# *What to do about Liquid Helium?*




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# *Helium Usage Profile (UKMRM 2012/13)*

***VOLUMES (2013)***

| | |
|---|---|
| *400-1400L/annum* | *5 labs* |
| *2100-2500L/annum* | *4 labs* |
| *3900L/annum* | *1 lab* |

***COMMERCIAL PRICES 2012 (Add 20% for 2013. Add 100-500% by 2021)***

| | |
|---|---|
| *£6.10/L* | *(No fill)* |
| *£10/L* | *(Expensive fill charge)* |
| *£15/L* | *(Cheap fill charge)* |

***EXPENDITURE 2012***

| | |
|---|---|
| *£4-6k/annum* | *10 Labs* |
| *£15-40k/annum* | *7 Labs* |



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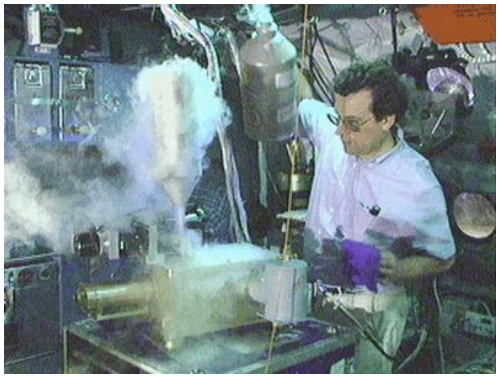
# Helium Recycling Possibilities



Capture and Compress boil-off



Hold-it in
(New magnets)

Capture and liquify boil-off



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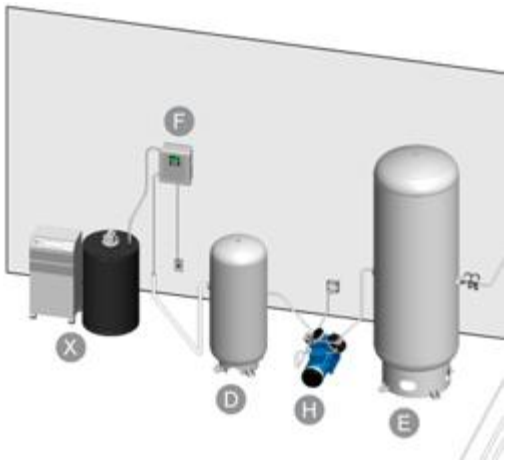
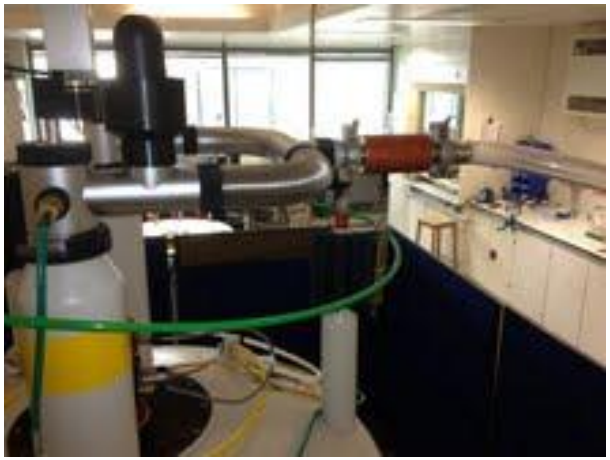
# Helium Recycling Possibilities




**Capture and Compress**

Capture boil-off into lines
w/ one-way/back-pressure valves

**~£5k-£10k** (depending on site/no. of magnets, etc)





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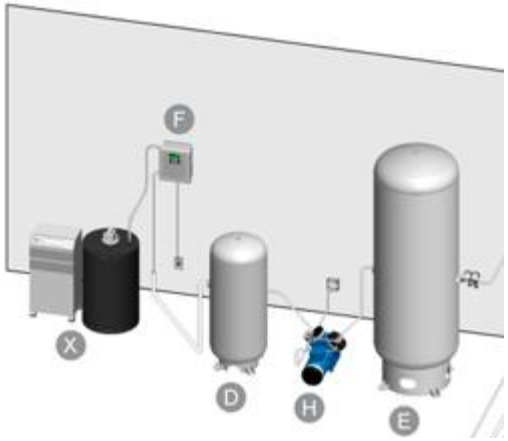
# Helium Recycling Possibilities




**Capture and Compress**

Gas passed to a bag (~2000L = 1mx1mx2m), then to a compressor (when critical pressure reached) and down to a bank of cylinders
**~£20-25k**

