTRACT. *It is generally accepted that increased air velocity can help to mitigate heat stress in livestock housing, however, it is not fully clear how much it helps and significant uncertainties exists when the air temperature approaches the animal body temperature. This study aims to develop a skin temperature model to generated data for determining the potential effect of air velocity to mitigate heat stress among growing pigs housed in warm environment. The model calculates the skin temperature as function of body temperature, air temperature and the resistances for heat transfer from the body to the skin and from the skin to the surroundings. The latter is modelled as the united resistance for convection, radiation and evaporation. The model considers that the thermal heat load affects the tissue resistance, the body temperature and the evaporation from the skin, which is managed by modeling the tissue resistance, the body temperature and evaporation from the skin as functions of the skin temperature. The results indicate that the combination of an air temperature of 24 °C and an air velocity 0.2 m/s results in the same skin temperature as the combinations of 27 °C and 0.6 m/s, and of 30 °C and 1.9 m/s.*

Keywords. Effect of air velocity Effective temperature, Heat stress, Pigs, Skin temperature.


Bjarne Bjerg
University of Copenhagen
80 PUBLICATIONS 1,283 CITATIONS


Poul Pedersen
SKOV
15 PUBLICATIONS 339 CITATIONS


Svend Morsing
SKOV A/S
36 PUBLICATIONS 682 CITATIONS


Guoqiang Zhang
Aarhus University
194 PUBLICATIONS 3,112 CITATIONS

Development of a model to simulate a heat stress related response.

Heat stress is related to several physiological parameter as heart rate, respiratory rate, body temperature and skin temperature. Among these, skin temperature has the advantage that it is affected by thermal conditions both at high and lower heat load, and therefore it occurs most relevant to investigate the possibility to model the skin temperature.

The skin temperature (t_{skin},°C) is related to body temperature (t_{body},°C) ambient temperature (t,°C) tissue resistance (R_{tissue}, °C m^{-2} W^{-1}), and resistance from the skin to the surroundings (R_{sour}, °C m^{-2} W^{-1}) as illustrated in Figure 5 and can be calculated as:

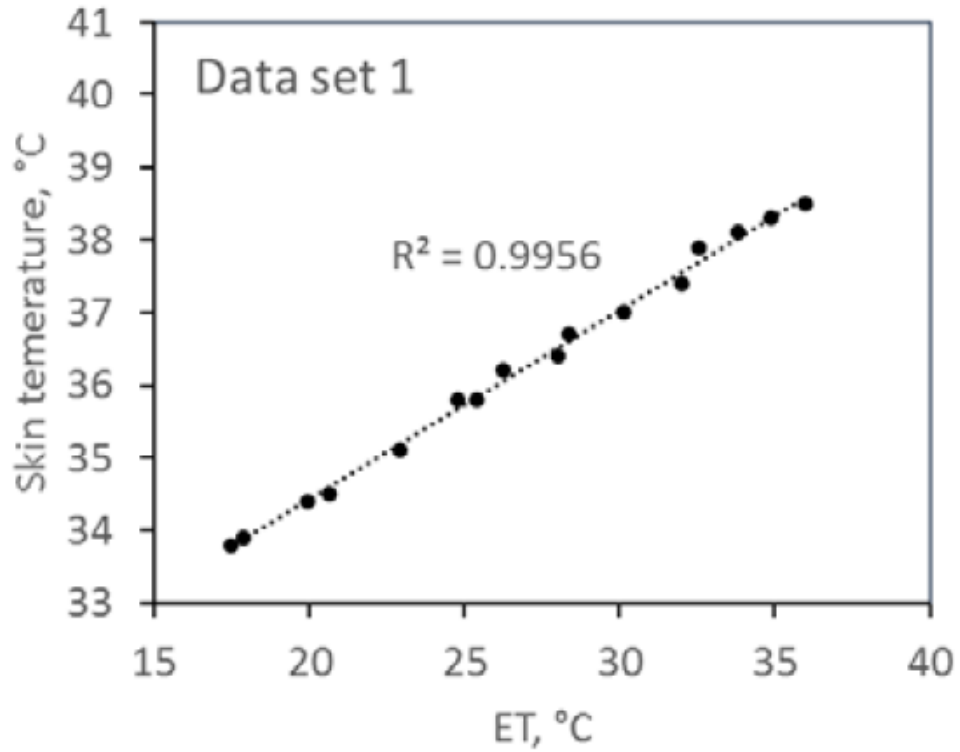
5種不同溫度和5種風速條件下的體溫

Table 2. Two dataset generated by calculating skin temperatures at 5 levels of ambient temperature and 5 levels of air velocity for two different assumption for skin temperature at 0.2 m s^{-1}, see Figure 8.

Data set		1					2				
Skin temperature at 0.2 m/s		As Huynh et al. (2005)					Alternative assumption				
Body temperature		Eq. 8					Eq. 12				
Tissue resistance		Eq. 11					Eq. 13				
Air velocity, m s^{-1}		0.2	0.5	1.0	2.0	3.0	0.2	0.5	1.0	2.0	3.0
Ambient temperature, °C:	20	34.3	33.4	32.4	31.1	30.3	35.5	34.0	32.2	29.9	28.5
	24	35.2	34.5	33.8	32.8	32.1	36.5	35.7	34.6	32.9	31.8
	28	36.4	35.8	35.1	34.4	33.9	37.7	36.8	36.2	35.3	34.6
	32	37.4	37.0	36.7	36.2	35.8	39.1	38.5	37.8	37.0	36.6
	36	38.5	38.3	38.1	37.9	37.7	40.0	39.8	39.6	39.2	38.9

