Notes: application CHO Perfusion cspr openloop

Here we run CHO Perfusion with cspr openloop for change of perfusion rate.

In [1]:
```
run -i BPL_CHO_perfusion_cspr_openloop_explore.py
```

```
Windows - run FMU pre-compiled JModelica 2.14

Model for bioreactor has been setup. Key commands:
 - par()       - change of parameters and initial values
 - init()      - change initial values only
 - simu()      - simulate and plot
 - newplot()   - make a new plot
 - show()      - show plot from previous simulation
 - disp()      - display parameters and initial values from the last simulation
 - describe()  - describe culture, broth, parameters, variables with values/units

Note that both disp() and describe() takes values from the last simulation
and the command process_diagram() brings up the main configuration

Brief information about a command by help(), eg help(simu)
Key system information is listed with the command system_info()
```
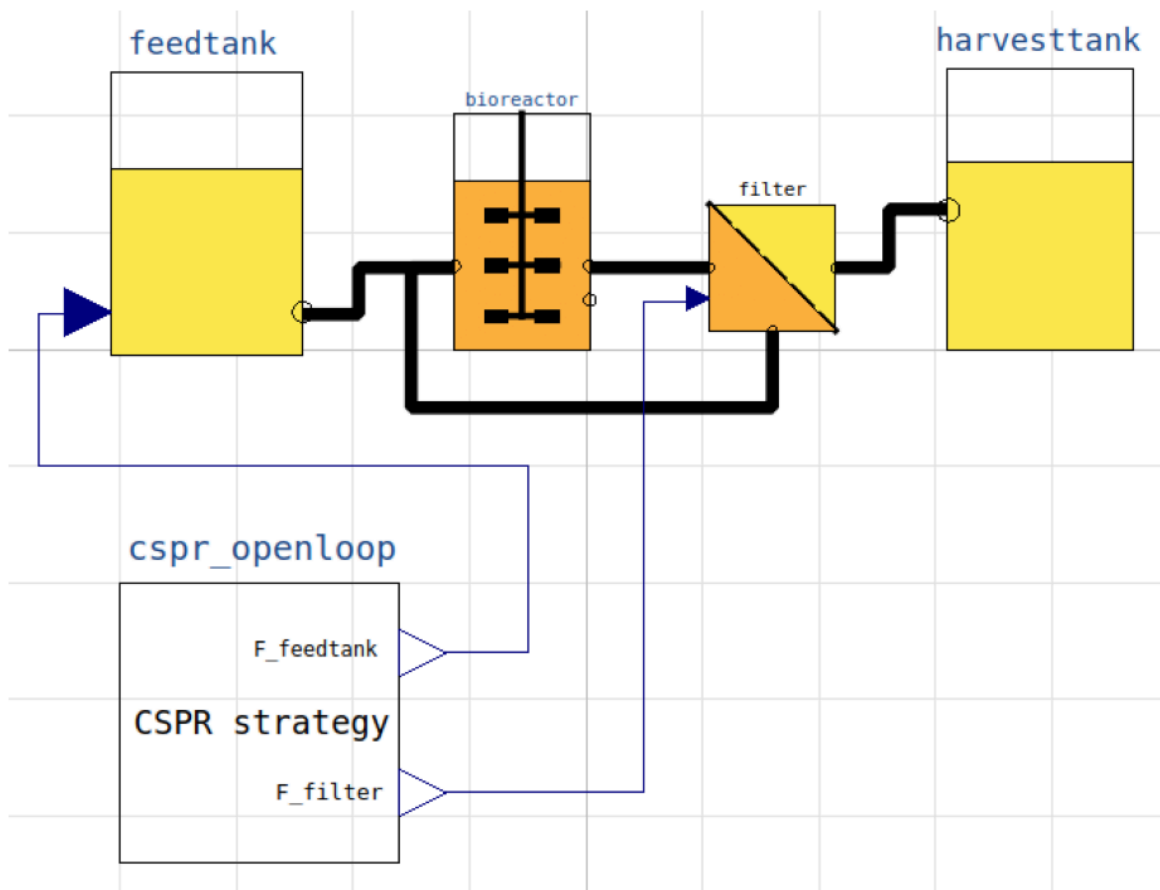
In [2]:
```
plt.rcParams['figure.figsize'] = [30/2.54, 24/2.54]
```

In [3]:
```
process_diagram()
```

```
No processDiagram.png file in the FMU, but try the file on disk.
```

```
In [4]:  describe('culture'); print(); describe('broth')
```