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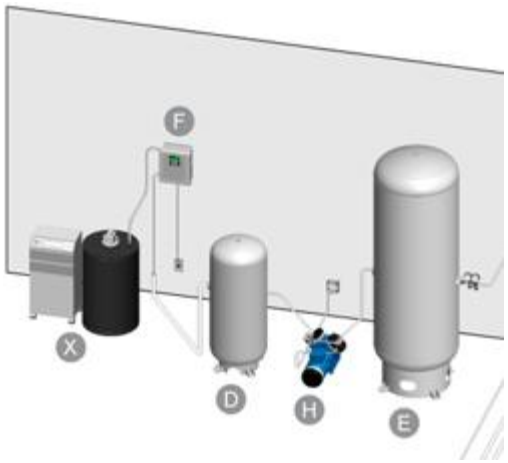
# Helium Recycling Possibilities




**Capture and Compress**

What to do with the gas…….?

‘Sell’ it to BOC (Juraj?)

‘Sell’ it to your Physics Department/liquifier

Get your Physics Department/liquifier to ‘sell’ you the liquid back again at a price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# *Helium Recycling Possibilities*

Summary of Capture and Compress:

| | |
|---|---|
| Installing capture lines | Cheap and straight forward.<br>Risks – back-pressure/vibration, gas contamination<br>Should we get a 'recommended method/hardware'? |
| Installing bag->cylinders | Moderate cost (~£30k), but you need to 'sell' the gas<br>Recovery levels ~90% (?) |

What to do with the gas:

(1) BOC will buy it (but volume limit? >5000 $m^3$, price = £1.50/L) *Rip-off??*

(2) Supply to a friendly liquifier (150L He cylinder = 10L liquid so **~£50 value?**).
Suggest sale of gas at ~£3/liquid litre (so ~£30/cylinder)?

| | |
|---|---|
| What is the problem: | Only 'subsidises' He used.<br>Doesn't offer surety of supply |



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# Helium Recycling Possibilities

**Capture and Compress – Cost/Benefit Analysis**

**Bristol's current model:**

2100L/annum @ £15/L (inc. VAT) £36k/annum (inc. fills)

**Bristol's future model:**

2400L/annum @ £7.50/L (inc. VAT) + £5k/annum fills £23k/annum

**Proposed Capture/Compress and sell to Physics**

80% Liq. He captured (we have two remote magnets that aren't worth it?)
Sell gas at 50% market rates (£3.75/ liquid litre)
Installation ~£20-25k, maintenance costs of £2k/annum
System lifetime >8 years

| | Cumulative Savings | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Liq. He** | **YEAR** | | | | | | | |
| **Inflation** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 10% | £22.4k | £16.1k | £9.0k | £1.2k | -£7.5k | -£17.3 | -£28.1k | -£40k |
| 20% | £22.4k | £15.4k | £6582 | -£4.3 | -£17.6k | -£34k | -£54k | -£78k |
| 30% | £22.4k | £14.6k | £3936 | -£10.5 | -£29.7k | -£55k | -£89k | -£134k |



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# Helium Recycling Possibilities

## Capture and Compress – Cost/Benefit Analysis

500L/annum (DIY fills)

| | | 1 year | 2 years | 3 years | 4 years | 5 years | 6 years | 7 year | 8 years |
|---|---|---|---|---|---|---|---|---|---|
| 10% | | 28488 | 28825 | 29095 | 29288 | 29389 | 29385 | 29259 | 28993 |
| 20% | | 28488 | 28674 | 28596 | 28189 | 27369 | 26037 | 24075 | 21337 |
| 30% | | 28488 | 28522 | 28067 | 26950 | 24947 | 21764 | 17019 | 10211 |

1000L/annum (DIY fills)

| | 1 year | 2 years | 3 years | 4 years | 5 years | 6 years | 7 year | 8 years |
|---|---|---|---|---|---|---|---|---|
| 10% | 26976 | 25650 | 24091 | 22271 | 20158 | 17719 | 14915 | 11702 |
| 20% | 26976 | 25347 | 23093 | 20072 | 16117 | 11023 | 4546 | -3609 |
| 30% | 26976 | 25045 | 22034 | 17596 | 11274 | 2477 | -9567 | -25862 |

1500L/annum (DIY fills)

| | | 1 year | 2 years | 3 years | 4 years | 5 years | 6 years | 7 year | 8 years |
|---|---|---|---|---|---|---|---|---|---|
| 10% | | 25464 | 22474 | 19086 | 15253 | 10928 | 6053 | 570 | -5589 |
| 20% | | 25464 | 22021 | 17589 | 11956 | 4865 | -3991 | -14983 | -28556 |
| 30% | | 25464 | 21567 | 16001 | 8241 | -2399 | -16810 | -36152 | -61934 |

2000L/annum (DIY fills)

| | | 1 year | 2 years | 3 years | 4 years | 5 years | 6 years | 7 year | 8 years |
|---|---|---|---|---|---|---|---|---|---|
| 10% | | 23952 | 19299 | 14081 | 8236 | 1697 | -5613 | -13775 | -22880 |
| 20% | | 23952 | 18694 | 12085 | 3839 | -6387 | -19005 | -34512 | -53502 |
| 30% | | 23952 | 18090 | 9968 | -1114 | -16072 | -36097 | -62737 | -98007 |



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# *Helium Recycling Possibilities*

**Liquefy your own**

Two approaches:

Large-scale Piston/Turbine-based Liquification

- 100 liquid L/day
- Requires gas bag as before
- Maintenance/Labour-intensive?
- £500k or more?


Small-scale coldhead-based Liquification

- ~10 liquid L/day
- Use the same tech. as cryoprobe coldheads
- £120k-£200k



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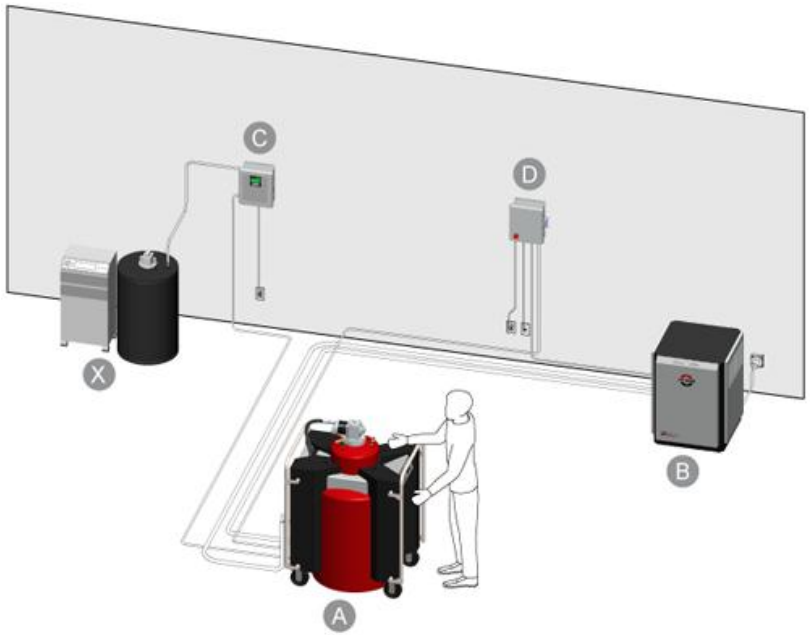
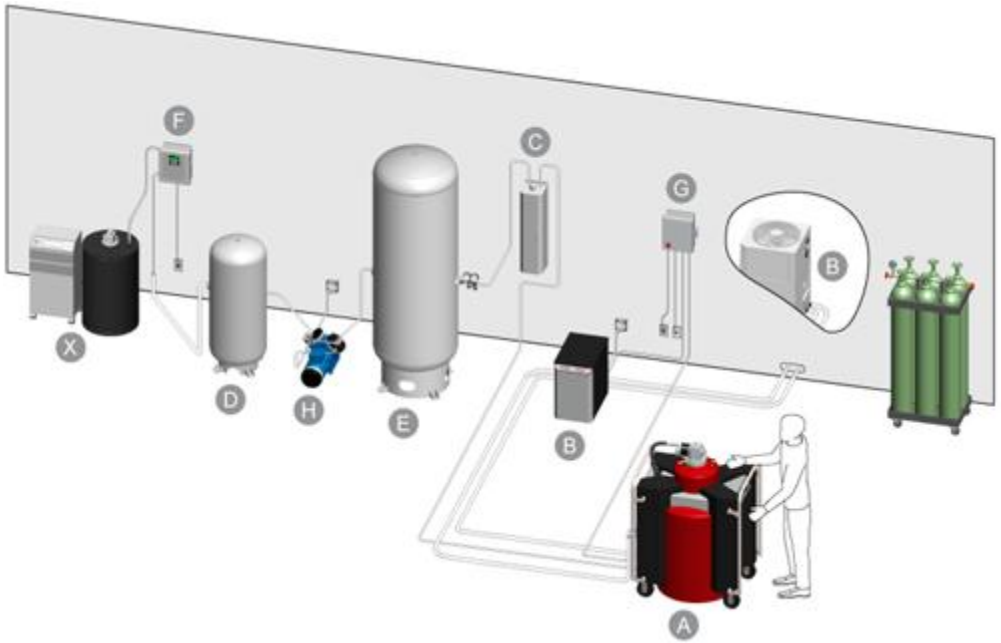
# Helium Recycling Possibilities

**Liquefy your own (Quantum Design ATL160 systems)**

Direct Recovery
(low pressure)
£150k
>80% recovery




Direct Recovery
(medium-pressure buffered)
£180k
>90% recovery

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# *Helium Recycling Possibilities*

**Liquefy your own (Quantum Design ATL systems)**

ATL80 and ATL160 (80L and 160L dewars). All further discussion based on ATL160

£150k-180k purchase and installation

Bi-annual maintenance/coldhead exchange (~£10k) but first maintenance inclusive.

Electricity usage <5kWh (<<50p/hour, <£10/day)

10L/day = 3600L/year limit

Use Sumitomo compressor/coldheads systems

New technology for NMR - first system currently being installed in the US (but been used for SQUID for ~10 years).



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# Helium Recycling Possibilities

**Liquefy your own – Cost/Benefit Analysis**

**Bristol's future model:**

2400L/annum @ £7.50/L (inc. VAT) + £5k/annum fills  £23k/annum

Liquefy with ATL160 (medium-pressure, >90% efficient)

20-30% Top-up He required (80% captured, >90% recycle efficiency)
Electricity @ £3k/annum
Maintenance costs of £2k/annum
System lifetime >8 years

| | Cumulative Savings | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Liq. He** | **YEAR** | | | | | | | |
| **Inflation** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 10% | 184236 | 174902 | 164374 | 164096 | 150768 | 148567 | 131791 | 127075 |
| 20% | 184236 | 173579 | 160008 | 154477 | 133086 | 119272 | 86429 | 60089 |
| 30% | 184236 | 172256 | 155378 | 143642 | 111898 | 81883 | 24685 | -37266 |



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# Helium Recycling Possibilities

## Liquefy your own – Cost/Benefit Analysis

3000L/annum

| | | 1 year | 2 years | 3 years | 4 years | 5 years | 6 years | 7 year | 8 years |
|---|---|---|---|---|---|---|---|---|---|
| 10% | | 177054 | 159820 | 140602 | 130764 | 106921 | 93154 | 63654 | 44942 |
| 20% | | 177054 | 157779 | 133866 | 115924 | 79640 | 47955 | -6333 | -58408 |
| 30% | | 177054 | 155738 | 126722 | 99207 | 46950 | -9731 | -101595 | -208612 |

4000L/annum

| | | 1 year | 2 years | 3 years | 4 years | 5 years | 6 years | 7 year | 8 years |
|---|---|---|---|---|---|---|---|---|---|
| 10% | | 170250 | 145532 | 118081 | 99187 | 65382 | 40657 | -897 | -32867 |
| 20% | | 170250 | 142810 | 109099 | 79401 | 29007 | -19608 | -94213 | -170667 |
| 30% | | 170250 | 140089 | 99574 | 57111 | -14579 | -96523 | -221228 | -370939 |

Bristol in 2016 (20% inflation will ~2x He price)

| | | 1 year | 2 years | 5 years | 6 years | 7 year | 8 years |
|---|---|---|---|---|---|---|---|
| 10% | | 168073 | 1409 | 52089 | 23858 | -21553 | -57767 |
| 20% | | 168073 | 1380 | 12805 | -41228 | -122334 | -206591 |
| 30% | | 168073 | 1350 | -34268 | -124297 | -259511 | -422884 |

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# *Helium Recycling Possibilities*

**To Capture or to Liquefy?**

**Annual Savings by 2021 (20% inflation)**

| | **Capture/Compress** | **Liquify Your Own** |
|---|---|---|
| 2000L/annum | £19k/annum | £29k/annum |
| 3000L/annum | £30k/annum | £52k/annum |
| 4000L/annum | £40k/annum | £75k/annum |

**Summary**

**Once liquefication breaks even in <6-8 years – it is better long-term value with sureity of supply and more local control.**



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