24℃ - 0.2m/s，27℃ - 0.7m/s，30℃ -1 .9m/s的體溫一樣

豬隻皮膚溫度與有效溫度



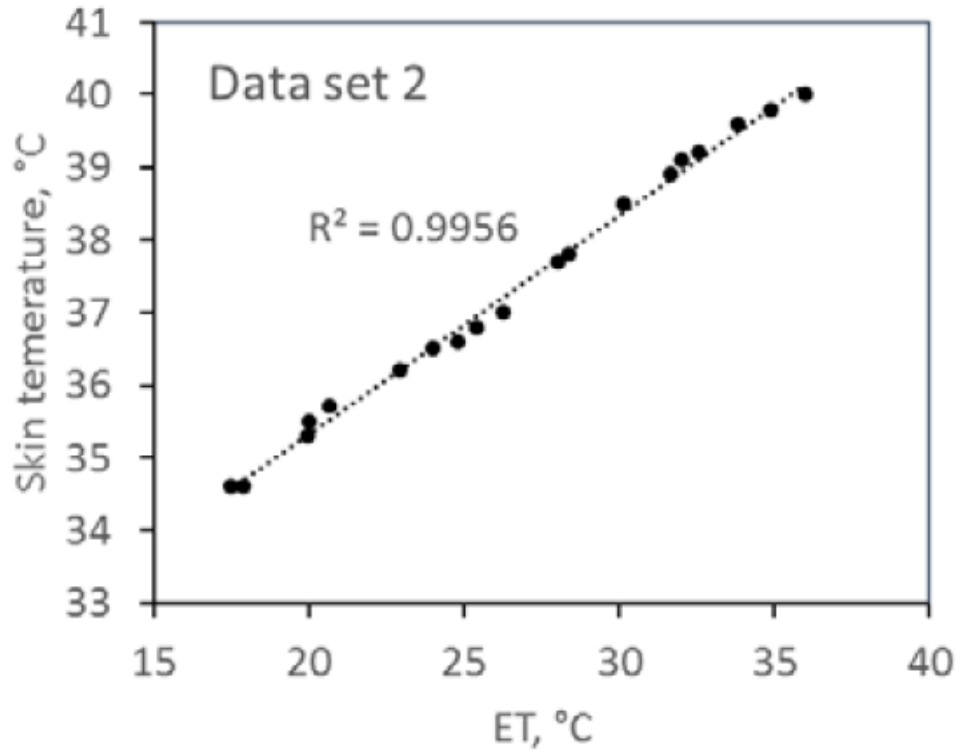


Figure 11. Estimated skin temperature as function of ET for the two data set mentioned in Table 2 (c=-1, d=42 and 2=0.28).

Effective Temperature on Animal in barn with tunnel ventilation

Meassured dry bulb temp:	Tdb	26.5	Link to Omni claculator for webbulb temp:	
Meassured Relative Humidity:		86%	https://www.omnicalculator.com/physics/wet-bulb	
Wet bulb temp From Table:	Twb	24.6	19.3	RH=50%
Constant of Eq.	c	-1		
Constant of Eq.	d	42		
Constant of Eq.	e	0.25		
Meassured/Designed:	v	1.5	m/s air velocity	

Equatioon	ET=	=Tdb+c*(d-Tdb)*(v^e-0.2^e)	
Calculation	ET=	19.7	Deg C
Chill effect		6.8	Deg C

Table 4. Chill effect of velocity calculated by Eq. 1, assuming c=-1, d=42 °C and e=0.25.

		Air velocity, m s^{-1}				
		0.2	0.5	1.0	2.0	3.0
Ambient temperature, °C:	20	0	4	7	11	14
	24	0	3	6	9	12
	28	0	2	5	7	9
	32	0	2	3	5	6
	36	0	1	2	3	4

$$ET = t_{ambient} + c(d - t_{ambient})(v^e - 0.2^e) \qquad (1)$$

The effect of air temperature, velocity and humidity on respiration rate and rectal temperature as an expression of heat stress in gestating sows

目標是開發一個生理有效溫度(ET) 方程來預測空氣溫度、速度和相對濕度是如何影響呼吸率 (RR)、肛溫（RT）和皮膚溫度（ST）當作懷孕母豬熱緊迫的表現，用以闡明熱參數與母豬對環境的感受之間的關係。

Journal of Thermal Biology 104 (2022) 103142

ABSTRACT

Global warming combined with increased production (i.e. more piglets, more milk and consequently more heat) means that sows are more often challenged by heat stress. The objective was to develop an effective temperature (**ET**) equation to predict how air temperature, velocity and humidity affect the respiration rate (**RR**), rectal temperature (**RT**) and skin temperature (**ST**) as an expression of heat stress in gestating sows in order to elucidate the relationship between the thermal parameters and the sows' perception of the environment.

The experimental room was equipped with a negative pressure ventilation system with diffuse air inlet through the ceiling, electrical heaters, steam generators and dehumidifiers. An air distribution unit was constructed to generate vertical air velocity. A total of 16 gestating sows were exposed to three temperatures (25°C, 29°C and 33°C), two levels of relative humidity (30% and 70%) and three levels of air velocity (0.2 ms^{-1}, 1 ms^{-1} and 2.5 ms^{-1}). The RR, RT and ST were recorded every 30 min throughout the three 2-h test periods.

The estimated effects of humidity and velocity in relation to effect of temperature was nearly independent of whether it was determined from RR or RT, whereas the effect of humidity was much smaller when determined from ST. High coefficients of determination (>0.97) were found for the second order relationship between the estimated ET and RR, RT and ST. An increase in relative humidity from 50 to 70% corresponded to an increase in ET of 0.9°C, while an increase in air velocity from 0.2 to 1.0 ms^{-1} corresponded to a decrease in ET of 1.2°C. The applied ET equation was useful for expressing the combined effect of temperature, humidity and velocity on animals exposed to heat stress. However, multiplying the effect of velocity by the temperature gradient between the animal and the surrounding air did not improve the estimation.

P. Brandt [a], B. Bjerg [a,*], P. Pedersen [b], K.B. Sørensen [c], L. Rong [d], T. Huang [d], G. Zhang [d]

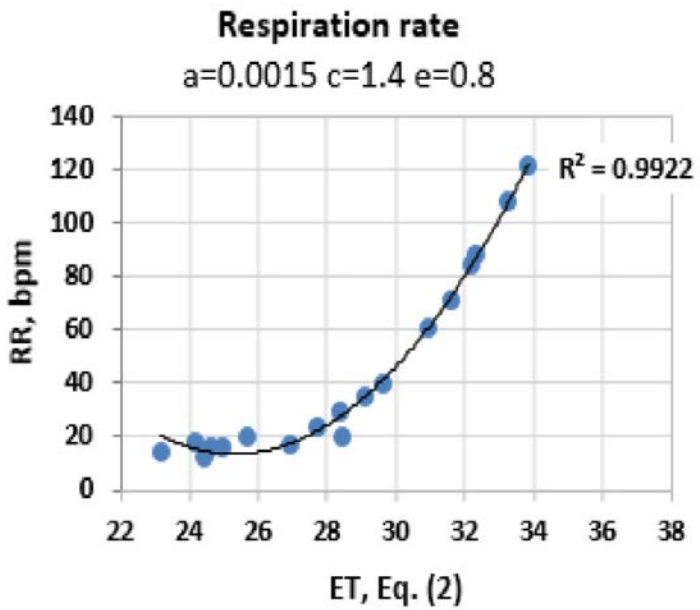
[a] *Department of Veterinary and Animal Sciences, University of Copenhagen, Grønnegårdsvej 2, 1870 Frederiksberg C, Copenhagen, Denmark*
[b] *Skov A/S, Hedelund 4, Glyngøre, 7870 Roslev, Denmark*
[c] *SEGES Pig Research Centre, Axeltorv 3, 1609 Copenhagen, Denmark*
[d] *Department of Civil and Architectural Engineering, Aarhus University, Inge Lehmanns Gade 10, 8000 Aarhus C, Denmark*

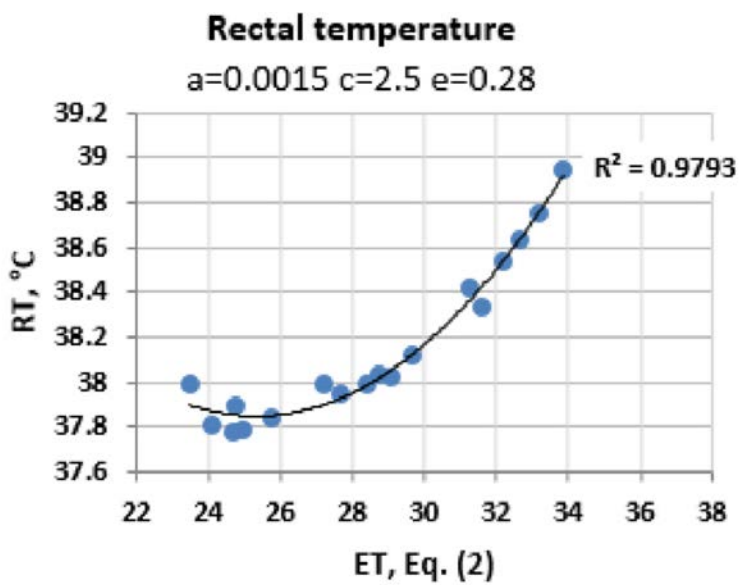
25/29/33三種溫度C，30/70兩種濕度%和0.2/1.0/2.5三種風速m/s條件看懷孕母豬的熱緊迫表現

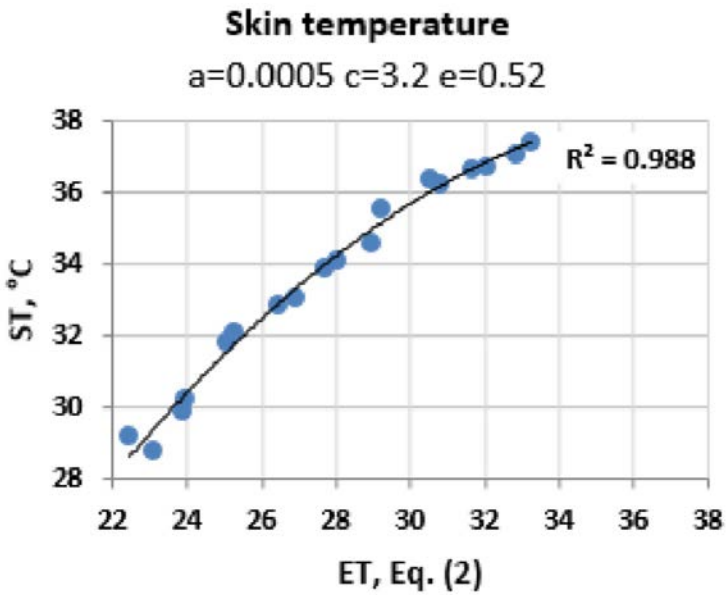
Table 2
Temperature, relative humidity, air velocity, RR, RT and ST for each of 18 combinations of temperature, relative humidity and velocity, average ± SD. Air velocity was measured 40 cm above the floor in the empty facility.

Temperature, °C	Relative, humidity, %	Velocity ms^{-1}	RR, bpm	RT, °C	ST, °C
25.1 ± 0.3	36.2 ± 3.9	0.17 ± 0.04	16.5 ± 9.6	37.78 ± 0.34	31.80 ± 1.59
25.1 ± 0.3	39.0 ± 2.9	0.61 ± 0.30	17.8 ± 8.5	37.81 ± 0.22	29.88 ± 1.28
25.0 ± 0.1	39.8 ± 3.1	1.41 ± 0.72	14.6 ± 9.1	37.99 ± 0.27	29.22 ± 1.36
29.1 ± 0.3	32.3 ± 3.7	0.17 ± 0.04	29.3 ± 22.5	37.99 ± 0.15	34.57 ± 1.02
29.0 ± 0.2	33.0 ± 2.0	0.61 ± 0.30	23.4 ± 15.2	37.94 ± 0.13	33.90 ± 0.89
29.1 ± 0.2	33.2 ± 4.2	1.41 ± 0.72	17.1 ± 11.6	37.99 ± 0.25	32.89 ± 0.95
33.0 ± 0.2	32.3 ± 1.2	0.17 ± 0.04	84.3 ± 41.3	38.54 ± 0.50	37.08 ± 0.58
33.0 ± 0.2	32.8 ± 2.8	0.61 ± 0.30	71.3 ± 33.8	38.34 ± 0.45	36.64 ± 0.70
33.2 ± 0.3	34.2 ± 6.1	1.41 ± 0.72	61.0 ± 38.9	38.42 ± 0.48	36.37 ± 0.64
24.9 ± 0.3	70.2 ± 3.6	0.17 ± 0.04	20.1 ± 12.5	37.84 ± 0.28	32.10 ± 1.47
24.8 ± 0.1	69.4 ± 1.8	0.61 ± 0.30	15.9 ± 9.4	37.79 ± 0.24	30.23 ± 1.00
25.3 ± 0.3	65.6 ± 2.5	1.41 ± 0.72	12.5 ± 6.1	37.90 ± 0.38	28.79 ± 1.20
28.8 ± 0.1	68.5 ± 3.8	0.17 ± 0.04	39.7 ± 30.6	38.12 ± 0.14	35.56 ± 0.64
28.8 ± 0.1	69.0 ± 1.9	0.61 ± 0.30	34.7 ± 28.6	38.03 ± 0.22	34.08 ± 0.85
29.1 ± 0.2	67.9 ± 2.1	1.41 ± 0.72	20.1 ± 13.6	38.04 ± 0.17	33.10 ± 0.92
32.8 ± 0.1	70.0 ± 0.5	0.17 ± 0.04	121.8 ± 41.0	38.94 ± 0.51	37.42 ± 0.52
32.8 ± 0.1	70.0 ± 0.5	0.61 ± 0.30	108.3 ± 47.9	38.75 ± 0.48	36.71 ± 0.55
32.9 ± 0.1	68.2 ± 3.0	1.41 ± 0.72	88.1 ± 61.4	38.64 ± 0.51	36.26 ± 0.47

Hypothesis 2a. Hypothesis 2a implies that the effect of velocity can be added to Equation [1] by subtracting a power law effect of air velocity. Bjerg et al. (2018a) suggested that the effect of velocity should be set to zero when the air velocity is 0.2 m/s, and we adopted this in our analyses as indicated in Equation [2]:

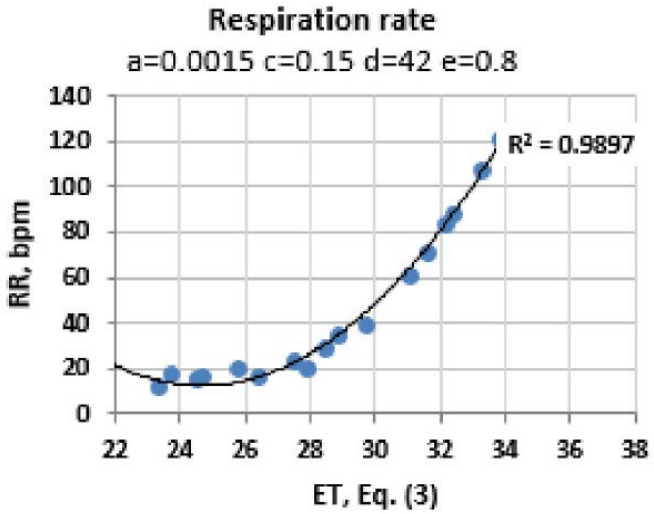


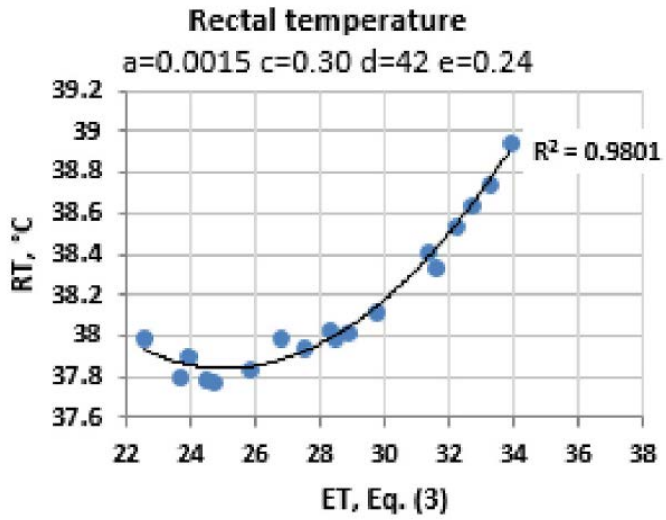


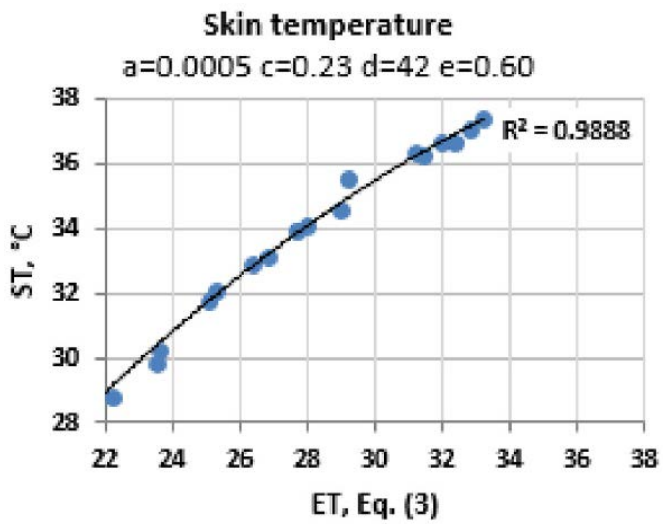


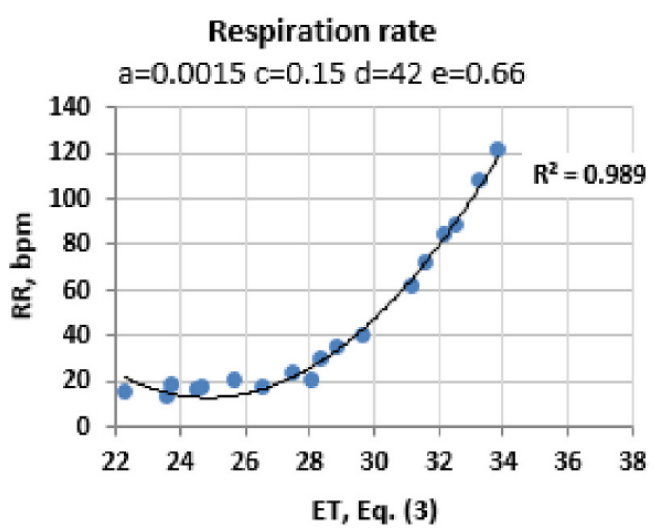
$$ET = T + a(rh - 50)T - c(v^e - 0.2^e)$$

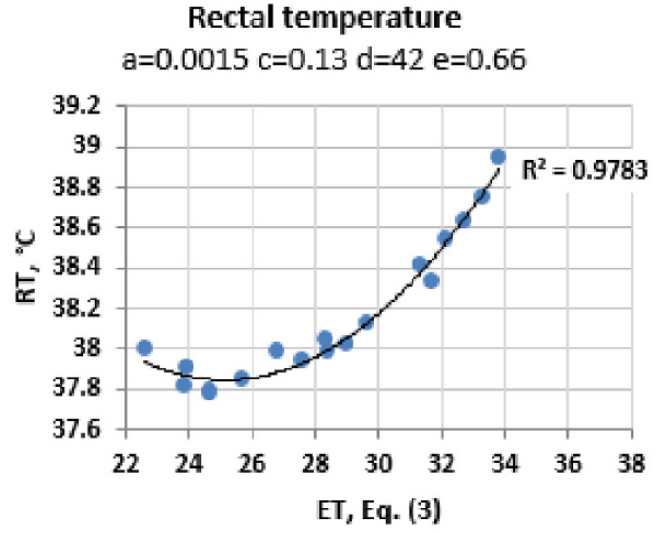
$$ET = T + a(rh - 50)T - c(v^e - 0.2^e)(d - T)$$

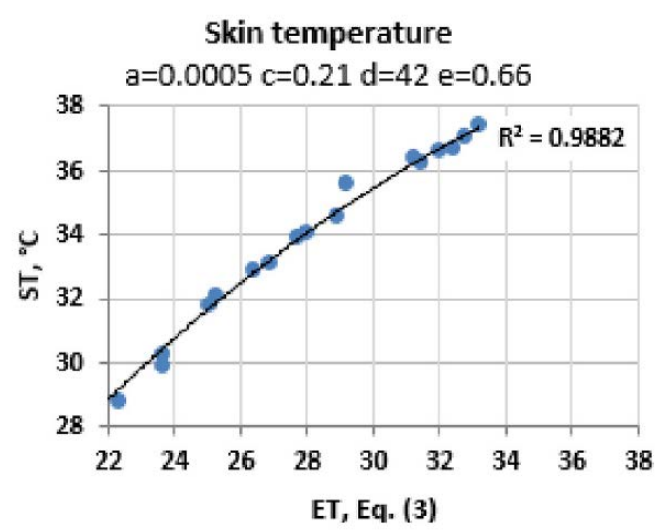




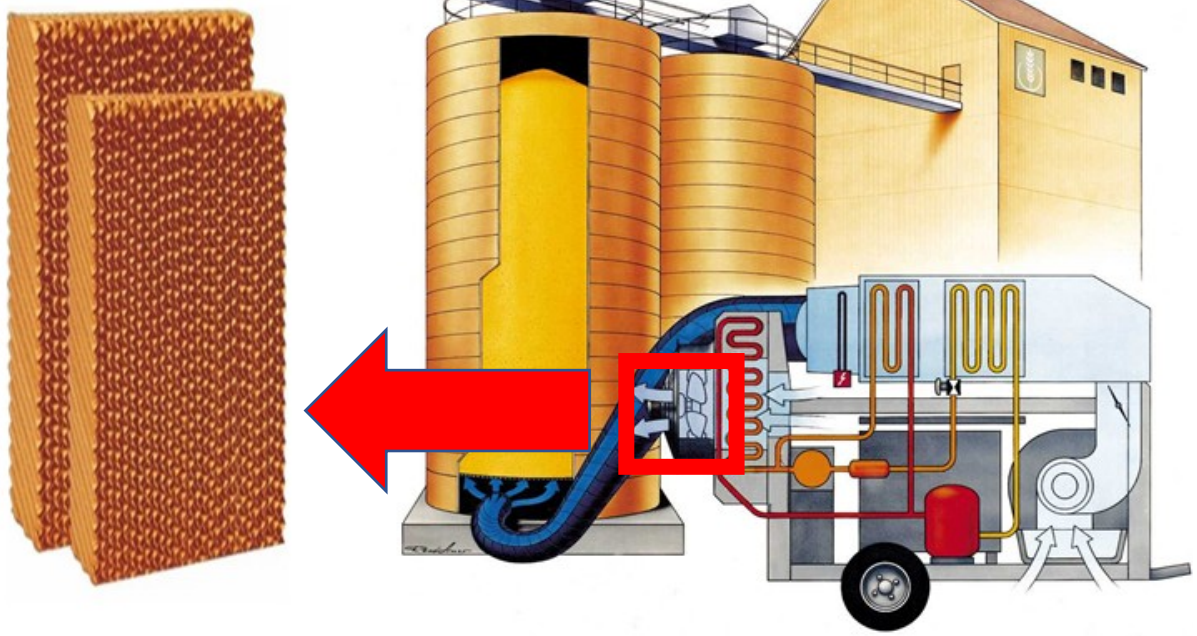








穀物冷藏機的應用－廢熱再利用

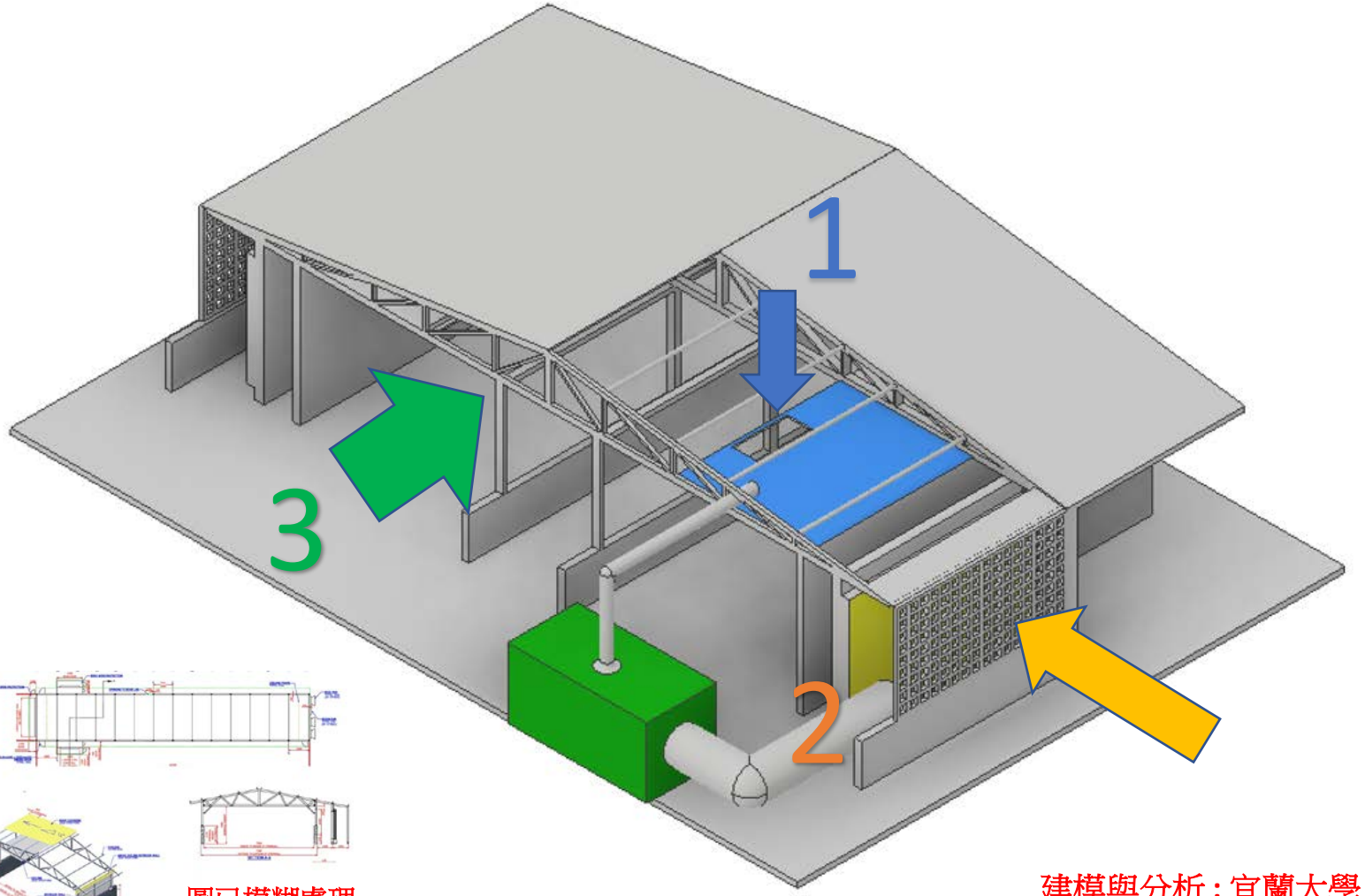


利用冷藏機低相對濕度的熱空氣提高水簾片的效率！

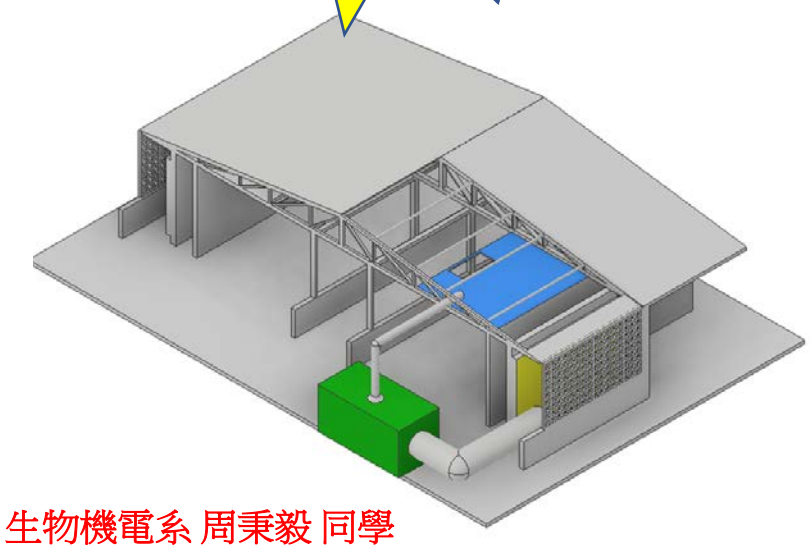
冷藏機的冷風溫度與相對濕度是可以控制！

種公豬環境實驗設計

1.冷氣入風端
2.冷藏機散熱風扇
3.冷氣與水濂降溫後空氣結合



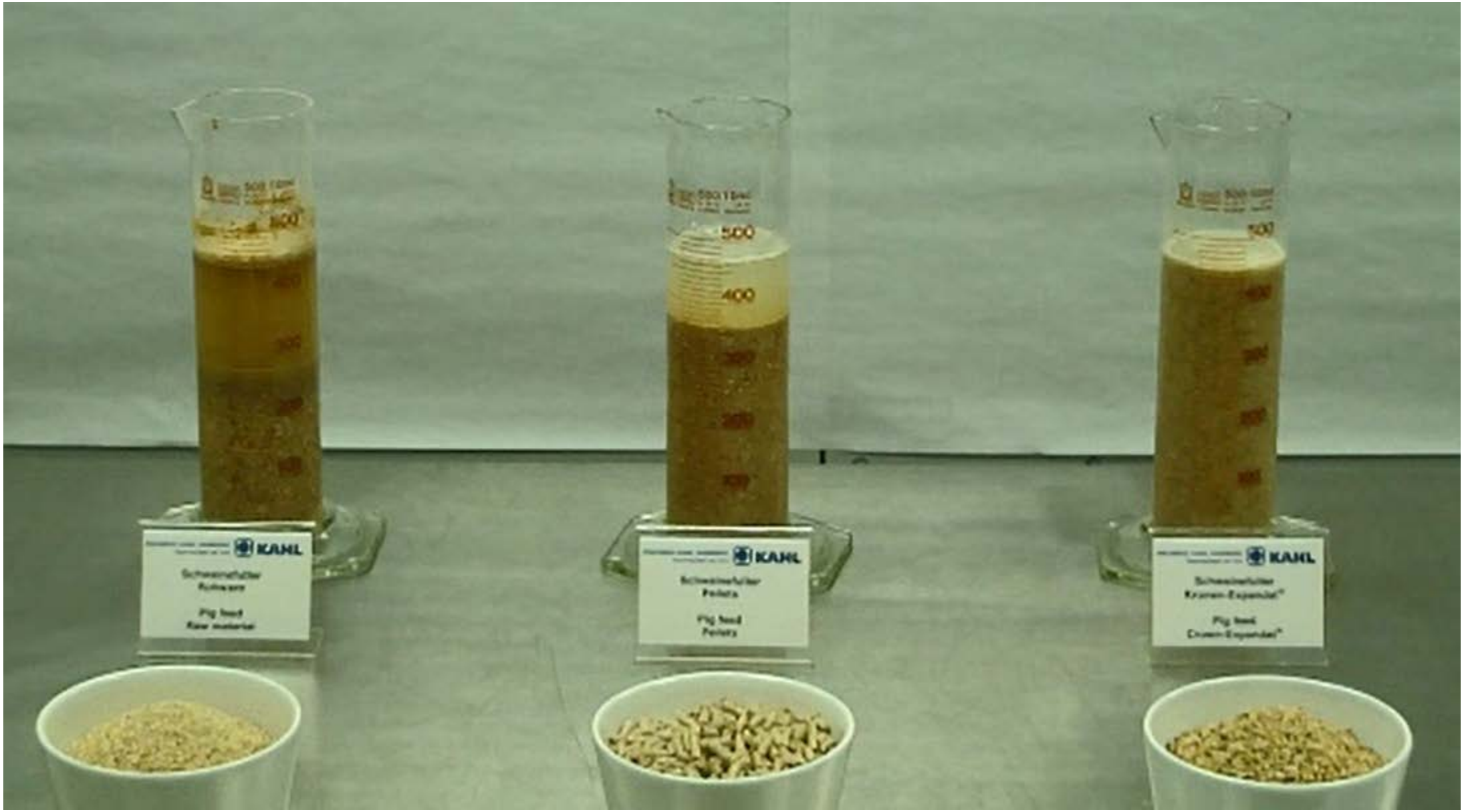
可調節溫濕度後輸出



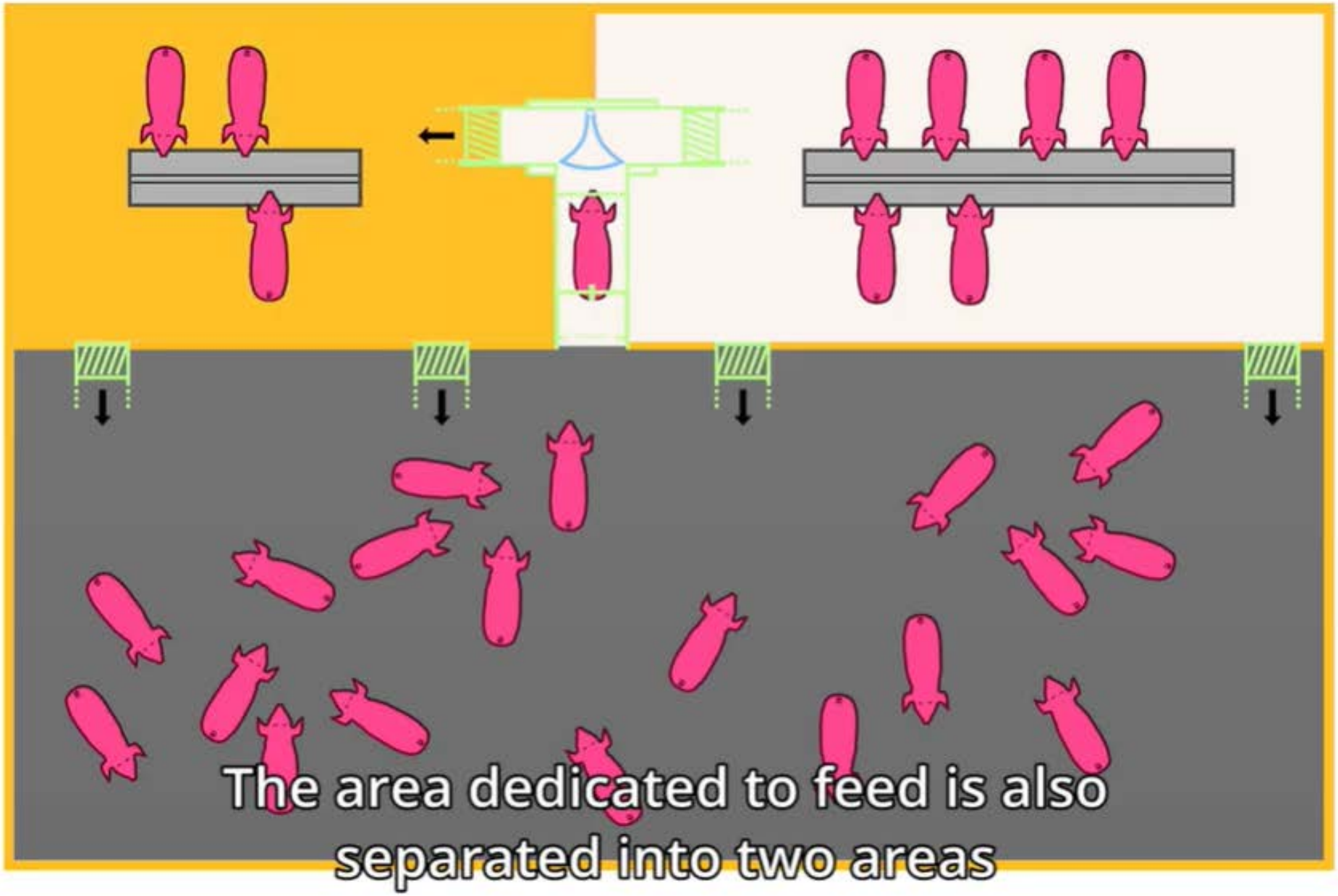
圖已模糊處理

建模與分析：宜蘭大學 生物機電系 周秉毅 同學

飼料加工影響給飼粉塵和消化


KAHL
Schweinefutter
Rohware
Pig feed
Raw material
KAHL
Schweinefutter
Pellets
Pig feed
Pellets
KAHL
Schweinefutter
Krumen-Expandat
Pig feed
Crumen-Expandat

肉豬自動重量分級 SKIOLD Tristar



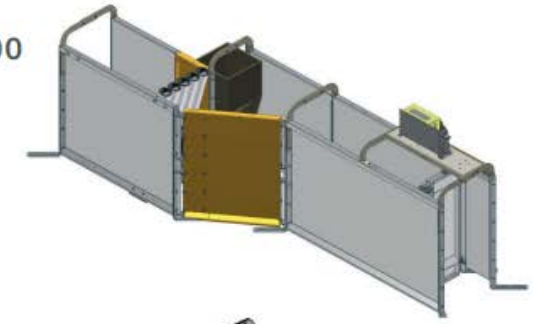
動物行為訓練

https://www.youtube.com/watch?v=gUMwC16sHFw

量身訂餐母豬自動給飼站

Training station including automatic control of the entry gate

140571100100



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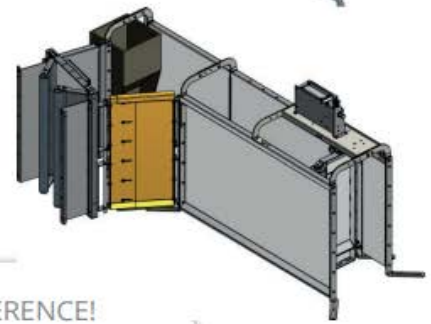
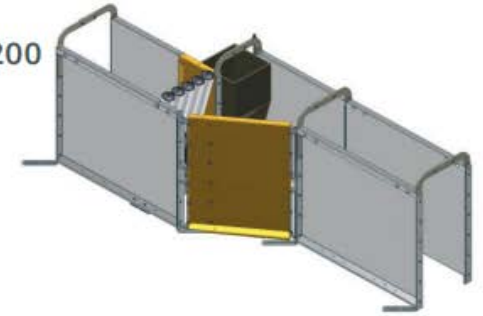


Training station without controlbox and entry gate

140571100200



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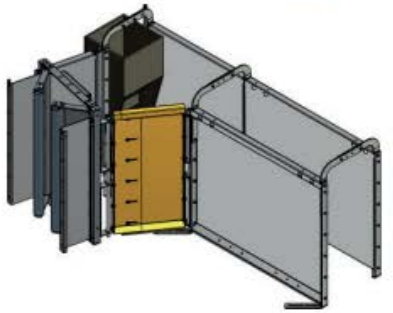


SKIOLD MAKES THE DIFFERENCE!

畜牧業的時代來臨

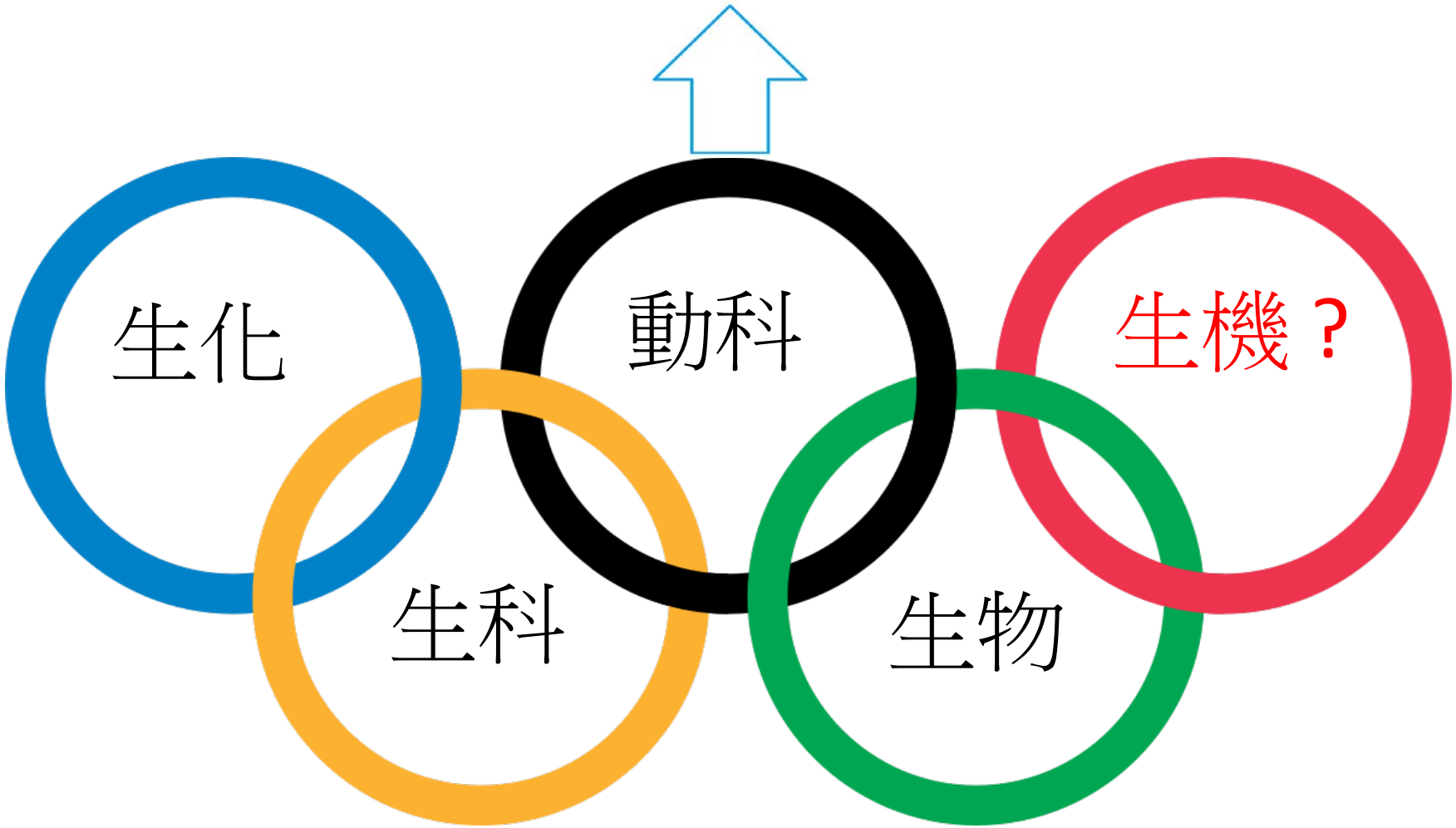
- 動物蛋白供應：豬雞鴨鵝、牛羊馬鹿、滿足動物蛋白需求。
- 動科專業人員：動物生殖、反芻動物、基因工程、遺傳育種、肉品加工、動物營養、飼料學等學門，動科人才齊聚。
- 飼養環境實務：動物農業與溫室氣體、養豬廢水處理技術與實務、動物資源經營學、動物生產自動化、環境生物技術、生質能源技術等學門。[蘇院士開課]
- 畜牧業的時代來臨，我們要專業人才

2022-04-29

狂賀！動科系蘇忠楨教授榮膺歐洲科學與藝術學院院士

台大動科系網站：http://www.ansc.ntu.edu.tw/News_n_1283_sms_10169.html

世界級的標誌－畜牧業



結語

- 有好的基因更要有好的環境
- 科際整合的高科技綠能產業
- 科學養豬可無屎無尿無污染5454556
- 畜牧結合生機動科更有生機

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