Reactor culture CHO-MAb - cell line HB-58 American Culture Collection ATCC

Reactor broth substances included in the model

```
Cells viable index =  1 molecular weight =  24.6 Da
Cells dead   index =  2 molecular weight =  24.6 Da
Glucose      index =  3 molecular weight =  180.0 Da
Glutamine    index =  4 molecular weight =  146.1 Da
Lactate      index =  5 molecular weight =  90.1 Da
Ammonia      index =  6 molecular weight =  17.0 Da
Protein      index =  7 molecular weight =  150000.0 Da
```

```
In [5]:  newplot('Perfusion cultivation', plotType='Extended')

         par(samplePeriod=1); par(F1=0.0020)       # General parameters
         par(mu_ref=0.04); simu()                   # First simulation (solid)
         par(mu_ref=1); simu()                      # Second simulation (dashed)
```
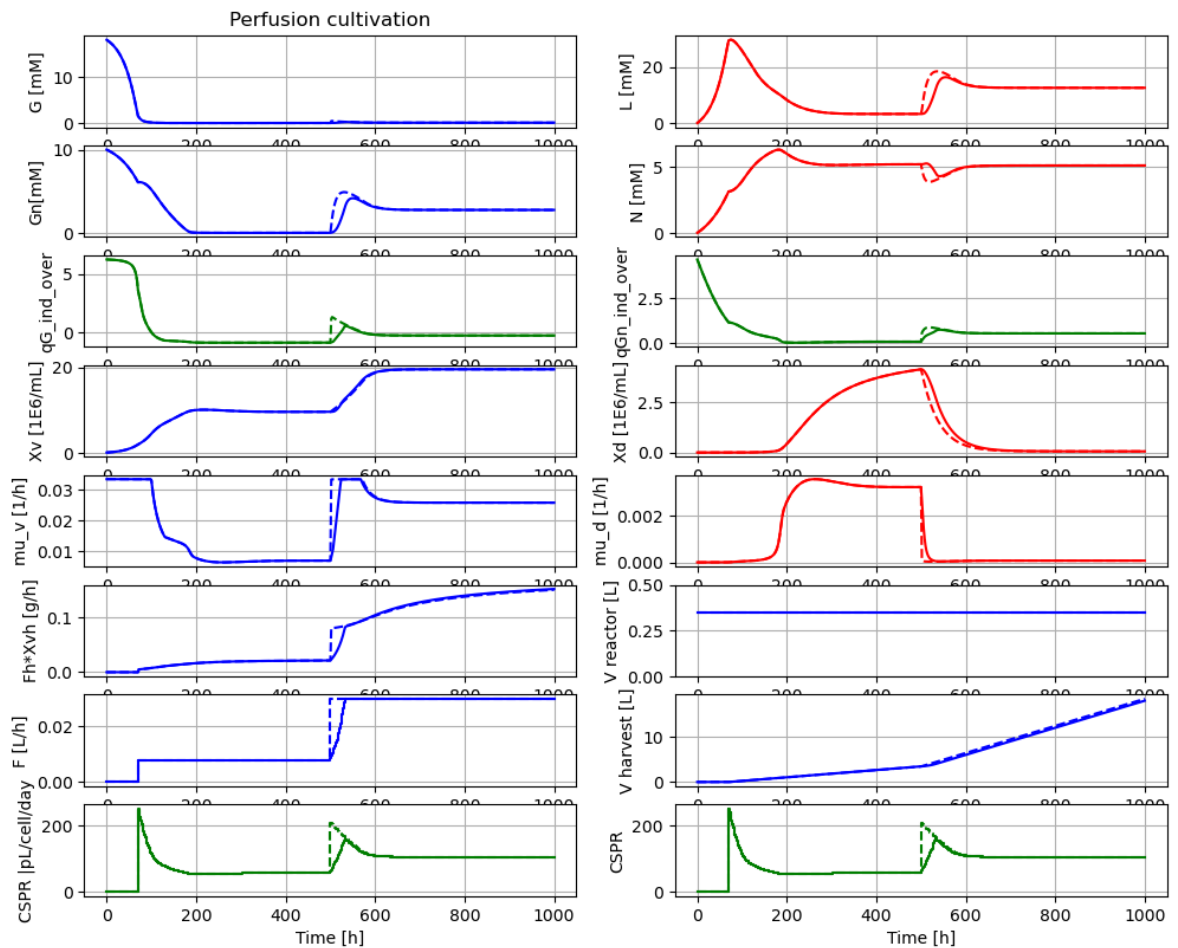
Perfusion cultivation
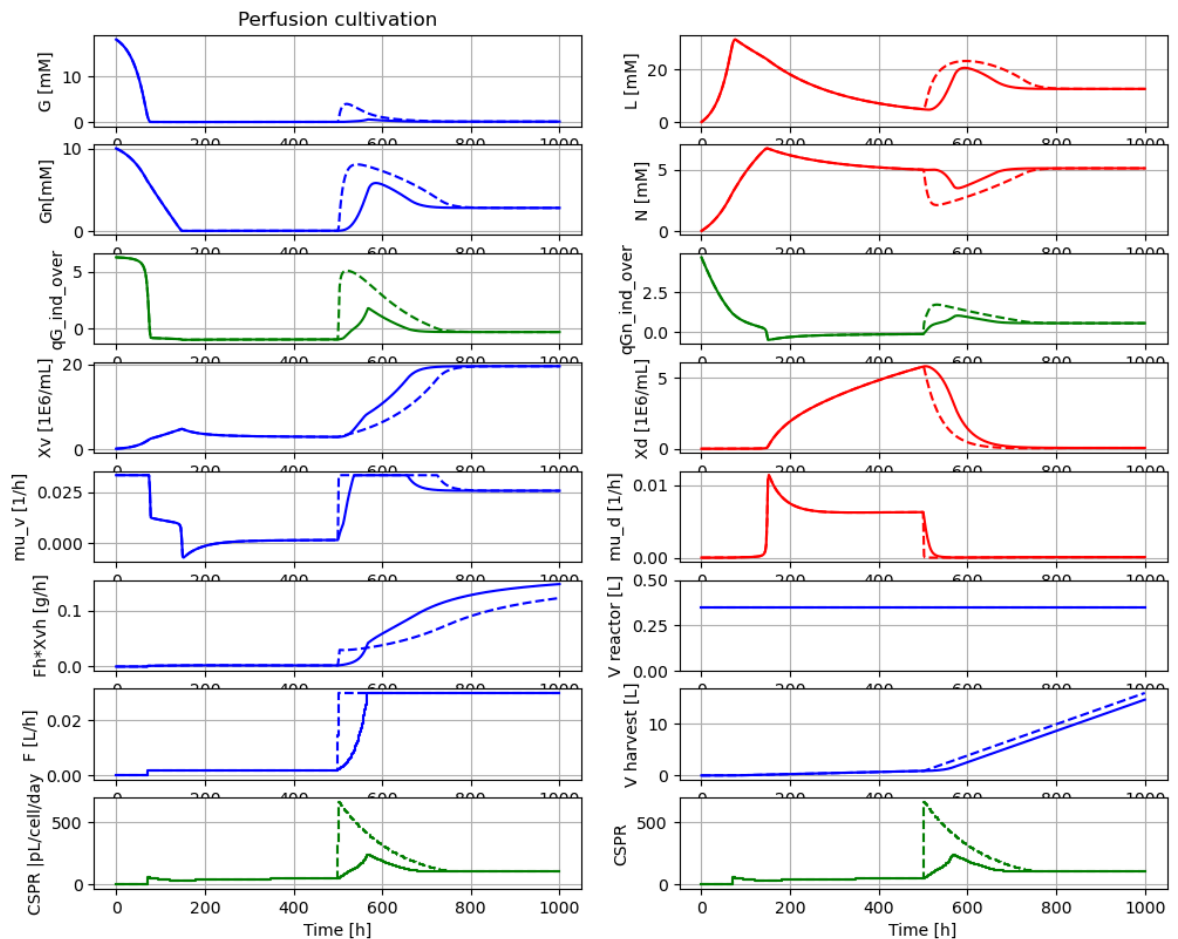
```
In [6]:   model.get('CSPR')

Out[6]:   array([105.41560997])
```

We see here the shorter settling time for cell conc Xv when the slower exponential
increase of perfusion rate is used, compared to an abrupt change.

```
In [7]:   newplot('Perfusion cultivation', plotType='Extended')

          par(samplePeriod=1); par(F1=0.0080)          # General parameters
          par(mu_ref=0.04); simu()                     # First simulation (solid)
          par(mu_ref=1); simu()                        # Second simulation (dashed)
```

Perfusion cultivation

We see that a somewhat smaller change in perfusion rate make the differnce in settling time of Xv for the two strategies to almost disappear.

In [8]:
```python
newplot('Perfusion cultivation', plotType='Extended')
simu(600)
simu(400,'cont')
```

Perfusion cultivation
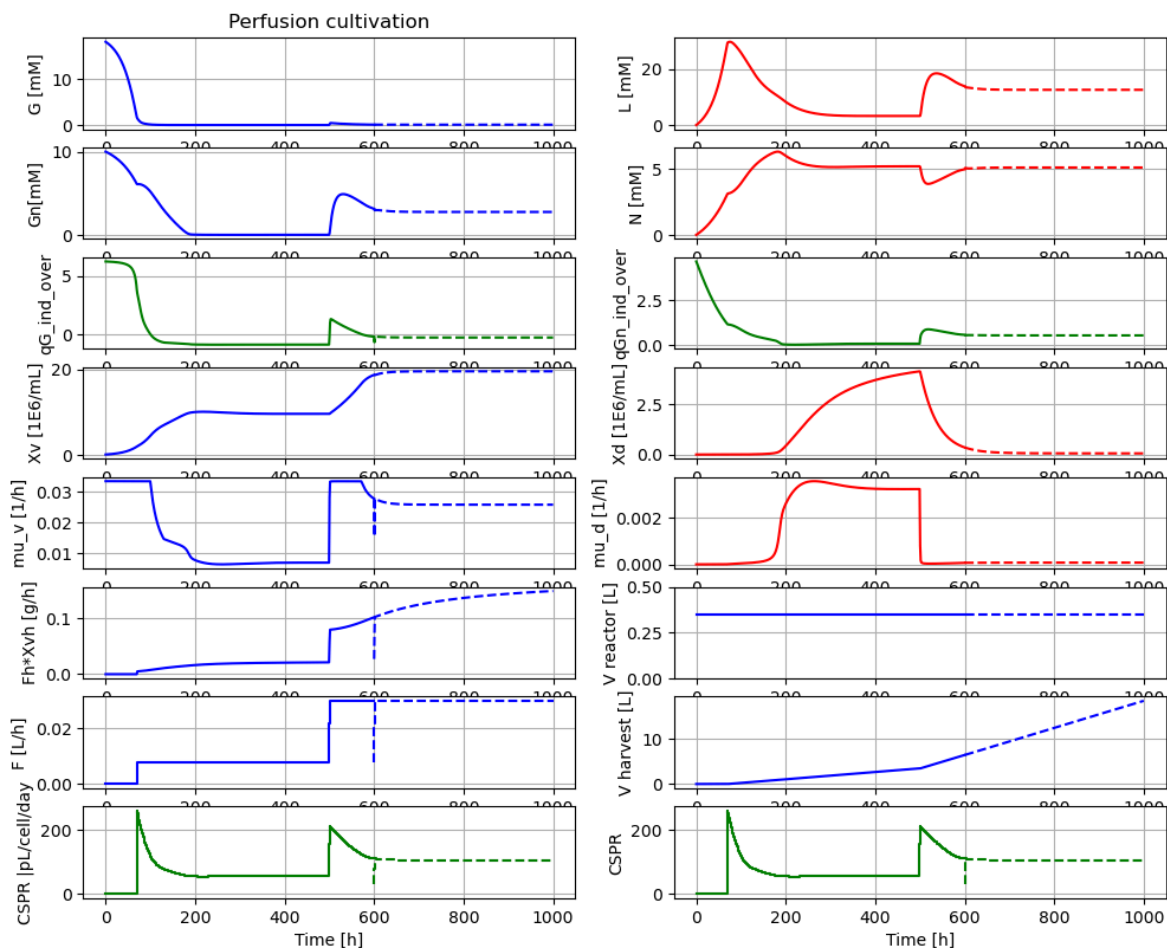
```
In [9]:   describe('feedtank.W')

          Reactor broth weight : 81.928 [ kg ]

In [10]:  describe('feedtank.V')

          Feed volume : 81.577 [ L ]

In [11]:  81.928/81.577

Out[11]:  1.004302683354377

In [12]:  describe('bioreactor.broth_decay.k_decay')

          Rate of decay of viable cells : 0.0 [ 1E9 cells/(L*h) ]

In [13]:  describe('k_lysis')

          Specific rate of lysis of dead cells : 0.0 [ 1/h ]

In [14]:  disp('culture')

          qG_max1 : 0.297
          qG_max2 : 0.038
          qGn_max1 : 0.124
          qGn_max2 : 0.022
          mu_d_max : 0.13

In [15]:  describe('mu')

          Specific cell growth rate variable : 0.026 [ 1/h ]
```

In [16]: `describe('parts')`

```
['bioreactor', 'bioreactor.broth_decay', 'bioreactor.culture', 'CSPR', 'cspr_open
loop', 'D', 'feedtank', 'filter', 'harvesttank', 'liquidphase', 'MSL']
```

In [17]: `describe('MSL')`

```
MSL: RealInput, RealOutput
```

In [18]: `system_info()`

```
System information
 -OS: Windows
 -Python: 3.10.13
 -Scipy: not installed in the notebook
 -PyFMI: 2.12.0
 -FMU by: JModelica.org
 -FMI: 2.0
 -Type: FMUModelCS2
 -Name: BPL_CHO.Perfusion_cspr_openloop
 -Generated: 2024-05-15T09:00:03
 -MSL: 3.2.2 build 3
 -Description: Bioprocess Library version 2.2.0
 -Interaction: FMU-explore version 1.0.0
```

In [ ]: